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Issue 6 2019

FIRST

Strengthening connections: Hong Kong-Zhuhai-Macao Bridge

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ARUP

Welcome

Welcome to the latest issue of Arup's FIRST magazine, celebrating quality and technical excellence achieved through foresight, innovation, research, sharing and training initiatives.

In this edition we look in detail at the Hong Kong-Zhuhai-Macao Bridge – the longest sea crossing in the world – and how we used a BIM-lite approach to realise the iconic design for the Philippines' second largest airport.

This issue also takes an in-depth look at our innovative solutions to fast-track the design and construction of Vietnam's tallest building in poor ground conditions and our research work to better understand walking behaviours and improve pedestrian analysis with emerging technology.

We also explore the future of building design, construction and operation, including our total engineering services for Hong Kong's first building using modular integrated construction technology, the circular economy concept behind the People's Pavilion made from 100% borrowed materials and our development of a digital hub platform which enables a data-driven approach for smart building operations.

Also in this issue you will learn about our latest foresight updates and hear the stories of Alice Chow and Ander Chow who spearhead the link to Arup's strategic, technical and management expertise to drive lasting value for our clients.

We hope you enjoy this issue and find it valuable. If you have any thoughts, questions or comments, we'd love to hear from you at **ea.arupuniversity@arup.com**.

FIRST is a publication produced by East Asia Arup University (AU) for our clients and partners, exploring design, innovation and technical solutions for the built environment. It takes its name from the unique model of AU: Foresight, Innovation, Research, Sharing, and Training.

Strengthening connections: Hong Kong-Zhuhai-Macao Bridge

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After nine years of construction the Hong Kong-Zhuhai-Macao Bridge (HZMB) opened to traffic in October 2018. Measuring 55km, the world's longest sea crossing opens a new and direct road link between the three cities, shortening travelling time between Hong Kong and Macao/Zhuhai from a 4-hour car journey or an hour's ferry ride to a mere 40-minute car ride. The bridge is a key initiative of the Chinese government's plan to drive the economic and social integration of the Greater Bay Area which encompasses 11 cities in southern China, including Hong Kong and Macao, the country's two special administrative regions (SARs).

The HZMB consists of three key elements: the main bridge and tunnel, the boundary crossing facilities at Hong Kong, Zhuhai and Macao and the link roads to the three cities. Arup provided a wide range of services for this mega project. These ranged from the preliminary design for the main bridge in the mainland waters to environmentally friendly reclamation solutions for the Hong Kong Port artificial island and the tender and construction of the Hong Kong Link Road. Arup also undertook the feasibility study and detailed design for the Tuen Mun – Chek Lap Kok Link (TMCLKL) Northern Tunnel and Southern Connection Viaducts, preliminary and detailed design for the Macao Link Road and the infrastructure works of the Macao Port.

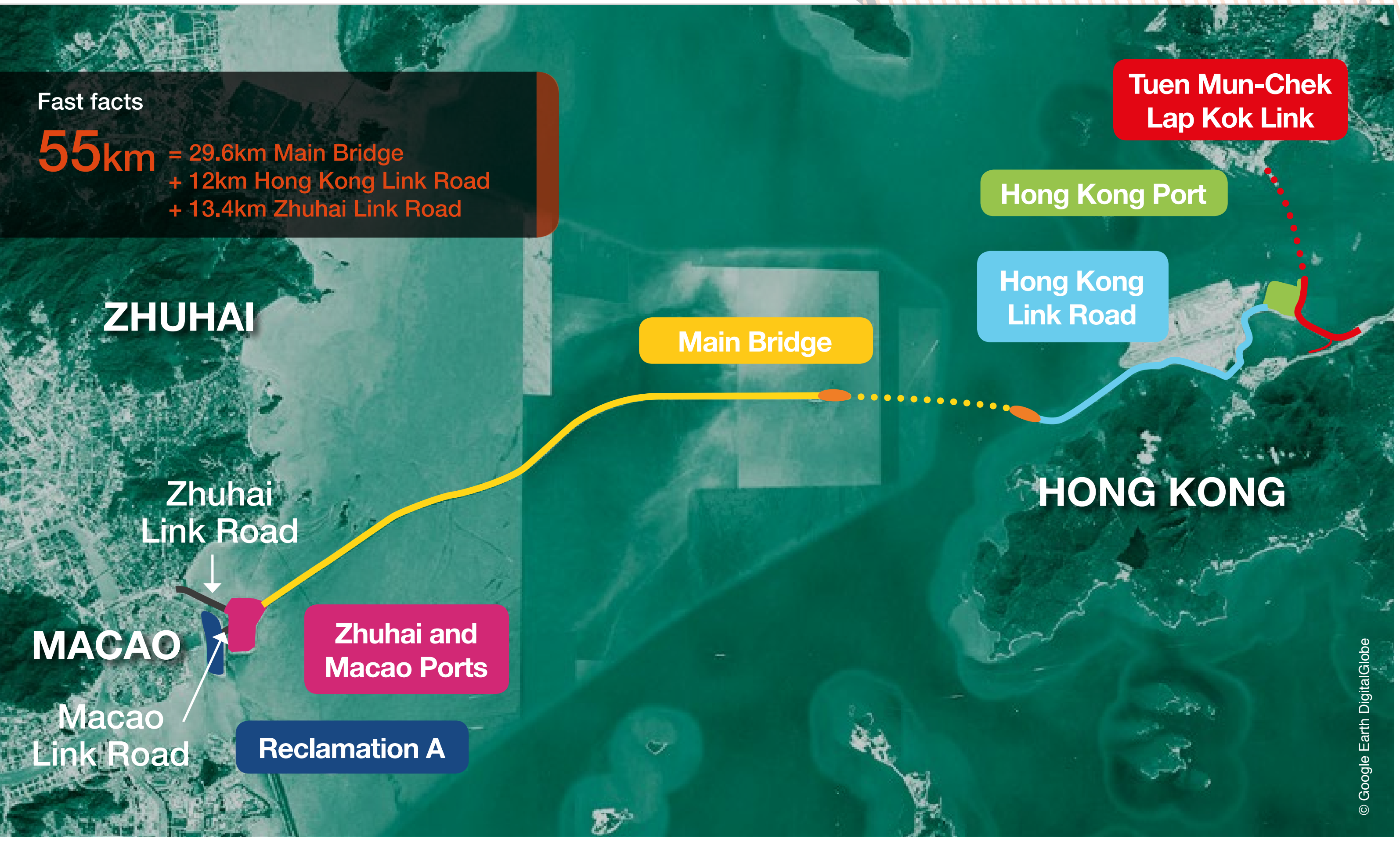
Client:
Highways Department, Hong Kong SAR Government; Gabinete para o Desenvolvimento de Infra-estruturas, Macao SAR Government; Hong Kong-Zhuhai-Macao Bridge Authority; Gammon Construction Limited; Dragages-Bouygues Joint Venture

Arup's scope of services:

Hong Kong
- Hong Kong Port (HKP): Feasibility study, overall planning, environmental impact assessment, preliminary design
- HKP Reclamation: Feasibility study, overall planning, environmental impact assessment, preliminary and detailed design, construction contract procurement and supervision
- Hong Kong Link Road: Feasibility study, overall planning, environmental impact assessment, preliminary and reference design, design & build contract procurement and supervision
- Tuen Mun-Chek Lap Kok Link: Feasibility study, detailed design

Zhuhai
- Hong Kong-Zhuhai-Macao Bridge Main Bridge: Preliminary design

Macao
- Macao Port infrastructure: Overall planning, preliminary and detailed design
- Macao Link Road: Detailed design



Project overview

Main section: unique and beautiful

The main section of HZMB in the mainland waters consists of a 6.7km long tunnel spanning two navigation channels (Lingding and Tonggu) and a 22.9km long bridge section which comprises three navigation channel bridges (Jiuzhou, Jianghai and Qingzhou).

Arup's involvement in the main section started in 2009 when the firm carried out the concept and preliminary design jointly with CCCC Highway Consultants (then known as the Highway Planning and Design Institute). As the bridge link would be prominent from the land, sea and air, a unique and aesthetic design was highly desirable. Arup proposed that all three bridges would be cable-stayed with central towers of different shapes placed between each span to give both a visual affinity and variety between the bridges.

From environmental considerations, single column piers were used to support the bridge decks with pile caps buried in the seabed for the approach viaducts. This minimises obstruction to water flow and impact on the habitat of Chinese white dolphins. In addition, precast concrete shell construction was adopted for the pile caps to reduce the amount of temporary works construction required, further lessening the impact on the environment.

The mega bridge structures are built for a design life of 120 years and are capable of withstanding extreme events such as typhoons and earthquakes. Friction pendulum bearings are used to absorb the seismic energy in every bearing connection, thereby isolating the seismic action from the foundation.

Jiuzhou Channel Bridge with sail-type towers. The form was proposed by Arup in the preliminary design.

Hong Kong Link Road: plugging Hong Kong into the Pearl River Delta

Arup was heavily involved in the design and delivery of the Hong Kong Link Road (HKLR) which connects the Main Bridge with Hong Kong Port. The dual 3-lane expressway comprises a 9.4km viaduct section, a 1km long dual-tube tunnel through Scenic Hill and a 1.6km long at-grade road section on reclaimed land.

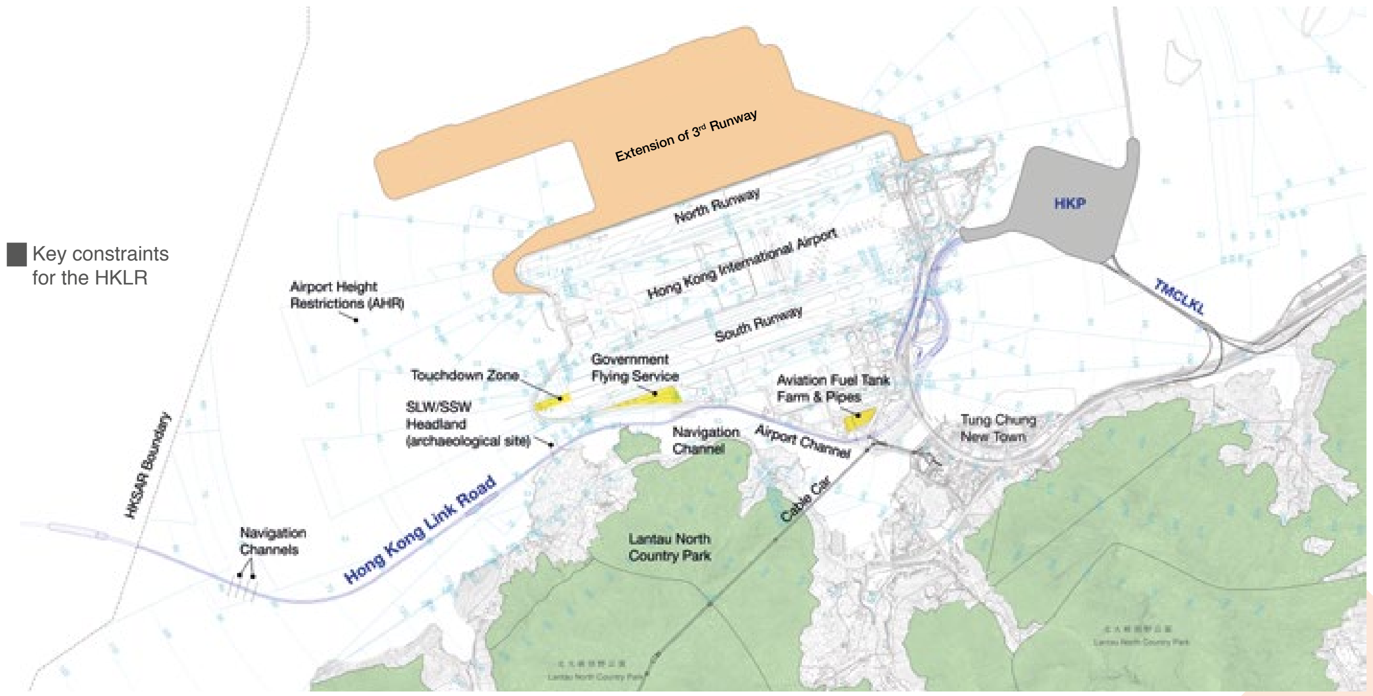
The proximity to Hong Kong International Airport and the tight airport height restrictions imposed severe constraints on the vertical and horizontal alignments of the viaduct section. Various alignment options were considered and after thorough assessment it was concluded that the Airport Channel would be the most viable corridor for the HKLR, away from the Third Runway development at the northern side of the Airport Island and sidestepping the ecologically-sensitive Lantau hillside. To avoid adverse impact on plane/helicopter operations the viaduct adopted an S-curved alignment to stay away from the touchdown zone of the airport southern runway and the Government Flying Service headquarters.

