ARUP

FIRST

Issue 13 2024

Foresight
Innovation
Research
Sharing
Training

Technical specialists drive total excellence

Preface

Welcome to the newest issue of FIRST, your go-to technical magazine from Arup University. This edition, with a focus on technical specialist services, is a celebration of our ability to combine the collective knowledge of our experts to deliver innovative solutions that span multiple disciplines.

In our Technical Solution section, we have handpicked a variety of projects from across East Asia that demonstrate the collective expertise of our specialists. Among them is the M+ museum building in Hong Kong, a standout project involving over 40 engineering disciplines including 14 technical specialist services. We also explore the OōEli Art gallery in Hangzhou, a project beautifully orchestrated by our lighting and building envelope teams, and the waste-to-resource facility O·Park2 in Hong Kong, where chemical and process engineering work in synergy. Additionally, we feature a story on the modelling of rockfall barriers using LS-DYNA, a key tool in finite element analysis.

Our Profile section introduces two technical experts from Arup: Nina Yiu, who leads building envelope in East Asia, and Mark Wallace, a Director of Infrastructure who focuses on underground and tunnelling projects. Their stories highlight the depth of expertise within Arup.

The Foresight and Innovation section offers a glimpse into two of our latest publications – *Future of Labs* and *Arup's Continuous Innovation Legacy*. The Research section presents an in-depth study on designing accessible means of egress for the ageing population. The Sharing and Training section features the Asian Knowledge and Innovation Forum 2024 and a course on lighting and landscape design at the University of Hong Kong, reflecting our aspirations to shape future built environments.

We hope this issue of FIRST provides you with a deeper understanding of our technical expertise at Arup.

Arup University (AU) is committed to delivering excellence in everything we do for our members, clients, and communities. We aid clients in understanding future trends in the built environment, spotting opportunities, and cultivating innovative ideas. We collaborate with external organisations to push industry boundaries and tackle complex problems. Our aim is to provide outstanding client service.

FIRST, a publication by East Asia AU, delves into design, innovation, and technical solutions for the built environment. It's named after AU's model: **F**oresight, **I**nnovation, **R**esearch, **S**haring, and **T**raining. We welcome your thoughts on collaboration, as well as any questions or comments at ea.arupuniversity@arup.com.

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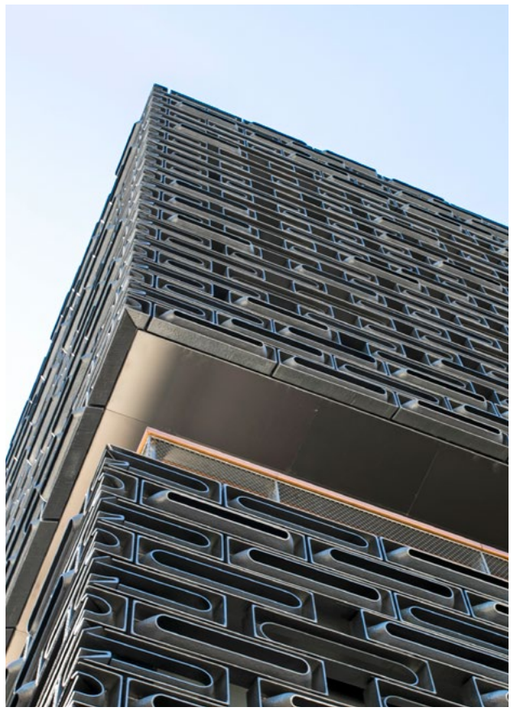
Technical specialists drive total excellence

At Arup, we pride ourselves on the technical excellence of our domain experts and specialists across disciplines. More than that, we value our ability to provide comprehensive, customised solutions to our clients' complex problems. We do not just offer single disciplinary services; our integrated, holistic approach goes beyond the ordinary, setting Arup apart.

Over the years, our multidisciplinary approach has allowed us to deliver numerous iconic structures, particularly in Hong Kong. We take great pride in projects such as M+, one of the world's largest museums of contemporary visual culture (see pages 8–15 for detailed coverage); the Hong Kong Palace Museum, a unique repository of Chinese art, culture, and history; and Tai Kwun, Hong Kong's most extensive historic building revitalisation project, among others.

These projects would not have achieved their harmonious blend of aesthetics, functionality, and sustainability without Arup's comprehensive design solutions. We believe in unity—the whole is greater than the sum of its parts. That is why we are committed to providing multidisciplinary services. Our in-house specialists and experts collaborate to ensure every aspect of our projects is strategically engineered and orchestrated.



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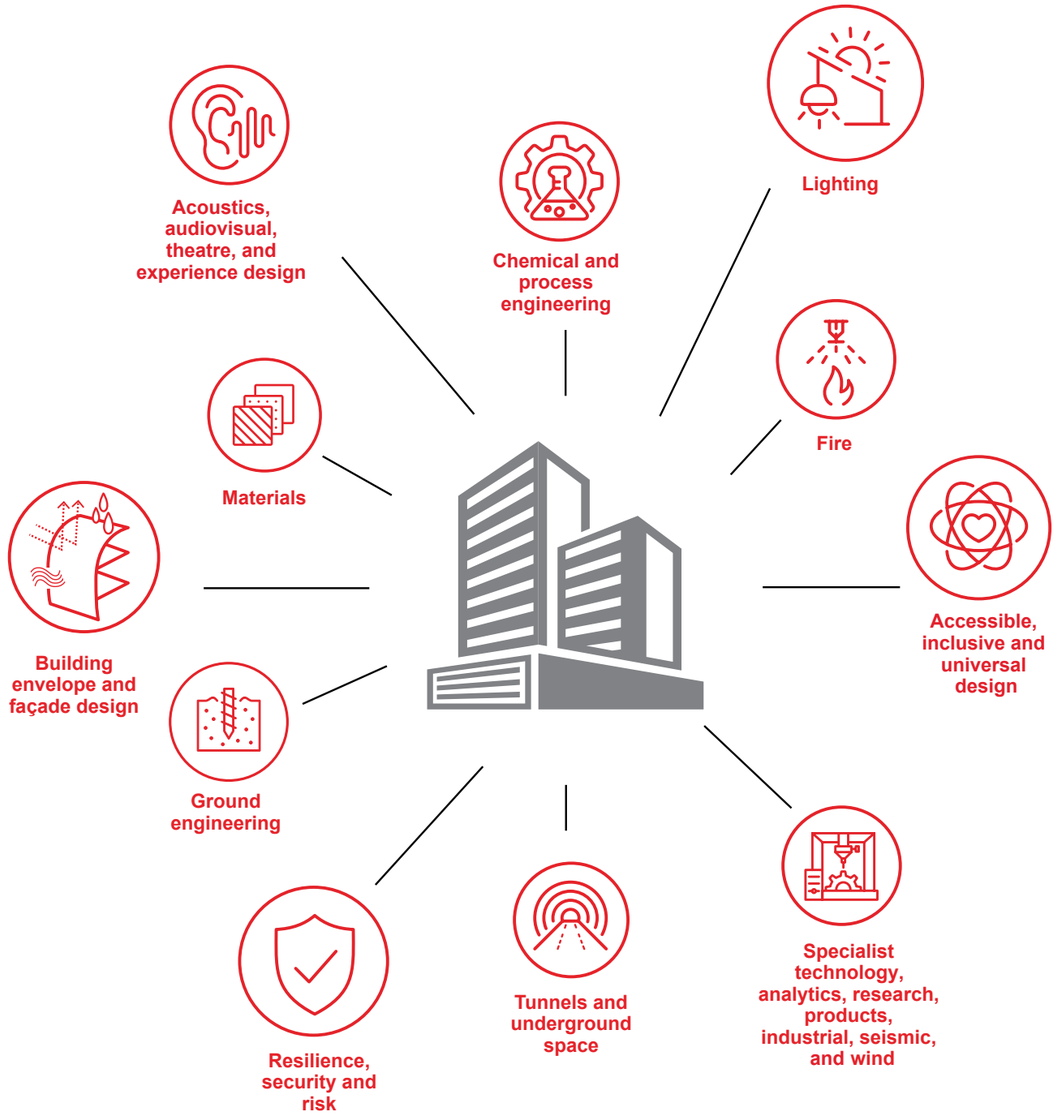
Tai Kwun (left), M+ (top right), and the Hong Kong Palace Museum (bottom right)

Our technical specialist capabilities are moulded by our engineering heritage and enriched by the diverse skills and experiences. Our top-tier disciplines cover a broad spectrum, each contributing uniquely to our projects:



Multidisciplinary synergy for safe, smart sustainability, and sensory design

At Arup, we unite our technical specialists to deliver unique client experience. Through our integrated expertise and innovation, we provide solutions that are safe, sustainable, and sensory-focused. This approach enables us to tackle complex challenges and create impactful spaces. Here are our three key focus areas:

Sensory design

Creating spaces for all

Spaces and places designed with all the senses in mind create better outcomes for communities, precincts, and cities. Tools such as the SoundLab, and lighting labs and our experience design expertise can support decision-making to create inclusive spaces designed for an impactful experience.

Project in focus:
Bjork - Reverb Chamber, The Shed, New York

Arup collaborated with Icelandic singer-songwriter Björk to create a unique reverberation chamber for her Cornucopia tour. The chamber was designed to capture the intimacy of singing live in a small room, providing a naturally enveloping acoustic environment. Björk and her team worked with Arup's acoustic designers, using the Arup SoundLab, to develop a form that achieves a lush natural reverberation. The design process considered various shapes and materials, as well as factors such as acoustics, audience sightlines, weight, portability, and durability for touring. This collaboration resulted in a unique approach to live stage performance after only 10 weeks of design, pushing the boundaries of the concert experience.

© Santiago Felipe

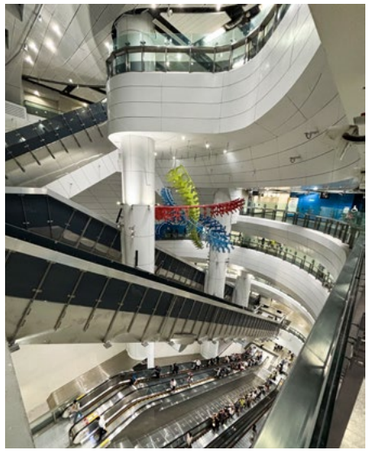
Safe

From construction to user experience

Safety extends beyond physical factors in the built environment. We broaden the concept of safety to encompass social, psychological, and environmental aspects. This comprehensive approach to safety ensures that we create spaces that are positively experienced by diverse individuals in various ways.

Project in focus:
Admiralty Station, Hong Kong

The Admiralty Station, set to be Hong Kong's busiest MTR hub, faced a complex challenge during its expansion. The project required new platforms to be excavated beneath the existing ones, raising significant fire safety concerns due to the confined space. Arup's fire engineers developed a strategy based on self-sufficiency principles for the station's 6-level basement. This plan ensured safe evacuation routes for occupants, using intelligent signage to guide them away from fire and a smoke control system for further protection. The innovative structural designs met all fire safety regulations, and the project's successful completion highlights the effective interdisciplinary teamwork of Arup's ground engineering, tunnelling, and fire engineering teams.

