Foresight ◤ Innovation ◤ Research ◤ Sharing ◤ Training

Issue 2 2016

FIRST

A ‘flagship’ in its own right
Raffles City Chongqing

© Safdie Architects / CapitaLand (China) Investment Co Ltd

40 YEARS IN HONG KONG | ARUP

Welcome

Welcome to the second issue of FIRST, Arup's biannual publication looking into the cutting-edge of the built environment.

Emerging technologies are constantly pushing the limits of possibilities by mixing the old with the new or remixing the old in the ways we'd never imagined before. In this issue, we take a close look at some innovative solutions we recently developed through mixing and remixing – the hybrid outrigger system which is critical to realise the rising symbol in Western China and the hybrid approach to combine the advantages of additive manufacturing with the technical familiarity of investment casting.

Also in this issue, we shine a light on transport infrastructure, from the Midfield Concourse at Hong Kong International Airport to Arnhem Station in the Netherlands. We not only develop fresh solutions for demanding technical challenges but also research into how such transport hubs can better drive city development together with the space above, below and around.

Innovation often starts with foresight. Here we discuss two of the latest foresight publications – Cities Alive: 100 issues shaping future cities, and Future Lujiazui which presents our ideas for future smart communities.

In this issue, we are pleased to feature Colin Wade, a living dictionary of Hong Kong's railway development; and Kang Man, one of the earliest Hong Kong engineers who ventured into mainland China. We'd also like to share with you some of the amazing projects we've had the privilege to work on recently including NTT FDC2, a state-of-the-art home for data, and Foshan Lingnan Tiandi, the world's first LEED-ND Gold certified retail community.

We hope you enjoy reading this issue and find it valuable.

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.

For more information on any of the topics featured in this magazine, please contact us at ***ea.arupuniversity@arup.com****.*

A ‘flagship’ in its own right

Raffles City Chongqing

Raffles City Chongqing is located at the very heart of the city, facing the confluence of the Yangtze and Jialing rivers. This strategic location places a great deal of symbolic significance on this mega-scale development as an icon of booming Chongqing, the gateway city to Western China.

Raising a rising icon

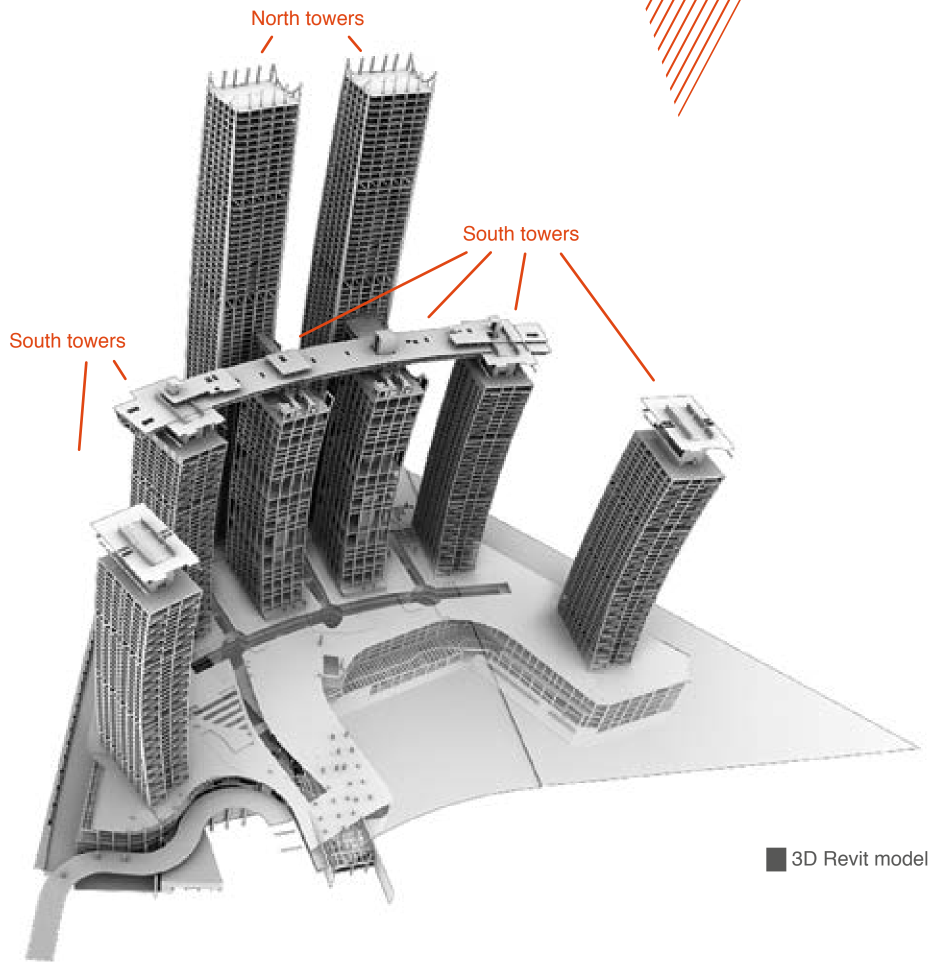
This mixed-use development comprises a shopping mall and eight towers , four of which will be capped by a conservatory, offering residential, office, serviced residence and hotel spaces with a total GFA of 1.1Mm^2. The complex will also serve as an important transportation hub integrating bus and ferry terminals and a subway station.

Client:
CapitaLand (China) Investment Co Ltd

Arup’s scope of services:
Structural engineering, civil engineering, fire engineering and building sustainability

Selected award:
China Innovation Award – Honourable Distinction, CITAB-CTBUH China Tall Building Awards 2016

© Safdie Architects / CapitaLand (China) Investment Co Ltd



3D Revit model of the development

Bridging across the towers

The most notable feature is the conservatory – a 300m-long glass-clad structure which sits astride four tall, slender and curved towers 250m above ground – unprecedented in terms of its length and height.

The articulation of the conservatory posed a major challenge to the Arup design team. The closest resemblance can be drawn from the Marina Bay Sands® development in Singapore, another Arup project. However, Raffles City Chongqing has very different design conditions: it boasts taller and more slender towers in a moderate seismic zone under relatively high wind loads at the confluence of two rivers. All these would require a completely different supporting system.

The Arup team compared different design alternatives with the conservatory fixed to or isolated from the towers, as well as their impact on the building costs, to determine the best option.

The baseline case was the conservatory rigidly fixed to the top of all four towers so the buildings are monolithically linked. However, this led to a high tonnage demand. The use of movement joints was also ruled out, because in extreme seismic events the towers could potentially be moving 3m apart. The team then concentrated on exploring the design options using bearings to isolate the conservatory from the buildings.

LS-DYNA models of the four supporting towers and the conservatory were developed to analyse the dynamic interactions during seismic excitation. The seismic analyses were carried out to extreme earthquake levels, higher than normally required, to justify the structural performance of the design options, and in total 900 analyses (approximately 27,000 hours) were run over the course of the project. These studies supported the hypothesis that the isolation options are beneficial to the design in terms of reduction of shear forces measured at the base of the towers. In the best case, the base shear reduction can reach 30% compared to the fixed conservatory option.

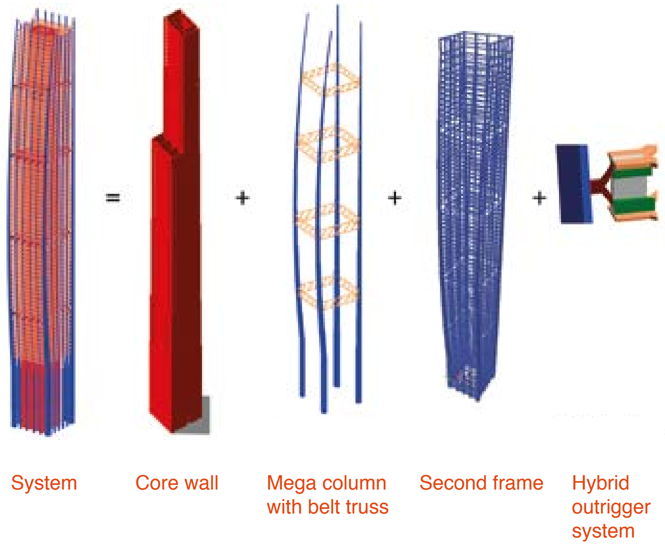
The chosen solution uses a combination of friction pendulum bearings (FPB) and dampers. The FPB provides resistance such that the conservatory is fixed to the towers under various serviceability loadings (design wind/thermal load) and Level 1 earthquakes. When the seismic activity reaches Level 2 or Level 3, the bearings will allow movements and the conservatory will become 'floating' and move separately from the towers thus dissipating the energy and helping to mitigate the effects of the earthquake.

The use of these 'pendulum' bearings and dampers provides the 'position self-restoring' power. A 1:25 scale shaking table test was carried out to demonstrate the seismic performance of the multi-towers and dynamically-linked bridges under extreme earthquake events.

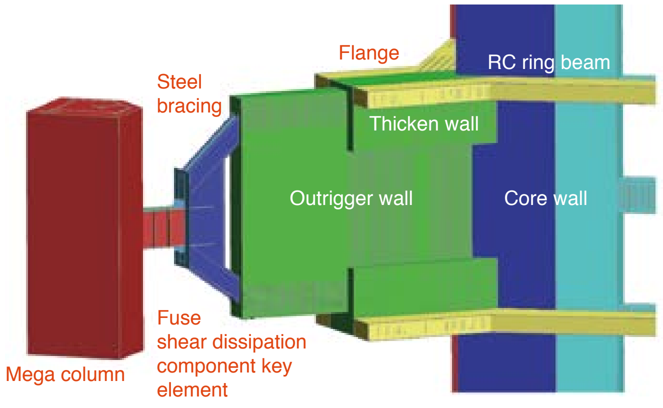
Realising the slenderness

Another major challenge was the high slenderness ratio of the north towers. The two 350m towers, which boast a slenderness ratio of 9.4 (compared to a slenderness ratio less than 8 for most super high-rises), would require a very strong structural frame for lateral stability system.

LS-DYNA model to analyse interactions between the conservatory and the towers during earthquakes



Structural system of the north towers



Innovative hybrid outrigger

From a structural viewpoint, the most effective design would be mega columns with a braced frame. However, the use of bracing would affect the views and is not, therefore, acceptable for hotel or residential towers.

The project team compared different options and finally adopted a structural system comprising a reinforced concrete core, four corner mega-columns, belt trusses, a perimeter moment frame and four levels of hybrid outriggers designed by Arup. This scheme is feasible for Chongqing, a moderate seismic zone, and will be able to provide enough stability.

The outrigger is not a new concept and has been applied to many high-rise buildings around the world. With the belt trusses and outer columns, the conventional outrigger acts as a 'rigid arm' connecting the building core to the outer columns and provides lateral stability for a tall building. However, Arup's innovative hybrid outrigger is a completely new concept.

This hybrid outrigger makes use of a 'seismic fuse' connecting the outrigger wall to the mega column to control load paths in major seismic events. Under Level 1 earthquakes and normal wind loads, the fuse will remain fully elastic. However, under Level 2 and Level 3 earthquake events, the fuse shear dissipation component will yield and deform and dissipate the energy. This damping effect will protect the outrigger wall and core wall from damage.

The hybrid outrigger also uses a reinforced concrete wall with minimal steel connecting elements. Compared with the conventional outrigger system which is predominantly structural steel, the hybrid outrigger system constitutes a significant cost saving, whilst achieving higher rigidity within a more compact refuge floor zone. Moreover, it shortens the construction time and thus achieves further cost savings.

This new application of a fuse in an eccentric braced frame is a major innovation by Arup, and we have already received the approval for the patent use of the hybrid outrigger wall system with empirical evidence.

The hybrid outrigger system has also been honoured at the inaugural CITAB-CTBUH China Tall Building Awards with the 'China Innovation Award – Honorable Distinction', for its integration of various structural solutions that yield exceptional performance under considerable seismic loads.

Arup's innovative solutions help to realise the unique architectural designs of this flagship project. Upon completion, the development will become a new landmark for Chongqing and will serve as a symbol for the city's thriving present and future.

Client:
Airport Authority Hong Kong (AAHK)

Arup's scope of services:
Aviation planning, structure, façade, MEP, sustainability, automated people mover, IT & communication systems, fire, lighting, acoustics, baggage handling systems and logistics

Selected awards:

Best Airport Project, Engineering News-Record Global Best Projects Awards 2016

Autodesk Hong Kong BIM Awards 2013

BIM Award for Innovation, Bentley 'Be Inspired' BIM Awards 2011

© Kerun Ip / AAHK

A triumph of total design:
HKIA Midfield Concourse

The Midfield Concourse (MFC) enables the Hong Kong International Airport (HKIA) to cater for more than 10 million additional passengers a year, strengthening the city's competitiveness as a regional and international aviation hub.