Over 5,700 precast bridge deck segments were used in the construction of the HKLR viaduct. Typical spans of the viaduct range from 65-75m to minimise the number of piers and reduce hydrodynamic and visual impact on the environment, while long spans up to 180m are used to cross the navigation channels in the western waters and the Airport Channel. A long-span viaduct 180m in length was also constructed to straddle the headland between Sha Lo Wan (SLW) and San Shek Wan (SSW), a designated Site of Archaeological Interest. As bridge pier construction works were not allowed on the headland, a specially made straddle carrier was used to lift, transport and install the deck segments without disturbing the woodland or the archaeological site on the headland. The bridge span set a record in Hong Kong at the time it was erected.

S-curved alignment inside the Airport Channel

A tailor-made straddle carrier was used for bridge deck erection across the Sha Lo Wan Headland

Key constraints for the HKLR



The tunnel section of HKLR passes through Scenic Hill and under Airport Road and the MTR Airport Express Line (AEL) railway on Airport Island to minimise environmental and visual impacts to Tung Chung residents. The complex and varied geological and site constraints led to different construction methods for different sections of the 1km long tunnel: drill and blast for Scenic Hill section, given the hardness of the rock, mining method for the Airport Road section, to maintain road traffic during tunnelling, whole tunnel box jacking for the AEL section, to meet the stringent settlement requirements for the railway tracks, and open cut-and-cover for the new reclamation area with fewer constraints.

Arup proposed a non-dredged construction method for the seawall and reclamation which provides 23ha land area for accommodating the tunnel eastern portal and the at-grade section of the HKLR, associated maintenance facilities and the connection roads between HKP and the airport. Compared with a conventional fully-dredged method, the non-dredged approach using stone column-supported seawall and band drains with surcharge reclamation minimises sediment dredging and disposal as well as impact on the overall water quality.

Hong Kong Port: western gate to the Greater Bay Area

Upon agreement of the three governments to adopt the concept of separate boundary crossing facility locations in 2006, Arup undertook a study to identify the possible site options and recommend the best location for HKP.

A 150ha artificial island at the northeastern waters of the Airport Island was created — 130ha to accommodate the HKP and 20ha for landfall of TMCLKL. The location of the artificial island has major benefits in terms of convenience to travellers and connectivity to nearby highways and the airport. It also avoids the principal sea channel north of the airport and minimises environmental impact by integrating the reclamation of the southern landfall of the TMCLKL tunnel.

Arup was also commissioned for the detailed design of the reclamation of the HKP. Building on the firm's experience in ground treatment methods and seawall building techniques, Arup developed two types of non-dredged seawall: a composite steel cell and rubble mound seawall and a simple rubble mound seawall. For both types, the design solution required treatment using stone columns – 53,000 in total, each 1m in diameter – inserted into the soil to create a drainage path for water in the soft sediment to dissipate.

(Top left) Detonation of explosives during the drill and blast process in the Scenic Hill section, (top right) mechanical excavation underneath the existing Airport Road, (bottom left) box jacked tunnel segment in the AEL section, (bottom right) cut-and-cover tunnels in the reclamation area

© Marcel Lam Photography

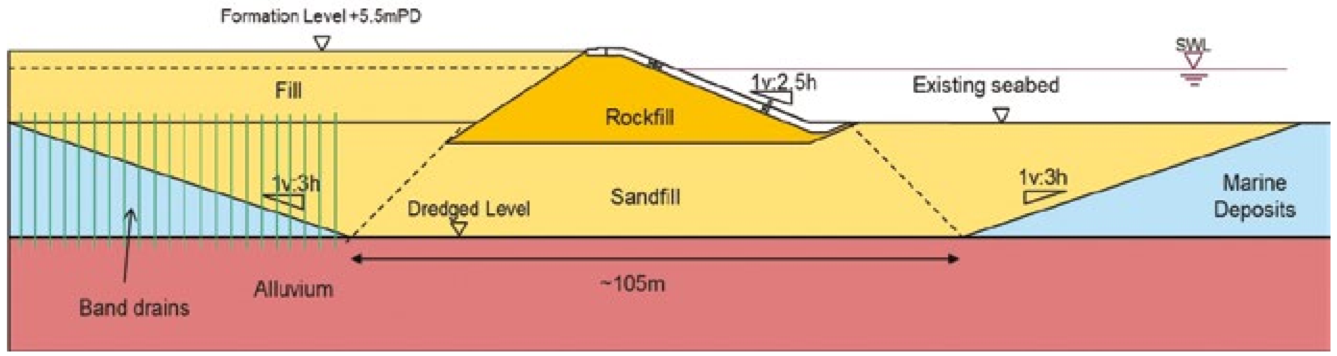
HKP and the artificial island

On the composite section of the seawall, 85 circular cells, each 32m in diameter and formed by 200 straight steel sheets, were sunk through the soft marine mud to form cofferdams and the steel cells were then filled up by sand or inert construction and demolition materials to form a robust structure. Although cellular structures on a similar scale have been used elsewhere, few have been used with the kind of deep, soft soils encountered on this project.

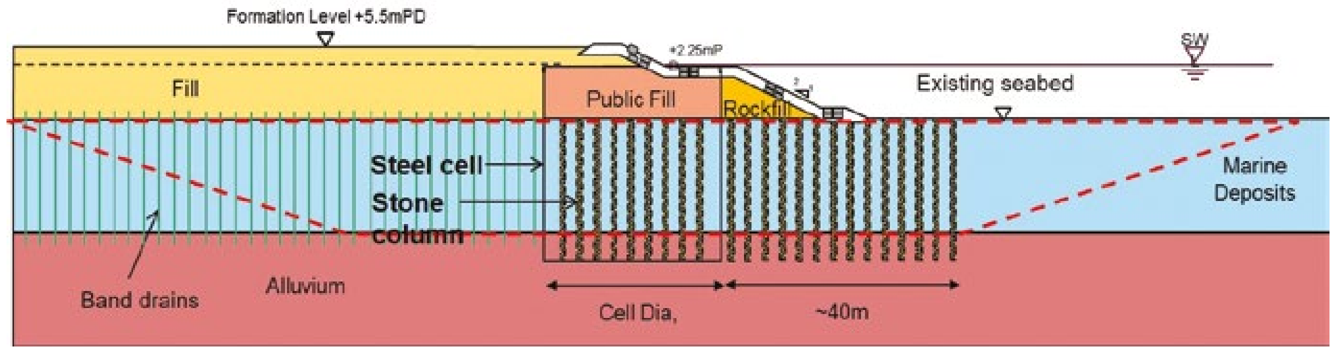
This innovative non-dredged design allowed the in-situ marine sediment to be left in place, avoiding the need to create a new mud pit for the excavated sediment and reducing the construction vessel traffic density, thereby significantly reducing impact on the environment and marine life.

The composite section of the seawall was constructed using a series of 32m diameter steel cofferdams

The completed reclamation was tested by two severe typhoons passing by Hong Kong before the HKP became operational and both the seawall and reclamation remained intact.



Conventional dredged method: marine sediment is dredged away and disposed of, then backfilled with a similar volume of sandfill/rockfill.



Non-dredged method: stone columns are installed to provide support for filling materials above and serve as porous drains, allowing the marine sediment to be left in place.

© Marcel Lam Photography

The Southern Section of TMCLKL connects the HKP and North Lantau on viaducts

Tuen Mun-Chek Lap Kok Link: an alternative route to the Airport

In support of HZMB, the TMCLKL provides a strategic link connecting the Northwest New Territories with the HKP, North Lantau and the airport. The 9km long dual 2-lane carriageway consists of two major sections: the Southern Section, which connects the HKP and North Lantau on viaducts, and the Northern Section, which connects the HKP with Tuen Mun via a sub-sea tunnel.

Arup was the Contractor's Designer for the Southern Section Viaducts. The marine section crosses about 2km of water including the Tung Chung Navigation Channel requiring a span of 200m, whilst the land section at North Lantau overpasses existing railway lines with skew angles requiring spans of up to 100m. In total there are about 9km of viaduct structures which were designed as prestressed concrete girders constructed by precast segmental method.

Arup also provided multidisciplinary engineering design for the Northern Connection Tunnel as the Contractor's Designer. Over 4.2km in length and running to a depth of 60m beneath the sea, this is the deepest, longest and largest sub-sea road tunnel in Hong Kong.

The twin bore tunnels were originally designed to connect with cut-and-cover launch and reception shafts within the northern section reclamation. To speed up construction Arup decided to extend the bored tunnels thereby eliminating the need for cut-and-cover tunnels. The modified design reduced the amount of excavation and enabled construction to take place above ground in parallel with the tunnel works. In addition, the bored tunnel method reduced risks as the depth of the climbing tunnels (55m maximum) would have significantly increased the forces on the supporting walls and temporary strutting for a cut-and-cover structure.

A tunnel boring machine (TBM) with an external diameter of 14.2m was used to construct the entrance and sub-sea tunnels while another TBM with a world-record external diameter of 17.6m was used to construct the three-lane exit tunnel. In order to launch and provide sufficient working space around these large machines, Arup designed the first cellular diaphragm wall cofferdam ever constructed in Hong Kong to provide an open strut-free environment which has since been adopted by others following its great success.

© Dragages-Bouygues JV

Arup designed the first caterpillar diaphragm wall cofferdam in Hong Kong for the northern launching shaft for the world's largest TBM

Macao Port and Link Road: improving connectivity in Macao

On the Macao side, Arup was commissioned by the Macao government in 2006 to undertake the feasibility study of the Macao Port and associated link roads. Unlike the final scheme, the Macao and Zhuhai Ports were originally proposed to be located at separate artificial islands. Arup successfully delivered the study with a combined island scheme bringing forward the port and infrastructural planning to the detailed design stage where we were responsible for the full design of all major infrastructure within the 70ha Macao Port, including viaducts, underpasses, roadworks, utility tunnel, drainage and sewerage.

Arup was also engaged in 2014 in a separate detailed design consultancy to design the Macao Link Road connecting the Macao Port, via a new artificial island (referred to as Reclamation A), to the Macao Peninsula.

As an alternative linkage from Macao Port and Reclamation A to Taipa, a new 3.5km long dual 3-lane sea crossing was strategised by the Macao government. Arup is the consultant for project management and site supervision for this Macao 4th Crossing, which will not only relieve the increasing traffic flow between the Macao Peninsula and Taipa but also help cope with the demand from completion of the HZMB and the future development of new reclamation areas.

Hailed as an engineering wonder, the HZMB will further improve transport connectivity between Hong Kong, Macao and major cities in Guangdong province. This marks a new milestone in the integration process of the Greater Bay Area – the Chinese government's national strategy to create a world-class city cluster to lead the country's future development.