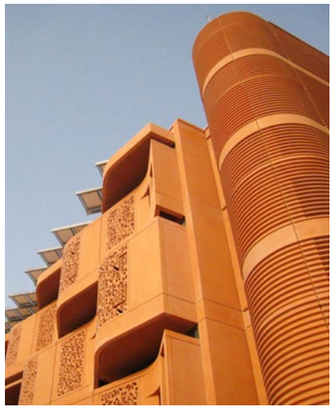


Smart sustain-ability

Building a better future

Our commitment to smart sustainability is another key theme that sets Arup apart. The built environment can play a significant role in combating climate change, and our specialist teams in materials, sustainability, façade, and acoustics are making substantial contributions.

For instance, our materials team has been innovating and promoting the use of more sustainable construction materials like green concrete and mycelium to reduce carbon impacts. Our façade team has been developing greener, better performing façades for years. Our tech specialists have been working for sustainable outcomes in line with the United Nations' Sustainable Development Goals.



Project in focus:
Masdar City, Abu Dhabi, the United Arab Emirates

Masdar City, one of the world's most sustainable cities, is pioneering innovative heat management techniques to create a comfortable, energy-efficient environment for future generations. Collaborating with Airshade and Metadecor, Arup is researching sun shading systems that respond to temperature-induced air pressure changes. These systems, suitable for new builds and retrofits, consume no energy, reducing the need for active cooling and cutting carbon emissions. This project showcases the application of façade skills, materials knowledge and advanced engineering technologies to address a challenging problem, with significant potential for carbon savings.

Arup: A powerhouse of technical specialists and multidisciplinary solutions

Arup specialists offer services to a multitude of markets, ensuring the best delivery across all projects. Our focus is on growth and integration of interconnected disciplines to pioneer world-class services. This approach allows us to bring forth multidisciplinary solutions that add significant value, breaking boundaries and fostering innovation.

Moreover, we harness resources from our global network, bringing together diverse talents and expertise. This global collaboration amplifies our impact, allowing us to tackle challenges with ease and efficiency.

So, here is to our technical specialists—the unsung heroes of the construction industry. Their presence is always felt, working diligently behind the scenes to ensure the success of every project. Their dedication and expertise, combined with our shared purpose to shape a better world, make Arup an unmatched force in the industry.

Behind the scenes at M+:
how technical specialists unite to create an inspiring masterpiece

M+ is an impressive museum for contemporary visual culture, standing proudly in the West Kowloon Cultural District of Hong Kong. Designed by Herzog & de Meuron in partnership with TFP Farrells and Arup, the museum building houses exhibition space across thirty-three galleries, three cinema houses, a Mediatheque, a Learning Hub, and a Roof Garden that faces Victoria Harbour. There is also a separate building of Conservation and Storage Facility.

Project Summary

65,000+m^2
total GFA

17,000m^2
exhibition space

423,000
glazed façade tiles

© Marcel Lam Photography

As you step into M+, the atrium stretching across five levels commands attention. Walking through galleries and descending to the atrium's lowest floor, you can still see sunlight filtering down from above. The building is spacious, but not overly noisy with echoes especially given its concrete finish. Despite the challenge posed by the central atrium to fire safety and security, our engineers and specialists have risen above it.

The creation of the M+ building was a result of the harmonious collaboration of our multidisciplinary teams. While M+'s architectural sophistication often takes centre stage, there is a deeper narrative waiting to be unveiled—one story of technical specialist expertise and collaboration behind the scenes. Their presence, though not always in the spotlight, is constant and integral to our success:

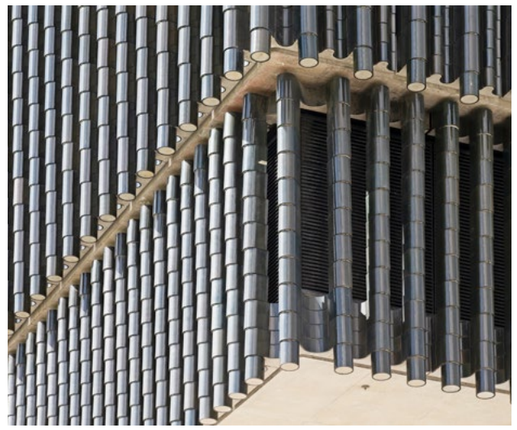
– Acoustics, audio-visual & theatre experience design
– Building envelope and façade design
– Fire
– Ground engineering
– Lighting
– Resilience, security and risk

Each specialist brings unique skills to our projects; but it's through collaboration that we truly add value. For the M+ building, our audiovisual designers and façade engineers worked closely to craft a sensory experience both inside and outside. Geotechnical engineers teamed up with audiovisual designers to address structural issues and ground-borne noise caused by underground trains. Meanwhile, fire engineers and security specialists developed bespoke measures to ensure safety and security for all.

In this story, we will delve into how these interdisciplinary teams came together to bring M+ to life.

M+ Facade: from modern LED spectacle to traditional Chinese motifs

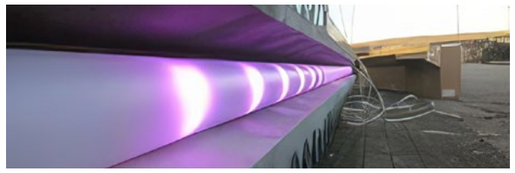
Our thoughtful design begins right from the exterior of M+, creating a visual spectacle that captivates even from a distance. The striking façade incorporating one of the world's largest LED displays is the result of a close collaboration among façade, audiovisual and lighting experts.



The scale terracotta tiles address the unique materiality found in traditional Chinese architecture

M+ has an inverted T-shaped profile with a tower atop a massive podium spanning 143m by 117m. The south façade of the tower features a gigantic screen, 65.8m high by 110m wide, made up of over 5,600 LED tubes installed on the panels. The screen serves dual purposes. The media façade of hybrid LED display consists of two types of RGB LEDs: high power LEDs (150mm pitch) for the far-field views, such as from across the harbour, and low power LEDs (50mm pitch) for near-field views, suitable for events held in the Art Park outside M+. This combination provides a high definition display from across the harbour and a smooth image for closer viewing.

Visual and production tests



LED lighting profile and performance tests

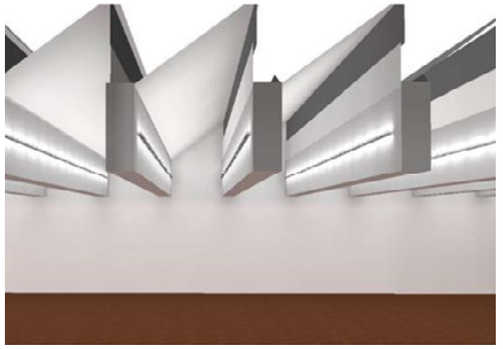
Beyond the LED screen, the tower façade is clad with custom-made precast units combining terracotta tiles and glass. Fabricated as a unitised curtain wall system, each façade panel supports a load of around 5kPa, four to five times heavier than conventional metal-framed panels (i.e. aluminium cladding panels of 1kPa). The overall M+ Facade includes terracotta and precast integrated curtain wall systems, skylights, jumbo-sized shopfront glass walls, windows, decorative or mechanical louvres, terracotta soffits, precast wall cladding and roof panels, entrance doors, and a building maintenance unit.

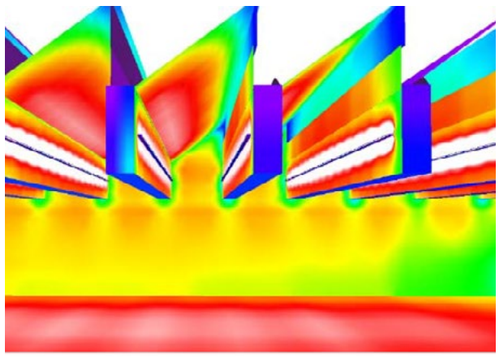
The terracotta tiles were mass-fabricated in Italy assisted by robotic production for glazing, whilst the precast and integrated curtain walls, including 2.4m by 9m tall panels, were fabricated in Shenzhen and transported to the site by a road vehicle. The units, weighing over four tonnes each, required customised strategies to ensure safe and successful installation. A series of performance mock-up tests were carried out, including impact tests, anchorage tests, thermal tests for terracotta tiles, bond strength tests, air infiltration tests, static water infiltration tests, dynamic water infiltration tests, structural safety load tests, displacement tests, and gondola tieback load tests. These tests were conducted to ensure successful on-site installation and safety.

The lighting also works together with the glass façade, ensuring a minimal visual boundary between exterior and interior spaces

Harnessing daylight as a sustainable lighting source

Our multidisciplinary approach allowed us to take visitor experience inside the building into consideration when designing the exterior of M+ Facade. We intentionally crafted the façade to bring natural daylight into specific galleries, creating an inviting and well-lit environment for art appreciation.





Light simulation at a gallery to bring in daylight
Top: greyscale representation
Bottom: false colour representation

Our lighting designers collaborated with architects and sustainable development specialists to integrate daylight into the museum's design. A unique exhibition space in M+ is the Sigg Galleries which integrate daylight from above. Located at the north-east side of the building podium, the gallery is equipped with louvers and glazing at the roof and is generally illuminated by daylight. A black-out shading system is deployed to adjust the skylight from the roof. The room is also supplemented with an electrical track lighting system for mounting additional spotlights, hence providing higher flexibility.

As part of the design plan, the lighting system aims to be subtle and unobtrusive while providing even illumination. It works in harmony with the raw interior structure, emphasising the materials and, most importantly, the exhibits. There should be no shadows or strong contrasts, as is typical in modern contemporary art galleries. Additionally, the ceiling design enhances visitors' spatial experience by maintaining a clean and organised arrangement of linear lighting.

Navigating geotechnical complexities and acoustic challenges

During the design and construction of M+, our engineers and specialists focused on creating a tranquil environment ideal for appreciating contemporary visual culture and the building's architecture. Our ground engineers and acoustic designers successfully tackled the substantial geotechnical and acoustic challenges posed by the existing subterranean rail lines.

The M+ building is situated directly above existing underground tunnels for the Mass Transit Railway (MTR) Airport Express and Tung Chung Line, which run just 1.5m beneath the museum site. Consequently, the excavation and construction of a new basement structure adjacent to the existing MTR tunnels posed a significant challenge for the geotechnical engineers.

The site is predominantly underlain by loose fill reclamation materials, with high underground water conditions near Hong Kong's Victoria Harbour. To address this, our geotechnical team developed a comprehensive detailed design for the deep foundation works and holistic excavation construction method sequences. These measures allowed us to navigate the strict deformation and settlement criteria while working alongside the existing tunnel structures.

After the successful excavation and construction of the spaces, our acoustic team faced a second challenge caused by the MTR lines. These rail tunnels generate substantial ground-borne noise and vibration, disrupting sound-sensitive areas like the M+ Cinema, the Grand Stair, and the Learning Hub.

