CEDD INNOVATION SERIES



Ultra-High Strength S960 Steel Footbridges: From Vision to Reality

Foreword

The Civil Engineering and Development Department (CEDD) is committed to providing the land and infrastructure essential to the development of the Northern Metropolis. To overcome these challenges, we are leveraging innovative solutions to enhance the speed, efficiency, quality and quantity of our project delivery. On the other hand, while Hong Kong has the distinctive advantages of enjoying strong support of the Motherland and being closely connected to the world, the Northern Metropolis is the best stage for transforming and upgrading high-end Chinese products and technologies to be exported to the world.

This ultra-high strength S960 steel initiative is a key example of how using high-quality Chinese steel can help enhance the speed and efficiency of infrastructure delivery in the Northern Metropolis. Through continuous University-Government-Industry partnerships, we have advanced and integrated cutting-edge construction technologies and material applications while promoting sustainability and enhancing architectural aesthetics to transform our urban landscape.

The pioneering application of ultra-high strength S960 steel in footbridge construction exemplifies how the development of new quality productive forces can enhance the efficiency, productivity, quality and safety of the construction industry. In collaboration with universities, research institutes, industry practitioners and other Government departments, we can establish an evidence-based approach to tackle technical challenges pertaining to the successful application of novel construction materials. With this pilot project in Fanling North New Development Area, not only did we demonstrate the project benefits of adopting high quality Chinese ultra-high strength steel in footbridge construction in terms of savings in project cost, time and carbon emissions, but we also demonstrated the capability of innovating our public infrastructure by adopting a similar evidence-based approach under a University-Government-Industry collaboration framework.

I extend my deepest gratitude to all the contributing parties of this innovative application. Their willingness to break through silos and work together to achieve the most efficient engineering solution has turned vision into reality.

This CEDD Innovation Series captures this journey as a signpost on the path to a new urban future. We share it to ignite ambition and inspire partners to think deeper and build better. Together, we are not just constructing infrastructure, but also cultivating a collaborative environment for the construction industry to explore innovative solutions to conventional problems. The journey continues. With every novel material used, every partnership forged, every idea tested, we are building the Hong Kong of tomorrow.



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CEDD

Disclaimer

This publication is intended solely for informational and experience sharing purposes. It should not be regarded as a mandatory handbook or comprehensive set of procedures. It does not constitute part of the official contractual documentation or mandatory requirements. Users are advised to consult the relevant standards, regulations, and contractual provisions applicable to their specific projects. The Civil Engineering and Development Department assumes no liability for any actions taken or decisions made based on this publication.

Abstract

This publication summarises the world's first application of ultra-high strength S960 steel in footbridge construction implemented in Fanling North New Development Area of Hong Kong by the Civil Engineering and Development Department (CEDD), with the policy support from the Development Bureau, in collaboration with the Chinese National Engineering Research Centre for Steel Construction (Hong Kong Branch) of The Hong Kong Polytechnic University, AECOM Asia Company Limited, Daewoo – Chun Wo – Kwan Lee Joint Venture and YWL Engineering Pte Limited under a Memorandum of Understanding signed on 27 June 2023. Through rigorous research, laboratory tests and quality assurance processes, the team has successfully commissioned the two S960 steel footbridges under the pilot project in 2026.

This publication focuses on the technological and institutional advancements in this application. The goal is to encourage the use of novel materials like high strength steel to enhance the speed, efficiency, quality and quantity of infrastructure construction projects.

The CEDD is grateful to the invaluable contributions of all involved parties whose collaborative efforts have been essential to the success of this pioneering application.

Contents

Title Page 1
Foreword 2
Disclaimer 3
Abstract 4
Contents 5
1 Background 6
2 Technological Advancements 8
2.1 Structural design validation 8
2.2 Material supply 9
2.3 Fabrication and logistics 9
2.4 Welding and site assembly 12
3 Institutional Advancements 15
3.1 Maximising Public Value 15
3.2 Collaborative Governance 16
3.3 Institutional Framework Contributions 17
3.4 Architectural Integration and Public Value Realisation through Art in Engineering 17
4 Way Forward 22
5 References 23
6 Acknowledgements 24

1 Background

Fanling North New Development Area (FLN NDA) is amongst the first batch of new development areas within the Northern Metropolis to enter the construction stage. Planned as a predominantly residential community, it is located within the Boundary Commerce and Industry Zone, adjacent to the existing new towns of Fanling and Sheung Shui. To accommodate the anticipated traffic demand, the Civil Engineering and Development Department (CEDD) undertook the Fanling Bypass Eastern Section project to provide major road infrastructure connecting the FLN NDA with the existing Fanling Highway.