© CHEC

Macao Port

Watch the video highlighting Arup's contribution to HZMB

Mactan-Cebu International Airport: a landmark gateway

© John Nye Photography

The undulations of the iconic roof of the new Terminal 2 are reminiscent of the waves around Mactan Island

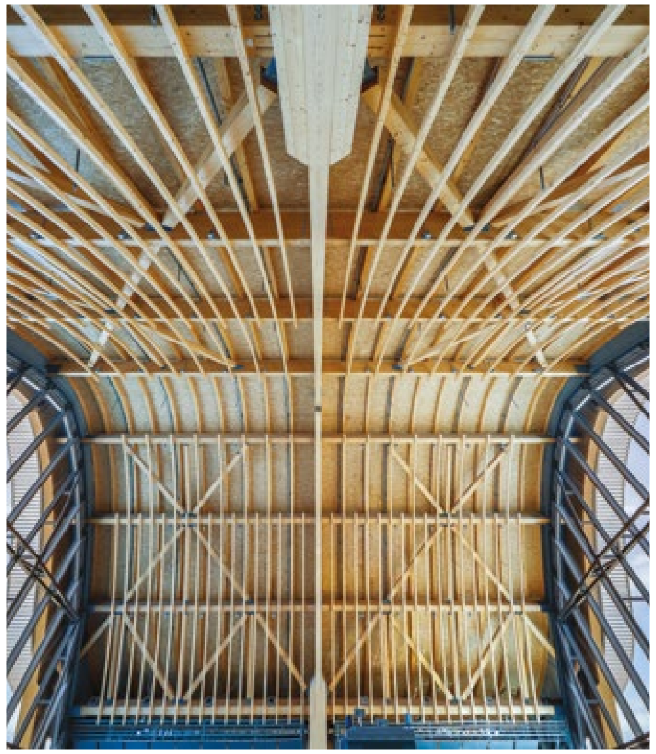
Client:
GMR Megawide Cebu Airport Corporation (GMCAC)

Arup's scope of services:
Aviation planning, airfield engineering design, transport planning and bridge, civil, electrical, façade, fire, highways, mechanical and structural engineering

As the second largest airport in the Philippines, the Mactan-Cebu International Airport (MCIA) underwent a major transformation to cope with a significant growth in passenger traffic. Central to the MCIA transformation plan is the new Terminal 2, and the project is a design–build–operate–transfer concession awarded under the private-public partnership programme of the Philippines government. The enhancement works also include a major reconfiguration of the existing Terminal 1, reconstruction of the existing apron and four main taxiways and a wholesale upgrade and expansion of the landside facilities and road network.

A 3-storey building of 65,500m² featuring an 18m-tall arched timber roof, Terminal 2 has been designed in a modular fashion for future expansion: Phase 1 of the development provides 11 contact stands and 17 remote stands to handle 15.8 million passengers per year, with onward expansion to 20 contact stands to accommodate 28.3 million passengers in Phase 2.

From the use of structural timber as its main element for creating the large-span arched roof to the rattan furniture and fittings that are Cebu's local art and craft, the terminal exudes a spatial elegance and earthy material warmth, befitting the title of 'Gateway to Cebu'.



© John Nye Photography

The glulam structure is exposed, doubling as the architectural finish.

Design challenges

The iconic roof of Terminal 2 is one of the largest supporting structures in the world made entirely of glulam (glued laminated) timber and the massive primary arches span 30m, enabling the building to be as column-free as possible. In the east-west direction (planar to the arch), the roof works as a three-hinge arch system whereby physical pin joints are introduced at the base and the apex of the arch. In the north-south direction, the two lower rows of purlins are connected by diagonals to form a continuous bracing truss over the length of the arch segments and additional diagonal bracings are introduced to the upper purlins to provide in-plane stability.

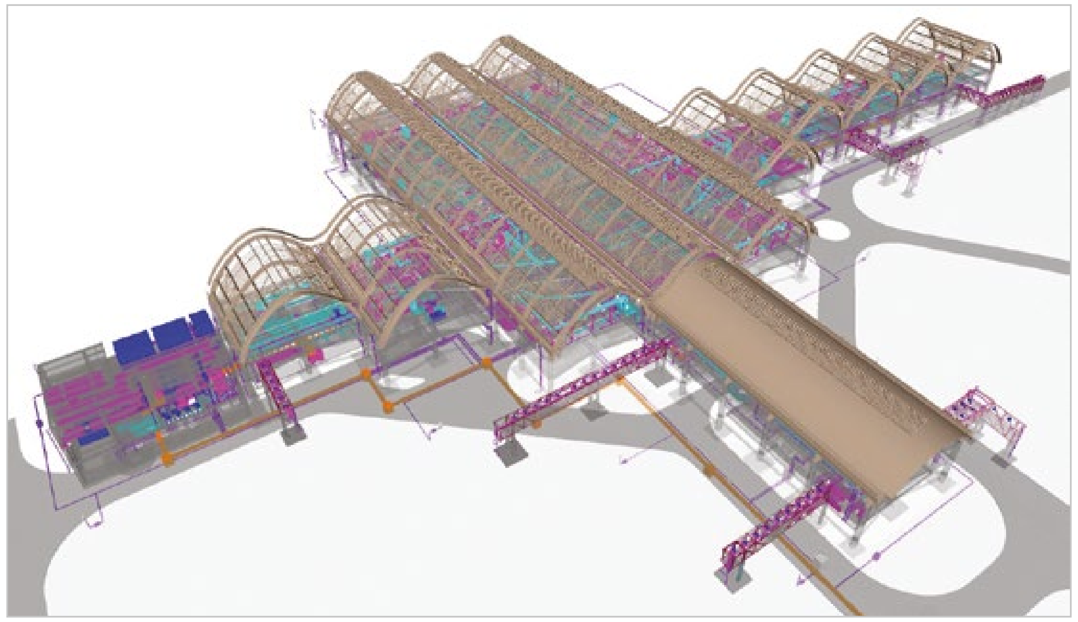
The Philippines is one of the world's major earthquake zones. To achieve high-quality seismic design, the structure is divided into five independently stable buildings separated by movement joints with seismic gaps ranging from 250mm at the Arrivals slab level to 550mm at the Roof Gutter level to ensure that they will not impact each other during a seismic event.

© John Nye Photography

The 30m-span, 18m-tall arches enable a column-free space inside Terminal 2 while glazed façade and roof skylights bring natural light into the building.

In addition to earthquakes the Philippines also experiences strong, destructive typhoons. Shielding of an inner arch by an outer arch is not allowed by the National Structural Code of the Philippines (NSCP), therefore, the whole building, including the roof, needed to accommodate 200kph winds causing a range of loading patterns ranging from wind pressure of -3.2kPa to suction effects of +2.0kPa. The wind forces were checked against the seismic forces to ensure that the actual capacity of the roof is either dictated by the targeted seismic force or the expected wind force that the structure will experience. To adopt the timber roof design the Arup team worked closely with the specialist timber roof supplier, undertaking analysis to redesign critical aspects of the initial proposal (designed using Eurocode) in order to take full account of the seismic parameters and follow the requirements of NSCP.

As timber is generally a brittle material that may cause sudden collapse, the design philosophy was to ensure that the connections within the timber structure will yield before any failure of the timber itself. A hierarchy of failure mechanism was targeted in the design: the reinforced concrete moment frame supporting the roof will reach flexural yielding first, followed by the timber roof connections and finally the timber elements. Analysis of the full building seismic structural system (combining the roof, superstructure and substructure) proved that the superstructure has lower ductility than the roof, thereby ensuring the concrete frame will yield first in the event of an earthquake.



The BIM-lite approach helped Arup to deliver a design that was incredibly well-resolved and, therefore, easy to construct.

Total architecture with BIM

Although the contract required the design model to be developed in BIM using Revit, there were no defined BIM guidelines and no BIM manager to oversee the project. With Arup's past experience of BIM implementation, our team decided to abandon the antiquated time-intensive methods and use BIM as a tool by adopting a new 'BIM-lite' approach which would allow a focus on the actual design.

Key features of this new approach:

- PDF drawings were produced directly from the 3D Revit model without the need for 2D CAD drawings. The design teams focused on coordination within the model files and full sets of PDF drawings were only shared when major design agreements were made around a group of related inputs between disciplines. This approach, instead of weekly or bi-weekly sharing of data, saved time adapting to incremental changes and encouraged active communication and engagement of the design team.

- A team-wide Common Data Environment (CDE) was not practical due to bandwidth issues of the diversely located team. However, each location's own CDE was set up in the same way using internal file share and an FTP site to exchange and issue models and deliverables. Model reviews and coordination were also facilitated frequently via Skype so that the design team members located in multiple offices could easily review, analyse, coordinate and resolve issues live in Revit.

- Clash detection was reviewed within Navisworks only and no clash detection reports were produced. Instead of trying to avoid clashes at every phase, clash-free was not targeted until the final issued-for-construction stage. This was a big step change from other BIM projects.

- Only the final BIM model was required to be LOD (level of detail) 300. Therefore, intermediate models could be developed with different LODs to suit each discipline's design development preferences and automation capabilities.

With the eradication of unnecessary processes, reports and repetitive tasks the team was able to work more efficiently in the BIM-lite environment, capitalising on development of smart workflows, automation, parametric modelling and inbuilt features of Revit.

Parametric modelling

Parametric modelling was used to optimise the geometry, member sizes and arch solution of the roof with a streamlined design workflow adopted to explore different structural schemes. Utilising Salamander and Grasshopper plug-ins, the project team was able to create multiple versions of the roof geometry in Rhino and then converted them seamlessly to Oasys GSA format for structural analysis. Other analysis inputs such as loads and section properties could also be added.

Member optimisation was carried out using Visual Basic scripting in Excel. Once an optimised design was achieved for each roof geometry, the GSA model was converted instantly back to Revit format using an Arup-developed plug-in tool.

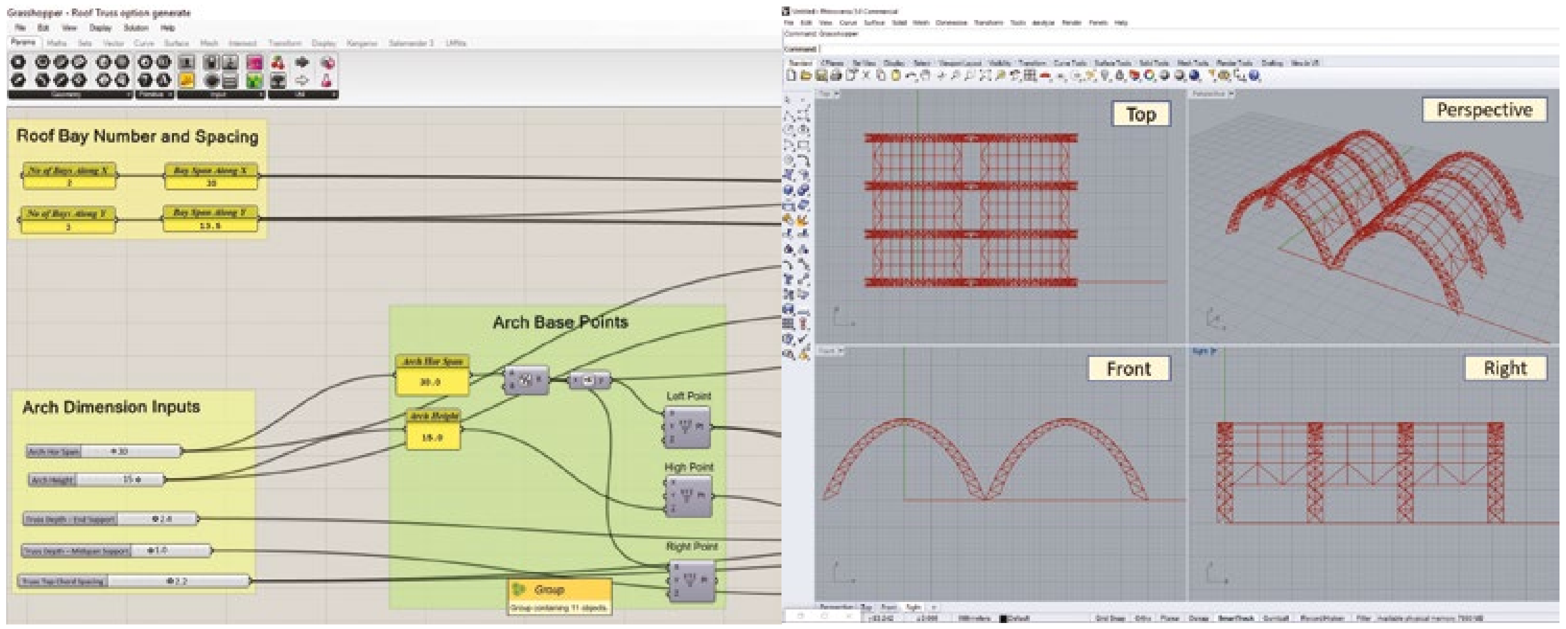
Design automation

Visual Basic coding and an Arup in-house plug-in were utilised to automatically update the beam sizes and annotations. Automation of the structural design analysis has not only achieved significant time savings of 60% compared to the conventional manual process requiring mark-ups but also improved the accuracy of the results.