To mitigate the structure-borne noise at M+, Arup's acoustic experts strategically isolated sensitive spaces from the foundations, instead of floating the entire museum building. This tailor-made mitigation measure, including 'box in a box' construction and floating slab, effectively enhanced constructability and resulted in cost savings.

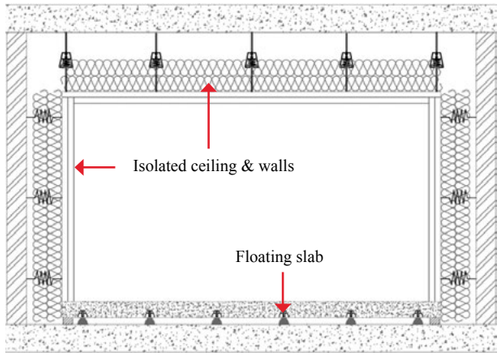
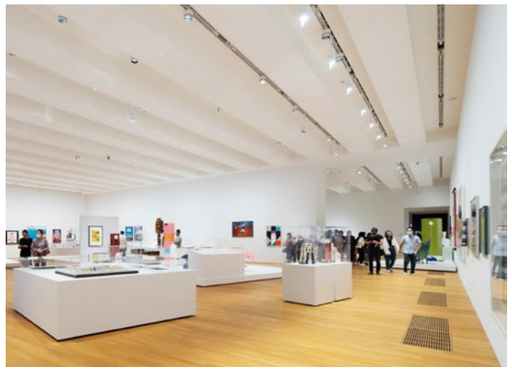


Illustration of the 'box in a box' solution

The project team developed a custom isolation system using raised slabs that considered the building's structure, utilities, fire safety, and other design needs. For instance, the cinema inside M+, with its high acoustic standards, posed the greatest challenge for our acoustic specialists. The box-in-a-box method effectively isolated the entire room from noise and structural vibration, with a floating floor, isolated ceiling and isolated walls.



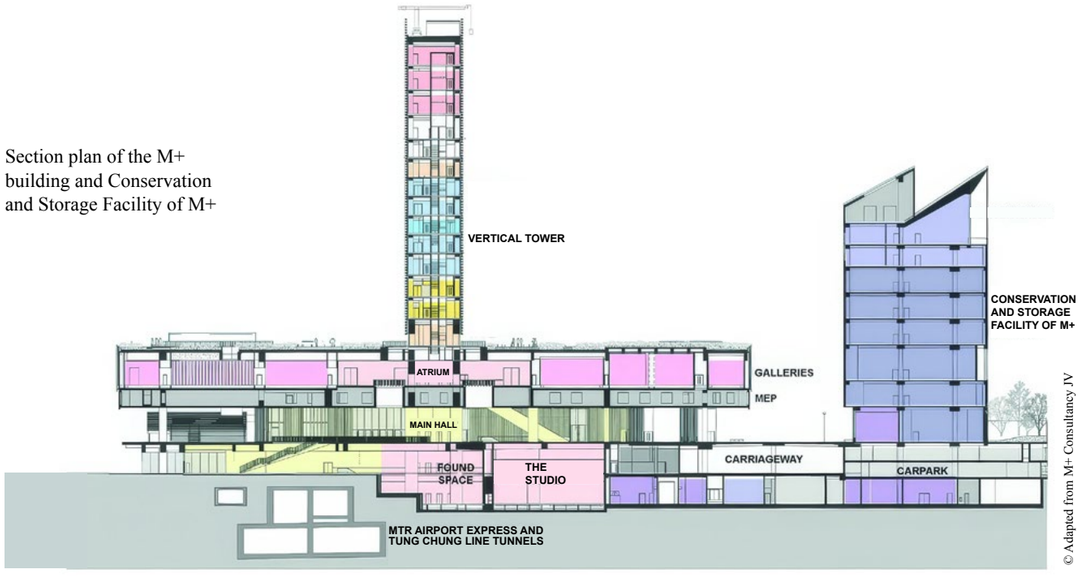
Acoustic absorptive ceiling

Silencing the concrete: acoustic triumph

As visitors wander through the atrium, the sense of space within the building is striking. Surprisingly, there is little echo, even though the building is finished in concrete—a material known for its echo-producing properties due to its density, hardness, and surface finish.

We benchmarked the reverberation time (RT) at M+ with local and international museums. RT refers to the time it takes for a sound to decrease by 60dB, and a shorter RT results in less reverberation and lower overall noise levels in the building. After obtaining the results, the team reduced the RT of different spaces at M+ to levels suited to their intended purposes through specially designed

Section plan of the M+ building and Conservation and Storage Facility of M+



Arup's SoundLab utilising 3D ambisonics sound system is a special tool that allows clients and designers to listen to 3D sound simulations

acoustic treatments. In most of the spaces, acoustic treatments are applied to the ceiling, but other areas, such as wall surfaces, are also designed with sound absorption materials.

During the design process, Arup's SoundLab was adopted to achieve optimal acoustic design for M+. It is an innovative tool for auralisation, fostering effective dialogue and design among clients, architects, and acousticians. It aids in understanding acoustics of spaces and optimising designs for various environments, from train stations and stadiums to concert halls and offices. The SoundLab allows users to hear a space before it is even built, enabling them to participate in design decisions that affect the acoustic environment. In addition, it can often facilitate rapid decision-making and cost-benefit analysis.

Through this simulation process, the anticipated level of underground train noise was simulated and the sound was considered desirable as agreed with the end users.

Safety by design: fire-proof and security-enhanced approach

In addition to acoustic challenges, the central atrium—which stretches across five levels from B2/F to 2/F, with large and unaligned openings on each floor—also posed challenges to fire safety and security, but our engineers and specialists have risen above it.

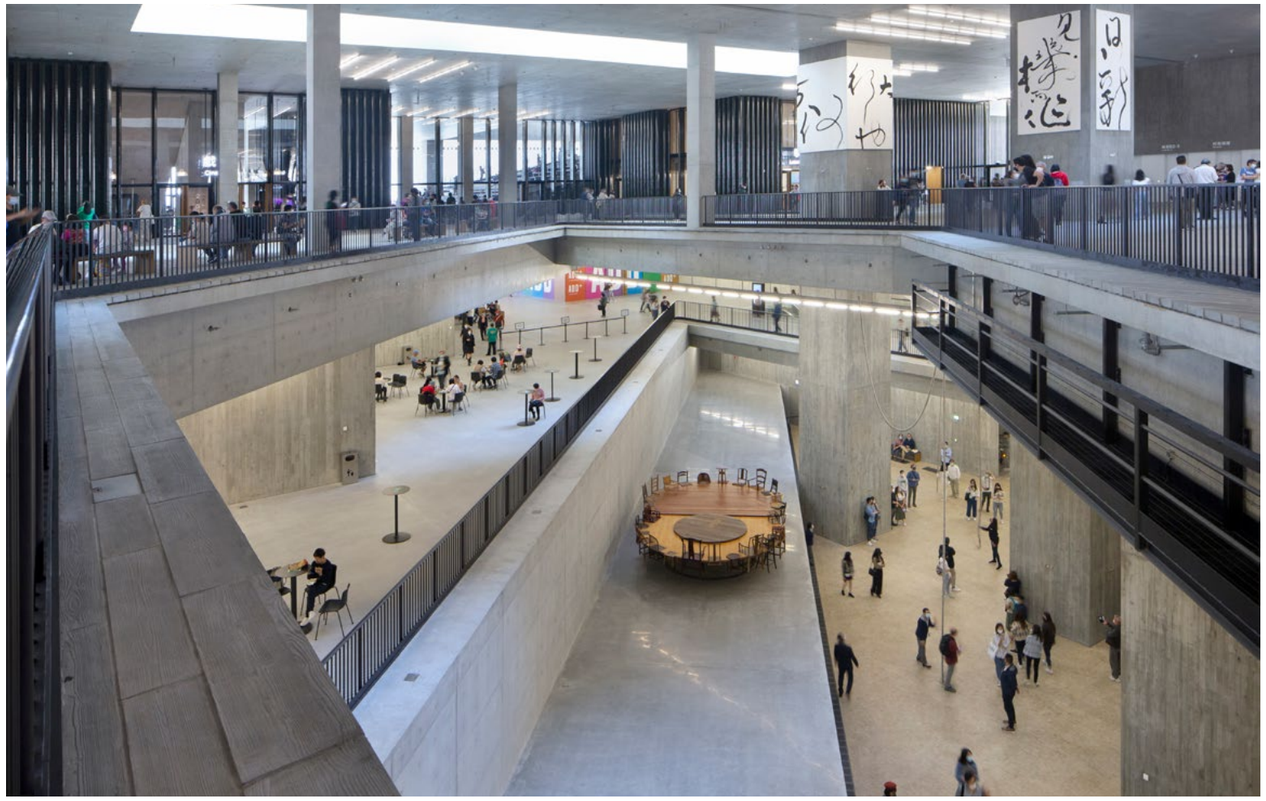
Given its distinct fire compartment design, spanning a substantial volume of roughly 68,000m^3 and standing tall at 32m, Arup had to adopt alternative safety measures to ensure compliance with local fire safety regulations.

Considering the anticipated high visitor numbers, Arup proposed to adopt a performance-based fire engineering approach with a range of customised fire safety protocols, including advanced fire detection systems, fire suppression systems, a smoke control system, and well-planned evacuation routes. The building's design has also incorporated fire-resistant materials and structural features to enhance its overall fire safety.

On-site long-throw sprinklers test (left) and hot smoke test (right) were conducted to provide invaluable insight into the effectiveness of fire safety strategies

Our proposed mitigation measure is to compartmentalise the whole building into distinct fire and smoke zones by the combination of fire shutters and smoke curtains. This can effectively confine fire and smoke to designated areas, allowing more time for evacuation. Designed specifically for the atrium are large horizontal smoke curtains, measuring 5.4m in width and 28m in length which allowed for the realisation of a spacious atrium up to 30m in height. The set-up ensured that the M+ building meets life safety standards for a public building receiving many visitors and housing valuable artworks.

Additionally, computer simulations were conducted to calculate the Available Safe Egress Time (ASET) to measure the efficacy of the proposed fire safety measures. ASET is the time that elapses between fire ignition and the onset of untenable conditions. Then the project team compared ASET with the Required Safe Egress Time (RSET), and the results showed where Arup's performance-based measures were implemented, the ASET consistently exceeds the RSET in all fire scenarios. During the final stages of construction, on-site hot smoke tests were conducted to evaluate the effectiveness of the proposed fire strategy. The tests involved igniting real fire and smoke traces to check smoke movement. The results confirmed the accuracy of the simulation results obtained in the previous stage and verified the life safety design. The tests were witnessed and accepted by the Hong Kong government's Fire Services Department.



The vast openings on each floor could accelerate smoke spread, increasing the risks associated with fire incidents

In addition to fire safety, having robust security protocols in place is paramount to protect the staff, visitors and the extensive collection housed at the M+. It is also essential to mitigate risks of accidental damage and intentional criminal acts, including theft. Arup's security specialists have developed a multi-layered strategy to counter threats ranging from terrorism, cyber attacks, criminal activities, and public disorder. These carefully crafted measures aim to safeguard not only the people within the museum but also its valuable assets.