Located to the west of Terminal 1 and between the two existing runways, the 105,000m² MFC provides 19 contact aircraft parking stands (two of which can accommodate Code F aircraft, such as the Airbus A380). The 5-storey complex features an architectural style that complements Terminal 1 with a large, clear, open span steel truss roof, high headroom and extensive use of glass to create a sense of openness.

Arup, in joint venture with Mott MacDonald, provided full multidisciplinary design and construction support for this project.

© Kerun Ip / AAHK

Air conditioning is provided via binnacles

© Airport Authority Hong Kong

PV panels on the skylight structures

Environmentally responsive design

To maximise efficiency and sustainability, Arup introduced 35 environmentally beneficial features to the concourse design including high-performance glazed panels, more than 1,200m² of solar panels to harness renewable energy and regenerative power for both the automated people mover (APM) and vertical transport systems.

Arup recommended a building orientation along the North-South axis to avoid the large solar gain from the south. The distinctively shaped building was also developed based on sustainability requirements: the glass façade on the west side is minimised to reduce heat gain from the hot afternoon sun, while the glass façade on the east side is maximised to admit more daylight to the space.

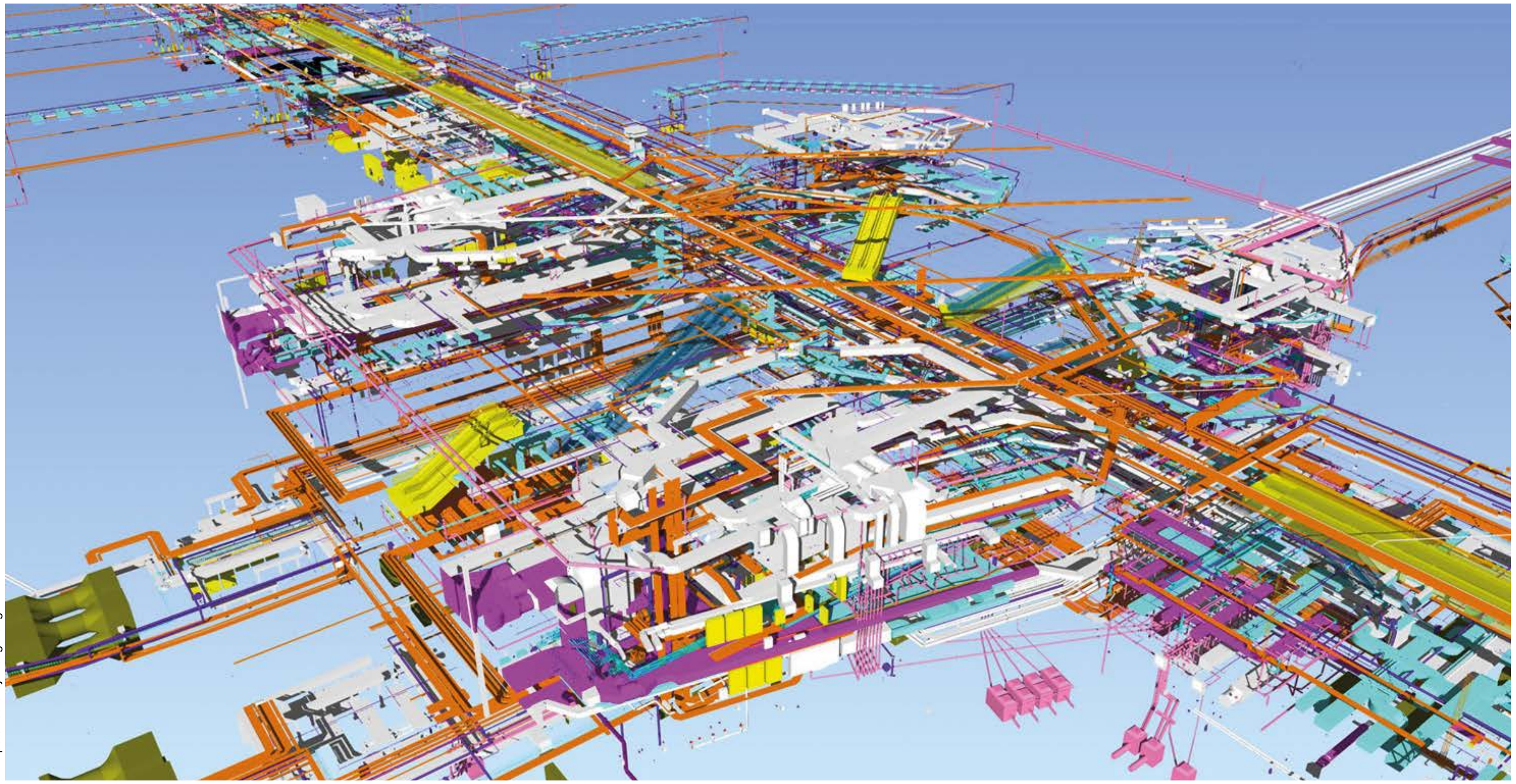
To maximise daylighting, north-facing roof skylights were introduced to bring natural light deep into the heart of the building to reduce artificial lighting and improve user comfort and experience.

Air conditioning is provided via binnacles. The cooled air delivered from the top of the binnacles sinks and forms a 'blanket' above the floor enabling efficient local cooling for the occupied zones only. All systems are variable in terms of volume and speed, allowing the building to react to different occupant capacities.

Locally sourced materials, both recycled and renewable, were used throughout design and construction and construction waste was recycled. Furthermore, the MFC was designed for flexibility so that the space could be adapted and changed in the future requiring minimal structural works or re-strengthening.

Water conservation strategies were also adopted, including the recycling of A/C condensate water and grey water from restrooms and kitchens to be used as makeup water for the cooling towers. These measures have successfully achieved a total potable water reduction well beyond our initial baseline.

The MFC has already received a BEAM Plus Provisional Gold rating and is currently undergoing final assessment.



© Airport Authority Hong Kong

3D model of the integrated building services and airport systems

New cameras, cables, access control doors, and leaky cables were provisioned, while some existing devices were either retained, dismantled or relocated. All new equipment was integrated into the existing system to operate seamlessly as a single unit.

Arup also formulated the strategy to divert the existing communication cable containment in order to spare the space for the new platform. Since these cables support various airport and mission-critical systems used in the air traffic control tower this diversion work was extremely critical to the operation of the whole airport.

The cable containment design was verified using the BIM model to ensure that the new design has a shorter route distance and there was sufficient slack to relocate the existing cables thereby avoiding the need to splice and reconnect the cables. Cable diversion risk assessment was also developed to identify the risks, the possible failure effect and migration methods.

Equipment and cables in the existing West Hall Radio Room were relocated for the construction of the new APM platform. Arup prepared a methodology for the relocations of the operators' radio equipment without disrupting the service, and worked closely with the mobile operators during construction to ensure smooth implementation.

An optimum solution using BIM

The Mott MacDonald-Arup Joint Venture, in conjunction with architect Aedas and sub-consultant Atkins, deployed multiple software platforms to deliver the design. Software integration through the BIM workflow enhanced project-wide collaboration, allowing rapid information exchange and helping to significantly improve inter-disciplinary coordination.

Opened in December 2015, the MFC is now in full operation. Arup's holistic solution helped our client achieve an important milestone in their visionary development plan.

APM: creating safe and seamless connectivity

The MFC is connected to Terminal 1 via an extension of the existing APM system. The 1km extension also provides a new station at the MFC, a route recovery line and a light maintenance area.

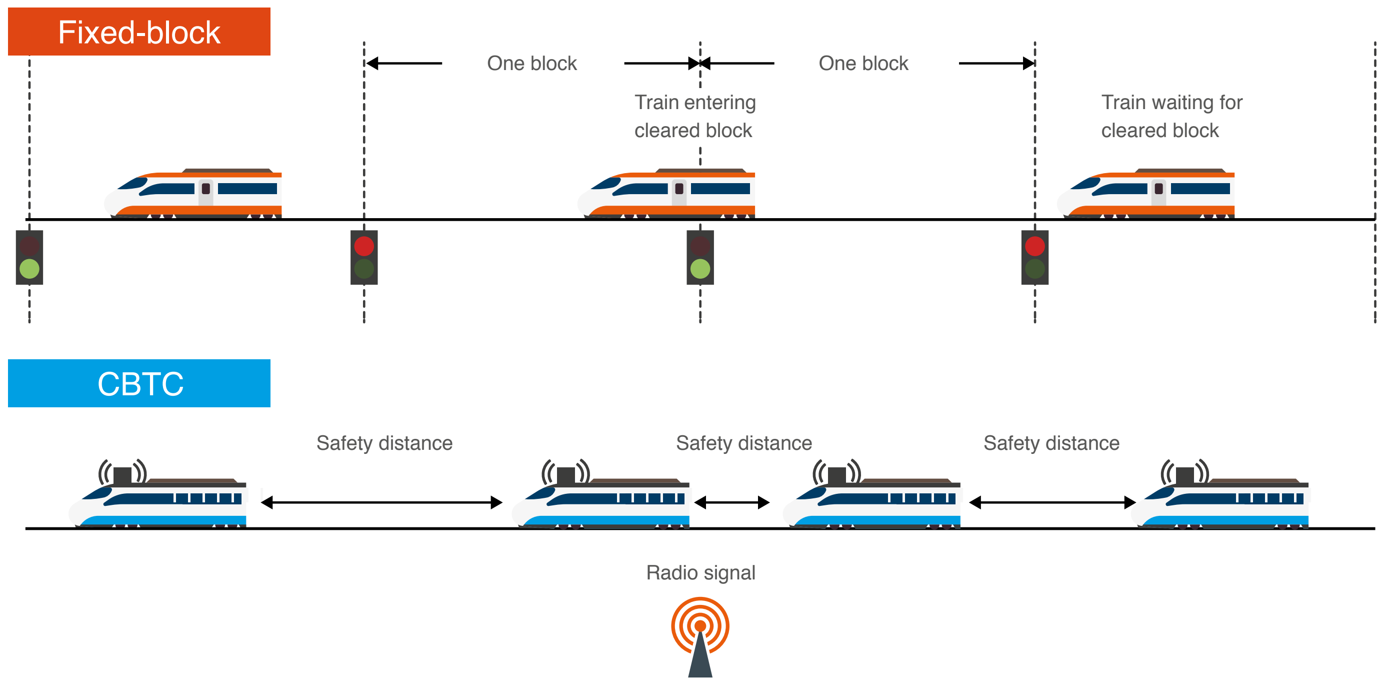
Arup was responsible for the upgrade of the existing APM signalling system from a fixed block system to a communications-based train control (CBTC) system. While the traditional fixed block system only allows one train to enter a block after the previous train has cleared, the CBTC moving block system uses bidirectional train-to-wayside data communications to continuously monitor and calculate the train status so that the trains can automatically adjust their speed while maintaining a safe distance from the preceding train. As a result, trains can travel at a closer distance, thus reducing the headway and increasing the system capacity.

To ensure continuous APM operations, installation of the new signalling system on the APM vehicles and along the tracks was performed as an overlay in parallel with the existing system: the fixed block system remained functional during daytime operations, and the APM then switched over to the CBTC system at night for testing. All train-side and wayside works and equipment installation were also carried out during maintenance hours (between midnight and 6am). The fixed block signalling system will be removed within a year of the new CBTC system being confirmed to work properly.