The project team also took advantage of the inbuilt functions in Revit to automatically create circuits, calculate electrical loads and populate MEP panel schedules. This saved approximately 10-15% of the effort producing and updating MEP schedules compared to performing the work in Excel manually; it also increased accuracy first-time.

BIM was not only used by the design team but extended to the sub-contractors as well. They were given direct access to the Revit models to extract requirements for installation and fabrication of MEP services. Also, AutoCAD Architecture with the HSBCAD plug-in (a software tailored for off-site construction) was used to check the glulam roof fabrication models against the required geometry.

By reimagining the project delivery approach to spend less time on process and more on actual design, Arup successfully delivered a project of national importance, despite the aggressive design and build delivery programme and stringent building code requirements, while keeping the costs to an absolute minimum. The MCIA BIM-lite approach has since become a standard for our Philippines' practice and its success is already encouraging other projects to explore BIM in new ways.



Parametric modelling helped the team to quickly analyse different heights, arch profile, and structural systems for the roof.

Landmark 81: reaching new heights


© Zhou Ruogu Architecture Photography

Client:
Vingroup

Arup's scope of services:
Structural engineering, geotechnical engineering, fire engineering

Soaring 461m into the air, Landmark 81 in Ho Chi Minh City is the tallest building in Vietnam and one of the tallest in the world. With a gross floor area of 241,000m², the 81-storey skyscraper comprises apartments, retail, hotel and an observation deck at the top, forming the centrepiece of the Vinhomes Central Park development.

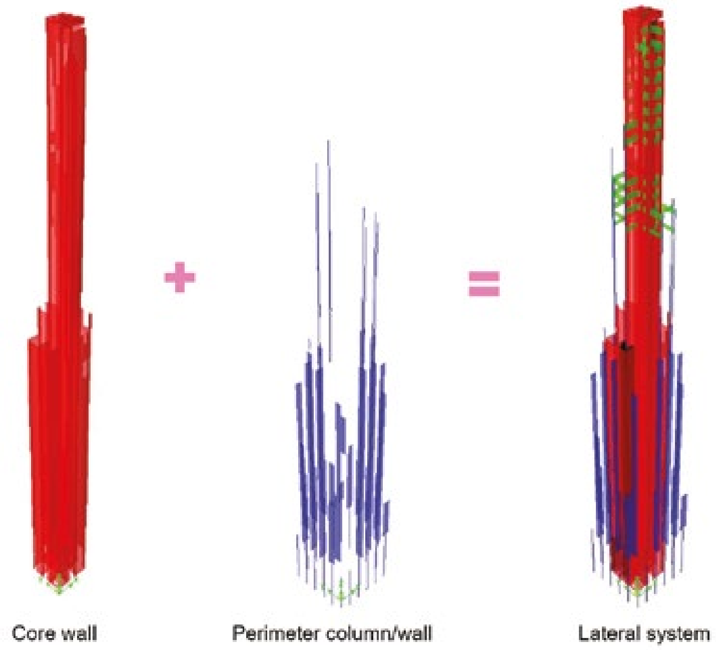
The design of the tower was carried out by an international team of consultants. Arup's work spanned from conceptual design through to construction with the Hong Kong and Ho Chi Minh City offices jointly providing geotechnical, structural and fire life safety services for the project.

Inspired by the concept of a bundle of bamboo – a traditional plant symbolising strength and unity – the form of the tower comprises a series of slender square tubes of various heights thereby creating its distinctive tapering profile. All primary structural elements of the building are cast in-situ concrete. Above the roof (at Level 82) a crown structure consisting of a steel frame partially clad with fins is provided as an architectural feature to the tower.

The structural system of the tower relies on a central core to provide lateral stability against wind and seismic loads. The core is assisted by a secondary system comprising perimeter walls and columns located at the centre of each square tube and connected to the core by beams. No transfer elements were used in the primary structure; loads are collected at nodes and then directed from the walls down through the columns to the base of the tower.

Since the square tubes have different heights and the size of the core reduces asymmetrically up the tower, the centroid and centre of twist will shift slightly as the tower rises, adding an extra layer of complexity to the system design. To ensure the stability of the tower, detailed structural dynamic analyses were conducted to verify that the possible displacement of the tower during an earthquake is well within the acceptable range.

A particularly challenging aspect for the structural design of the tower is the foundation – the site's ground conditions, as for most of Ho Chi Minh City, are poor for construction and the top 30m is essentially mud with little load bearing capacity. Combined with the heavy weight of the reinforced concrete tower and the proximity to existing buildings this posed significant challenges for the design team. Furthermore, the fast-track design and construction programme meant that the foundation solution had to be developed simultaneously with the superstructure.



Lateral system of Landmark 81

© Courtesy of Bachy Soletanche (2015)

Installation of the reinforcement cage of a barrette pile


© RWDI

Wind tunnel test for Landmark 81

Arup's solution was to adopt a thick raft supported on rectangular barrette piles. Compared to circular bored piles the rectangular barrette pile solution provided greater capability to accommodate different loads by varying size and orientation and, therefore, gave greater flexibility to accommodate changes in subsequent development of the design.

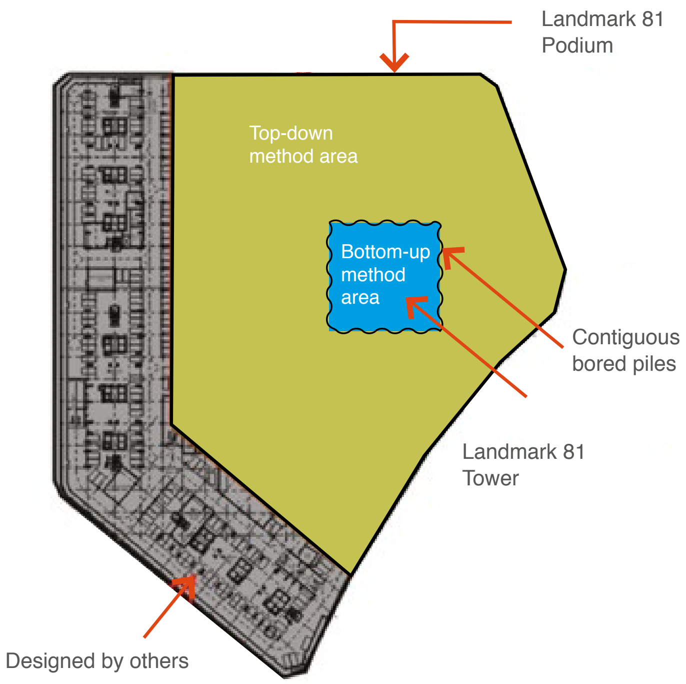
Trial pile tests were conducted to verify the design assumptions for the foundation. Due to the size of the barrette piles it was impractical to perform static load testing. Therefore, an Osterberg cell test was performed - using a load-generating hydraulic cylinder installed within a foundation pile to measure sidewall friction and end-bearing capacity and can accommodate much larger test loads than the conventional method. Results confirmed that design parameters adopted were within an acceptable range.

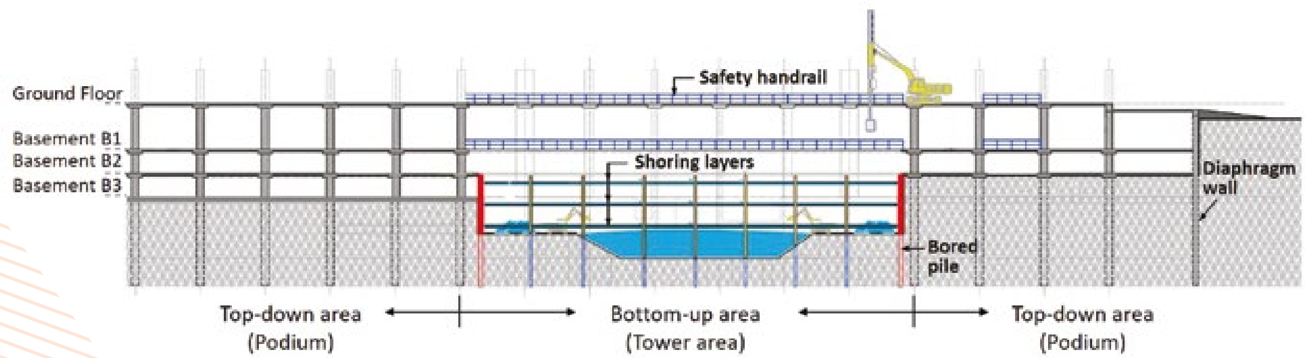
Some of the barrettes are also provided with shaft grouting to further increase their load bearing capacity and to minimise the number of piles. The load distribution in the barrettes was analysed using the Arup-developed Oasys GSA Suite and the pile design was optimised through an iterative process where the sizes, orientations and positions of the piles were varied until the capacity of each pile was satisfactory for each thickness of raft investigated. The final scheme included a total of 147 barrette piles with dimensions of 1.2m × 2.8 m or 1.0m × 2.8m, of which 28 piles were shaft-grouted. And the final raft profile is 8m thick at its maximum, making it the thickest pile cap constructed to date in Vietnam.

Construction of the 3-level basement employed both top-down and bottom-up methods. Diaphragm walls 800mm thick and 32m deep were installed to keep groundwater out of the excavation area. Due to the greater loading demand of the tower columns bottom-up construction was adopted for the central zone, while the top-down method was applied to the perimeter ring slab (podium area) to save construction time.

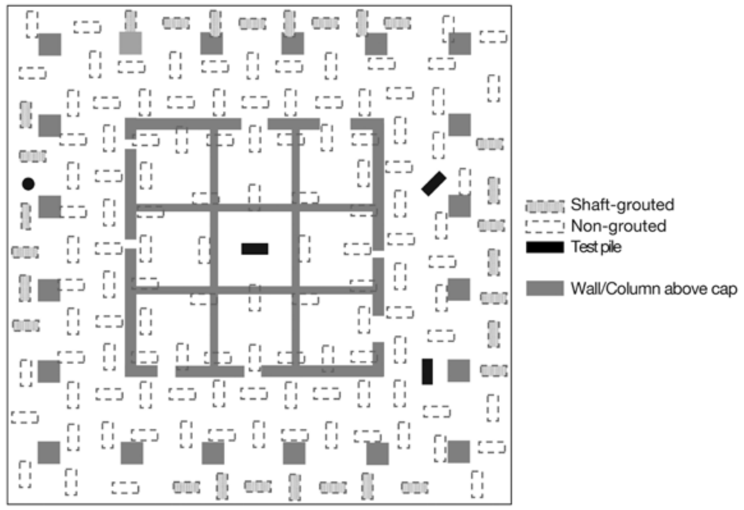

© Coteccons

Site photo showing the central zone (bottom-up method area) and perimeter ring slab (top-down method area). The photo also highlights the space constraints of the site.





Basement construction showing top-down and bottom-up zones: (top) plan view, (bottom) side view



Final pile layout showing the barrette piles orientated to suit the specific loading requirements of each location

The top-down construction sequence involved casting the ground floor slab and leaving muck openings for excavation downwards to level B1. The B1 slab was then cast and the process progressed downwards to the lower levels until all base slabs were completed. To limit cracking and allow better control of its temperature the B3 raft was cast in two layers to reduce the volume of concrete in each pour.

Another innovative design feature of Landmark 81 is the use of lifts for evacuation in the event of a fire for occupants with various mobility conditions. As the application of prescriptive local fire safety codes is not suitable for a building of this height, Arup's Fire Engineering team developed a fire safety strategy based on conformance with the internationally recognised NFPA 5000 Building Construction and Safety Code.