By integrating these strategies and leveraging data-driven insights, M+ exemplifies a proactive and holistic approach to safety and security in the face of evolving threats.

A beacon for multidisciplinary projects in East Asia

This is the story of how our technical specialists work in synergy to deliver a sensory experience while ensuring safety and security at M+. This approach brings together a range of experts to design and build, demonstrating Arup's commitment to holistic solutions.

Like pieces of a puzzle, the work of each individual contributes to the bigger picture. This shared purpose drives the success of every project. The M+ project is a great example, where the combined efforts have led to an outcome that could not have been achieved by any single discipline alone. This achievement in Hong Kong stands as proof of Arup's ability to excel in multidisciplinary endeavours, ensuring all aspects are considered and resulting in a project that is more than just the sum of its parts.

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OōEli: Shining a light on advanced façade design

© TraceImage

Completed between 2020 and 2021, OōEli is a multi-purpose complex in Hangzhou, China, designed to house the headquarters of the fashion brand JNBY and the design institute GOA. Inspired by Renzo Piano, the design aims to create a unique green urban plaza with a simple, industrial-style façade that enhances the overall project. All the buildings, including their lobbies and retail spaces, are oriented towards the urban park featuring a grand piazza, water features and gardens that provide spaces for people to gather, relax, and connect.

As the concept designer for multidisciplinary services, Arup worked closely with Renzo Piano Building Workshop (RPBW) and GOA to bring the design to life. Our lighting and façade teams collaborated closely to ensure the project's success. The lighting team meticulously designed the illumination to complement the façade, enhancing the building's aesthetic appeal during the night. Meanwhile, the façade team ensured the design's practicality and durability. This collaboration resulted in a façade that is not only visually stunning but also functional and resilient, truly embodying Arup's commitment to excellence in design and execution.

Project Summary

230,000m²
total GFA

17 buildings
offering art galleries, event space, designer shops and commercial space

260m x 175m
site surrounded by buildings to create a green urban park

Glass curtain wall: crafting from aluminium to artistry

In the design phase, we aimed to showcase the elegance of modern architecture using a metal surface. We chose an aluminium alloy for its unique characteristics. The bespoke façade design was challenging due to its detailed nature and the need for top-notch craftsmanship, which is uncommon in China.

We used anodising to create a durable, clear finishing layer on the aluminium, revealing its natural colour. Anodising is a process that uses electrolytic oxidation to form a transparent oxide layer of at least 20 microns on the metal surface. This layer not only safeguards the aluminium but also provides a consistent natural finish.

After achieving the desire finish, our team dedicated significant effort to determine the best method for adding detailed patterns to the aluminium surface. After exploring various metal processes, the team found that cold stamping with batch anodising was the most effective. Committed to precision, we conducted several rounds of full-size mock-ups to refine the design and ensure it met our high standards.

Arup collaborated with material scientists in determining the suitable alloy, anodising requirements, and production techniques to select a supplier capable of meeting these standards. A German manufacturer was eventually chosen due to its production capabilities, global experience and familiarity with RPBW's projects.

The first (left) and second (right) rounds of full-size mock-ups

Despite the challenges, we successfully assisted our clients with design, procurement and the selection of the right contractors to deliver a high-quality façade that met all aesthetic and performance requirements.

Lighting: reinforcing external experience after dark

Architectural lighting design plays a pivotal role in enhancing the identity and ambiance of OōEli at night, establishing a pleasant atmosphere with thoughtfully positioned illumination. Arup's expertise in electrical lighting design was instrumental across both exterior and interior communal areas of the development, encompassing the landscape, entrance lobbies, art gallery, auditorium, event space, typical offices, and public circulation areas. Additionally, we offered daylighting consultancy for the main gallery, which features integrated skylights.

© Kinglay Architectural Photography

OōEli's glass curtain wall

OōEli's lighting design is a collaborative effort involving our London, Tokyo, and Shanghai teams. Our aim is to create an inviting landscape and subtly enhance the buildings to attract visitors. We employ lighting to emphasise the ground axes, trees, and buildings, and use water reflections to maximise visual elements at night. Lighting from within the buildings also plays a role, serving as a backdrop for the external illumination.

The lights are placed to enhance the visual impact of the geometric axes in the landscape. Selective trees are uplit and inground marker lights are placed along the key paths to provide subtle illumination and guide visitors throughout the development.

Supplementary low-level lights are incorporated where appropriate including the sunken gardens and steps, creating a soft and pleasant atmosphere. Lastly, wall-uplighters are strategically positioned along concreate walls, accentuating the identity of the development after dark.

Iconic sail shading system for the art museum

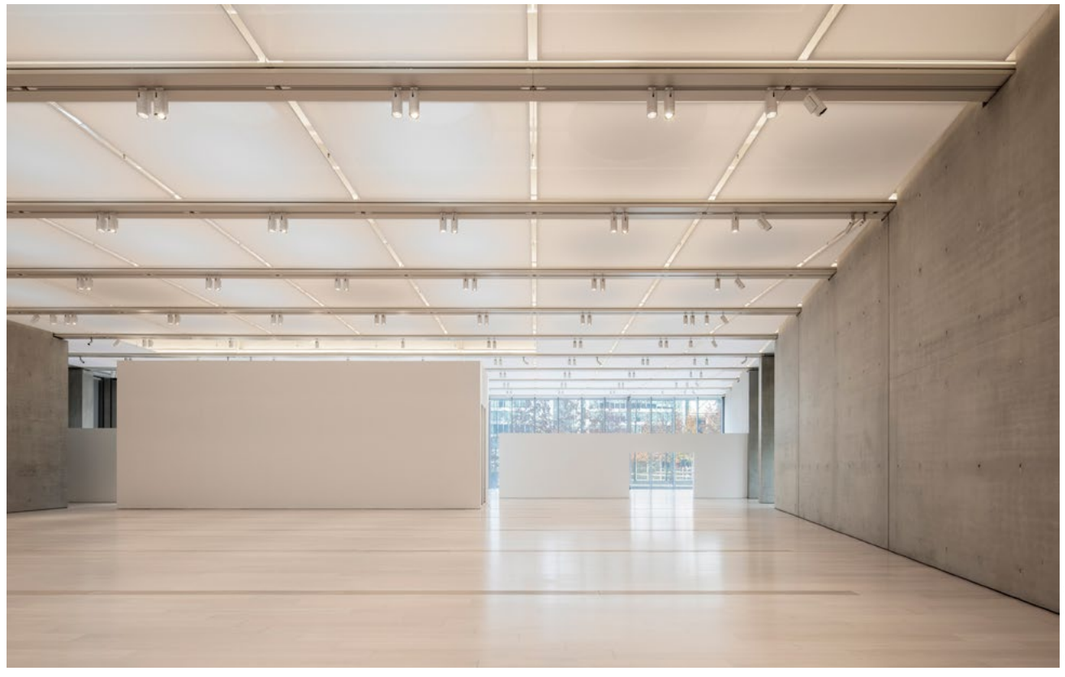
In 2021, the contemporary art museum was opened as part of the JNBY headquarters. Named as 'By Art Matters', the art museum comprises approximately 1,500m² of exhibition space with the main gallery located on the ground floor of Building 1.

Arup's approach to achieving a world-class art gallery design, as required by the client, involved maximising the use of natural light while controlling glare and sun penetration in the exhibition spaces.

The main gallery boasts iconic sail shading above a skylight system, largely placed at both ends of the gallery space. The upper structure overhangs above the central area, posing challenges in evenly distributing daylight throughout the gallery.

The skylight system works in conjunction with a sail shading system designed to filter the incoming daylight

Daylight enters through the skylight, creating a soft and gentle glow on the ceiling scrim



The interior of the main gallery

During the day, the sails above the skylight block direct sunlight, allowing only diffused light to enter the gallery and creating a soft glow on the ceiling scrim. These sails, designed to open skyward while blocking sun penetration, preserve the view and enhance the connection with the outdoors.

In the central area where daylight cannot reach, LED skylights have been installed to provide supplementary ambient light during the day. The LED light source was extensively tested to identify the ideal colour temperature to match the daylight entering through the skylight system. After testing through mock-ups, the colour temperature was set to a single value for ease of control.

The skylight systems create a unique atmosphere within the exhibition space. Linear lights are integrated into the beams above the ceiling scrims to enhance the ambient lighting in the gallery space.

Track lighting has been installed throughout the gallery to provide flexibility in accentuating the art displays. This allows for easy adjustment and repositioning of lights to highlight specific artworks or create desired visual effects.

After dark, the ceiling uplights come into play, creating a warm and welcoming ambience. These uplights are carefully positioned to cast a gentle glow on the sails of the roof, resulting in a striking visual feature for the external appearance.

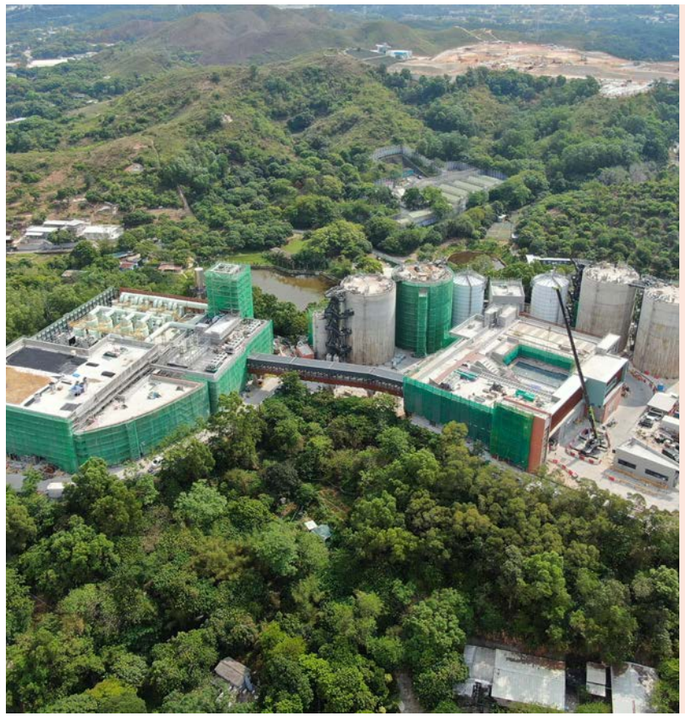
All in all, the OōEli project showcases how façade engineering and lighting design can work together in designing and creating beautiful, functional and sustainable spaces. It is a shining example of Arup's commitment to engineering excellence, pushing the boundaries of design and functionality.

Charting the future of food-waste management: Hong Kong's O·Park2

Hong Kong is making significant strides in waste management, aligning with the Waste Blueprint for Hong Kong 2035. Two pioneering facilities, O·Park1 and O·Park2, have been at the forefront of this revolution turning waste to resources. Arup's contribution to both facilities showcases the power of multidisciplinary design in addressing Hong Kong's food waste issue.