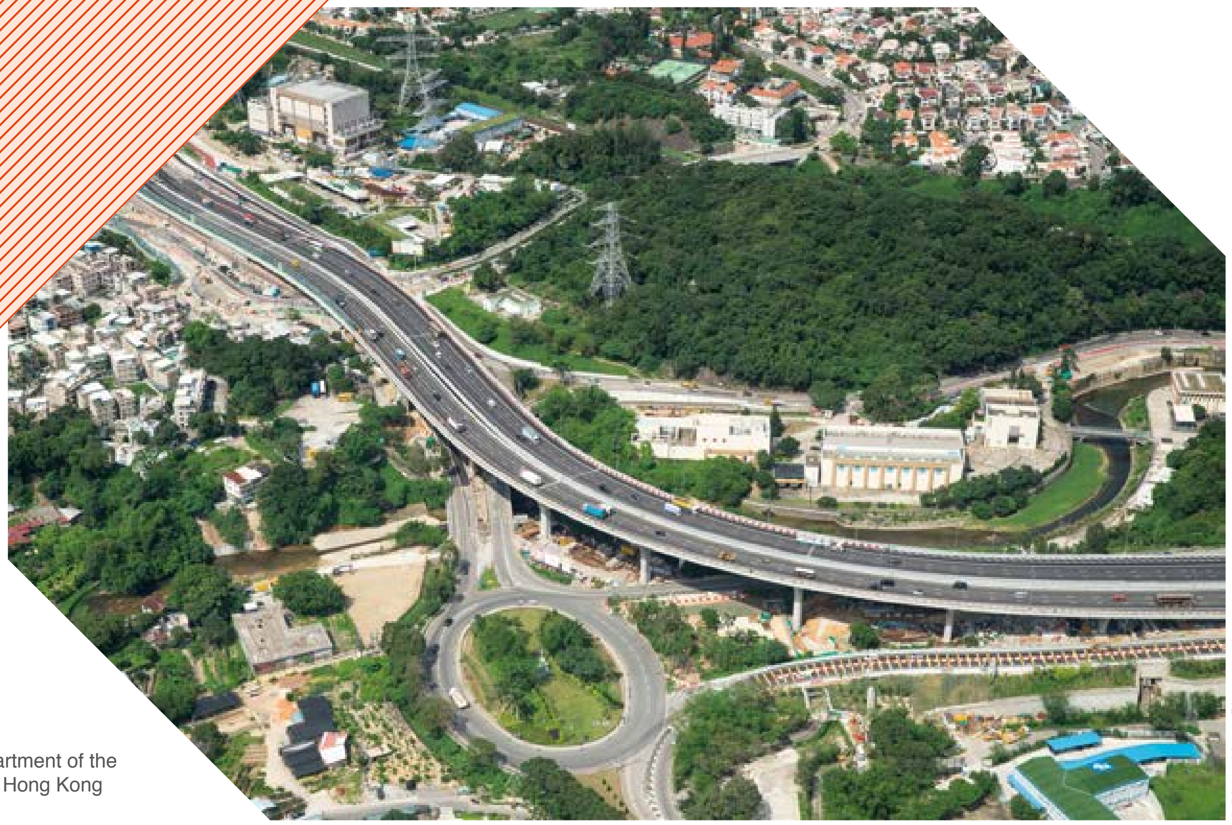
This is Hong Kong's first CBTC overlay project. The whole process, including testing and commissioning, took four years to complete. The well-planned process designed by Arup helped to avoid disruption of the APM operations and allowed seamless transition to the new signalling system. Arup is currently working on the Terminal 2 line upgrade to CBTC to match the signalling system on the Terminal 1 line.

Mission critical: integrating the systems

The APM system expansion also required modification of the existing airport systems in the Terminal 1 West Hall, due to the construction of the new APM platform and route recovery line.



Schematic diagram of fixed block system vs. CBTC system



© Marcel Lam Photography

Client:
Highways Department of the Government of Hong Kong

Arup's scope of services:
Civil engineering and structural engineering

Selected awards:
Grand Award, Highway and Transportation Excellence Award 2016, Hong Kong Institution of Highways and Transportation

Levelling the difference: Tolo Highway widening

The project included the widening of a 5.7km section of the Tolo Highway and a 3km section of Fanling Highway in Northern New Territories in Hong Kong from the existing dual 3-lane carriageways to dual 4-lane in order to alleviate traffic congestion and to meet future demands of the area.

In a joint venture with Hyder and Black and Veatch, Arup was responsible for the detailed design and construction works for all the highway bridges, the traffic study and the traffic control and surveillance system.

Under normal circumstances, widening of an existing 2-carriageway road would be carried out with the symmetrical addition of lanes on each side of the road and the central median would be maintained at its original location. (Fig. a)

However, due to site constraints this approach could not be adopted at several locations along the Tolo Highway. As a result, a new 4-lane carriageway was constructed at one side, and the original road was then modified to become the other 4-lane carriageway. The bridge decks of the existing carriageways in these areas were 'stitched' by concrete and then resurfaced to form the new road. (Fig. b)

But complications arose at two locations (Bridge 11 and Bridge 13) where the existing carriageways were at different levels and crossfalls. When connected they would form an undesirable road surface which would be dangerous for traffic travelling on the new road. (Fig. c)

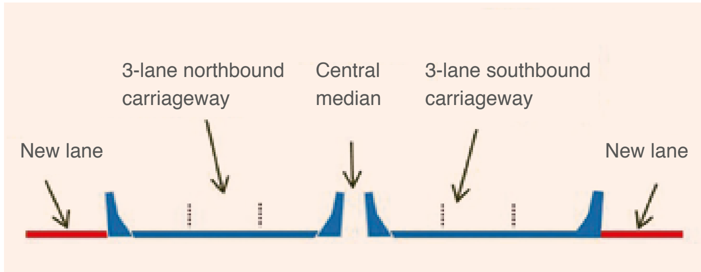
The Arup project team developed three options to tackle this problem:

Option 1 – To demolish and replace the existing bridge decks. This would be the most straightforward solution. Yet this option would be costly and not environmentally friendly since it would involve large-scale demolition works.

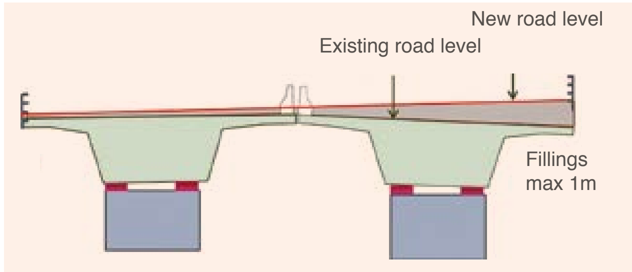
Option 2 – To fill up the road level of the existing southbound carriageway using bitumen and concrete. But the extra loading would damage the bridge.

Option 3 – To tilt and jack up the existing southbound carriageway bridge to match the future road level. This had not been done in Hong Kong before and would involve many technical challenges. However, since it would bring the best value to the client, Arup proposed this option.

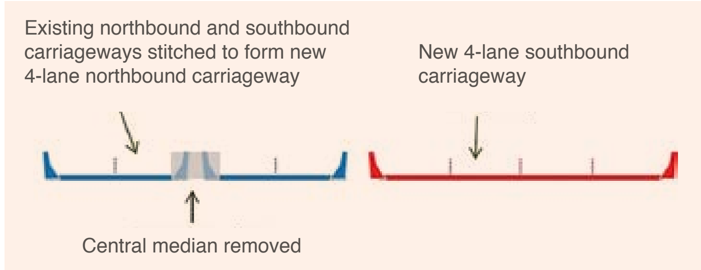
Condition surveys were first carried out to determine whether Bridge 11 and Bridge 13 were in a good state as both were more than 30 years old (otherwise demolition would be unavoidable). After determining that the bridges were suitable for the operation, the challenge was how to lift the concrete bridge deck without excessively twisting and breaking it, as each bridge deck was approximately 4,000 tons in weight and 160m in length.



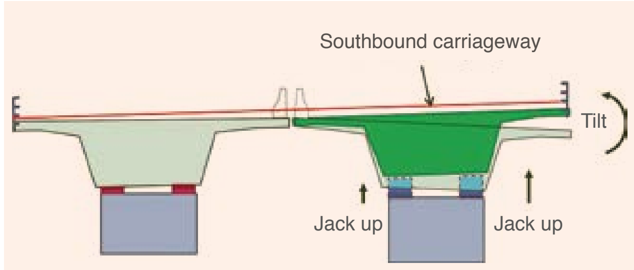
(a.) Conventional approach to widen highways



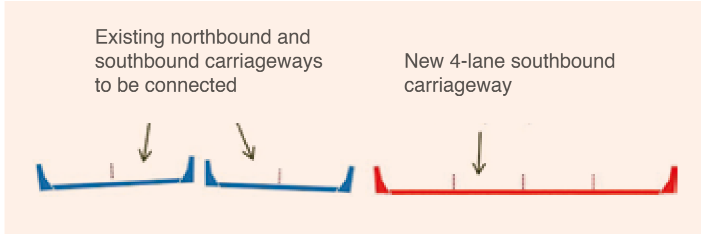
Option 2 - raising road level with fillings



(b.) Alternative approach to widen the Tolo Highway



Option 3 - tilting and jacking up the bridge



(c.) Level and crossfall differences between existing northbound and southbound carriageways at Bridge 11 and Bridge 13

16 jacks beneath the bridge controlled by jack synchronous system

The Arup project team proposed ten jacking points along the bridge deck (five along each edge). In theory, using an automatic jacking system could provide full synchronisation of the jacking points and prevent any twisting or bending of the deck. However, in reality a 100% synchronous jacking system could not be guaranteed, since there would be slight differences in the distance between jacking points, as well as variations in the friction and pressure in the tubes of the hydraulic jacks.

Bridge decks stitched

Taking these factors into consideration, the project team employed the GSA Bridge software (designed by Oasys Ltd., the software house of Arup) to set up a 3D computer model to calculate the maximum differential movement that the bridge could tolerate in the longitudinal and transverse directions, and these criteria were listed in the specifications in the contract. Since the loading conditions would change after the existing carriageways combined, additional stress analyses were also performed to determine whether strengthening would be required for the new bridge.

Fully adopting our design, the operation was carried out by the sub-contractor using a 16-jack synchronous jacking system under close supervision of the Arup project team. The resulting maximum differential movement between each jack was 1mm, within the required range.

With careful advance planning by the Arup project team, this first bridge tilting operation in Hong Kong only took three days and was successfully completed with no sign of cracking found on the bridge deck either during or after the jacking operation. The project demonstrated a simplified bridge construction method saving time and money and creating a sustainable solution by minimising waste. Building on its success, Arup will be able to apply the method to future highway projects.


© Foshan Shui On Property Development Co Ltd

Client:
Foshan Shui On Property Development Co Ltd

Arup's scope of services:
Sustainable masterplanning

Foshan Lingnan Tiandi Lot 1:
LEED certified retail community

Foshan Lingnan Tiandi (LNTD) is a mixed-use urban redevelopment project aims to revitalise the historic old town of Foshan in southern China while creating a modern sustainable community to accommodate growth and building a 'total community' with a full range of facilities for residential, office, retail and leisure.

As the sustainability consultant, Arup was responsible for LNTD's master planning, and helped it achieve the LEED for Neighbourhood Development (LEED-ND) certification, a system which looks beyond individual buildings targeting the creation of better, more sustainable and well-connected neighbourhoods. In particular, LEED-ND contains a set of measurable standards that collectively identify whether the development of multiple buildings can be deemed sustainable.

Old meets new

Using the LEED-ND framework, we further developed sustainable strategies for Lot 1 which includes 30 individual buildings covering a total GFA of 67,800m². The area was redeveloped for commercial use while maintaining the architectural and cultural features through retaining old building structures and reusing over 20% of the existing historic building stock. In addition, the web of alleyways, arcades and open spaces of the area have been preserved to encourage pedestrian activity.

Master site approach

Our sustainable strategies allowed for the achievement of LEED master site credits for Lot 1 which can be shared by all buildings seeking certification within the site. Due to the many design constraints from the historic buildings, this has significantly increased the design flexibility of the whole project.

Arup identified 10 individual buildings within the Lot 1 master site to apply for the LEED for Core and Shell Development (LEED-CS) Multiple Buildings Certification since they share similar business natures and were constructed at approximately the same time. This process allows for a streamlined documentation and review of the certification and also allows for the 10 buildings to collectively use the master site credits of Lot 1.


© Foshan Shui On Property Development Co Ltd

Historic buildings were redeveloped into shops and restaurants

Keeping it cool

Providing thermal comfort in Foshan's warm and humid weather presented a challenge. Most of the buildings have three storeys and small floor plans; therefore heat transfer through the brick façade would have a big impact on the indoor environment. Furthermore, since the building structures must be retained as much as possible, the E&M systems in some buildings need to be detached from the building shell (e.g. placing the A/C unit in a separate kiosk). And as most of the selected buildings are of different, irregular shapes, the project team had to create a separate energy model for each building, increasing the complexity of the analysis.

The project team eventually opted to use a district cooling system to provide the large cooling capacity required. Although the district cooling plant lies outside the project boundary and, therefore, does not contribute to the LEED credits, this method has led to less cooling requirements and a more compact air-conditioning unit for each building, better suited for the historical district.

Lingnan Tiandi Lot 1

Helping it breathe

Since LNTD lies in the old town of Foshan surrounded by tall buildings in nearby new development it can get little relief from the prevailing wind, especially in the narrow alleyways.

The Arup team conducted computational fluid dynamics (CFD) air ventilation assessment to investigate site permeability and decided to install fans along the alleys to improve ventilation and provide thermal comfort to the pedestrians.

The alleys are also covered and retrofitted with skylights, providing cover from rain to promoting walkability in the open-air retail areas.