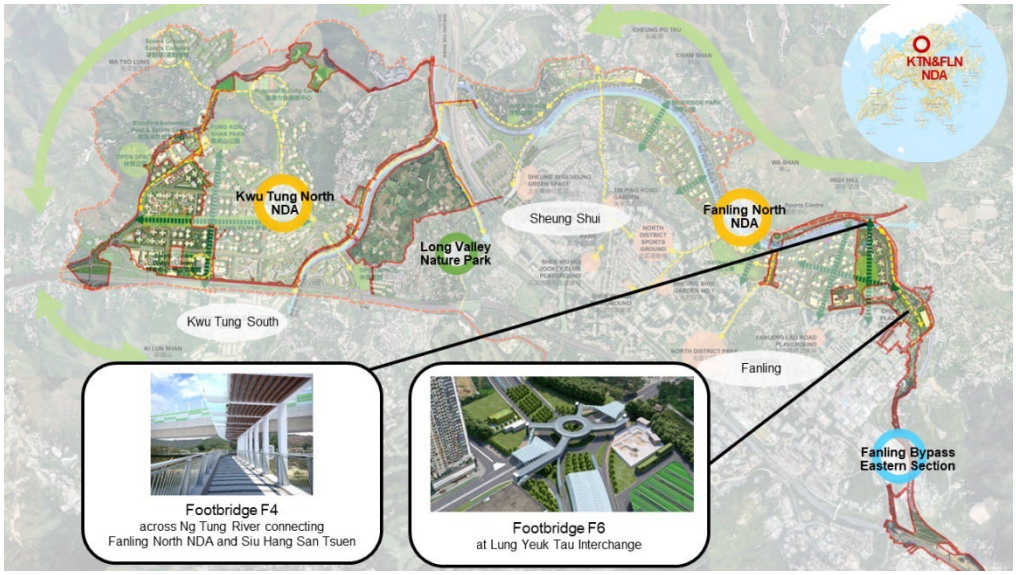


Figure 1 – Layout of Fanling Bypass Eastern Section

In August 2020, CEDD entered into contract no. ND/2019/04 with Daewoo – Chun Wo – Kwan Lee Joint Venture (DCK JV), with AECOM Asia Company Limited (AECOM) as the *Project Manager* and the *Supervisor*, for the construction of Fanling Bypass Eastern Section between Shek Wu San Tsuen North and Lung Yeuk Tau. Since contract commencement, the project team faced several physical and operational constraints, including limited productivity during the COVID-19 pandemic, site availability subject to land resumption progress and complex utilities across the sites, imposing a strict construction programme to meet the population intake target.

Pedestrian connectivity was identified as a key consideration for promoting sustainable modes of transport, necessitating the construction of two footbridges alongside the carriageways:

- **Footbridge F6:** A cycle track cum footbridge featuring a 40-metre diameter circular deck founded monolithically on the piers at the Lung Yeuk Tau Interchange, with four link bridges of span up to 36 metres and eight lifts for connecting the cycle tracks on the deck level to the extensive network in the North District.

- **Footbridge F4:** A two-span footbridge crossing the Ng Tung River, connecting the FLN NDA with Siu Hang San Tsuen. It features two 35-metre-long spans that connect monolithically to a viewing platform at the pier supporting the viaducts of the Fanling Bypass Eastern Section and are supported by bearings on the riverside abutments.

Under the conforming scheme, the proposed concrete girder form posed operational challenges. The Lung Yeuk Tau Interchange is a three-layered structure to be constructed across the existing Sha Tau Kok Road, the main artery of the North District carrying heavy traffic on the ground and housing all major underground utilities. The elevated structure of Footbridge F6 at the Lung Yeuk Tau Interchange had to be constructed concurrently with an at-grade roundabout and the vehicular underpass for through traffic of Fanling Bypass Eastern Section, during which the traffic and utilities serving the district must not be disturbed. This setting created a challenging environment for building substantial substructures.



Figure 2 – Congested site for the construction of Lung Yeuk Tau Interchange

Constructing Footbridge F4 over Ng Tung River meant works would be affected by highly variable water flows during dry and wet seasons, particularly during increasingly frequent extreme weather conditions. The erection, maintenance and dismantling of falsework for cast in-situ construction would introduce safety risks to workers. The limited working space, as confined by viaduct construction above, highly variable water flow underneath and high voltage overhead power cables in the vicinity, essentially hindered the efficient construction of the footbridge.

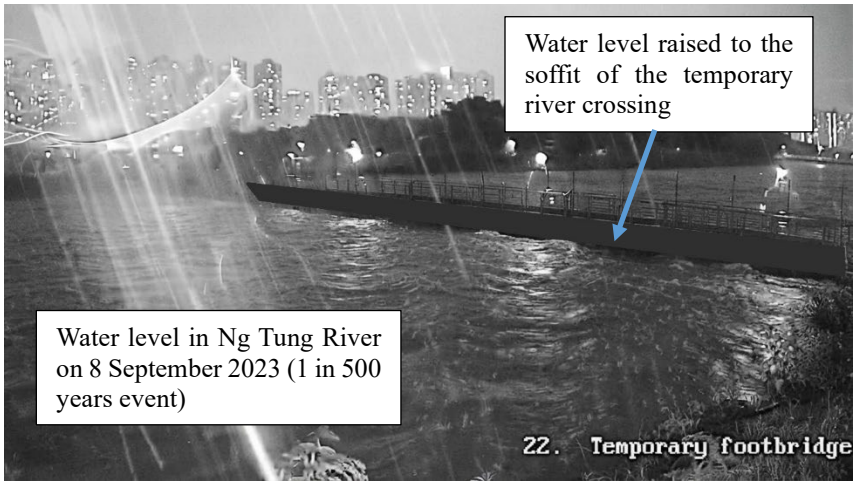


Figure 3 – Extreme weather causing highly variable water flow along Ng Tung River (Photo clarity enhanced by AI)

2 Technological Advancements

To manage the risks in footbridge construction effectively, the project team was keen on seeking alternative solutions capable of reducing superstructure weight, minimising foundation works and maximising off-site fabrication. The team explored options to optimise the superstructures, and their attention was drawn to the global trend of steel bridge construction and the technological advancement of high strength steel production and fabrication in the Chinese Mainland.