O·Park2, in Sha Ling, is set to become the largest food waste recycling facility in Hong Kong by 2024. Arup has been appointed as the independent consultant for O·Park2 by the Hong Kong government and the Alchmex-Jardine-Agrivert (AJA) Joint Venture.

Our role involves independent advisory services on multidisciplinary aspects for the design, construction, commissioning and initial operation of the project. This encompasses chemical and process engineering, architecture, civil, structural, geotechnical, mechanical and electrical engineering, control and automation systems, environmental impact assessments, fire safety and so on to ensure that all the design, construction and operational requirements are in compliance of contractual, statuary and industrial practices.



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O·Park2

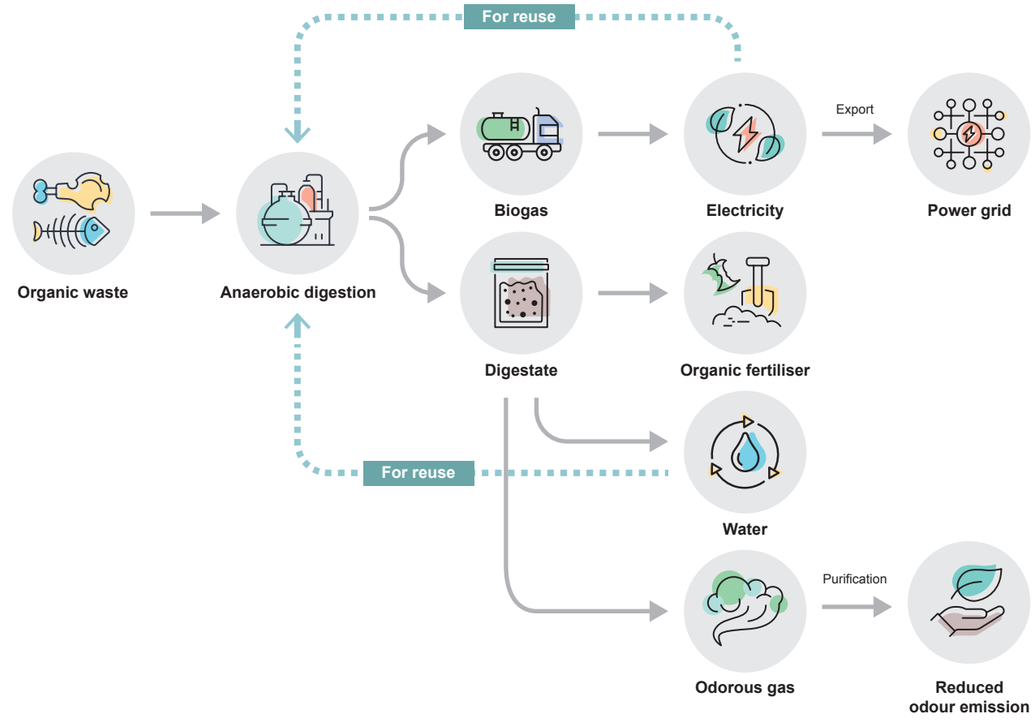
Project Summary

300tonnes
daily food waste handling capacity

24million kWh
annual surplus electricity to the grid

110,000tonnes
landfill waste reduced per year

67,000tonnes
greenhouse gas reduced per year



Engineering the process from waste to watts

O·Park2 recycles food waste into biogas and fertilisers using anaerobic digestion and composting or granulation technologies.

Food waste is collected and brought to the facility, weighed, and then processed. Inorganic materials like plastic and metals are separated for recycling, while organic materials are shredded and macerated in preparation for anaerobic digestion to produce biogas.

This biogas is purified and stored for power generation. The facility aims to be self-sufficient in electricity, with surplus power being exported to the grid while reducing greenhouse emissions. It is projected to generate about 24 million kWh of surplus electricity annually, equivalent to the electricity consumption of approximately 5,000 households.

The remaining substance after biogas extraction from anaerobic digestion, known as digestate, is separated into solid and liquid components. The solid digestate is transformed into high-quality fertiliser, to be sold as commercial organic fertiliser product. The liquid contains high pollutants, along with wastewater from the pre-treatment stage, is collected and treated through wastewater treatment and recycling systems, with about 70% being recycled within the facility and the remainder sent to municipal sewage treatment works. Odorous gases are extracted and processed using two purification stages combining chemical wet scrubbing followed by activated carbon absorption, helping to reduce odour emission from the facility.

The hammer mill in O·Park2, first of its kind in Hong Kong, provides a comprehensive solution to purify and separate organics before digestion

Building on the success of O·Park1, O·Park2 has further optimised its waste management system by expanding capacity and enhancing sustainability, with Arup reviewing the optimisation scheme as an independent consultant:

1. A shallow moving floor system was introduced to O·Park2, resulting in a 96% reduction in floor area.
2. The traditional wastewater treatment systems are replaced by advanced high rate and membrane treatment technologies, reducing footprint and pollutant loads while enabling on- site recycling for non-potable uses.
3. The solid digestate is processed into high-quality fertiliser through a fully enclosed granulation system for not just soil conditioning but also cultivating instead of spacious composting and maturation chambers, reducing space and odour.

Achieving carbon neutrality: an award-winning approach to sustainability

Arup's proficiency in sustainable design and construction played a pivotal role in steering the project towards the use of low-carbon construction methods and materials. This included the use of low-carbon concrete, which incorporates 60% ground granulated blast furnace slag (GGBS), carbon-captured concrete blocks, low-carbon cement, and fully recycled low-carbon steel reinforcement. We as independent consultant reviewed and certified these materials for green building construction.

In addition, innovative materials for anti-corrosion protection were used. These encompassed fibre cement or iron-powder-reinforced cement, along with a high-density protective layer cast into the material. These cutting-edge materials ensure that the food waste processing machinery is resistant to acid, high temperatures, ageing, and wear, thereby prolonging their lifespan and enhancing the project's sustainability.

Beyond material selection, the site office was also outfitted with energy-efficient appliances and lighting equipped with motion sensors. Solar panels were installed on the Reception Building, and Smart Electricity was utilised to monitor daily power consumption and solar power generation. Modular Integrated Construction (MiC) technology and Design for Manufacture and Assembly (DfMA) technologies were also employed to lessen the environmental impact of construction.

In recognition of its innovative approach to sustainability, O·Park2 has been acknowledged for its excellence in green building design. The project received the Merit Award in the 'New Buildings Category: Projects Under Construction and/or Design – Institutional' at The Green Building Award 2023. This award is a testament to the project's dedication to environmental sustainability and innovative design. It acknowledges the efforts of the entire team, including Arup, in implementing sustainable practices throughout the design and construction process.

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Along with contractor and employer's representatives for O·Park2, Arup's Director and East Asia Skills Leader in chemical and process engineering Dr Simon Tsang (third from left) represented Arup as independent consultant to receive the Merit Award at the Green Building Award 2023

A sustainable future to waste management for Hong Kong

Arup's multidisciplinary advisory role, encompassing a broad spectrum of engineering and environmental disciplines, ensures that all design, construction, and operational aspects in O·Park2 adhere to quality, contractual, statutory, and industry practices. The project is a major step towards sustainable waste management in Hong Kong. In alignment with the Waste Blueprint for Hong Kong 2035, it highlights the city's dedication to waste reduction and resource circulation – circular economy, and paves the way for a sustainable, waste-free future for Hong Kong.

Further initiatives advancing sustainable waste management

Beyond the O·Parks, Arup has spearheaded a number of projects that the city's commitment to waste reduction, resource circulation, and zero landfill by 2035.

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Advancing co-digestion of food waste and sewage sludge

This novel method, initially tested at Tai Po Sewage Treatment Works provides a synergy to co-locate and co-treat to utilise the existing capacity of the anaerobic digestion plant at existing sewage treatment works as a demonstration plant, maximising space efficiency, energy optimisation and cost effectiveness. It targets to transform more than 50 tonnes of food waste and 150 tonnes of sewage sludge daily into energy, thereby reducing greenhouse gas emissions as part of decarbonisation strategy. This experimental programme is under operation. Given the satisfactory performance of the plant so far, the approach will be implemented across other sewage treatment works for co-treatment, establishing a new benchmark for organic waste treatment in the region.

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Fireproofing an incineration plant for mixed municipal solid waste

Arup's fire engineering service is integral to the Integrated Waste Management Facilities Phase 1 (I·Park1) at Shek Kwu Chau island. I·Park1 includes an incineration plant and a recycling plant, handling up to 3000 and 200 tonnes of municipal solid waste daily, respectively. Given the remote location, Arup has developed a fire safety strategy taking into account the fire emergency and rescue plans, including firefighting boat access and an on-site emergency response team. Our performance-based fire engineering design, including a custom static smoke control system, ensures safety and meets the city's growing waste treatment needs. In addition to fire engineering, Arup has also provided MEP and chemical and process engineering services for this Project.

Revolutionising landslide modelling with Arup's pioneering use of LS-DYNA

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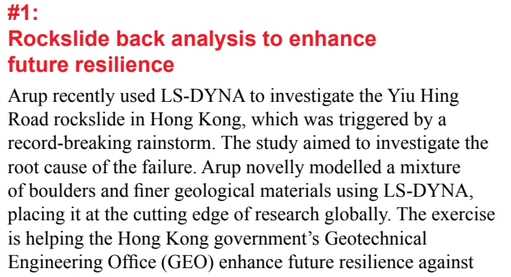
A flexible net barrier used in landslide mitigation

Arup has been at the forefront of slope engineering and landslide prevention in Hong Kong for over 40 years. Our involvement started with the response to the tragic 1972 Po Shan Road landslides, even before we set up our permanent office in the city in 1976.

Indeed, with over 60% of Hong Kong's land being natural terrain and an average of 300 landslides annually, the need for effective mitigation measures is paramount. Developing mitigation measures for landslides involves several stages of study. Two stages that strongly benefit from computer-aided analysis are determining the trajectory of the landslide and determining the dimensions and properties of the barrier(s) that are to be installed. Mitigation measures that are typically constructed in Hong Kong include flexible net barriers, which have only been recently adopted for widespread landslide mitigation. Flexible net barriers advantageously blend in with the environment, and are relatively easy to transport and install.

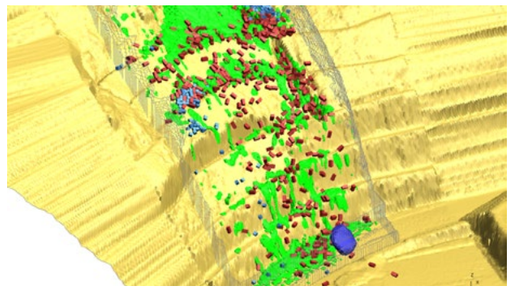
The design of flexible net barriers typically employs a highly simplified energy approach, which assigns a rating to each barrier based on how much energy it can absorb without failing. For modelling landslide paths, pseudo-3D software like DAN-W has been used worldwide since the early 2000s. However, such software cannot model debris directly interacting with barriers, which is a major limitation for designers. This has led to the development and proliferation of simplified approaches, wherein debris runout and flow-structure interaction are analysed separately using different tools.