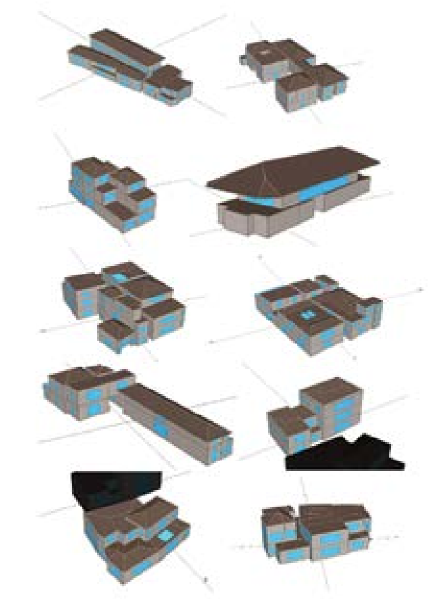
Living the green way

To enhance the sustainable features, landscaped roofs were installed to increase greenery in the area and to provide natural roof insulation. Some buildings are retrofitted with skylights to maximise natural daylighting inside, and solar panels are added to heat the hot water system at the on-site hotel and to provide electricity for street and landscape lighting.

There is also a 'sustainable' exhibition centre which showcases sustainable building technologies, promoting a sustainable way of living.

LNTD has achieved an outstanding performance under the LEED-ND scheme including locations with reduced automobile dependence, walkable streets, stormwater management and other innovations.

The project has demonstrated a balance between preservation and development. Our holistic approach has helped the project to achieve a sustainable and well-designed community promoting walkability and connectivity. It has also built a strong foundation for the sustainable design framework of the master site for future development.



Energy model of the 10 buildings identified for the LEED-CS Multiple Buildings certification

- World's first LEED Version 3 project awarded utilising Master Site
- World's first Retail LEED project awarded Gold rating under Group Certification
- Asia's first Retail LEED project awarded under Group Certification

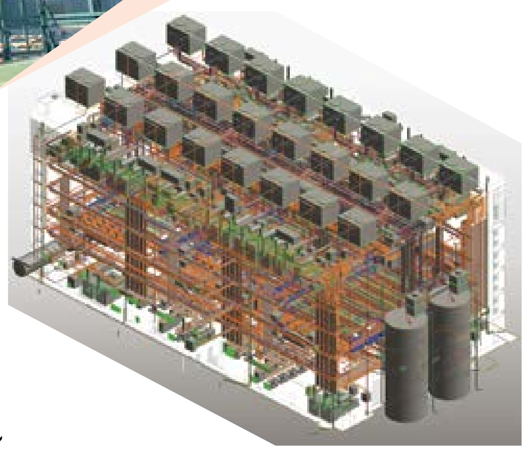

© NTT Communications Corporation

Client:
NTT Communications Corporation

Arup's scope of services:
MEP infrastructure
Industrial consulting

Selected awards
Best Project Award 2015, the Institution of Mechanical Engineers Hong Kong branch

BIM model of NTT FDC2



NTT FDC2: a cool home for data

Dealing with big data requires a special kind of infrastructure. As sensitive information such as those from financial institutions is being processed 24/7, data centres require extremely high level of power continuity and operational reliability.

As the MEP consultant for the NTT Communications' Financial Data Centre 2 (FDC2) in Hong Kong, Arup devised a number of innovative solutions to help the mission critical facility to meet the reliability challenge and achieve energy efficiency and design flexibility.

Resilience, reliability and redundancy

NTT FDC2 is designed to be compliant with the Uptime Institute's Tier III and IV requirements, the highest rating measuring the quality and reliability designed into a data centre. It will support non-stop business throughout the year for end-users and no downtime would be allowed for the systems during fault or maintenance.

To achieve this, a continuous cooling system is vital. Arup developed a pioneering emergency cooling strategy using two thermal energy storage (TES) tanks employing the water stratification principle, the first of its kind in Hong Kong.

Since water density is inversely proportional to temperature, the cold water can be completely separated from the hotter, lighter water at the top with a thermocline. The designed cold water temperature and volume can then be secured during the operation at all times and scenarios to feed the data centre cooling system, while the return hot water is being trapped in the upper layer.

In this project, two TES tanks, each 25m in height and 1,800m³ in volume, were designed to provide cool water storage and to achieve the water stratification effect. Arup conducted computational fluid dynamics analysis to verify that the thermocline could effectively separate the cold water from the warm water, and each tank could provide 21 minutes of chilled water backup in case of any power breakdown.

Energy efficiency

Together with all the associated systems, the total planned duty power and standby supply requirement of this 5-storey building will be equivalent to 62 transformers and sufficient to power ten 24-storey Grade-A office buildings.

Given this high power demand, Arup employed various cooling approaches to improve energy efficiency and save costs for the client. These include front-flow air handling units, indirect free cooling from the cooling towers in winter, and high-efficiency water-cooled chillers equipped with variable speed drives running at high cooling water supply temperature of 14ºC, which can achieve a coefficient of performance of 7.3.

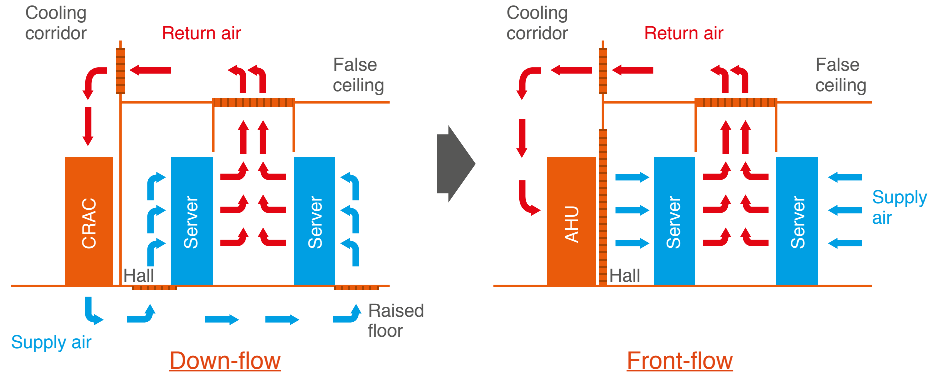
As a result, the power usage effectiveness (PUE) value (the ratio of total power consumption of the data centre to the power used by IT equipment) can be maintained as low as 1.5 in summer and 1.4 in winter, compared with the local average of 2.42.

Front flow air handling unit

Traditionally, data centres use a 'down-flow' air-conditioning approach. Computer room air conditioning (CRAC) units dispense cold air into the under-floor plenum, which then rises through the floor grilles and flows through the server racks. The warm air exits from the rear of the racks and circulates back through the top of the CRAC units. This results in raised floor space (thus reduced headroom) as well as higher fan pressure drop and heat loss – therefore a higher fan power requirement.

'Down-flow' air-conditioning also has considerable issues in handling high-power-density racks, particularly for large variable heat loads. The major concern is balancing large air volumes in the testing and commissioning stage and ensuring effective insulation for preventing condensation in the under-floor plenum.

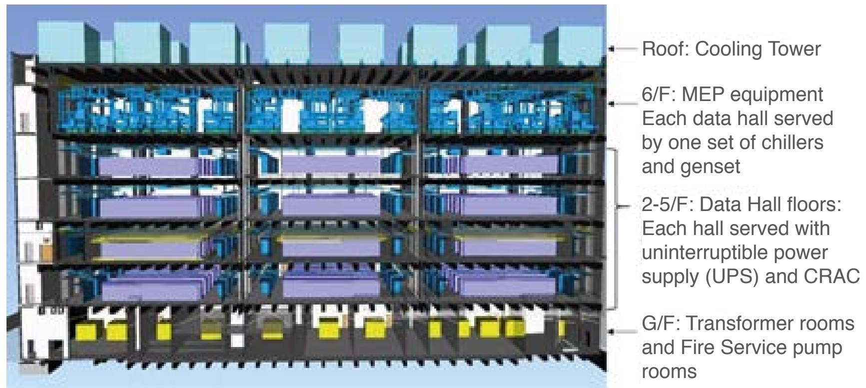
In NTT FDC2, Arup adopted a different approach. Using a 'front-flow' design – for the first time in Hong Kong, the customised air-handling units (AHU) blow the cold air horizontally and directly onto the server racks and circulate the warm air back up. Since there is lower resistance to the air flow, this discharge system is more energy efficient and provides a more uniform air distribution.



Conventional down-flow approach vs. front-flow approach


© NTT Communications Corporation

Front flow air handling unit in front of the server aisles



Modular design

This design can effectively handle load variations and can cater for high IT loading density up to 10kW per server rack, the highest in the region.

Compared with a conventional CRAC unit, the customised AHU could provide the same amount of cooling with reduced chiller power consumption and achieve 50% of energy savings.

Modular design

The centre adopts a modular design approach. The building has been subdivided into 12 data halls, each with independent MEP systems, allowing phased capital investment.

The modular design provides the foundation for a flexible, adaptable and scalable infrastructure: the design for one data hall can be replicated easily in others, facilitating construction and maintenance. The end-users can also tailor-make their own solutions if multi-tier is required (i.e. co-location of Tier III and Tier IV).

This also allows the building to react to changing business requirements and technological advancement in the future with minimum impact on the operation, hence facilitating deployment, saving costs and reducing risks to other operating areas.

Client:
ProRail, Ministry of Infrastructure & the Environment, the Municipality of Arnhem

Architect:
UNStudio

Arup's scope of services:

Masterplan phase: Structural engineering & transport planning

Design & specifications phase: Structural engineering & lighting design (public transport terminal)

Engineering & Construction phase 1: Structural engineering, lighting design, climate & sustainability consulting

© Hufton+Crow

Creating a smooth transition: Arnhem Station, the Netherlands

The new Arnhem Station is a soaring modernist structure made of glass, concrete and steel. Opened in November 2015, the terminal makes use of a unique freeform shape to provide passengers with a smooth transition between modes of transport.

Arnhem Station was designed within the footprint of the city's original station and bus square built in the 1950s. Working in close collaboration with architect UNStudio since 1996, Arup engineers developed a unique structural design within the small site footprint creating a true multi-use space for a new station hall, bus deck, bicycle storage, parking garage, offices and shops.

Shape and lighting as guide

Since six modes of transport converge at the Arnhem Station, it was essential to design a building that would be sufficiently easy to navigate to ensure swift and efficient transfers. UNStudio and Arup started with a study to understand how people moved around the station. Using data supplied by the municipality of Arnhem, the Arup team generated calculations showing the passenger movements relating to different transport modes and of those simply walking through the station to the city. Based on these results, UNStudio then designed the passenger terminal around activities taking place in the transfer hall to minimise crossing traffic and conflicting routes.

The resulting design of the passenger transfer hall was based on the 'Klein bottle' principle, a closed surface with only one side which folds from inside to outside in a never-ending loop. The large open column free space enables unobstructed views from one side of the transfer hall to the other. Ceilings, walls and floors all seamlessly transition into one another, allowing people to move around without being hindered by structures such as walls and columns. The gently inclined surfaces guide them intuitively through the building.

The same design philosophy was also applied to other areas of the station. For example, after parking underground users find their way upwards intuitively, ascending through V-shaped shafts that bring in daylight and accommodate the staircases. Arup's innovative lighting design further helps to augment this intuitive approach to wayfinding. With the intelligent design of the station passenger flows are being directed with remarkable ease and minimal signposting is required.

© Hufton+Crow

The balcony, supported by the front twist, provides both interior and exterior views to assist in wayfinding

Making the perfect 'twist'

The sinuous form of the building created several structural challenges. As the design of the transfer hall did not aspire to the use of traditional columns, Arup engineers had to devise other ways to support the 46m roof span. This was achieved through a 'twist' around the central column, which created a relatively compact support that would bend and curve to find stability. The final shape was optimised through detailed computational analysis.

The underground car park presented another challenge: it must support the levels of the building on top of it while also aligning with the 'Klein bottle' theme of openness. UNStudio and Arup devised the solution using V-shaped walls that were capable of supporting the floors while forming shafts through which daylight enters the underground public area.

Designing with digital

The project started at a time when digital design was still in its infancy. To meet the unique challenges of the project, the Arup and UNStudio team tailored a number of software programmes. These digital tools helped Arup structural engineers analyse the building model and calculate and control the forces and form of the 'twist' to support the concrete roof of the transfer hall.

The analysis also indicated that with the double curved design of the roof and irregular shapes of the twists the thickness of the concrete would have to vary from 300mm to 700mm, leading to concerns of possible buckling in the concrete shell roof. Based on these results, it was decided that steel should be used for the roof and twisting column resulting in a much lighter structure.

Arup also developed a special parametric meshing toolbox in order to create a detailed digital 3D model of the transfer hall, since standard software lacked the computing capacity required to calculate the extremely complex geometry where every single bend and curve is unique.

The Arnhem Station rewrites the rulebook on station design. Together with UNStudio's architects, Arup has designed a terminal which links architectural expression to human behaviour in a unique and enlightening way. The sleek new station will raise the city's profile and put it on the map as a major European transport hub.