In Hong Kong, while the opening of the Cross Bay Link at Tseung Kwan O in December 2022 marked the first use of high strength S690 steel in vehicular bridge construction, there was no precedent for using higher steel grades in infrastructure.

Against this background, CEDD and The Hong Kong Polytechnic University (PolyU) signed a Memorandum of Understanding on 27 June 2023 to deepen the collaboration on development and promotion of effective use of ultra-high strength S960 steel for facilitating the innovative application of ultra-high strength S960 steel in footbridge construction under the Fanling Bypass Eastern Section project. The signing was witnessed by the directorate of AECOM, DCK JV, and their designer, YWL Engineering Pte. Limited (YWL), who formed a cross-sector team with CEDD and PolyU to collaborate on the pioneering application of ultra-high strength S960 steel in footbridge construction.



Figure 4 – Signing of Memorandum of Understanding on 27 June 2023

During the collaboration, the team addressed variables in structural design validation, material supply, fabrication and logistics, and welding and site assembly.

2.1 Structural design validation

A primary technical requirement was addressing the absence of codified design rules for ultra-high-strength S960 steel. The established European Standards EN 1993, which Hong Kong follows, only provided design rules for structures with steel grades up to S700. To establish a codified design approach, the Chinese National Engineering Research Centre for Steel

Construction (Hong Kong Branch) (CNERC) at PolyU reviewed literature, conducted destructive testing and performed detailed analysis to compile the *Technical Guidance on Structural Design of Plate Girder Structure using Ultra-high Strength S960 Steel*, which provided additional guidance for extending relevant rules of EN 1993 to cover the effective use of S960 steel class 4 sections with explicit allowance for the effects of local buckling in the elastic design. With insights from Tsinghua University, this academic validation served as a functional design standard, enabling YWL to finalise the structural design as plated girder structures with due consideration of structural safety.



Figure 5 –Technical Guidance on Structural Design of Plate Girder Structure using Ultra-high Strength S960 Steel

2.2 Material supply

Historically, high-strength steel required advanced metallurgical engineering that necessitated importing materials into China, resulting in higher costs, longer lead times, and supply chain uncertainties. Drawing on the technological advancements in steel production, Chinese steel producers can manufacture S960 steel plates that are in full compliance with the mechanical property requirements of structural steel to EN 10025, supported by complete traceable records (Leung et al., 2026).

2.3 Fabrication and logistics

Chinese steel fabricators are used to fabricate bridges with steel grades up to S690 and mechanical equipment with steel grades of S960 and beyond. In this pioneering application of S960 steel in footbridge construction, AECOM and DCK JV visited several steel fabricators in Guangdong and Jiangsu Provinces. After due consideration of the technical and logistical aspects of the fabricators, DCK JV partnered with Daming Heavy Industry in Jiangsu Province, with ultra-high strength S960 steel plates produced by Nanjing Steel Group Company Limited.

To minimise complex on-site welding, the team adopted an extensive modularisation strategy. Footbridge F4 was fabricated into six modules weighing 85 tonnes in total, which were fitted into standard racks for shipping to the Kwai Chung Container Terminal and then transported to the site on standard trailers in June 2024.



Figure 6 – Delivery of Footbridge F4 modules

However, the more extensive superstructure of Footbridge F6 presented a logistical challenge. If the modules were to fit within standard racks like Footbridge F4, the footbridge would have to be divided into 53 modules. Given the complex physical conditions and limited local welders on site, assembling these modules would take at least 9 months, even in favourable weather. To maximise the efficiency of welding ultra-high strength S960 steel by the steel fabricator, the team optimised the modularisation of the footbridge into 40 modules of width up to 7.8 metres, which could fit into an envelope of 7.3 metre-wide and 4.9 metre-tall when measured with the trailer and the tilting table meticulously designed by YWL to hold the modules in a tilted position steadily in motion.



Figure 7 – Trial assembly of Footbridge F6 modules in the fabrication yard

While these oversized modules had no issue being transported by sea from the fabrication yard in Jiangsu Province to the temporary cargo handling area established by the project team at Ho Wo Street, Tuen Mun, they still needed to reach the site via a 34 kilometre-long land route.

To ensure the technical feasibility of this modularisation strategy, the team collaborated with the Modular Integrated Construction Laboratory (MiCLab) of the University of Hong Kong (HKU), which had developed the 3D Swept Path Analysis with support from the Smart Traffic Fund administered by the Transport Department (TD). Utilising the 3D spatial data from the Lands Department, the analysis identified critical junctions and advised on the clearance between the convoy and existing features through virtual trial runs.