To deliver more accurate solutions for landslide mitigation, Arup has pioneered the use of LS-DYNA for landslide modelling since 2012. LS-DYNA is fully 3D, enabling direct modelling of debris interaction with barriers. LS-DYNA also provides better prediction of debris runout, thickness, velocity and depositional extent, regardless of the topographical complexity. Furthermore, LS-DYNA enables the explicit modelling of structurally complex barriers, such as flexible net barriers, and can capture non-linear stress-strain responses of individual barrier components. Arup's approach of explicitly modelling net barriers can be preferable to using the simplified energy approach mentioned earlier, since interactions between landslides and the barrier can vary greatly depending on where impact occurs.



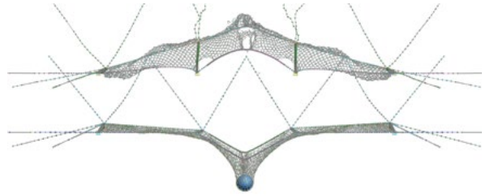
Although our application of LS-DYNA to landslide-structure analyses originated in Hong Kong, we have since expanded our expertise globally. We have provided advisory services on landslides in various locations including Mt. Umyeon in Seoul, South Korea; Queensland and Christmas Island in Australia; Freetown, Sierra Leone in Africa; amongst others.

Recent case study



#1: Rockslide back analysis to enhance future resilience

Arup recently used LS-DYNA to investigate the Yiu Hing Road rockslide in Hong Kong, which was triggered by a record-breaking rainstorm. The study aimed to investigate the root cause of the failure. Arup novelly modelled a mixture of boulders and finer geological materials using LS-DYNA, placing it at the cutting edge of research globally. The exercise is helping the Hong Kong government's Geotechnical Engineering Office (GEO) enhance future resilience against such rockslides.

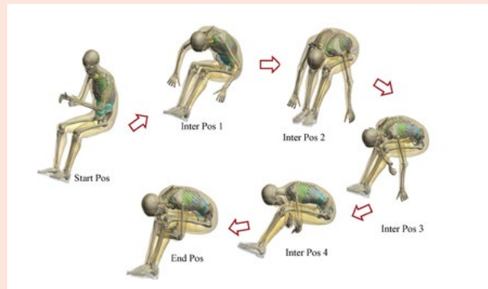


#2: Multiple flexible barriers for landslide mitigation

Landslide catchments in Hong Kong are often small, making the installation of a single large barrier impractical. Arup has been using LS-DYNA for a long-term project to evaluate the effectiveness of using multiple flexible barriers to mitigate both rockfalls and landslides. We started with a study on the energy dissipation mechanisms between rockfalls and a single barrier, and have since extended the study to include the impacts of landslides on flexible barriers and the effects of rockfalls on multiple flexible barriers arranged in series. This innovative approach, if proven effective, could revolutionise landslide mitigation strategies, marking a significant step forward in public safety measures.

Advanced technology and research (AT&R)

With over 30 years of experience, Arup is an expert in leveraging the robust capabilities of LS-DYNA to address complex engineering challenges. We excel in providing digital analysis consultancy services in various areas, including crash analysis; noise, vibration and harshness; fatigue analysis for automotive applications; seismic and stress analysis for structures; crash barrier analysis; and electric vehicle battery analysis.



Arup developed a positioning script in the Oasys software (a pre- and post-processing software designed to work with LS-DYNA) to position the Total Human Model for Safety (THUMS) into a knee brace posture for aviation impact analysis. This pioneering effort opens up further opportunities for research and collaboration with the aviation industry.

Engineering in harmony with nature

Mark Wallace

Mark Wallace is an accomplished engineering geologist with a remarkable career spanning over three decades, all with Arup.

In his current role as a Director, Mark brings a wealth of experience and expertise in various areas of engineering geology. His passion for sharing knowledge extends beyond his work. From 2018 to 2022, he served as the Skills Leader for the Underground and Tunnelling discipline in East Asia at Arup.

Beyond Arup, Mark is an active member of various learned societies and serves as a part-time lecturer at the University of Hong Kong.

Developing an interest in engineering geology

Mark's journey into engineering geology is an inspiring example of how one's interests can lead to a rewarding career. His fascination with geology developed while he studied mathematics and computer science.

After completing his first degree in geology and master's in engineering geology, Mark joined Arup in 1988 as an engineering geologist in Birmingham.

Mark Wallace (first from right) in 1992, working as a resident engineer during a pipe jacking project at Birmingham Airport in the UK

"In Birmingham, I specialised in underground and limestone mine projects. Our team used advanced techniques in evaluations such as downhole geophysical methods, ultrasound surveys, and pulse laser surveying to assess the stability and risks of mineworking."

His first job involved evaluating the re-use potential of old colliery spoil heaps in the West Midlands. The team innovatively blended and mixed the spoil with lime to create a sustainable, low-cost, low-strength setting material called 'rock paste'. This solution not only cleared old spoil heaps but also served as infilling mine workings to prevent collapse.

Afterwards, he worked on different projects across the UK, first in Cardiff, then Belfast, and later to Edinburgh in the early 1990s.

Taking on new horizons

Before moving to Hong Kong, Mark worked as a site design liaison engineer for the civil works and approach roads on the Skye Bridge project in Scotland, a complex operation involving marine works in deep water.

Mark, pictured in the mid-1990s shortly after his relocation to Hong Kong

In 1995, he relocated to Hong Kong to address the major traffic congestion near Tuen Mun Road. The proposed solution involved highway realignment and widening to augment the road's capacity.

Drawing on his experience from the Skye Bridge project, Mark was responsible for conducting soil and rock slope design assessments, boulder assessments and stabilisation design, soil stabilisation, foundation and caisson inspections, slope drainage, as well as addressing general design queries and site alterations for the Tuen Mun Road widening project.

Mark inspecting hand dug caissons on Tuen Mun Road widening project in 1995

The challenging project required strict adherence to contractual obligations. He was also involved in deep caisson inspections for the first and last time, in addition to stabilising large rock slopes and boulders on unstable hillsides.

Leading pioneering underground space studies

Mark has taken on a leadership position in Hong Kong, overseeing teams focused on tunnelling, engineering geology, and geographic information systems (GIS). Under his guidance, these teams have excelled in major infrastructure projects across the region. He was also the editor for the updated Geoguide 4.

His most notable achievements include the MTR Shatin to Central Link Contract 1103 Hin Keng to Diamond Hill Tunnels and the Cavern Masterplan of Hong Kong. Both projects received the International Tunnelling Association (ITA) Tunnelling Awards in 2017.

One of Mark's long-term projects was a rock cavern study that spanned over a decade. Working with the Hong Kong government's Civil Engineering and Development Department and the Planning Department, Mark played a key role in formulating a long-term strategy for rock cavern development. This involved the identification of 48 strategic cavern areas suitable for development, contributing to the formulation of a cavern masterplan for Hong Kong. The plan was widely recognised for its innovation, winning the Innovative Underground Space Concept of the Year at the ITA Tunnelling Awards 2017.

Mark presenting the cavern masterplan for the Hong Kong government during a meeting in 2013

Mark developed a unique approach to hillside solar farm development on marginal land with erosion and landslide issues

Unlocking insights through geological data acquisition and maintenance

Thanks to his background in computer science, Mark played a pivotal role in developing GIS for Arup in East Asia from 2001 to 2015. As part of this effort, Mark hired the firm's first cohort of programmers in 2005 to integrate GIS solutions into engineering processes.

To support the development of developing countries, Mark highlighted to policymakers the significance of collating and preserving urban geological data, borehole surveys and ground models. He advocated for making these databases freely accessible, and stressed the importance of regular investment in acquiring, maintaining and reviewing the data. This approach can enable developing countries to collect information on their natural resources and potential hazards such as earthquakes and landslides, facilitating informed decisions for future urban planning.

In a recent project, Mark has developed a unique approach to hillside solar farm development on marginal land with erosion and landslide issues. He created development constraint maps to identify hazards and recommended offsets and buffers to strategically position the photovoltaic (PV) solar panels.

He also came up with the idea to develop an automated digital solution for panel placement on undulating terrains. This solution, which prioritises hillside restoration, has been successfully implemented in the Philippines and other regions.

Restoring balance with nature-based solutions

Mark believes that engineers and geologists should not try to control nature, but instead respect and learn from its strengths. As cities grow, efforts to go against natural processes become unworkable. Engineers should adopt solutions that work with nature to tackle the challenges of evolving urban areas and help nature heal. Therefore, it is important to work in harmony with nature and focus on sustainability to build a better future.

A closer look at Mark's project

Mark was the project director for the Contractors' Design for Arup

Tuen Mun–Chek Lap Kok Link, Hong Kong

This strategic linkage between the Northwest New Territories and the Hong Kong Boundary Crossing Facilities, North Lantau and the Hong Kong International Airport significantly enhances Hong Kong's connectivity within the Greater Bay Area, making another highlight in Mark's career.

As the project director, he oversaw the Contractor's Design of the Northern Subsea Tunnel section of the Link. This critical role involved managing the design and construction of the Northern Section Tunnel, which stretches over 4.2km and dives 60m beneath the sea. Notably, the tunnel accommodates three lanes of traffic at its northern entrance, requiring a world-record external diameter of 17.6m for the Tunnel Boring Machine (TBM) used in its construction.

Instead of the conventional deep cut-and-cover tunnel, the project team innovatively opted for a large-diameter bored tunnel for the three-lane northern approach ramp structure. This strategic shift not only reduced risks but also significantly accelerated the construction process. Mark actively assessed geological and geotechnical risks throughout the project.

To accommodate the launch and provide ample working space for the large TBMs, the team designed the first cellular diaphragm wall cofferdam ever constructed in Hong Kong. This unique approach created an open, strut-free environment, and set a precedent for future projects.

Mark inspecting the project site in 2015

Passion turned into mission

Nina Yiu

Meet Nina Yiu, an Arup Director currently heading the Building Envelope and Materials team for the East Asia region. With a distinguished career spanning over 25 years, Nina has a passion for creating iconic façades that shape the cityscape, and nurturing talent for the industry.

Nina emphases the significance of striking a harmonious balance among aesthetics, functionality and structural integrity in façade design and engineering. As sustainability gains prominence, there is now a growing emphasis on the entire lifecycle of curtain wall systems, including a shift towards using low-carbon materials to reduce environmental impact.

After attaining a higher diploma in structural engineering in the early 1990s and gaining experience with contractors, Nina briefly worked at an American façade consultant before joining Arup. Over two decades ago, façade design was mostly considered a part of structural engineering. However, as building design has evolved to prioritise aesthetics and the functionality of curtain wall systems, a dedicated discipline for building envelope and materials has emerged within Arup.

Throughout her career at Arup, Nina has contributed to numerous iconic projects. Her leadership has been instrumental in establishing Arup's crucial role in achieving innovative building façade design.