© Hufton+Crow

Users of the underground parking garage can find their way upwards intuitively

© Hufton+Crow

Gently inclined surfaces and carefully designed lighting guide pedestrians intuitively through the building.

Cities Alive cards:
100 issues shaping future cities

Developed by Arup's Foresight + Research + Innovation team, the Cities Alive workshop cards help stakeholders at all levels – citizens, planners, and officials – prioritise and explore issues that are shaping the future of their city. Being a thought-leader in the cities realm, Arup developed this card set as part of our Foresight-led Future Cities Programme to support our Global Cities Strategy.

The cards cover 100 future issues which are organised across the STEEP framework: Social, Technological, Economic, Environmental, and Political.

They can help facilitate conversations, enhance understanding, support decision making, and help cities develop new ideas and solutions in a myriad of contexts.

Download the cards

Cardiff workshop: Growth vs. Liveablity?

This workshop convened city stakeholders from a variety of disciplines to collaboratively explore Cardiff's ability to maintain and improve its liveability whilst continuing to grow at the rate projected.

The event aimed to promote longer-term, systemic thinking and to facilitate a shared understanding of the range of challenges facing Cardiff as it seeks to achieve its ambition to become the most liveable European capital city.

The workshop successfully enabled a focused exchange of ideas and stimulated conversation. In moving forward, the opportunity lies in continuing this conversation by facilitating more in-depth engagements with city stakeholders and building on the ideas the workshop generated.

Possible workshop settings for using the cards include:

Trends and implications

Group participants into teams and assign each team one of the STEEP categories. Ask each team to choose, from that particular category, five key issues driving change in their city, and to explore future possible implications. This exercise is particularly useful for identifying current friction points and methods for enhancing city vitality.

Future news

Using the cards to inspire more insights, workshop participants create a set of five future newspaper headlines representing city-related news and events. As a premise, participants are given a topic of particular relevance to the focus city. This exercise is particularly useful for detecting and shaping emerging contexts and trends.

Design charrettes

Group participants into teams. The facilitator acts as a 'client' and randomly selects five cards for each team. Use these cards as inspiration and constraints during design development for an urban area or set of city systems. This exercise is particularly useful for re-evaluating and developing existing strategic plans with innovative design ideas.

If you would like to discuss how to use the cards in your organisation or receive a printed copy, please contact **foresight@arup.com** or **Shu-wei.wu@arup.com**.

Envisioning future Lujiazui

Lujiazui in Pudong is part of the Shanghai Free Trade Zone where it is home to the largest and most capital-intensive CBD in Mainland China and the only national development zone designated as both ‘finance’ and ‘trade’.

Download the report

Having thus become one of the benchmarks for China’s development, Lujiazui is expected to shape China’s future urban construction and development. It now hopes to build a smart community with integrated information management systems, efficient resource use and effective problem solving which will improve the quality of life and facilitate community development. It will provide a reference model for future operation and development of other cities in China.

Arup has proposed a vision for ‘Lujiazui 2025’. Our study addresses the existing problems and challenges to the community, such as traffic congestion and a floating population, as well as short- and long-term expectations of the community residents including healthcare and clean air.

These challenges and expectations were categorised into five themes: transportation, environment, life, social and community building. In every category, a set of innovative ideas were proposed to inspire future community building and while some initiatives address the immediate needs of the residents others are long-term solutions that require greater government involvement.

These ideas include:

- Personal Rapid Transit – small driverless transport pods available to passengers through smartphone app.
- Bus Stop Air Filter jointly developed by Arup and Sino Green to tackle pollution at the roadside
- Food scanning nutrition app to detect the chemical makeup of food
- Anti-litter campaign using DNA scraped from discarded objects to reconstruct the identity of litterers
- Exploration app which guides users through place-based narrative experiences, superimposing augmented reality graphics and audio stories over a walk through the city

Our work has been well received by the local authority and forms a major part of the Lujiazui Community White Paper 2015.

Over the coming decades, Lujiazui’s development needs to address both existing and new challenges, and meet the expectations of an evolving community. The people of Lujiazui and beyond are encouraged to join us in developing more innovative ideas for the future of Lujiazui, and ensure that it continues to be a model for urban community development and management.

Bus Stop Air Filter

Personal Rapid Transit

Glimpsing a world below: TOD and underground space in China

Indistinguishable station hall design and basement entrance of a shopping centre

As cities continue to expand, urban sprawl and the building on greenfield are no longer viable options. Underground space can provide a solution.

In recent years, many Asian cities have invested heavily in underground passages for commercial purposes. In China, going underground is an increasingly popular tactic to improve urban connectivity while creating new public spaces and commercial zones protected from adverse and extreme weather conditions. The government benefits from increased land sales that offsets the new infrastructure cost while the developers attract passengers through direct connections to their buildings.

A much needed study

A challenge for planners and designers in China is the paucity of publicly available information that would be useful for guiding current and future projects. To bridge this gap, Arup's Shenzhen Architecture & Planning team carried out research to understand transit oriented developments (TOD) and underground space development in China, looking at its impact on neighbourhoods, commercial integration, operation and management, and the pedestrian experience.

The research looked into 18 metro stations in three Chinese cities: Shanghai, Shenzhen, and Tianjin, most of whom were located in city centres and interchange stations. This study was to be an index or a reference to understand the physical make-up, positioning, commercial development, metro/TOD integration with surrounding developments, operation and management of commercial spaces, spatial quality and pedestrian safety of the three cities. Understanding the built conditions across different types of cities and stations, and assessing what works or not, will allow Arup to design better metro, commercial space and integrated developments for future projects.

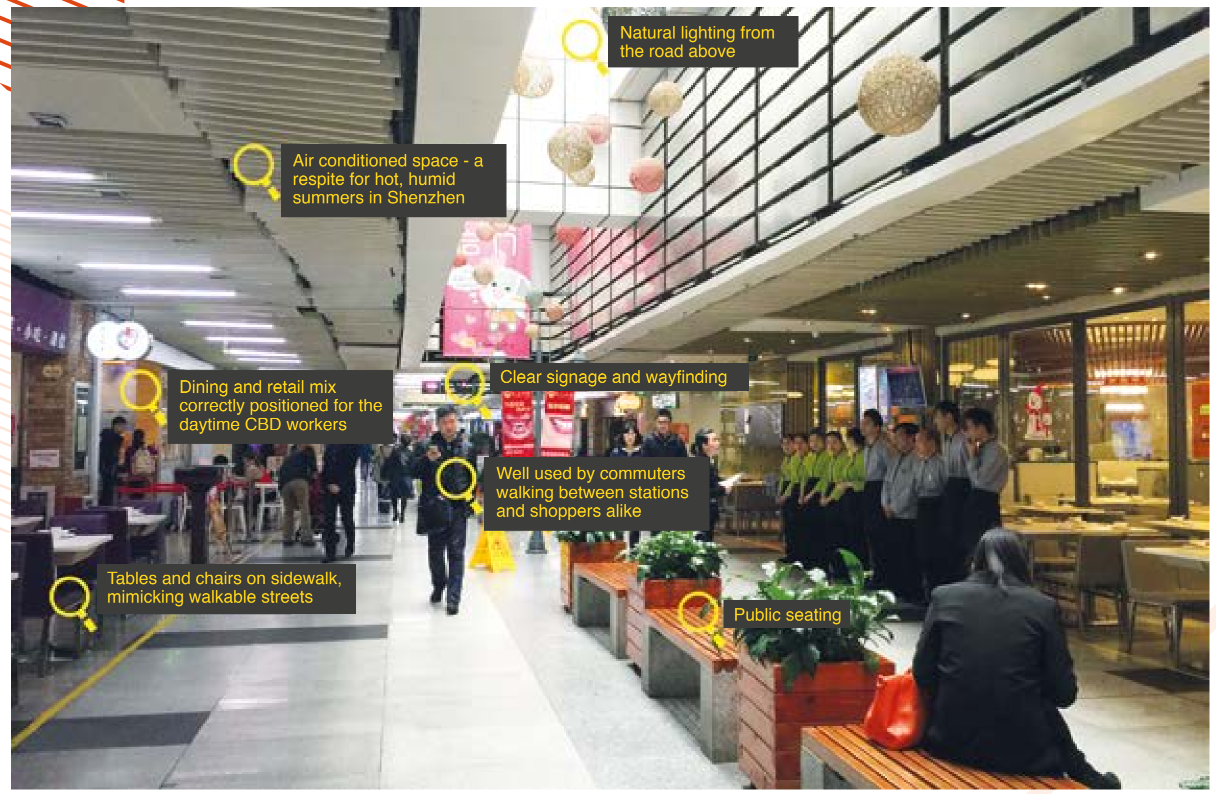
The dark and isolated entrance makes people feel unsafe

Major findings

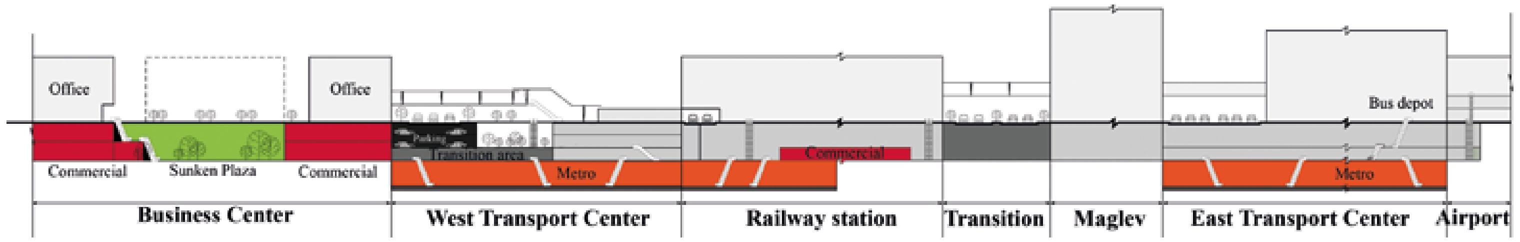
In the study, it was revealed that integrated design and development produce the most desirable underground space, especially those with coordinated private and public development.

Spatial comfort is also key to retaining and attracting footfall, as no pedestrian wants to linger in a space with dark corners and poorly lit corridors and passages. The best underground spaces focus on unified and consistent interior design, as well as integrating sunken plazas and natural lighting from the street level. They provide strong wayfinding and give pedestrians a sense of security and physical comfort when walking through.

The research team determined that underground space should also be planned with the correct positioning of uses in congruence with the commercial needs of the neighbourhood above. It should contain a variety of uses — not just trendy and expansive stores — in order to attract pedestrians throughout the day and week and draw urban street life downwards. They found that when positioned correctly, the underground space can thrive despite modest interior decor. Similarly, if the neighbourhood above is not ready or fully developed, however well programmed and designed below ground commercial corridors will fail due to lack of visitors.



Features observed at Link City in Shenzhen make it one of the most popular and thriving underground corridors in the city



Mapped underground sections for the Shanghai Hongqiao Airport super hub, showing relationship between various functions above and below ground

Sunken plazas provide breaks for going underground, providing a public social space for pedestrians to rest and socialise

One important design consideration for TODs is how they integrate into the city-wide super transport system. As the cities build new metro lines and stations, every metro city becomes effectively a hub. These hubs combine complex systems of multiple transportation modes alongside retail, office, residential and civic uses, all connected by underground corridors.

Well-designed super hubs under construction or awaiting development of the surrounding neighbourhoods will often reserve space within the underground terminals for future metro, bus and maglev connections, with retail booths and shops reserved for future tenants. In the case of hubs, the good underground spaces are usually also connector spaces. Their spatial quality depends entirely on the developer and operator. As an observation, spaces operated by the city metro in China often seem to have a more pleasant environment than those operated by the national railway.

The way forward

This research has uncovered a range of the best and worst case scenarios to guide Arup designers. Using these findings teams will be able to design underground spaces which will not only ensure a fantastic pedestrian experience but also give exceptional value to the development operators.

For developing cities around the world, local governments should take the opportunities of building or expanding their metro rail network to look hard at including underground spaces. These places no longer need to be the cold, dark and unpleasant links between destinations. In the 21st century, underground spaces can be vibrant, diverse and public friendly places in their own right.

The future of airports and real estate opportunities

Airports are catalysts for city development. Due to their location and connectivity to other metropolitan areas and the number of people, vehicles and goods that pass through their facilities, airports can be significant drivers and facilitators of regional economies. This has provided the opportunity for a new line of business: airports as real estate developer and strategic partner for cities.