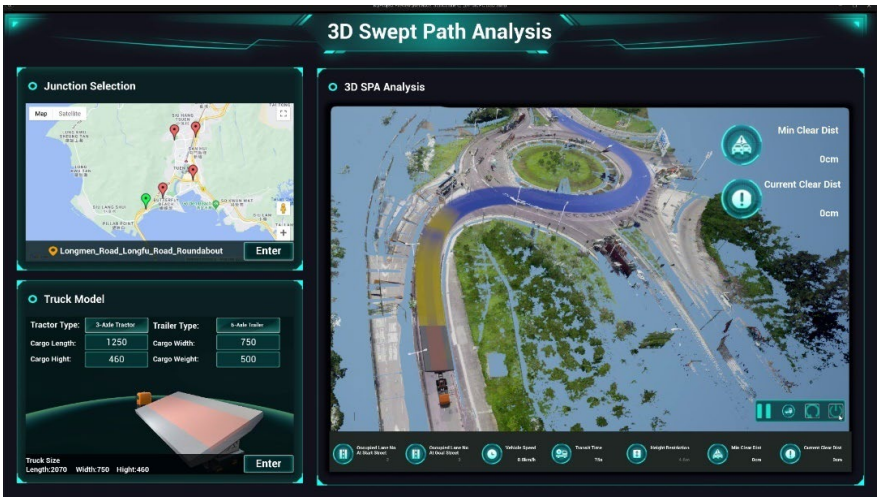


Figure 8 – Screenshot of the 3D Swept Path Analysis
From: Smart Traffic Fund Project Reference: PSRI/69/2306/RA, "A Smart Planning Platform for Safe and Efficient MiC Module Transport" by MiCLab, HKU)

The analysis was particularly useful when liaising with TD and the Hong Kong Police Force to assess the feasibility of the delivery proposal, the necessity of modification of existing features, and to plan the escorting arrangement, and hence facilitated the swift planning, approval and completion of the delivery of all segments across 12 nights between February and April 2025.



Figure 9 – Oversized modules delivery

2.4 Welding and site assembly

Welding may cause microstructural changes and reduce strength and ductility in S960 steel. To minimise the adverse effects, all S960 steel plates featured a low Carbon Equivalent Value, and low-hydrogen solid wire electrodes were adopted. Through extensive research, experimental investigations and numerical simulations, CNERC identified optimal heat-input energy ranges and developed welding procedures in collaboration with experienced local welding experts and practitioners. To address the local skills gap regarding S960 steel, local welders were extensively trained in this pilot project, and robotic site welding was introduced to improve efficiency and provide help to local welders. The team also collaborated with the Hong Kong Institute of Construction of the Construction Industry Council to organise training programmes on S960 steel welding robot operation, further equipping the local industry with the capability to weld S960 steel.



Figure 10 – S960 steel local welder training

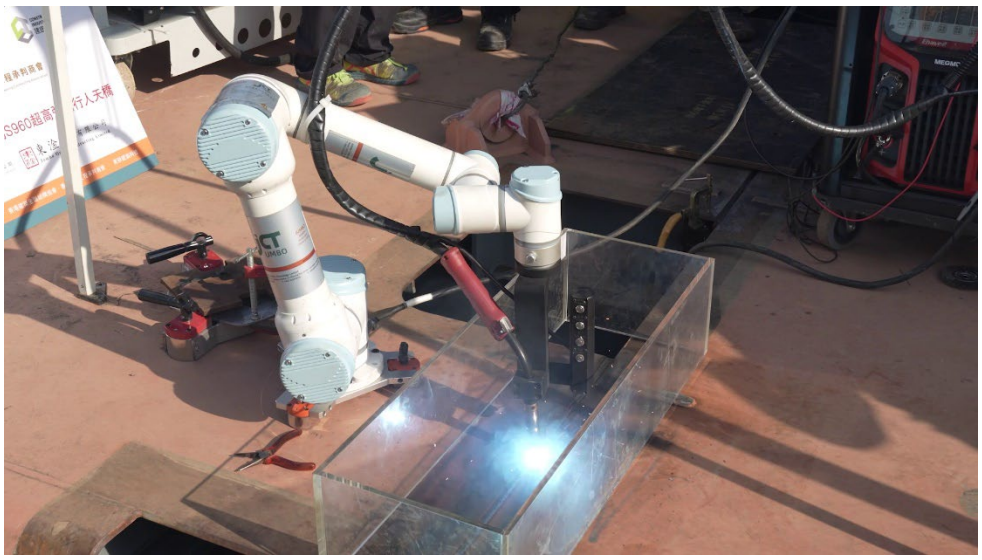


Figure 11 – S960 steel robotic welding

As an effort to minimise site welding, Footbridge F4 utilised bolted connections to join three modules into a complete 36 metre-long span, which could be lifted into the design position by mobile cranes on site even when constrained by the viaduct construction above and overhead power cables in the vicinity.