A unique façade for every building

Over the past decade, Nina has focussed on the Southern China market where she has taken on a leading role in designing façades and managing installation works for landmark projects. They include the various buildings at Guangzhou Zhujiang New Town, Shenzhen CRC Headquarters, Shenzhen Raffles City, and more recently Taoyuan T3 Airport, Hong Kong International Airport Third Runway Concourse, Two Taikoo Place, and the China Overseas Headquarters building in Shenzhen.

"Each façade design project we undertake presents a unique set of challenges," she says. "Two Taikoo Place, a 41-storey Triple Grade A-rated office tower spanning about 1 million ft^2, is a prime example."

Standing at a height of 195m, Two Taikoo Place is clad with a 'typical' but specific curtain wall system at tower using square glass to balance visibility and modularity. It also features a raised podium made of full-height glass panels reaching up to 15m.

In a seminar hosted by the Hong Kong government's Leisure and Cultural Services Department, Nina emphasised the growing importance of incorporating the entire lifecycle into façade design

Designed without mullions or bars, these panels provide an unobstructed view through the windowpanes.

Arup faced two significant challenges for this project. Firstly, the architectural capping needed to align with the client's vertical design language, deviating from codified requirements at that time. Through rigorous documentation and demonstrations, Arup convinced the Government engineers of the structural adequacy of vertical capping, leading to a later amendment of the code to a more reasonable design approach.

Secondly, a unique single rod system, a first in Hong Kong, was implemented. Vertical supporting members were concealed between the glass, enhancing the internal space. Despite initial concerns about the high pretension load, our façade and structural engineers worked together to design mega steel beams at top and bottom of the glass wall system to transfer the load to column structures. This innovative solution led to the approval of the first pretensioned glass system in Hong Kong. To bring the design to life, Arup also closely collaborated with the contractor on sourcing and quality control of materials, testing, assessing buildability, and initiating a life-long monitoring programme.

The COVID-related lockdowns and travel restrictions caused delays in shipping raw glass materials from Europe for the tower glass, further complicating the implementation of the project, Nina recalls.

Two Taikoo Place, Hong Kong

"I've always had a passion for undertaking grand, ambitious projects. The desire to create towering, awe-inspiring structures has been my driving force, and I've been fortunate enough to bring such projects to life in my career."

Nina inspected a glass factory in 2005

A sustainable approach to drive façade design

In addition to aesthetics, functionality, and structural integrity, there is a growing importance in incorporating the entire lifecycle of a building into façade design. A building's life involves design, construction, operation, and end-of-life considerations.

"From the design stage onwards, it's just as important to prioritise the use of sustainable, recycled or recyclable materials. This approach can help reduce resource consumption and minimise the environmental impact throughout the building's entire lifecycle."

Similarly, selecting low-carbon materials, such as recycled or low-carbon alternatives, can significantly reduce the environmental impact. Her team actively uses life-cycle assessment tools and databases to evaluate the environmental impact of material choices. This allows Arup to take a more informed and sustainable approach to façade design.

Nina envisions a future where life-cycle assessment tools and carbon calculations are seamlessly integrated into total design automation. This means that designers and engineers will have access to advanced tools and algorithms that can automatically analyse the environmental impact or carbon emissions of building materials.

The same applies to passive design strategies, which involve incorporating features that maximise natural lighting and promote natural ventilation into the building façade. Take The China Overseas Headquarters building in Shenzhen as an example. The project is a near-zero energy building, where Nina's team, alongside Arup's MEP team at Shenzhen, formulated a passive façade strategy to minimise energy consumption while ensuring thermal comfort for the occupants.

Words of wisdom for young engineers

"For young engineers looking to join the façade design industry, it's important to pay attention to details and keep challenging yourself. The consequences of overlooking even the finest detail can potentially be dangerous, so staying vigilant is key, and every case can be different."

"Moreover, maintaining a strong passion for your work is essential. Let your passion drive your continuous pursuit of improvement, stay abreast of industry advancements and incorporate these learnings into your life. Façade design is one of the most fascinating aspects of building engineering, involving not only functionality and sustainability, but also aesthetics and use of materials,"

Integrity is just as important for consultant in this industry, where design and build contracts are common and close collaboration with suppliers is necessary, she notes.

"By placing emphasis on integrity, you can ensure ethical conduct and minimise the risk of being swayed by temptations. Upholding high ethical standards not only preserves your professional reputation but also fosters trust and strong relationships with suppliers and stakeholders."

A closer look at Nina's project

China Resources Headquarters, Shenzhen, China

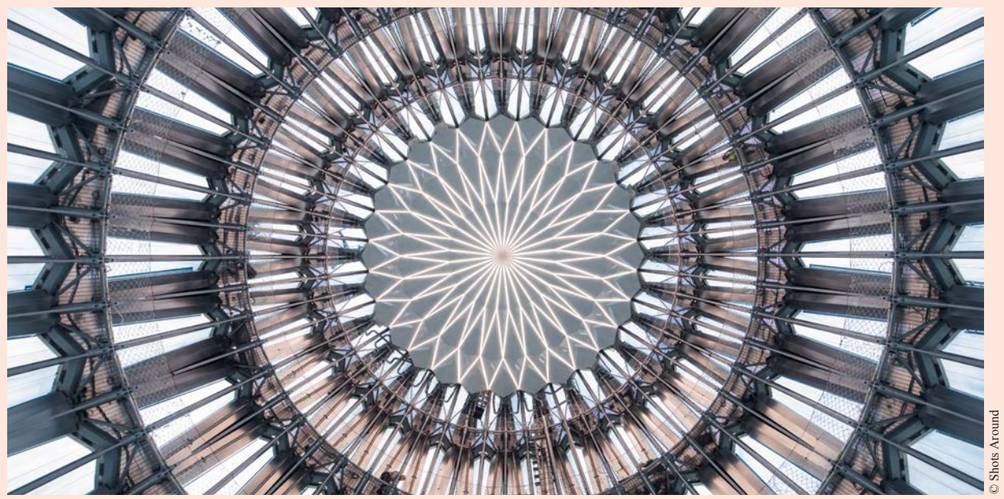
Nina harbours a deep passion for creating iconic landmarks that profoundly shape a city's identity. As part of Arup's multidisciplinary project team, Nina delivered the distinctive building envelope of the China Resources Headquarters.

The towering Grade- A office building rises to 392.5m in the bustling heart of Shenzhen Bay. Its design, echoing a 'bamboo chute', is not just an architectural feat; it embodies the ceaseless growth, energy, and importance of the city of Shenzhen. Nina and her team provided comprehensive façade engineering consultancy services, from the conceptual stage through to on-site inspections and completion.

The curtain wall system, a standout feature of the building, integrates glass and stainless-steel units. The 'bamboo chute' design presented a unique challenge due to the varying curved façade on each floor. The stainless-steel feature underwent a transformation, with widths ranging from 1280mm to 760mm, lengths from 1050mm to 600mm from the face of the glass, and curve radii from 1099mm to 804mm on each floor.

To address this challenge, Nina collaborated closely with the structural designers at Arup. They met the architect's requirements by using 'trapezoidal columns' and optimising the façade fixing bracketry without compromising the water-tightness feature of the façade system, which included breaks at every floor. Also,

together with the architect, they developed an integrated solution involving 100mm wide small pieces of stainless-steel plates and two transfer plates (ranging from 40mm to 140mm) on both sides. This ingenious solution facilitated the creation of different shapes of the stainless-steel feature on each floor, bringing the architect's conceptualised 'bamboo chute' design to life.



Bottom view from inside the building

Future of Labs: a localised lens on lab design in East Asia

The latest Arup University publication of *Future of Labs* (Chinese edition) delves into the scientific research ecosystem in East Asia. This work is an expanded version of the well-received English publication *Future of Labs* republished in 2020, with updated case studies and a stronger Asian focus.

Read the English & Chinese editions

Building upon the insights from these two publications, we can identify pivotal trends that are moulding the future of laboratory environments across the globe:

– Wellbeing and place: User experience and wellbeing will be enhanced through geographic location and the occupant's interaction with the space.

– Adaptable spaces: Flexible, generic designs will be favoured in research facilities to accommodate diverse scientific activities.

– Digital disruption: Tech-driven solutions like artificial intelligence and big data are transforming labs from traditional to smart.

– Cities as labs: Cloud-based labs, co-working spaces, DIY spaces, and living labs, particularly in urban centres, are becoming new spaces for research outside traditional institutions.

Arup, through our real-world examples, demonstrates our approach to building, designing, and consulting on future-proof labs and research facilities. Our goal is to establish efficient, sustainable spaces that will continue to serve their purposes for the future.

The Shanghai R&D Center of Innovent Biologics set to be operational in 2024 exemplifies how Arup conceptualises and realises 'wellbeing and place' in our project. Its design fosters innovation and employee motivation through social interaction and collaboration, with R&D spaces conveniently located near services and management offices.

Shanghai R&D Center of Innovent Biologics

Future lab trends via building retrofit

As we look towards the future, we see a growing trend of transforming existing offices and industrial buildings into cutting-edge scientific laboratories due to limited city spaces. The future of research labs is not just about constructing new buildings, but also repurposing existing buildings, which is both cost-effective and environmentally friendly.

Retrofitting buildings to accommodate scientific research requires a deep understanding of what the research community needs and the limitations of the existing infrastructure. This is why Arup brings together its in-house experts specialising in structure, acoustics, lighting, and fire safety together in a bid to deliver total design solutions to meet clients' needs. By doing so, we ensure that the buildings we retrofit are not only fit for their new purpose but also ready for the future, able to adapt to the ever-changing needs of scientific research.

Arup's legacy of innovation

In the world of design and engineering, few names resonate as powerfully as Arup. With a rich legacy of innovations, Arup has consistently provided groundbreaking solutions to some of the most challenging projects worldwide.

To celebrate these achievements, a publication named *Arup's Continuous Innovation Legacy* was launched in June this year to showcase some of the most innovative projects completed over the years — from Arup's very first project, Penguin Pool in 1934, to the latest accomplishment, Lib Earth House model A completed in 2024. More than 50 projects of various nature and from across the globe are curated.

Lib Earth House Model A is Japan's first 3D printed earth prototype house, using soil as the primary material. This innovative approach promotes a circular economy in construction, reducing costs, carbon emissions, and environmental impact. A specially developed algorithm ensures successful 3D printing by considering printer capabilities, material properties, and construction sequences. The project's core innovation was achieved through out-of-the-box engineering, using cutting-edge digital tools and novel construction methodologies.