The lift-assisted evacuation strategy, the first of its kind in Vietnam, is part of this design and will help reduce total evacuation time and the risk of injury.

Arup's practical solutions helped realise the architect's vision for this iconic tower. The project also helped enhance the capability of the local market. For example, site-specific seismic ground investigation and wind tunnel testing, both still relatively uncommon for projects in Vietnam, were undertaken to provide the design spectrum for this supertall building which has exceeded most of the parameters currently set out in the Vietnamese construction regulations. By demonstrating our expertise, Landmark 81 reinforces the Arup brand in Vietnam and provides a strong foundation for future development in the country.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Client:
Construction Industry Council (CIC), Hong Kong

Arup’s scope of services:
Total engineering services including architecture, structural, building services, foundation, façade, traffic and fire engineering

MiC Display Centre:
a showcase of latest construction technology

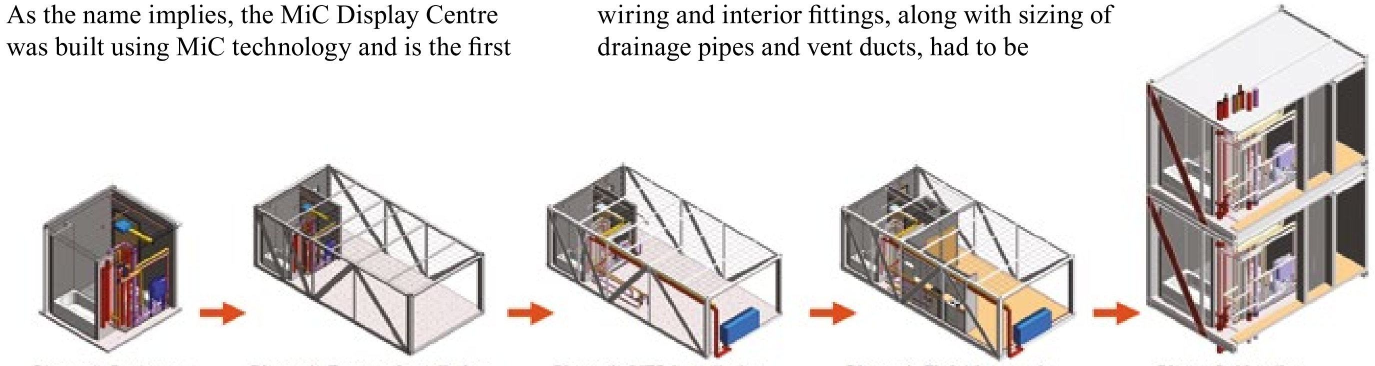
A demonstration centre to showcase the latest trend of using modular integrated construction (MiC) technology has opened in Hong Kong.

This technology, also referred to as Prefabricated Prefinished Volumetric Construction (PPVC), is an innovative construction method under the concept of Design for Manufacturing and Assembly (DfMA) in which self-contained integrated modules – complete with finishes, fixtures and furniture – are prefabricated and then transported to site for installation. By transferring the labour-intensive site construction processes to a controlled factory environment different modules can be built in parallel and the construction period can be substantially reduced, thereby enhancing quality, productivity and cost-effectiveness. Additionally, since field work is minimised, MiC can enhance safety of the workers and reduce construction waste.

As the name implies, the MiC Display Centre was built using MiC technology and is the first of its kind in Hong Kong. Established by the CIC it addresses government initiatives and heads a range of pilot projects to challenge conventional building methods with the important objectives of helping resolve the shortage of housing supply and construction labour force.

The 2-storey building has an area of approximately 300m² formed by ten integrated steel frame modules (five on each floor). To demonstrate the MiC technology flexibility and capability a variety of sample units are featured, including an elderly home unit, a hotel room, a hostel room as well as a 1-bedroom apartment and a 3-bedroom apartment. The building also comprises an in-situ element to house the staircases, lift for the disabled, electrical room for power supply and fire services panel.

As the modular units are prefabricated, all elements, including internal partitioning, electrical wiring and interior fittings, along with sizing of drainage pipes and vent ducts, had to be decided at an early stage. Careful and detailed resource planning was, therefore, key to the project’s successful delivery. With the help of the BIM model, the project team was able to plan the architectural and building services elements and minimise conflicts.



Example of MiC production sequence

The module under fabrication in the factory (left) and a trial assembly carried out before shipping (right)

Although the building is being used for demonstration only and is not actually fully functional, the project team, nevertheless, thoroughly considered the design and installation requirements according to regulations in Hong Kong. For example, steel frames for the floor were backfilled with light-weight cement to reduce vibration and make them feel more solid and comfortable to occupants and, since a sunken structure could not be provided in the steel frame module for installation of drainage pipes, the shower stall has been designed as a raised platform to provide space for the drainage pipes; the arrangement will also facilitate future maintenance.

Three different module sizes (2.8m × 6m, 3.5m × 6.5m and 4.5m × 6.5m) were used in this project and the completed modules, with weights ranging from 12.4 tons to 19.6 tons, were shipped by sea from the factory in mainland China to Hong Kong. As all the modules exceeded the width limit of 2.5m and would occupy more than one traffic lane, special traffic arrangements had to be made and the modules were transported to the site and installed over three nights. The modules were bolted together and connected to the in-situ part by movement joints.

The modules being installed

MiC is being increasingly adopted worldwide and has been used to construct high-rise buildings in New York, Singapore and the UK. While the technology is still new to Hong Kong, this project demonstrates how the versatile construction method can be applied to different building types and will help build up consumer confidence for wider adoption.

© Shots Around

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View of some of the units: (left) elderly home, (centre) 3-bedroom apartment, (right) hostel. All finishes, fixtures and furniture are prefabricated with the modules.

Learn more about the MiC Display Centre

People's Pavilion: a circular experiment

© Photo Filip Dujardin

Client:
Dutch Design Foundation

Arup's scope of services:
Structural engineering, sustainable building design

In collaboration with Dutch architects Overtreders W and Bureau SLA, Arup has delivered a radical building which takes the concept of circular economy to its limit.

The People's Pavilion in Eindhoven was the main venue for the Dutch Design Week, one of the largest design events in Northern Europe with a focus on innovation in design. Created to promote the value of a closed-loop construction system where materials can retain 100% of their value, rather than being lost as waste, the pavilion was built entirely from borrowed materials and was dismantled after the event with all components returned to their suppliers for new uses.

Measuring 250m² in area, the cross-shaped pavilion could host 200 people seated or 600 people standing. The key challenge for Arup's structural engineering and sustainable design team was to design a safe building capable of accommodating a large group of people without damaging the materials in any way. This meant the team had to devise a construction technique that didn't require the conventional connection methods that require alteration of the borrowed materials, like glue, screws, bolts or nails.

© Photo Filip Dujardin

The frames were first constructed on the ground and then hoisted into place

The beam elements were strapped together to create trusses in between the concrete columns to secure a safe and stable structure

Lab tests for the composite beams

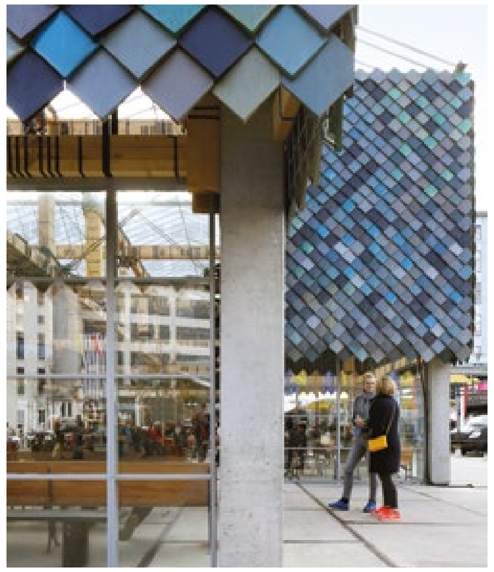
Arup's solution comprised a main structure made up of a wooden frame strapped to columns with dry connections . The frame was constructed with standard off-the-shelf timber beams ranging in length from 240cm to 480cm tied together with steel straps to make longer beams, and different configurations were tested to see which ones would produce the strongest composite elements. Twelve 7m-tall prefabricated concrete foundation piles served as columns, while steel rods taken from a demolished office building were reused as cross bracing. The whole primary structure was then tied together using 350 high-capacity ratchet straps, creating a stable structure capable of withstanding strong wind conditions.

To guarantee the safety of this unconventional structural system the strength and stiffness of the borrowed materials were checked. And for the few components which sources could not be identified the lowest capacities were assumed to provide an extra safety margin. The design calculations were also validated by experiments carried out in cooperation with the Eindhoven University of Technology. Composite timber beams were tested under bending to determine the amount of deflection under the expected loading and a few composite beams were further tested to their ultimate limits to establish the maximum load the building could take.

Along with the primary structure, the remainder of the pavilion was also made from borrowed or recycled materials. For the podium borrowed concrete slabs were used and the building was topped with a glass roof lent by a greenhouse supplier. The lower façade was glass saved from a demolished office building while the upper façade was clad by bespoke coloured shingles made from recycled plastic waste sorted by colour and collected mostly from the inhabitants of Eindhoven. Additionally, the lighting, heating and all other interior elements of the building were loaned by suppliers and local residents.

© Bureau SLA

The materials ready to be returned to their suppliers



© Photo Filip Dujardin

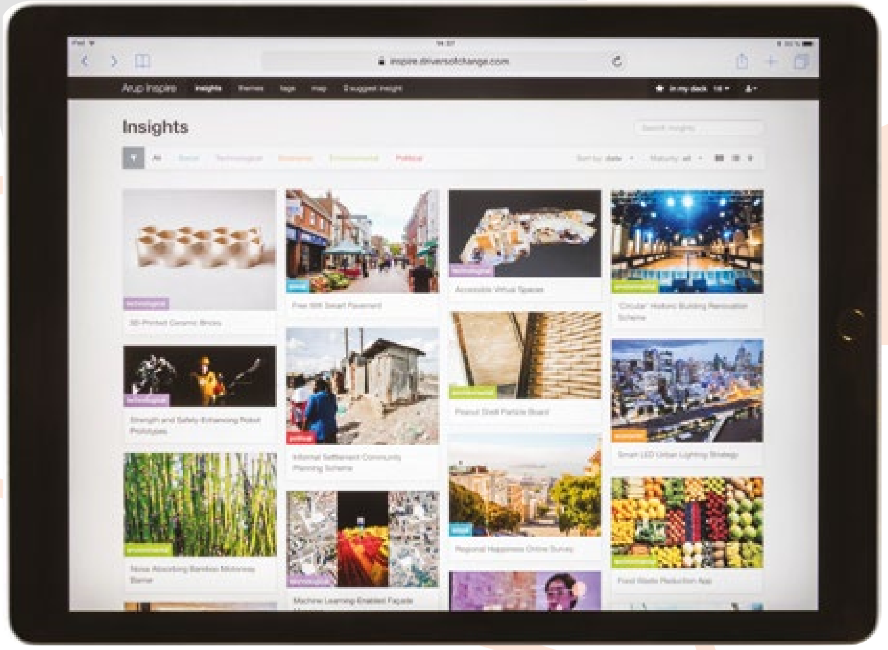
The distinctive coloured shingles were made from recycled plastic waste

The building was dis-assembled after the event and the materials were successfully recovered without damage. All components, except the coloured shingles which were distributed to Eindhoven residents as souvenirs, were returned to their suppliers for new uses.

The People's Pavilion demonstrates how circular economy thinking can be applied to the built environment in contrast to the usual linear model of 'take, make, use and dispose' more often adopted by the construction industry. By means of borrowing and returning materials the ingenious design for the pavilion achieved a close to zero-carbon footprint and revealed a new future for sustainable buildings.

Watch the video illustrating the structural design concept

Arup Inspire



Arup Inspire is a browser-based collection of emerging ideas and case studies from around the world. Created by Arup's Foresight team, it acts as a catalyst to find new approaches and define better solutions.