Figure 12 – Footbridge F4 Assembly Ceremony



Figure 13 – Lifting of Footbridge F4

Geometry control was also a challenge on site, especially for the circular deck of Footbridge F6. The team deployed strong backs, clamps and heat-straightening processes to release locked-in residual stresses.

With over 1500 metres of on-site welding completed, Footbridge F6 was successfully installed to the design position with strand jacks for the quadruple-span circular deck in July 2025, and with mobile cranes for the four link bridges of span up to 36 metres by September 2025.



Figure 14 – Quadruple span lifting of the circular deck of Footbridge F6

3 Institutional Advancements

By unprecedently and innovatively using ultra-high strength S960 steel in footbridge construction, a common infrastructure project was transformed into a complex exercise in strategic public management and transformation. This chapter summarises the institutional advancements achieved, particularly in public value and collaborative governance.

3.1 Maximising Public Value

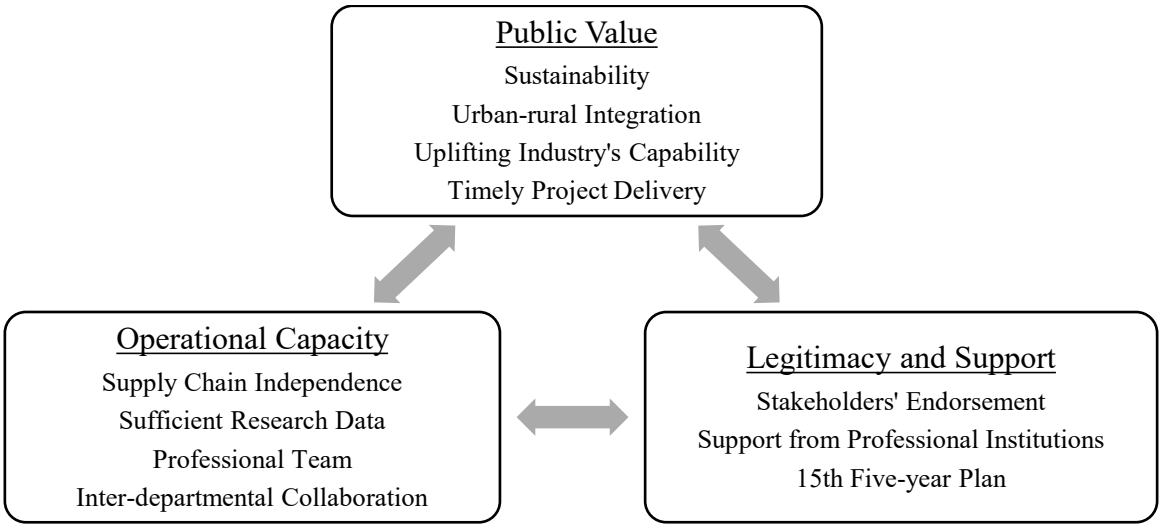


Figure 15 – Mark Moore's Strategic Triangle on Public Value Management (Moore, 1995)

A successful initiative can be implemented only when it achieves Public Value, Operational Capacity, and Legitimacy and Support (Moore, 1995). In our case, with nearly three times the strength of conventional S355 steel, S960 steel was used to achieve a 90% reduction in structural weight compared to a traditional reinforced concrete superstructure. This resulted in an approximate saving of 2,400 tonnes of carbon dioxide emissions, representing a 35% reduction in the project's overall carbon footprint, in alignment with China's "3060" dual carbon targets. Furthermore, the footbridges provided significant social value by connecting the modern FLN NDA with the surrounding traditional villages, hence fostering urban-rural integration. Promoting the use of high-strength steel in bridge structures broadened engineers' understanding of its benefits and the capability of the Chinese steel supply chain. The welding of over one kilometre of high-strength steel on site uplifted the capability of the welders, advancing their skills in heat-input control and welding techniques. The use of ultra-high strength S960 steel resulted in a lightweight solution for the construction of the Lung Yeuk Tau Interchange, ensuring the timely commissioning of the Fanling Bypass Eastern Section and meeting the public's aspirations. These public values were achieved only through the operational capacity for supply chain independence developed by the Chinese Mainland, including the ability to produce ultra-high strength steel plates, competent fabricators, and skilful engineers and welders to assemble the plates together as a bridge. With sufficient research data from PolyU to support the structural adequacy and efficiency of the proposed use of ultra-high strength S960 steel, we fostered inter-departmental collaboration to facilitate approvals and implementation of the project. Last but not least, the legitimacy and support empowered by the 15th Five-year Plan, along with stakeholders across the Legislative Council, District Council, local communities, and practitioners in academia and industry, were essential

to drive this innovation forward and enabled the public to envision the public value this innovation could achieve.

3.2 Collaborative Governance

The team executed this innovative application by utilising several layers of collaborative governance models.

First, the core of the collaboration within the project team was established by the target cost contract framework under the NEC3 Engineering and Construction Contract, with emphasis on the spirit of mutual trust and co-operation, early risk identification and problem solving, as well as the pain/gain share mechanism. This framework created a welcoming environment for the parties to the contract to identify project risks and incentivised their early mitigation collaboratively.