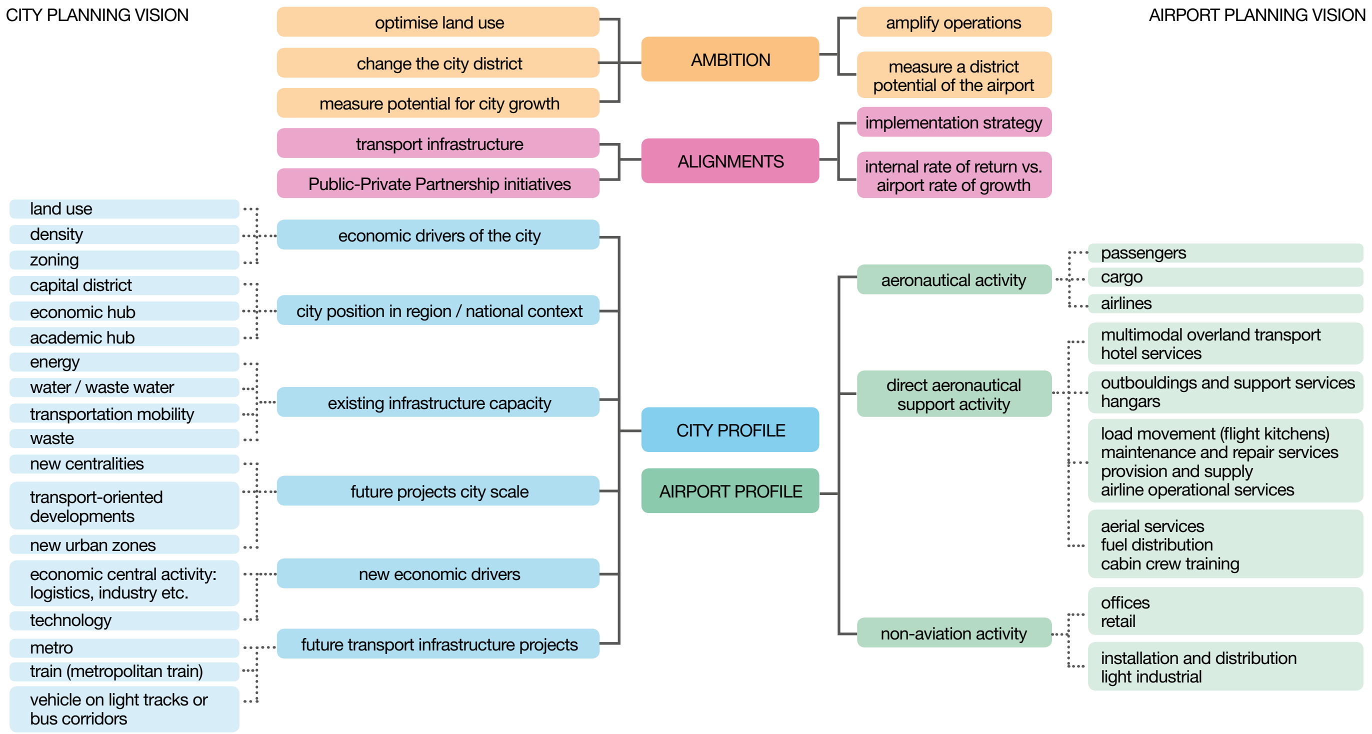
Due to rising operating expenditure, airports all over the world (whether privatised or government-owned) are exploring ways to offset costs and to diversify and maximise their revenues. The objective is to generate revenue from non-aeronautical business ventures to fund the growth and maintenance of the airport, while keeping landing and terminal fees to a minimum to attract airlines and passengers.

There has also been a shift in the way airports develop their action plans. Instead of the traditional masterplans, which are more focused on short-term and singular objectives, airports are now adopting more dynamic and strategic planning that takes into account the future growth and development of the surrounding city. This will help to coordinate between the city and the airport to achieve the development goals of both parties, and create unique opportunities and potential for significant growth for businesses located in and around the airport.

Although the concept of airport cities and airport regions have been gaining popularity in recent years, not all airports have the scale or profile to benefit from substantial real estate development. To help Arup and our clients better understand the challenges and opportunities of airport-related real estate development, Arup Americas has conducted research to explore the planning issues and different real estate offerings in, on, and around the airport.

Key drivers in two overarching categories have been identified. City drivers are primarily based on land use optimisation and maximising efficiencies on infrastructure capacity, while airport drivers focus on the direct aeronautical support activities and the non-aviation business activities. By aligning these two sets of drivers, the city and the airport can reduce their investment risks and be able to transform underutilised real estate assets into significant revenue generators.

Arup has analysed various airports around the world and selected several as benchmarks. The exercise indicates that airports can use the economic potential of the regional infrastructure, such as cargo rail lines and regional road infrastructure. Airports which are big cargo centres can drive a distribution/industrial strategy, while those located near to metropolitan cities have the potential for retail/commercial development and can evolve into part of the cities and trigger further economic activity. To measure the size of potential non-aeronautical commercial opportunities, an airport will need to assess several key variables, including passenger growth rate and the maximum private land adjacent to airport land with good access infrastructure.



Key drivers diagram

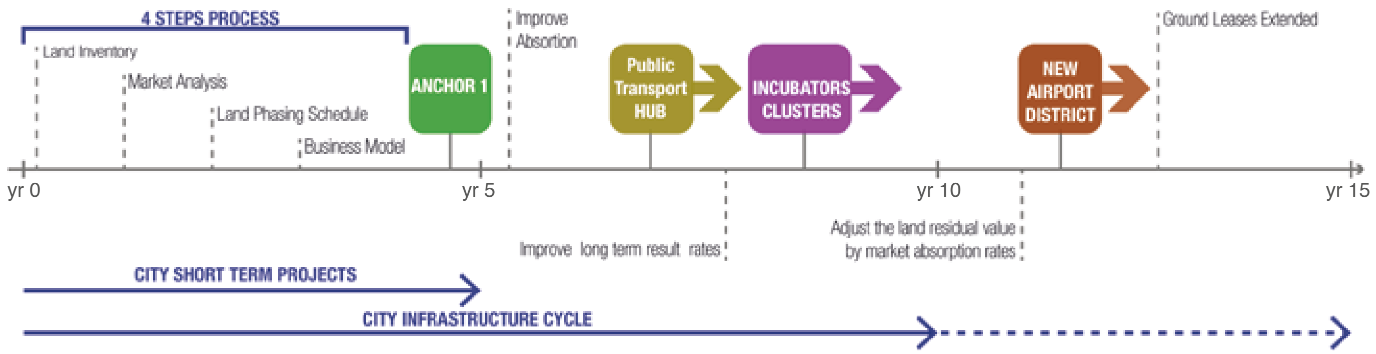
The study also looks at different real estate offerings related to the airport, including those in the terminals, on the landside and airside areas and in the surrounding airport city/region. These non-aeronautical activities can be important revenue sources. For example, retail accounts for 35% of non-aeronautical revenues for airports in Europe.

A 4-step process developed by Arup highlighting the key inputs, studies, and deliverables for developing a financially viable portfolio will help our clients to assess the feasibility and plan for airport-based real estate developments.

Implementing a real estate strategy requires significant planning. While airport cities are often misconceived as a 'one-size-fits-all' strategy, our research creates a clear and methodological framework that would help Arup and our clients to have a better understanding of the challenges and opportunities of airport-related real estate development.

Please contact **Pablo Lazo** (Pablo.lazo@arup.com), Arup Brazil Integrated Planning Lead, for a copy of the report.

The research was conducted by a multidisciplinary team of specialists in Arup's Americas region from aviation, transport planning, economics, masterplanning and urban design.



Airport-oriented city development timeline diagram

Enabling new applications: hybrid additive manufacturing

Innovative building designs often present significant technical challenges to engineers and require costly, custom-made components to construct.

Additive manufacturing (AM), commonly known as 3D printing, provides a promising way forward as it offers great geometric flexibility. However, it is difficult to apply such technologies directly in construction projects due to high costs and long production time compared with conventional fabrication methods.

Arup's Tokyo office is undertaking a research to explore the possibility of introducing a hybrid AM process into the building industry. This approach combines the geometric flexibility of 3D printing with the technical familiarity of investment casting (lost-wax casting), allowing customised components to be batch produced cost effectively in a large selection of metals and alloys.

Developing the prototype

In Phase 1 of the research, the team tested this approach and demonstrated its value in one of the structural components of a stadium project in Japan.

The stadium's moveable roof had a mesh structure consisting of interlocking cables. The clamps holding the cables in place were subject to multi-axial loads and each clamp had to cater for different joining angles depending on its location in the system. This meant each clamp might contain the same basic design but they could not be mass produced as they were all slightly different.

A conventional manufacturing approach would produce the clamps by welding standardised parts together at different angles; if the proposed hybrid AM approach was used, clamps of different shapes could be produced accurately as single pieces, removing the need for welding and hence reducing the risk of human error.

As a proof of concept, a 1:5 scale Polylactic acid (PLA) prototype of the clamp with slight modifications in the design was produced with a desktop 3D printer. The prototype demonstrated satisfactory qualities, in terms of surface finish, tolerances and structural integrity, to potentially be used as a pattern during the investment casting process.

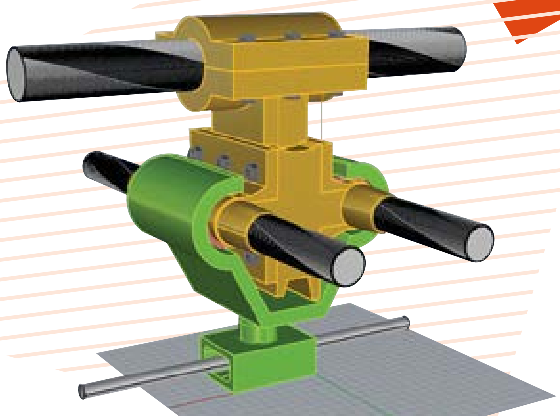
Through the casting process

The team then partnered with Japanese casting firm, Nippon Chuzo, in Phase 2 to establish whether such 3D-printed PLA patterns could be used in the standard casting process with standard equipment (replacing ordinary wax patterns) to produce structural components that comply with the Japanese building standards. A simpler, hypothetical x-shaped structural component was designed to test the approach.

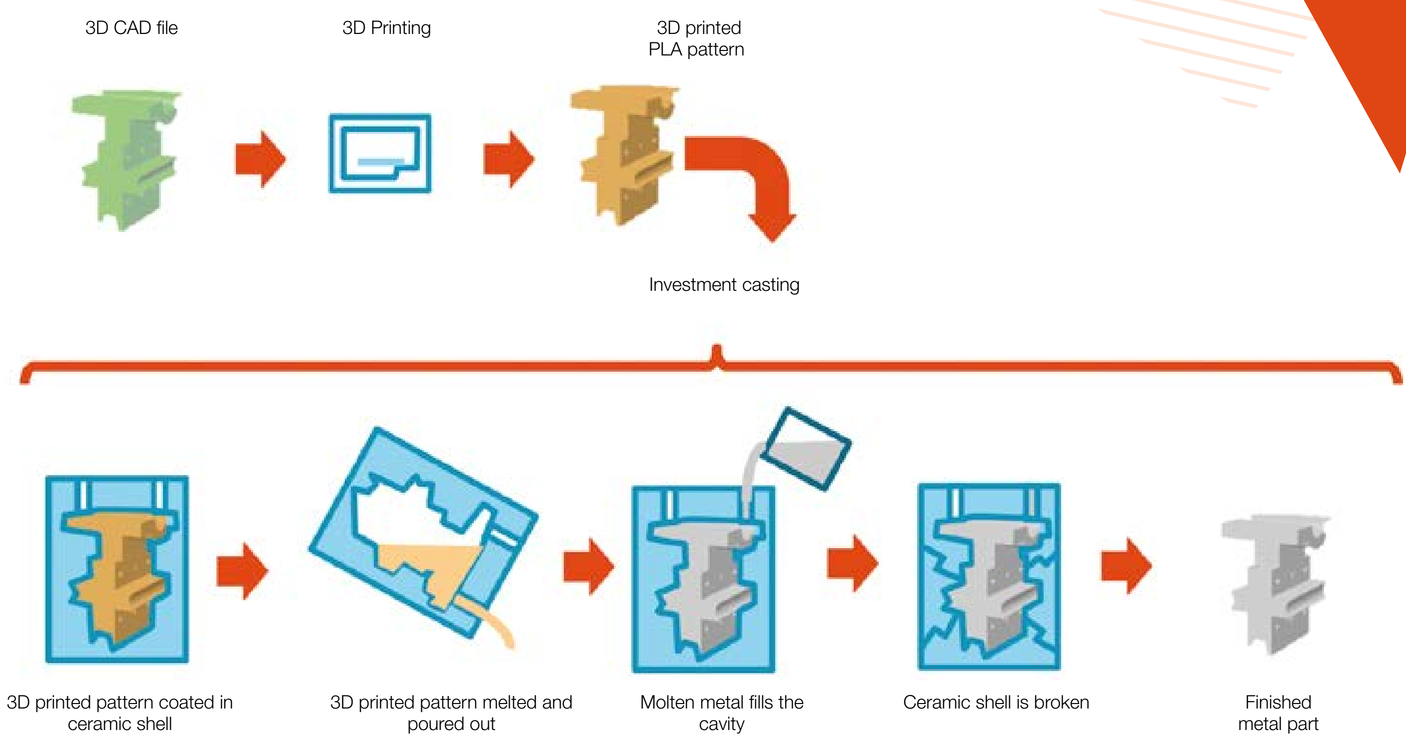
One major concern was whether the use of PLA might have any undesirable effects on the final product since PLA has a higher melting point (210°C) than wax (60°C) and a standard wax-melting facility could only heat the mould up to 180°C. It was anticipated that the PLA core would not be fully melted and the mould would have to be pre-heated to 600°C before casting to burn away any remaining PLA. This could leave a trace of carbon residue which might potentially change the chemical composition of the molten metal being poured in later. Nippon Chuzo was also aware of the risk so the sprue and risers were positioned to flush out impurities and oxidised metal as much as possible during the casting process.