Inspire is informed by Arup's multidisciplinary expertise and experience in the built environment. The database currently contains over 1,500 emerging insights and ideas highlighting change and innovation in the built environment. A global network of Arup 'Inspire scouts' also helps discover and share local projects, adding to the ever-expanding collection of innovative ideas and revolutionary processes from around the world.

Previously for use by Arup staff only, Inspire is now open to external users with three service levels to choose from. An open-version provides access to 100 case studies and emerging ideas with basic functionality; full access is available through a paid membership subscription service; and a custom version of the platform provides organisations with curated content focused on a specific business requirement or challenge.

Insights can be filtered by STEEP (Social, Technological, Economic, Environmental and Political) categories, maturity level (Now, New, Next), geography and themes to make it easy for users to explore and discover. The platform provides a dynamic resource for initiating research, empowering workshops and engaging with clients and can be used as a source of inspiration for corporate foresight, strategy and risk processes.

For more information about Arup Inspire

The construction industry is undergoing rapid and fundamental changes. Developments in robotics and machine learning are supporting radical new building techniques, both on and off-site. These changes are challenging how we design, how we make decisions and what materials we use.

The 'Designing with digital fabrication' workshop in Tokyo brought together industry practitioners and thought leaders as well as Arup staff from Tokyo, Hong Kong and Shanghai.

Designing with digital fabrication

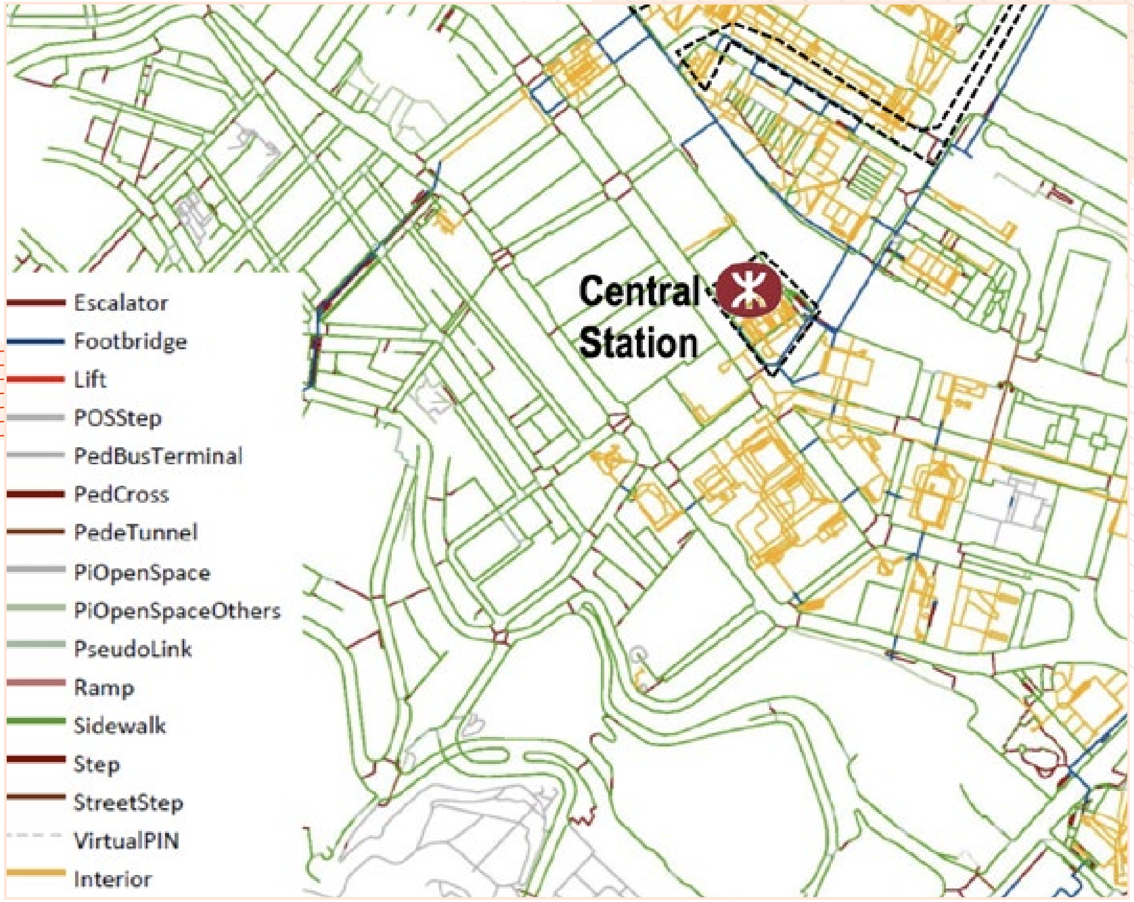
Arup's Foresight, Research and Innovation team has been hosting a global workshop series called 'Arup Explores'. The series examines emerging trends and technologies that have important implications for the future of Arup and the industry, both in terms of opportunities and risks. Past themes included 'Big Data' and 'Biomimicry' and the latest theme is 'Designing with digital fabrication'. Several workshops have been held around the globe, bringing Arup staff together with leading industry practitioners and thought leaders to discuss and share their experiences and the challenges they face in the digitalisation of the construction sector.

Digital fabrication promises to revolutionise the construction industry by making mass customisation possible, speeding up construction and reducing waste. It also presents opportunities, not merely to execute traditional designs more efficiently but to experiment with new paradigms and structural forms unimaginable using a traditional approach.

Digital fabrication technology has already been applied on some of our projects but the full potential is yet to be unlocked. Through the Arup Explores programme we, as well as our clients and collaborators, can better understand emerging trends, spark new insights and create value from future opportunities. Together we must re-think our design process to consider these disruptive trends from the very early stages and understand the implications they might have on the way we advise, design and construct our future built environment.

© Thijs Wolzak

This robot-printed pedestrian bridge in Amsterdam, which welds traditional steelwork and advanced digital modelling, is an important marker for the future of architecture and construction. Arup is the project's lead engineer.



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■ Indoor and outdoor pedestrian network in Central (partial view)

Towards walkable cities: International Walking Standard - Hong Kong Case

Traditionally, urban planning focused on vehicles and public transportation while walking was either not accounted for or heavily underestimated as a means of transport. However, in recent years more emphasis has been placed worldwide on the walkability of cities. To create more pedestrian-friendly city environments comprehensive information about walking is necessary and a set of international guidelines for the collection, analysis and dissemination of quantitative and qualitative techniques for measuring walking was required. As a result, the International Walking Standard was established to ensure the accuracy, consistency and comparability of travel survey data.

This Standard, however, mainly represents European countries and thus there is a need to develop a set of planning and design standards for Asia. In light of Arup's participation in the 'Walk21 Hong Kong' conference in 2016 (the first time this conference series on walking and liveable cities was held in Asia) and involvement in pedestrian studies to support the Hong Kong government's 'Walk in Hong Kong' initiative, research was carried out to develop a planning standard that pertains to the local context. This includes the humid subtropical climate and the city's characteristics (e.g. compact area and well-developed public transport system). The research findings will be submitted to the International Walking Standard as a Hong Kong case and provide guidance on national and local walking policies for other densely populated cities in Asia.

Over the past decades Arup's Transport Consulting team has been appointed by Hong Kong's Transport Department to carry out Travel Characteristics Surveys (TCS) to collect data for updating the Government's comprehensive transport model and provide information for future transport planning. Although an abundance of travel data has been collected, the data on walking has never been thoroughly analysed even though it contains valuable information to demonstrate the deviation of walking patterns in different districts. The aim of this research, therefore, is to tap into this TCS data to understand which factors can affect pedestrian behaviour.

The TCS walking data across the 26 districts in Hong Kong was, therefore, overlain with other data such as income level, population and thermal comfort. Results indicated that the provision of footpaths, mixed-use areas and environments with low sky view factors (i.e. sheltered or shaded) encourage walking, while income level and age have no direct relationship on people's willingness to walk.

Arup collaborated with three academic institutions and business corporations in this research to gather a wider range of attributes to further understand the pedestrian behaviour in each district. Two of the case studies are highlighted:

Case study 1 – Kowloon Bay:

Although the TCS has previously identified that 80% of the people travelling from the MTR Kowloon Bay Station to the MegaBox shopping centre will choose mechanised transport with only 20% walking, the underlying reasons were not explored. By collaborating with **WildFaces.ai** video analytics were used for people counting along route 1 and the results showed that while many people walked in the covered areas (section 1a), there were few pedestrians on the open streets (section 1b).

To investigate the correlations between the environmental attributes and this walking behavior surveyors from **The Institute of Future of Cities of the Chinese University of Hong Kong** collected thermal comfort data (including relative humidity, wind speed and shading provided by buildings) along route 2. The results indicated that radiant temperature was the dominating attribute deterring people from walking. The provision of a pedestrian linkage network and more shading could thus be considered to improve pedestrian comfort.

Case study 2 – Central:

TCS findings indicate that the mean walking time for passengers from the alighting point of a mechanised transport mode to their trip destination was 4 minutes. However, the area that could be reached within 4 minutes from the MTR Central Station could differ significantly when comparing a straight-line isochrone map with one based on actual pedestrian facilities.

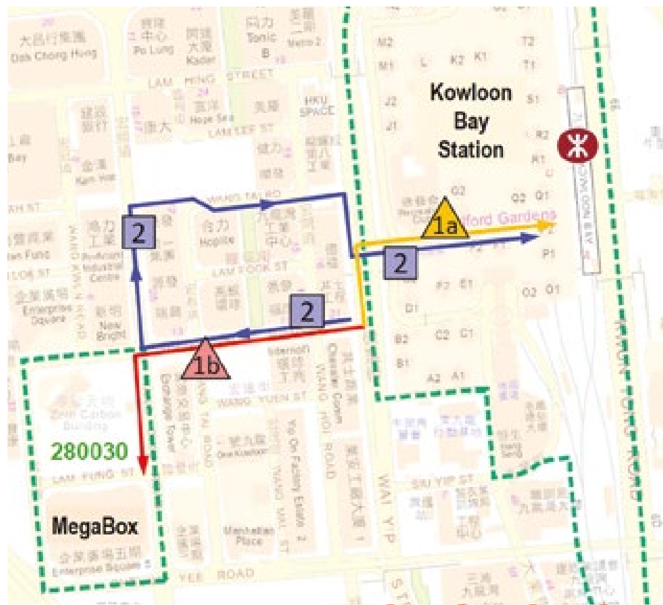
© WildFaces.ai

■ Video analytics example

By using a comprehensive 3D pedestrian network of Hong Kong, developed by **The Faculty of Architecture of the University of Hong Kong**, covering both indoor and outdoor pedestrian facilities and taking topography and sheltered areas into account, the research team was able to conduct a much more accurate pedestrian accessibility analysis of Central. 'Walkable' ratings were given to different pedestrian infrastructure including stairs, footbridges and escalators to pinpoint locations for improvement.

By combining these findings with the TCS data, the research has identified walking patterns and the factors that can enhance walkability in different districts. The use of new technology such as video analytics has not only saved significant time and effort required to conduct people counts and improve the accuracy of results but has also enabled more effective understanding of pedestrian patterns.

For the next step, Arup is planning to seek collaboration with mobile service providers in Hong Kong. By mapping the mobile data with the pedestrian network and TCS data, a profile of walking behavioural changes in terms of days, weeks and months could potentially be developed. This will allow better understanding of pedestrian movement and route selections so that deficiencies in the current facilities can be identified and connectivity improved.



■ People count and thermal comfort data were collected between Kowloon Bay Station and MegaBox

Building systems data at a glance

Digital Hub Platform: a data-driven approach for smart building operations

Modern buildings are complex mechanisms of systems and technologies. In managing and running facilities operators typically face many challenges, including getting up-to-date information on building assets, verifying the accuracy of reference operation and maintenance manuals, identifying equipment operating modes and status and determining building performance and energy costs. Although building automation and energy management systems have been around for some time, they focus mainly on monitoring and providing alarm capabilities. With the increasing convergence of building systems there is great value in a central analytics platform which can provide more insight from the combined data.