Second, the project team extended its collaboration to academia and industry practitioners beyond the contract framework to navigate innovation hurdles with the necessary expertise across sectors. The Universities-Government-Industry collaboration was vital to validate the use of novel construction materials against prevailing international standards and test the practicality of innovative ideas, such as the oversized module delivery. This collaborative governance framework coincides with the Triple Helix Model of Innovation advocated by Etzkowitz & Leydesdorff (2000) and Etzkowitz (2008).

Third, the Government's shift from risk-averse administrators and regulators to active facilitators of technological advancement was also essential to this successful innovative application. By pioneering the use of S960 steel, the Government demonstrated its capabilities in absorbing and managing the institutional risks pertaining to the use of innovative solutions to achieve long-term strategic goals, a risk which private sectors are typically unwilling to bear. By positioning itself as a Public Entrepreneur (Osborne & Gaebler, 1992; Bozeman, 2007), the Government was actively contributing to the creation of a market for innovative solutions, including high strength steel, in the construction industry.



Figure 16 –The Ombudsman's Awards for Teams of Public Organisations 2025 recognised the seamless interdepartmental collaboration on oversized modules delivery

3.3 Institutional Framework Contributions

A key legacy of the project is its contribution to the evolution of global engineering standards. The empirical data and technical guidance generated by the project validated and contributed to the *Standard for design of steel structures using 690 to 960 MPa high strength steel*, which was promulgated by the China Steel Construction Society, taking effect on 1 October 2026.



Figure 17 – A visit to the footbridge with the Secretary-General of China Steel Construction Society before standard promulgation

By leveraging normative isomorphism, this standard strives to lower the cognitive barrier for engineers around the world to use high-strength steel in structures under different regulatory frameworks. This contributes to the global trend of constructing more efficient, environmental friendly infrastructure.

3.4 Architectural Integration and Public Value Realisation through Art in Engineering

Beyond structural efficiency, the two footbridges also generate substantial public value by connecting urban and rural communities. Footbridge F6 took a step further by introducing architectural features which transformed a public infrastructure into a public art open space.

With a diameter of 40 metres and a structural depth of only 1 metre, the circular deck of Footbridge F6 was a unique articulation of a footbridge in Hong Kong, with its only counterpart at Yee Wo Street in Causeway Bay. To preserve the natural architectural form, only minimal functional lighting fixtures were installed, concealed and recessed in the canopies and balustrades. The preference for warm LED indirect lighting over cool T5 direct lighting elevated the appearance of the circular deck to a “Floating Light Ring” at night.



Figure 18 – Illustrations of cool direct lighting (left) against warm indirect lighting (right)

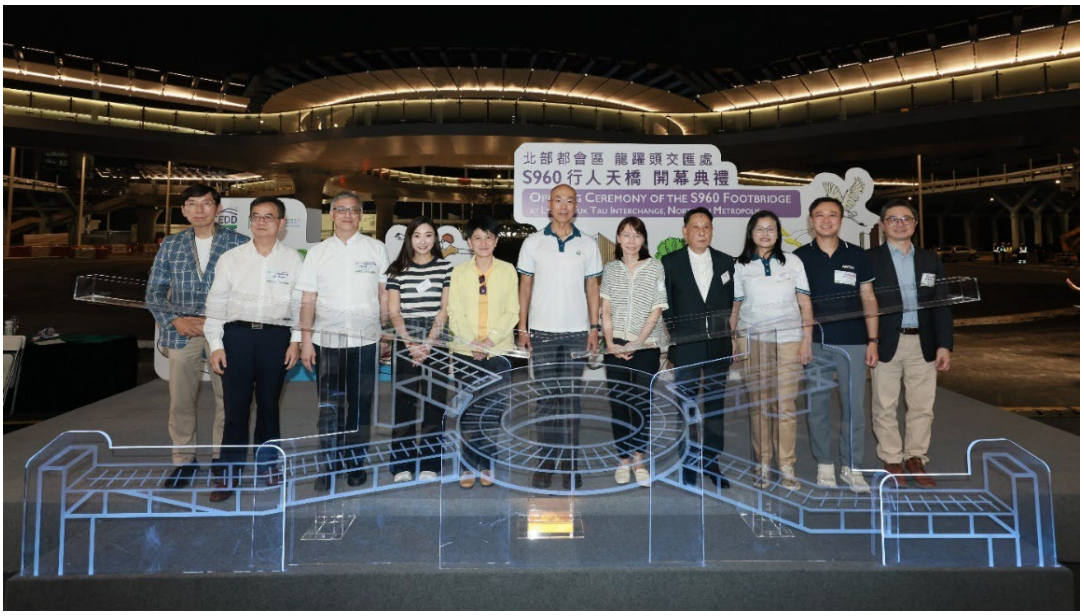


Figure 19 – Functional lighting switched on at the Opening Ceremony of Footbridge F6

Featuring LED light strips, the glass balustrade at the circular deck was envisioned as a canvas for artwork. To make best use of this canvas, the team collaborated with professional institutions to organise the "Glowin the Art" visual design competition, in which creative proposals on the glass balustrade are invited from the public and professional communities. The competition received 34 entries with graphic design themes around urban-rural integration, innovative application of S960 steel in structure, blue-green conservation, heritage features in the vicinity and public aspiration to future development. Through an intensive adjudication process, representatives from the supporting professional institutions selected 16 winning entries, which were displayed upon the commissioning of Footbridge F6. Integrated with these graphic designs, the "Floating Light Ring" is further elevated to a public art corridor with community ownership.