The manufacturing process was completed successfully. The PLA patterns were treated together with other wax patterns under the same factory routine except for the additional step required to burn the PLA core. Initial

3D printed PLA prototype of the clamp



Concept design of the clamp



Flow of hybrid additive manufacturing

examinations of the finished metal parts showed that the dimensional accuracy and surface finish were identical to typical casts produced by wax patterns, and their structural integrity and chemical composition could meet the building standards of Japan.

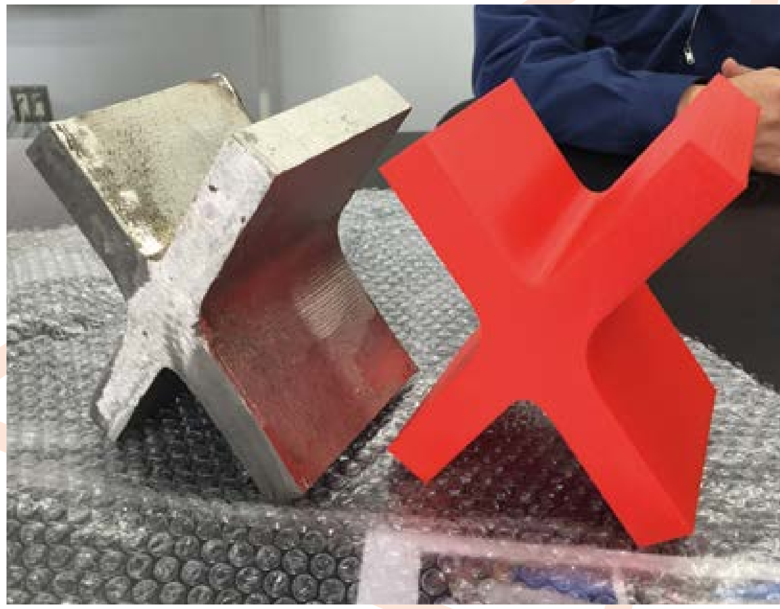
Breaking off the ceramic mould

The way forward

Recent acceleration in casting related AM technologies development indicates that the value of a hybrid AM approach is becoming more widely recognised. After proving this particular process is also technically feasible for large-scale structural elements, the next step (Phase 3) would be to compare it against other alternative manufacturing methods.

Arup's Tokyo and Amsterdam teams will jointly continue the research to explore the advantages and limitations of different AM methods, and the products will be compared on various factors including freedom of form, fabrication process, product quality, cost effectiveness and lead time.

The ultimate aim of the research is to develop a selection tool of alternative manufacturing approaches that will in turn enable designers and engineers to explore the use of highly customised components in projects, allowing them to innovate engineering solutions for clients and bring exciting new possibilities to the built environment.



The final product vs. the PLA prototype

Mastering the new to lead: AU Masters modules

To cope with the ever-changing built environment and provide better solutions for our clients, Arup University (AU) offers one-year internal Masters modules jointly developed with world-class universities such as Imperial College London and Boston University.

These programmes are designed to advance our skills in emerging topics of strategic importance. Current modules include 'Data Analytics in Built Environment' and 'Energy Futures and Transitions'. Four to five master modules are offered annually and they are usually phased out after two to three years to ensure that we are keeping up with the latest industry trends.

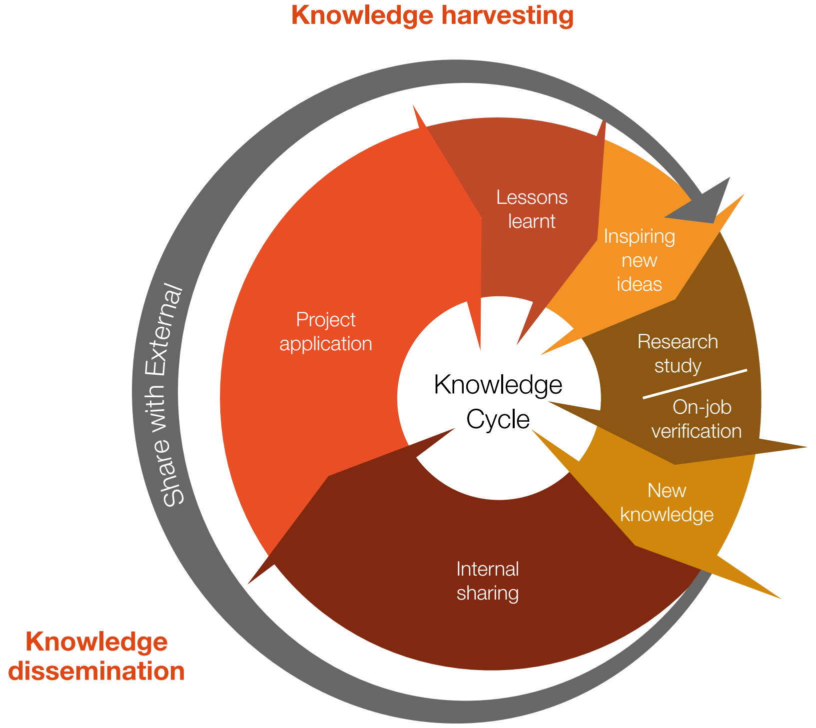
These courses are led by academics and complemented by Arup tutors. While the programmes vary, they usually comprise webinars, reading assignments, group projects and two residential workshops in Europe, the US or China. This allows the students to develop a much deeper and broader understanding of the topic than they might develop from day-to-day work.

The Masters modules are typically in topics relevant to a broad range of disciplines or businesses, enabling the students to develop cross-disciplinary understanding. The modules also provide excellent networking opportunities for students from across Arup, facilitating future collaboration between offices and disciplines to develop new technologies.

The Masters modules successfully equip participants to be future leaders in new business areas, enabling them to bring new knowledge and insights to our works and to identify new opportunities for Arup and our clients.

Students in group discussions

A field trip in Vancouver for students in the 'Cities as systems: urban mobility' Masters module



Arup recognised as the Most Admired Knowledge Enterprise

From the onset, knowledge sharing has been at the heart of Arup. Our founder's passion for total architecture and his vision of what was possible through collaboration set Arup on course to become the unique organisation it is today.

Effective sharing and collaboration are important in the knowledge-based economy today; and it is even more so in the built environment industry where the business is usually project-driven and their success relies on how the staff can effectively apply their knowledge and experience to cope with complex situations.

For global firms like Arup, an open-sharing atmosphere and the effective connection between all offices and disciplines are critical to ensure their service is built on their global pool of knowledge. This is exactly what makes Arup stand out from its competitors.

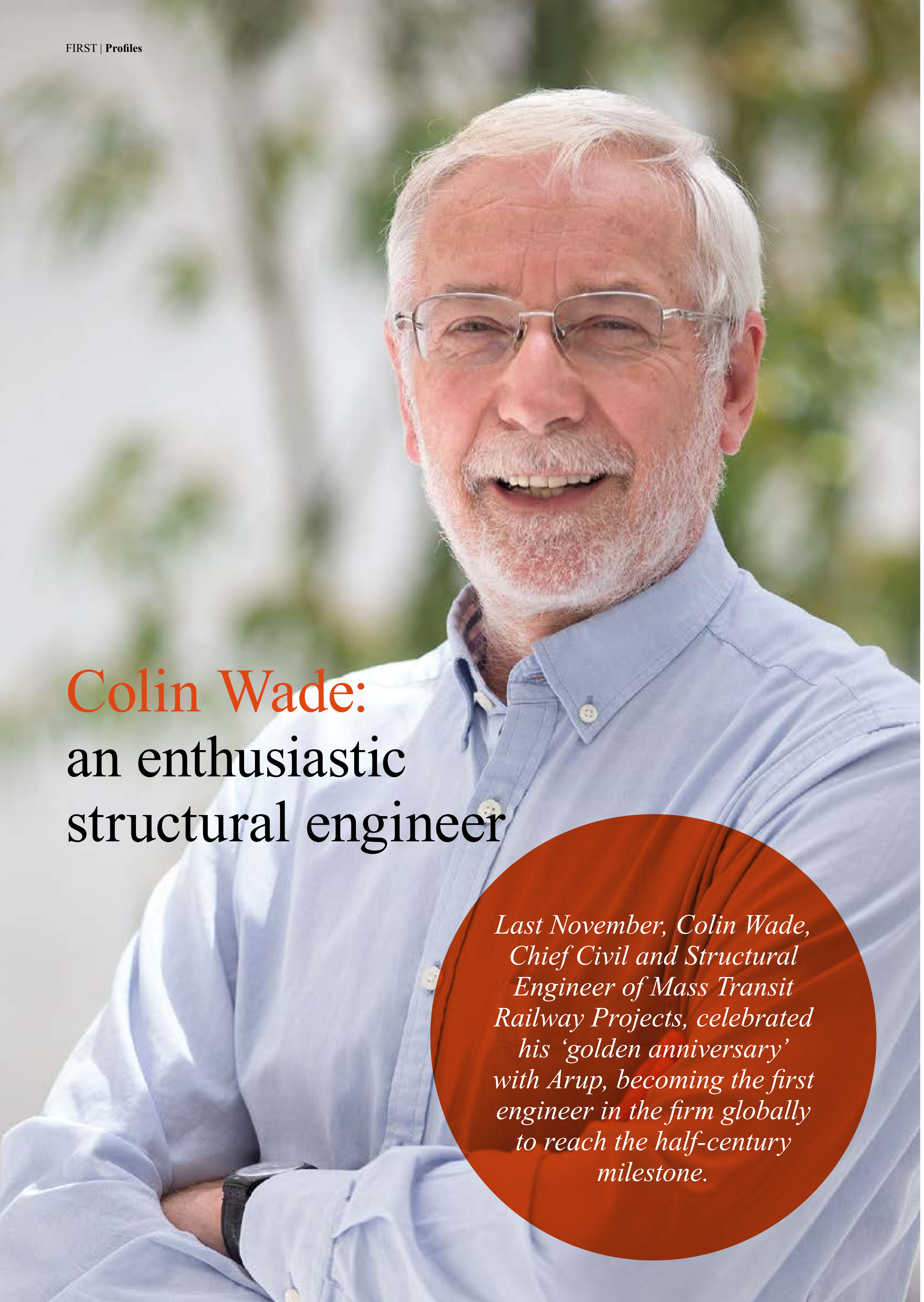
Arup formalised a Knowledge Strategy in 2001, which has been continuously refined based on staff feedback. These knowledge management practices have been well-recognised with multiple awards - the Hong Kong office has received the Hong Kong and Asia Most Admired Knowledge Enterprise (MAKE) Award for several years and received the Global Independent Operating Unit (IOU) MAKE Award in 2015.

This robust knowledge system not only focuses on knowledge harvesting and sharing; significant resources have also been invested in creative ideas incubation, business-oriented research and piloting new skills. The objective is to ensure that the knowledge cycle at Arup can spin smoothly and fast enough to cope with new industrial trends.

Arup also offers knowledge management consultancy services to clients such as the international academic publisher Taylor & Francis Group.

"...only limited use is made of all the existing technical knowledge... a wealth of new knowledge, new materials, new processes has so widened the field of possibilities that it cannot be adequately surveyed by a single mind."

Sir Ove Arup, 1942



Colin Wade: an enthusiastic structural engineer

Last November, Colin Wade, Chief Civil and Structural Engineer of Mass Transit Railway Projects, celebrated his 'golden anniversary' with Arup, becoming the first engineer in the firm globally to reach the half-century milestone.

Today we can still see him seven days a week in the office, burying his head in problem-solving or speaking to young engineers, always with vigor and energy.

"'Insane workaholic' is a description I've been given," admits Colin, "I'm not a role model in this sense, but I just can't help throwing myself into projects! I just love designing things and seeing them built."