Arup's Digital Services team has been researching the development of an integrated 'BIM (Building Information Modelling) + IoT (Internet of Things) + Analytics' platform for smart buildings. The outcome is the Neuron Digital Hub Platform, a cloud-based centralised management platform which provides a foundation to connect disparate building systems and equipment, making them easily accessible and facilitating operation and maintenance. The research started as a study to explore the applications of IoT technologies to provide a more comfortable and customisable office workspace. Through subsequent development phases the platform was expanded to include machine learning and artificial intelligence capabilities to become a comprehensive smart building management solution.

The Neuron Digital Hub Platform is an intuitive and fully customisable visualisation tool to engage users, enhance building efficiency and optimise operational workflows. One of the most innovative features of the platform is the interaction between the building's 3D BIM model and real-time data captured automatically from building management systems and HVAC systems using open protocols including Building Automation and Control networks (BACnet) and Modbus.

By clicking on an item in the 3D BIM model, operators can visualise specific parameters and statistics for the item through interactive and responsive dashboards, making building performance data more transparent and usable. Also, 3D BIM further improves the capability of real-time monitoring of building system parameters and by capturing changes in the dynamic environment, the integrated platform can generate timely responses to abnormal or threshold triggers and thus reduce energy consumption.

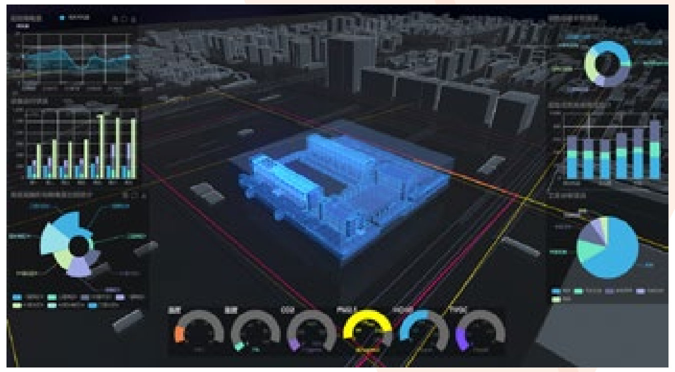
The Neuron platform also brings a new dimension to asset management, operations and maintenance by creating a digital twin for the building. Using this dynamic real-time view of the integrated systems of the building, operators can quickly retrieve asset information for decision-making, diagnose problems remotely and test a proposed fix for a piece of equipment before applying it to the physical component.

The Neuron Digital Hub Platform also offers other smart features. Precise measurement of indoor environment parameters such as temperature, humidity, indoor air quality and air contaminant levels are provided by a network of IoT sensors and equipment gateways. By leveraging the computational power of AI together with machine learning, the platform provides various functionalities to transform building operations:

- **Trend discovery and energy forecast:** large historical data sets can be analysed to uncover hidden patterns to better estimate future energy usage and allow better planning.
- **Building system optimisation:** the building management system can be controlled and adjusted automatically based on the statistical insight retrieved from historical data, leading to automated workflows, energy usage reduction and sustainable building performance.
- **Fault detection:** AI facilitates early detection and timely resolution by identifying anomalies in system data and verifying fault occurrences.
- **Predictive maintenance:** AI helps to monitor and estimate the condition of equipment and their components by analysing usage patterns, frequency of maintenance and operational parameters such as vibration and acoustics so that system maintenance can be scheduled in advance of disruptive unplanned downtime.

The Neuron Digital Hub Platform has already been applied to several pilot projects including the iconic Water Cube in Beijing. Through energy usage optimisation and predictive maintenance a substantial energy saving and improvement of operation efficiency have been achieved. Additionally, with air pollution being a major concern for Beijing, a network of IoT sensors deployed in the venue continuously monitor the indoor air quality and collect data to help optimise building system operations.

Building automation data can be easily reviewed through the 3D BIM model



Digital twin of the Water Cube

The techniques, technology and software employed in the Neuron Digital Hub Platform are a culmination of Arup's building domain expertise and innovation. The integrated system is constantly learning and working to improve its performance and the data collected will help our clients create better buildings and facilities in the future. The Neuron Digital Hub Platform takes the concept of smart buildings to a new level and will change the way buildings are designed, constructed, managed, operated and maintained.

For more information about Neuron Digital Hub Platform

Shaping a sustainable future:
East Asia Design School 2019

Are you a tree hugger, a problem solver, an optimistic dreamer or maybe a good cook? Do you have a passion for change and strive to make an impact?

These were the questions for the delegates to the 2019 East Asia Design School, an important part of Arup University's innovation training for our young designers, engineers and planners to encourage interdisciplinary collaboration, develop creativity and enable thinking outside discipline/project constraints.

Themed 'Planet B?', this 2-day event examined waste management and was aimed at inspiring attendees to find ways to reduce, reuse and recycle waste in their daily work and life. The delegates participated in a cooking workshop to make effective use of food leftovers and then designed a 'new and improved' sustainable version of an existing product being used in the food and beverage industry. They were further challenged to design and build a food delivery container from waste materials and then put the design to the test by competing in a 'triathlon' consisting of running, cycling and walking along an obstacle course. The designs were not only judged on the best delivery time and least spillage but also on their durability and the quantity of materials used to build the containers.

At Arup we have committed to aligning our work and our business with the Sustainable Development Goals (SDGs) set by the United Nations for the year 2030. This Design School is part of the effort to drive this agenda in East Asia and to create awareness that there is a lot each person can contribute individually, both as a member of Arup and as a citizen of our planet.

Overall, Arup's East Asia Region will adopt a 4-step approach:

- Learn: build capability through research, learning, knowledge sharing and communication;
- Integrate: make sustainable development the foundation of our business strategies and corporate practices;
- Act: deliver impact through project delivery, client engagement and new services;
- Influence: amplify our impact by using our knowledge and influence to promote sustainable development and lead the way.

Infrastructure is fundamental to human well-being, economic development and environmental management and, as a leading consultant in the built environment, Arup can make a critical contribution to achieve the SDGs. We will, as we always have done, use the very best of our ingenuity through the quality of our work and our total design approach to provide a safe, inclusive, sustainable and resilient future for all.

© UN

Arup's East Asia Region Chairman Michael Kwok giving a speech at the forum

Asian Knowledge and Innovation Forum

Arup has spent more than 70 years at the forefront of the built environment. Encouraged by our vibrant and open knowledge culture, innovation continues to play a central role in how we think, work and grow.

To demonstrate our continuing commitment to be an innovative and knowledge-sharing enterprise, Arup jointly organised this year's Asian Knowledge and Innovation Forum (AKIF) with the Knowledge Management and Innovation Research Centre of the Hong Kong Polytechnic University. The annual forum provided a unique occasion for management and organisational development professionals to exchange, benchmark and review their know-how and knowledge technology adoption with best practices from corporations and organisations from different fields across the globe.

Through the keynote speeches industry experts discussed innovation in the construction industry, an open innovation platform to test out ideas for smarter living experiences and decision support applications with data modelling. We also introduced our Foresight concept and facilitated an interactive workshop in which attendees used the 'Arup Inspire' and 'Drivers of change' card sets to explore new ideas and discuss key global issues and trends that may help shape future learning environments.

The inaugural Global Most Innovative Knowledge Enterprise (MIKE) Award was held in conjunction with the AKIF forum. Established on the original Most Admired Knowledge Enterprise (MAKE) Award basis, the MIKE Award recognises companies that excel in innovation and knowledge management in the new knowledge economy. Through a sharing session the forum attendees learned from the success stories of the MIKE Award winners on how to cultivate and convert their enterprise knowledge into superior products, services and solutions by bringing the intellectual capital framework to a new dimension.

Global case studies from Arup Inspire helped participants explore new ideas for future learning environments

Alice Chow
keeping the race with yourself

"Never give up. Give it another try or find another way to get there. If you do something at full power eventually you will accomplish something"

Alice Chow is the first female technical director of Arup's East Asia Region (EAR) and leader of programme and project management (PPM) and advisory services.

The journey into PPM

Alice graduated from Southampton University and joined a UK company as a bridge engineer before returning to Hong Kong to work for a local consultancy in 1987 on high-rise buildings. "At that time there were no bridge projects in the Hong Kong market and tradition prevented women from going into tunnels," she reflects.

One year later she joined Arup, continuing to design tall buildings. "At Arup, I was given the opportunity to work on mega multidisciplinary projects where I had to manage different parties. During the process, I also saw much inefficiency in the construction industry that could be eliminated with better management," she says, noting that the experience paved the way for her later 'mutation' into a dedicated project manager.

The catalyst was the San Miguel Brewery project in Hong Kong in 1994 for which Arup provided project and construction management services in addition to full design and design co-ordination. Alice led structural design in close collaboration with the project management team. "This project really embedded in my mind how important project management is," she says.

■ San Miguel Brewery, Hong Kong

What made the journey special

© Leigh & Orange Ltd

HSBC data centre, Hong Kong

Hong Kong's first new build data centre, which helped establish Arup's reputation in this niche market and led to appointments to another five data centre projects in a decade.

© China State Construction International Holdings Ltd

CUHK Medical Centre, Hong Kong

A milestone for Arup's healthcare business. Arup has since secured two more hospital developments in Hong Kong – the major ones under the government's 10-year Hospital Development Plan to cope with the aging population.

Rajiv Gandhi International Airport, Hyderabad, India

A hub for India's domestic and international passengers and cargo traffic. Alice led the project from inception to delivery and established the PM team as well as the Mumbai office.

© PID

Beijing Capital International Airport Terminal 3, Beijing, China

A much-needed infrastructure project in response to the increased passenger influx driven by the Beijing Olympics. Alice stayed in Beijing for one year for design management and later set up the PM team there.

Asia Aluminium flat-rolled product facility, Zhaoqing, China

One of the world's largest facilities of its kind. Arup's PPM team was appointed when the project stalled after two years of design. Alice brought on board Arup's multidisciplinary team providing total design services introducing a partnership approach – involving the client as the turnkey contractor to facilitate the complex project. After this, a PM team was established in Shenzhen.

© RICS

■ The PPM team has managed a wide range of award-winning projects and one of the recent ones is the Chu Hai College new campus in Hong Kong.

In 2000, Alice took over the PPM operation in Hong Kong, and since then she has pushed the PPM business into strategic markets such as data centres, healthcare and industrial facilities while building Arup's PPM capacity in Beijing, Shenzhen, Shanghai and Mumbai.

The intersection of art and science

PPM is indeed a science as it involves a fair degree of tools, techniques and processes to plan, organise and manage the various resources to ensure a project is delivered on time, in budget and to quality.

However, as Alice states, it's more an art: "PPM depends heavily on the right people with the right skills. It is dependent to a large extent on people dynamics – problem solving and inter-personal skills which can make or break a project.

"To successfully manage a project one needs to address PPM as both science and art and use the right tools and processes while choosing the right people to work on the culture, communications and leadership.

"Arup's engineering background and large variety of skills and technical know-how put us in a good position to manage complex projects. We also dare to speak up – why this won't work and what alternatives are available. All this makes our PPM team well-positioned to help the client look at the overall picture and drive the success of the project," she adds.

Looking into the future, Alice sees continued demand for PPM services from the healthcare and elderly care markets as well as the data centre sector driven by the aging population and digital revolution. "To adapt to rapid changes governments, companies and organisations are looking for expert advice to help them design for the future with necessary operational changes.

"The role of project managers will also change. As the digital transformation continues, most tedious work will be taken over by digital tools. Project managers will no longer survive as coordinators or messengers; they need to be truly decision-makers who build trust, forge collaboration, solve problems and drive the process with good communication skills," she says, confident of advisory services' future prospects.

From experience to expertise

What makes a good project manager? Alice encourages young people to be flexible, open-minded and sensitive to the needs of the world. She also encourages people to pay site visits. "Spot discrepancies on site, discover and understand the problems first-hand and sort them out with the team."

"Always plant the seeds, labour and wait for harvest time. This applies to both personal and business development," she advises. "Don't rush, but get prepared – invest in your experience, expand your vision, build connections and knock on the door. Someday you may find you have opened the door by applying something you picked up elsewhere."