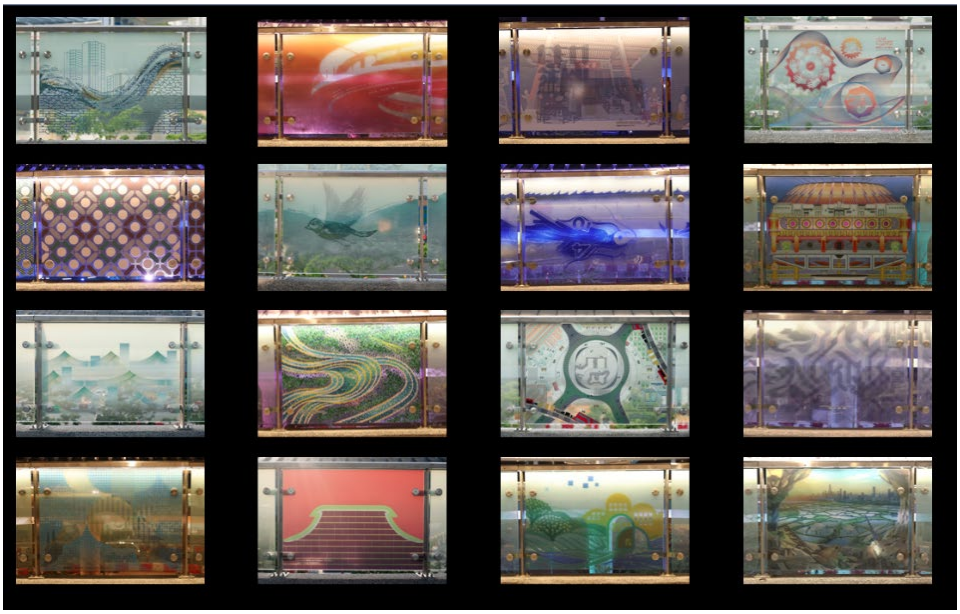


Figure 20 – Winning entries of the Glowin the Art Visual Design Competition

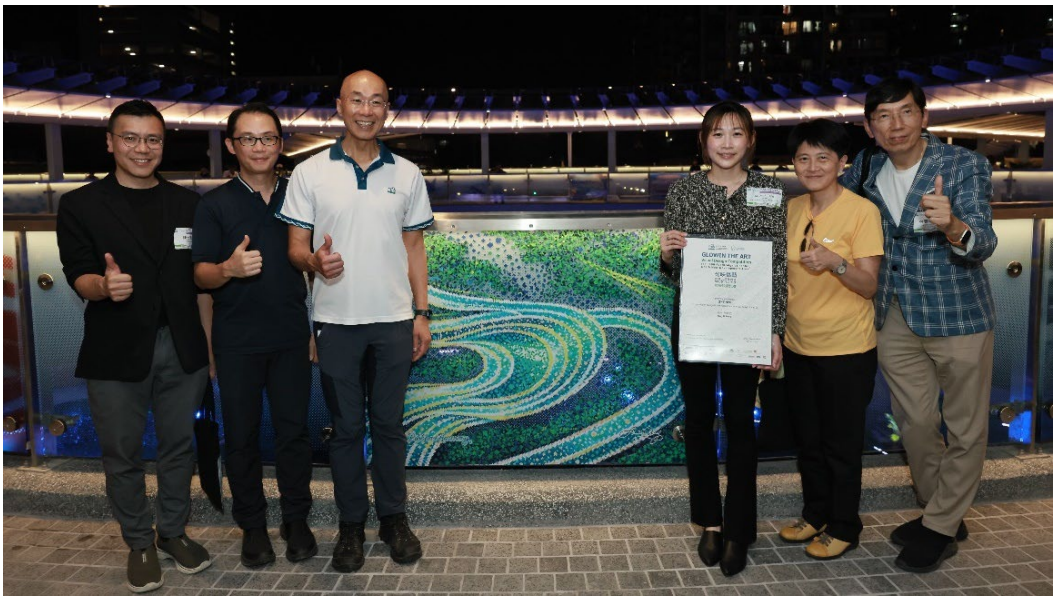


Figure 21 – Appreciation of winning entries at the Opening Ceremony of Footbridge F6



Figure 22 – The slim articulation of S960 steel footbridge being appreciated by the public

Introduced during the Opening Ceremony as "Seasonal Lights in Communities", the soffit of the circular deck was illuminated with decorative lighting with changing colours. The visually pleasing lighting effect was praised by local stakeholders, and hence the team further developed the decorative lighting scheme with varying colours inspired by the eight astronomical seasons in the Twenty-four Solar Terms in the Chinese Agricultural Calendar, an Intangible Cultural Heritage of Humanity recognised by the United Nations Educational, Scientific and Cultural Organisation (UNESCO, 2016). This chromatic design serves as a gentle visual cue, celebrating seasonal shifts while reminding the community of the timeless importance of family gatherings, particularly during key occasions like the Winter Solstice. The decorative lighting gave the "Floating Light Ring" cultural value, with roots deep in the agricultural origin of the traditional villages of Lung Yeuk Tau.