Always the next project

Colin says the biggest thing that keeps him with Arup is the people he's worked with and worked for. "The number of people I didn't get on with over all these years has been so small that I could probably count them on one hand!" he chuckles. For a firm that's so big and so diverse, he believes this tells something – "it's a great firm."

He has not seriously thought of retirement yet, though, at the age of 70, he clearly knows that the day is approaching. "It's not ego; it's not because I want to win a prize for the biggest railway station on earth…" he pauses, searching for words, "It's really…the next project, something else coming up".

Looking back, Colin deeply appreciates the opportunities he has been given to work on a wide array of projects in various parts of the world. "I haven't done incredibly huge jobs that blow your mind – I've not done a Sydney Opera House or the Channel Tunnel Rail Link in England, but I've just done enough jobs that give me satisfaction," he says.

Colin marks his 50th year with Arup

A living dictionary of Hong Kong's railway history

Today, Colin is seen as a living reference book of Hong Kong's railway development, but probably few know that he is a structural engineer who has worked on a variety of buildings both in and out of Hong Kong.

He joined Arup in London back in 1964 after some two years with another engineering firm. Working in what was then the Overseas Group, Colin took on projects in out-of-the-way places including Libya, Tunisia and Kuwait.

Then came the first pivotal moment in his career, he recalls, in 1971 he moved to the multidisciplinary Building Engineering Division, and luckily worked on the Carlsberg Brewery in Northampton in the UK. This opened up working directly with people in other disciplines such as quantity surveyors and construction programmers and, in particular, MEP engineers. Colin describes it as "a 'mini-cultural shock' that pushed a narrow-minded structural engineer to understand other people's problems".

In 1980, he was asked to go to Hong Kong for an in-depth study of the Taikoo Shing Cityplaza II project. "I had never for a moment given Hong Kong a thought – other than when you look at the shirts your mom bought that were labelled 'Empire Made' – which meant made in Hong Kong then!" says Colin. However, the 3-month project turned out to be another critical juncture both in his career and life – he met the girl who was to be his future wife there. This made the decision much easier when he was asked to settle down in the city two years later.

After the golden age in the 1980s, in early 1992 the Hong Kong workload was nose-diving, and Colin began to look at

5-decade career in projects

1964 – 1973

Tripoli University in Libya
A diverse mix of buildings to house the various teaching faculties.

1974 – 1983

The Royal Danish Embassy in Sloane Street, London
Designed by the famous architect Arne Jacobsen, the project involved meticulous architectural detailing and an excellent multidisciplinary Arup design team.

1984 – 1993

Hollywood Terrace, Mid-levels, Hong Kong
An extremely challenging geotechnical project – two 35-storey residential blocks with a podium on a site that had an extremely chequered ground movement history.

1994 – 2003

© Airphoto International Ltd

KCRC Kowloon Southern Link Feasibility Study
This was the link between East Rail and West Rail where the previous consultant chose a route that was going to be very difficult with an undesirable station layout at East Tsim Sha Tsui. Arup's new route along Salisbury Road and Canton Road was accepted by the Government as the basis on which the route was built.

2004 – 2013

© MTR

Admiralty Station for the South Island Line and Shatin to Central Link
The most difficult project so far attempted by the MTR Corporation at an operating station. It comprises deep rock caverns for the South Island Line and Shatin to Central Link platforms and a very deep and complex cut-and-cover station box.

© Zhou Ruogu Architecture Photography

Beijing South Railway Station

what was in store back in the UK, but things were no better. At that time, an advertisement appeared in the press that MTR Corporation would be needing consultants to design the then named Lantau and Airport Railway. Colin immediately dived in with other colleagues to put together Expression of Interest brochures to get on the MTR's preferred bidder list.

"First Kowloon Station, then Tsing Yi Station, Tung Chung Station, Hong Kong Station and a little later on the Ground Transportation Centre at Chek Lap Kok. We won all these truly gigantic projects! I suddenly found myself doing railway projects," exclaims Colin, still in an unbelievable voice. With this incredible workload, any return to the UK wasn't an option and the rest is history!

Good design is good business

Colin has been in the industry long enough to see the changes. "There is no doubt", he says, "that the use of computers has made it possible to design structures that couldn't have been managed decades ago, and the advance of BIM is significantly facilitating the construction process".

Yet, he still admires the 'old school craftsmanship' of design and engineering – the real models you can touch and gaze into; and more importantly, a spirit to always think what can be done better rather than do things quickly to keep the 'bottom line'. "I believe we should continue to make design the top priority; if we can achieve good design, we can still make money," he says.

When naming the essentials of a good design, Colin 'steals' from the ancient master builder, Vitruvius: 'commodity' which can be taken as being useful, 'firmness' taken as being structurally sound, and 'delightful', to him meaning good to look at. With the above, he adds his own ingredients: simplicity, durability and ease of build and maintenance.

Colin views the huge roof over Beijing South Railway Station as his best design solution so far. The original scheme consisted of strange looking triangular steel trusses, which failed to realise the 'Temple of Heaven' motif as envisioned by the architect. Colin and his team came up with an elegant alternative – a cable-supported roof for the elliptical shaped station. "It's pleasing to the eye and was much lighter and easier to build," he says.

Rail future

Looking into the future, Colin believes the rail business will be driven by easy train travel and interchanging within ever growing cities and travellers' rising aspirations for comfort, speed, privacy, communication and recreation during the journey.

"This means that we need to diversify from civil, structural and geotechnics into smart technologies in the fields of traction power, signalling, alternative energy systems and ticketless technology, to name but a few."

Diversification is not new to Arup. He says, back in 1971, we did this in London when multidisciplinary Building Engineering was formed out of what was effectively a firm of structural engineers. "We have never looked back since then and the whole firm has gone from strength to strength. So the rail future should not daunt us," he says.

On the individual level, he encourages young engineers to study and appreciate a bigger picture than just 'engineering'. "We seem to be too tied up in our own discipline – we must connect with those in the industry who care about quality design and also steer some clients in that direction," he points out.

"We can only do this if the next generation appreciate and can 'talk the talk' not just of engineering, but can support and empathise with those in other disciplines that want good design."

Kang Man: making a quiet difference

"Building structural design expertise is a continuous journey during which you constantly rethink your work and how it could have been done better." - Kang Man, Arup Shenzhen Office Leader and East Asia Board Member

Everything seems to come naturally to Kang, no drama but plenty of excitement. "Life's choices are so 'natural' when you are too young to understand the implications," he chuckled. Structural engineering was a 'logical option' for young Kang who enjoyed the intellectual challenge of mathematics, and venturing into China was simply a 'why-not' step.

Every little counts

Kang was one of the earliest Hong Kong engineers working on the mainland. It was 1988 and Kang, then in his twenties, was the only resident engineer on the site of Shanghai J.C. Mandarin Hotel, working with a group of local construction workers who had very limited experience in handling tall buildings with a basement as deep as 10m.

Always with skepticism in mind and anxiety on his face, Kang had to make quick judgments and decisions and negotiate for acceptable workmanship on his own at a time when the quality standards were different on the mainland, his nearest help was in Hong Kong – thousands of miles away, and telephones were then a luxury.

"Those were my days of fastest growth," he reflected, "It was really challenging and I survived with more confidence and independence." Also in those days, the young man started to understand the art of communication: "You have to look from the other's perspective and focus on how to push your ideas further and get it done," he said.

He then had a 1-year assignment in London, working on the design of Deliberatif, Hotel du Department in Marseilles, a long-curved-section convention building of the local government.

Kang described it as another 'unique experience' – a real enjoyment for him to spend a year working on the design from concept to every detail. "It gave me the chance to appreciate the beauty of design. We refined every detail through debate and discussion, good training for thinking and rethinking to develop the best solution," he recalled. It ended up with a highly efficient structure-façade integrated system and steel casting joints developed from a simple sphere.

Things picked up when he returned to Hong Kong – the city's construction industry heralded its golden age with many building and infrastructure projects planned and deployed. From hospitals to tourist destinations, from railways to urban renewal developments. At any time Kang had a number of projects on hand, all of totally different types!

Among those the Peak Tower redevelopment, located in a dip on the hillside with a narrow site area, and the KCRC headquarters building which involved upgrading the permanent way depot facilities, pre-stressed concrete design and close co-ordination with various interfaces, stand out. "The former pushed the limits of full integration of structural design with building form and construction whilst the latter enabled me to look beyond buildings, understand implications and think about ways of putting things together to make the project happen," Kang said.

Then came Langham Place, which Kang prizes as his best solution so far. The mega urban renewal project comprises a 250m office tower, a 40-storey hotel tower and a 12-storey retail tower with a 5-level basement in two congested sites surrounded by utilities, box culverts and MTR facilities… all those you can imagine in the old districts of Hong Kong.

Kang at the topping-out ceremony of Shanghai J.C. Mandarin Hotel in 1988

A mixture of structure construction was adopted to tackle technical, site and programme constraints. The structural system of the office tower consists of composite mega columns with a steel outrigger while the Grand Atrium uses a mega structure which comprises giant portal frames on pinned bases that form the tallest single span glass wall in Hong Kong, recreating a unique open public space together with the 'spiral' retail space within the building. A pair of mega braces were designed to allow the changing of floor levels for the street-like shopping arcade.

This project, Kang felt, was the epitome of what he had learnt and gained over the years, which translated into compact solutions. "Looking back, nothing is too trivial as long as you immerse yourself in it and spend time reflecting on the lessons learnt," he said.

Quiet influence

Today Kang is better known as a managerial leader, serving both on the regional board and global trustee board. He started to spearhead Arup's development in South China in 2003 and officially became the Shenzhen office leader in 2006. It was a natural evolution and there is no clear-cut line between technical and managerial roles. "Solid technical experience is always the basis," he said.

He sees his role as much more than a 'manager'. "Apart from running and organising, you have to see the big picture and think thoroughly – whether the local operation needs diversification, how to keep the business robust and cultivate local leadership and so on", he said.

His biggest sense of fulfillment comes from the growth of the people. "You witness their growth just like you see your design being built. This brings me more satisfaction than anything else", he said. Now half of the senior leadership in Shenzhen and Guangzhou offices are locally developed.

His secret for successful leadership? "Lie back," he replied, "To give people enough space to develop their own design talent, you should keep your hands off whilst getting your invisible helping hand ready," admitting that it's not easy.

Kang believes this style is a legacy of Arup people and culture. He felt lucky that along his journey many people have influenced him: "They all have a persistent but open-minded attitude for quality design and let me know that 'you can have your own way as long as you are capable of and really committed to realising your ideas'." Now he's passing it on.

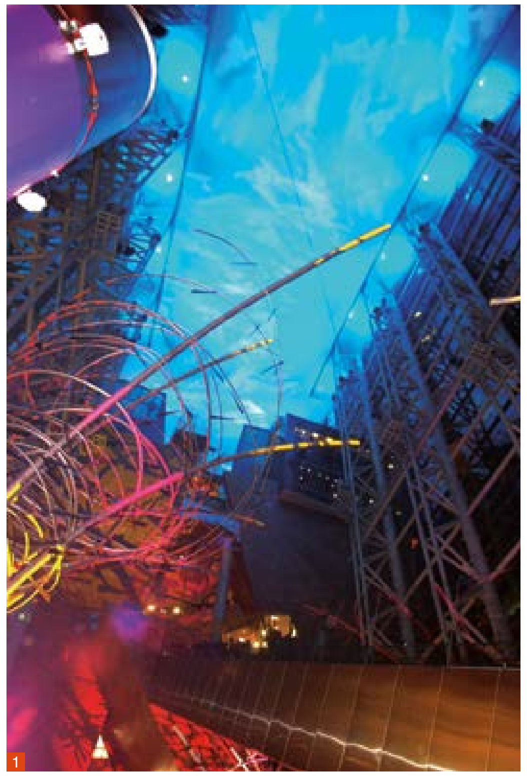
Parting thoughts

Looking into the future, Kang opines that materials and building information modelling (BIM) will further drive the evolution of structural engineering. "New materials will open up more design possibilities; and BIM will continue to transform the design process and enhance the design quality," he said.

He sees it as a trend that BIM will be used in early design stages and this requires structural engineers to improve their capability in concept design, "flaws will have nowhere to hide in BIM," he pointed out.

To meet the challenge, he advises young engineers to go back to basics and rethink, rethink and rethink "how could I have done it better?"

"Learn to see structure design as a process to find a solution to functions/purposes and, most importantly, keep your mind and heart open – 'know' before you say 'no'," he said.



1 Langham Place, Hong Kong
2 KCRC headquarters building, Hong Kong
3 The Peak Tower, Hong Kong
4 J.C. Mandarin Hotel, Shanghai
5 Deliberatif, Hotel du Department, Marseilles