Alice reminds us that PPM cannot be learned from textbooks but from experience, so mentorship is very important in the development of PPM capability. She also emphasises the importance of sharing. She believes that any successful project, big or small, has one thing at its core, effective collaboration, which can be achieved through knowledge and experience sharing. "Sharing helps you grow and generate new ideas. You will find you get more than you give," she says.

From 'leaning in' to defining your own purpose

As the first female technical director in the EAR and, for a long-time, the only female in many leadership meetings, Alice is affectionately called 'The Lady' in the circle and is seen as an advocate of female empowerment. She speaks widely at conferences and to the press on this topic and has been appointed to the Hong Kong Institution of Engineers' taskforce of women in engineering to attract more females into the industry and help with their career progression.

"Men and women complement each other", Alice notes. "Women are more observant than men generally and they tend to see the entire picture along with the small details. Women are also more decisive and good at execution. All these enable women to facilitate processes without missing important steps. The industry needs to better tap into this workforce."

Over the past decades, the industry has welcomed more women but many of them drop off or step into an easier industry in the middle of their career to take care of families. Alice believes that flexible working provides a choice for women and the firm as well. She is a strong proponent of this policy and three of her team members have been working on a part-time basis with full support from the rest of the team.

"But remember, the industry doesn't owe you anything," Alice reminds women in the male-dominated industry. "Ask yourself what you can do for the industry. Don't focus on leaning in or standing out; instead define your own purpose and journey and then race against yourself. Never stop exploring and improving your own worth."

© Medecins Sans Frontieres

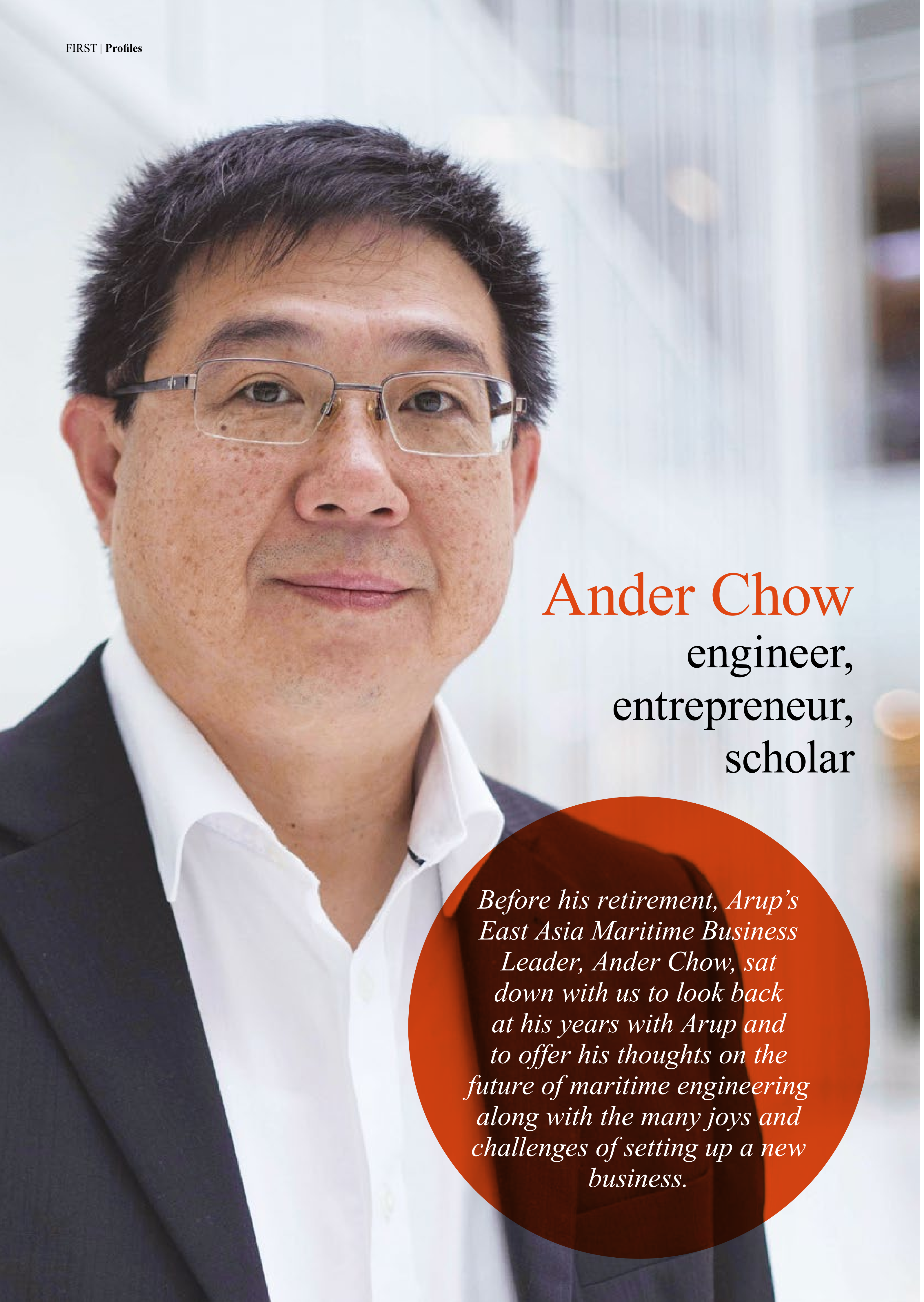
In pursuit of meaning

"At the beginning of my career, work was my whole life as I wanted to learn more. Later, I found I needed to do something else, more meaningful, using my engineering skills".

In 2002, Alice decided to rise to the calling from her inner self – do something special and meaningful.

She took a 1-year leave to join Médecins Sans Frontières (MSF) as a volunteer to help people in underdeveloped countries: establishing a nutrition programme in Afghanistan and developing an emergency programme in Ethiopia. Both assignments included various logistic management, construction management and day-to-day operation of MSF volunteers.

In addition, she provided relief work in Banda Ache, Indonesia after the devastating tsunami in 2005 and ran emergency work in Sichuan, China, following the catastrophic earthquake in 2008. She is also a volunteer in hospice care.



Ander Chow
engineer, entrepreneur, scholar

Before his retirement, Arup's East Asia Maritime Business Leader, Ander Chow, sat down with us to look back at his years with Arup and to offer his thoughts on the future of maritime engineering along with the many joys and challenges of setting up a new business.

A token of appreciation from James Sze, Director of Infrastructure, at Ander's retirement party.

"This is my second retirement," he chuckles, "I enjoyed two years of doing nothing before joining Arup." Looking back, Ander has carved out an unconventional career path in the industry, not only as an engineer but also as a scholar-turned-entrepreneur.

A technopreneur

Born and raised in Hong Kong, Ander went to Canada for further education in the late 1970s. After obtaining his PhD degree from Queen's University in 1989, he co-founded his own company in Mississauga, Ontario, responsible for numerical modelling and business development in coastal and water resources engineering.

He returned to Hong Kong with his family in 1994 and started a joint venture with a local design and engineering consultant looking after the environmental sector. A dozen years later he opted for early retirement after selling all his shares when the firm went public.

During those years Ander wore multiple hats and took on varied roles, but what he enjoyed most was always technical innovation.

He designed the first berm breakwater in Hong Kong for the Hei Ling Chau Typhoon Shelter project. "Compared to the conventional approach, the berm breakwater has a dynamic profile and, requiring smaller armour rocks, is easier to construct," he says. This innovative design saved millions of Hong Kong dollars in construction cost.

During the dotcom boom he also led the development of a web-based environmental monitoring and audit system which can be used to assess and monitor proposed and on-going construction projects for environmental impact assessment purposes.

"I love new approaches and technologies," he says, "If I could travel back in time, I would probably continue to explore technical innovations such as AI and machine learning. And I'm keen to develop knowledge-based systems for business applications to improve productivity and reduce cost."

Site visit to assist Taiwan in post-typhoon reconstruction in 2009

Into new waters

After his career break, Ander decided to come back by taking up a new challenge – setting up the maritime business for Arup in East Asia.

"The market was on a downturn following Hong Kong's changing position in the regional port and logistics business," he reflects. In view of this, his top priority was to shift the direction from port structures to a broader spectrum of maritime engineering including maritime


© Courtesy to CLP

The study looked into the vulnerabilities of three CLP power stations under super-typhoon conditions

planning, reclamation, coastal hazard assessments, typhoon modelling and climate resilience studies.

"Climate change poses both risks and opportunities for all parts of the maritime business. It is an issue requiring action from all parts of society including governments, designers, planners and engineers to integrate different skills," he says.

Over the years, Arup has built a reputation in this field with a series of high-profile projects in the local market. For example, the super-typhoon study commissioned by CLP Power Hong Kong Ltd. integrates typhoon, wind force and flooding for the first time in Hong Kong. The study investigated vulnerabilities of three CLP power plants under super typhoon conditions; typhoon wave modelling and 2D coastal flood modelling were used to determine the extent of possible flooding in these mission-critical facilities.

Another significant and far-reaching project was the climate resilience studies for the Hong Kong Government's Civil Engineering and Development Department where Arup reviewed the climate change situation in Hong Kong and, in particular, the long-term sea level rise and changes in storm surge and wind speed. Consequently, the design standards in the Port Works Design Manual and other guidelines in government works were reviewed and updated to cope with climate change for new coastal structures and to reduce the risk of coastal flooding.

With these projects Arup is continuously building up its capability and today the East Asia maritime team comprises specialists in two areas: coastal structures and resilience-related consulting.


© Terence Leung

Review climate change impact on coastal structures

On the horizon

Looking into the future, Ander sees a world of opportunity. "There are opportunities in major reclamation projects in Hong Kong and mainland China and port expansions in Southeast Asian countries such as Vietnam, Singapore, Malaysia and Indonesia."

"Coastal flood prevention and climate-resilient design will continue to be a growing area with frequent extreme events like Typhoon Hato and Mangkhut", he adds.

Ander points out that to capture these opportunities Arup must strengthen its existing skills in maritime structures and develop simulation capability for waterfront planning and other emerging areas.

"Knowledge-sharing and multidisciplinary collaboration is crucial", he says. "Maritime must work with geotechnics, structures, water, infrastructure, energy, transaction advice and many other disciplines to provide integrated services."

Equally important is understanding and meeting increasingly sophisticated client expectations. Ander emphasises that engineers must not only solve problems but also anticipate and address potential concerns and uncertainties of clients.

He notes that digital tools will play a bigger role in maritime engineering in terms of loading calculations, modelling, forecasting and monitoring along with warning and management systems for safer, smarter and more human-centered design.

"Though some concepts and technologies are there for a long time, the advancement of computing power, speed and networking will unlock more possibilities," he says.

To retire but not rest

Despite a fruitful career, Ander still has goals to reach. "I'm always interested to understand physical limits." He cites the probable maximum precipitation value as an example. This key parameter is used to estimate the probable maximum flood which is important for dam safety and civil engineering purposes. What maximum is maximum? He is keen to continue his research with local universities after retirement.

A sought-after industry expert, Ander also plans to teach, coach and share his knowledge with university students. He believes that universities have a pivotal role to play in the maritime industry – building fundamental scientific competence as a basis for professional development and innovation.

So what advice would Ander impart to young engineers? "Stay curious and keep exploring. A good engineer has to be risk-aware, cautious, multi-tasking and multi-disciplinary. An inquisitive mind and an open and collaborative attitude will give you more exposure and quicker lessons learned to acquire these qualities."

Some of Ander's work

CLP Offshore Wind Farm Project, Hong Kong

Arup designed the offshore meteorological mast, using a 'suction can' foundation system, to collect wind and wave data for a wind farm feasibility study.

Sengkang LNG Terminal, Indonesia

Arup provided structural, geotechnical, civil and maritime engineering for an innovative 88,000m³ membrane-lined LNG (liquefied natural gas) storage tank and the associated marine facilities.

Marine Cargo Terminal Development, Hong Kong

Arup was appointed by the Hong Kong Airport Authority to develop the masterplan for the Marine Cargo Terminal, a strategic component of aviation logistics services at the airport offering comprehensive air-sea intermodal transportation services.