Figure 23 – "Seasonal Lights in Communities" showcased at the Opening Ceremony of Footbridge F6

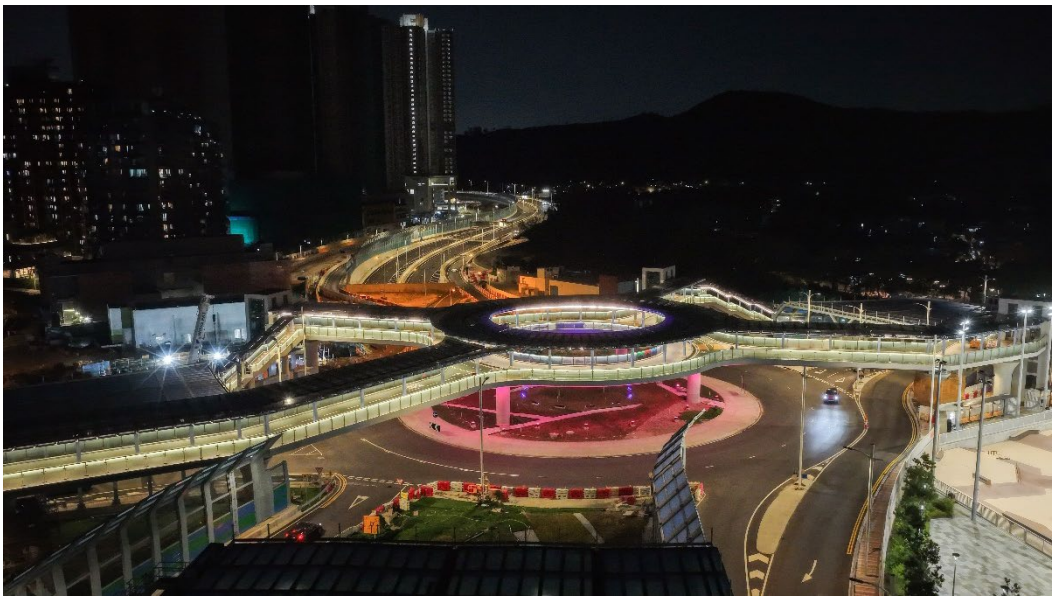


Figure 24 – Decorative lighting adding cultural value to Footbridge F6

By integrating warm, functional, and cultural decorative lighting features alongside glass balustrades designed by the community, this structurally efficient S960 steel footbridge demonstrated how the concept of "Art in Engineering" can be realised in public infrastructure.

4 Way Forward

The commissioning of the S960 steel footbridges demonstrated the practicality of innovation in infrastructure projects under the current public administrative framework, and its success relied on both technological innovation and institutional advancement.

Compared with conventional structural forms, adopting S960 steel reduced the extent of foundation works and overall construction material use. This contributed to the efficiency and sustainability of the project, delivering measurable public value.

To promote a broader adoption of high-strength steel in the construction industry, experts at the China Steel Construction Society and CNERC reviewed the consolidated experimental and technical data obtained in the course of research, development and application of S960 steel, and compiled the "Standard for design of steel structures using 690 to 960 MPa high strength steel", which will provide engineers with a reliable reference to design high-strength steel structures. This enables the export of technologies and standards from the Chinese Mainland to the rest of the world through Hong Kong.

To support the practical implementation of these technologies, the project team also collaborated with the Building Technology Research Institute to compile technical guidance and specifications for robotic welding on high-strength steel to provide assurance that welding on high-strength steel is manageable within the industry.



Figure 25 – Technical guidance published with the experience of the pilot project

The S960 steel footbridges demonstrated the value of collaborative governance across universities, government, research institutes and industry. By identifying operational capacities, defining public value, mitigating risks and contributing to international standardisation, the project affirmed Hong Kong's strategic roles as a "Super connector" and "Super value-adder" in alignment with the National 15th Five-Year Plan.

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6 Acknowledgements

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The policy support in adopting high-strength steel from the Development Bureau and the technical support from the Lands Department, Transport Department, Hong Kong Police Force, and the MiCLab of the University of Hong Kong for the delivery of oversized S960 steel footbridge modules in Hong Kong are gratefully acknowledged.

CEDD is also grateful to the Highways Department and Electrical and Mechanical Services Department for their valuable advice in the design and maintenance of the innovative structures and lighting systems.

Last but not least, CEDD is grateful to the China Steel Construction Society for promulgating the Group Standard titled *Standard for design of steel structures using 690 to 960 MPa high strength steel*, in which the data collected from this innovative application was used to support design rules capable of being understood by engineers from China and abroad. This is an important step for Chinese high strength steel to be capable of being used in steel structures globally.

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