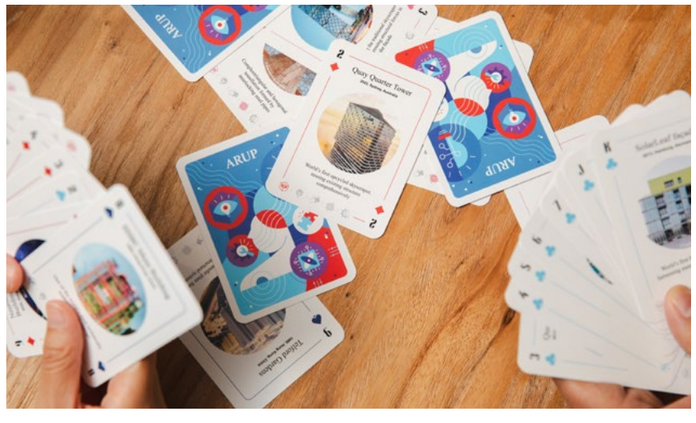
Another innovative project worth highlighting is the Quay Quarter Tower in Sydney, Australia, considered the world's first upcycled skyscraper. Built in 1976, it was retrofitted instead of demolished, retaining 65% of the original structure and 98% of the structural walls and core, saving approximately 12,000 tonnes of embodied carbon. This innovative approach sets a new standard for sustainable building design.

© Lib Work

Lib Earth House Model A

Arup's innovations captured in playing cards

In addition to a publication, this curation of Arup's innovative projects has also been reimagined as a set of playing cards, each featuring a different project and a line capturing its innovative essence. These cards serve as an engaging learning tool for both Arupians and external parties, providing insight into Arup's innovative capabilities. It is a celebration of Arup's commitment to pushing boundaries and a source of inspiration for practitioners in the built environment.



Read the publication

Designing future-proof buildings: ensuring accessible means of egress for all

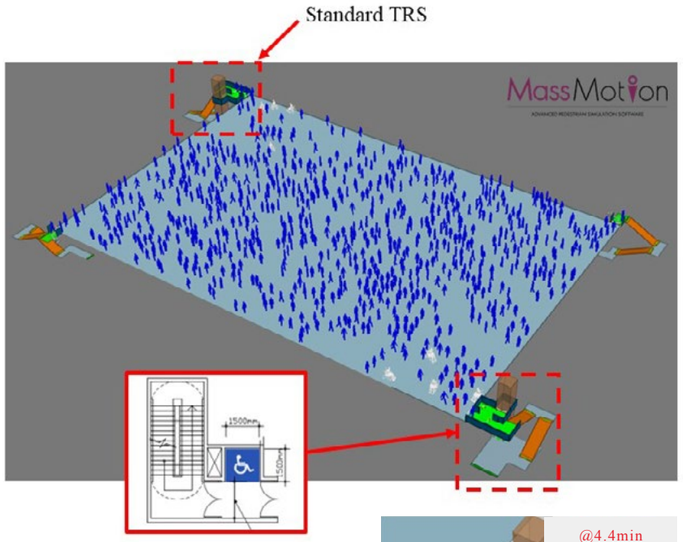
Arup's fire engineers have identified a key opportunity to improve egress routes for persons with reduced mobility (PRMs), particularly in light of an ageing population.

To raise awareness about the necessity of accessible evacuation routes in buildings, comprehensive research has been conducted. This research investigates whether compliance with current fire codes adequately meets the evacuation needs of all individuals, both now and in the future.

A comparative study on fire safety codes and accessibility

This research examines accessible building designs and compares fire codes globally. It finds that most codes and standards do not link the required quantities of accessible means of egress (MOE), like refuge spaces and evacuation lifts, to the number of PRMs or wheelchair users.

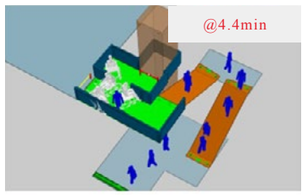
Notably, fire codes in the UK, US, and Singapore have stronger provisions for accessible evacuation compared to those in East Asia. For instance, the Hong Kong fire code requires only one temporary refuge space for each fire compartment, regardless of the number of wheelchair users; whereas the London Plan published in 2021 requires that all buildings provide at least one fire evacuation lift per core.



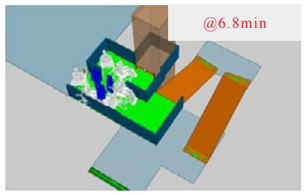
(Above) A hypothetical low-rise building model is set up to simulate different scenarios with 800 occupants, 4 escape stairs, and 2 temporary refuge spaces (TRS)

(Right) Computational simulations show that with 1%, 2%, and 3% wheelchair users, the final person reaches safety in 4.4, 6.8, and 11.1 minutes respectively. In the 3% scenario, some wheelchair users cannot enter the protected area (in green) and some non-wheelchair users are blocked from evacuation

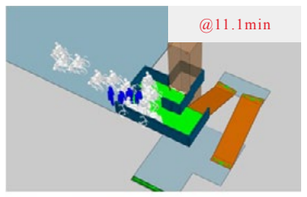
To understand trends for future ageing population, we used 20 years of Hong Kong census data. Forecasts indicate that wheelchair users will constitute 2-3% of the total population in the next 50 years. This prediction should apply to most public buildings without specific entry restrictions, like transportation hubs and shopping centres.



1% wheelchair users



2% wheelchair users



3% wheelchair users

Arup adeptly conducts and visualises evacuation analysis studies across buildings with varying proportions of PRMs. The complexity of egress flow, encompassing individuals with and without disabilities, necessitates computational simulation tools. This approach clarifies the building's maximum accessible egress capacity, enabling optimised management to prevent an excessive influx of PRMs or wheelchair users.

The study concludes that buildings adhering to current fire safety codes may not cater to future needs due to the growing number of PRMs or wheelchair users. Given the longevity of buildings, it is important to design with the future in mind. Provisions of accessible MOE are easier to incorporate in building design stage than adding in the later stage as alterations and additions works in buildings.

Arup's recommendations for accessible evacuation

Following evacuation studies, our engineers have devised recommendations for architectural designs to accommodate an increasing number of PRMs and wheelchair users. These proposals, mindful of client needs, spatial limitations, and project stages, are organised into three levels.

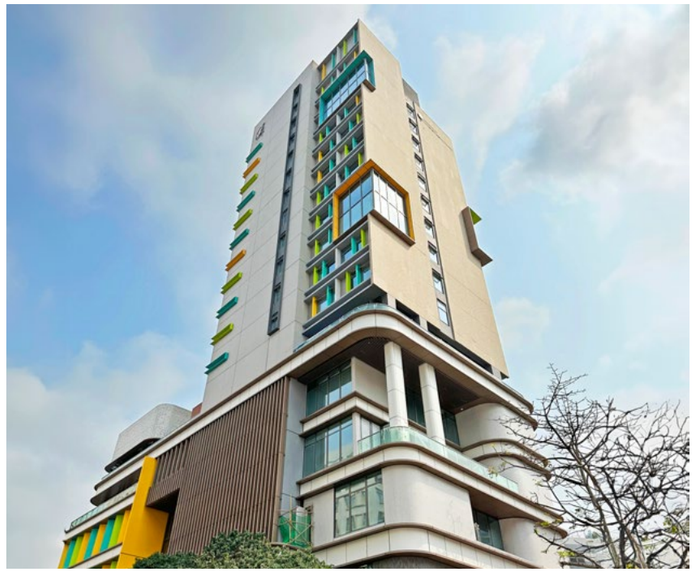
1. Statutory compliance—ensure a minimum provision of accessible MOE according to the statutory requirements.
2. Acceptable level of fire safety for PRMs—provide sufficient accessible MOE to allow PRMs to stay in a fire protected area for subsequent assisted evacuation.
3. Independent MOE for PRMs—provide sufficient accessible MOE to enable unassisted evacuation of PRMs.

Take a recent project as example, the Ronald McDonald House's RMHC (Kwun Tong House) Jockey Club Building, which fully complies with the Hong Kong fire code. Arup conducted an inclusive fire safety review for this project. We used 3D simulations to demonstrate potential fire safety challenges identified for all users, including children and individuals with disabilities. A tailor-made fire safety management plan, including personal emergency evacuation plans, was also provided, ensuring the best possible escape plan for those requiring special assistance. For this client, our efforts aim to improve their fire safety plan from level one to level two.

A vision for inclusive and sustainable infrastructure in East Asia

Arup advocates for the international standard of inclusive design by recommending the inclusion of evacuation lifts in all multi-level building projects in East Asia. Our vision is to promote independent evacuation routes for PRMs, enabling all of them to evacuate without assistance. This suggestion goes beyond elderly residences or hospitals, extending to major infrastructures such as airport terminals and train stations.

With the rapid development in East Asia, numerous new high-rise buildings and densely populated facilities, like integrated resorts, theatres, arenas, and exhibition halls, will benefit from accessible evacuation routes. This approach fosters a design that is both sustainable and inclusive, upholding the dignity and independence of all users.



RMHC (Kwun Tong House) Jockey Club Building is a 16-storey building, providing hostel accommodations and supporting facilities for families with sick children who often require extended stays in hospitals for necessary treatment

Connecting minds:

synergy on generative AI and knowledge management at AKIF 2024

Most Innovative Knowledge Enterprise (MIKE) winners from around the world united at AKIF 2024, with Dr Bernard Chan (front row, fourth from left) as guest of honour

In March 2024, East Asia Arup University hosted the Asian Knowledge and Innovation Forum (AKIF) in joint effort with The Hong Kong Polytechnic University (PolyU). The two-day event brought together professionals from management and organisational development fields, creating a unique platform for sharing knowledge, expertise, and innovative strategies.

The central theme was generative AI, a technology poised to revolutionise knowledge management and innovation. Dr Bernard Chan, Hong Kong's Under Secretary for Commerce and Economic Development; Michael Kwok, Arup's East Asia Region Chair; and Professor Wing-Tak Wong, Deputy President and Provost of PolyU graced the event with their presence.

Distinguished speakers from academia, and commerce, including Arup's East Asia Data & Analytics Skills Leader Kevin Ip, shared insights on generative AI. They explored its ethical implications, impact on knowledge management and learning, and application of large language models.

Kevin Ip from Arup sharing the application of large language models in knowledge management

Following the keynote speeches, Arup's Senior East Asia Innovation Manager Jasper Hilkhuijsen led a mini workshop on generative AI. In this workshop, participants explored AI's impact on knowledge management, discussing both benefits and concerns from organisational and end-user perspectives.

The event also celebrated the Global and Hong Kong Most Innovative Knowledge Enterprise (MIKE) Award 2023. Co-organised by Arup, MIKE Award recognises organisations for their exceptional innovation in leveraging knowledge to create, valuing their efforts in implementing good practices in knowledge and intellectual capital management, which result in superior products, services, and solutions. During the event, winning companies from Hong Kong and rest of the world came together to showcase their best knowledge management practices. The first day concluded with innovation tours to Hong Kong Science and Technology Park, Microsoft, and Towngas, providing attendees with a firsthand experience of cutting-edge technology and innovative practices in action.

Mini workshop on generative AI held by Jasper Hilkhuijsen from Arup University

Day two of the event featured a series of concurrent sessions, where experts shared insights on leveraging AI in knowledge management, showcased successful business strategies from MIKE winners, and explored the future of knowledge management in the AI era.

Harnessing AI for enhanced knowledge management at Arup

Arup has been a key player in advancing AI-based knowledge management. Through the efforts of AKIF, we have diligently fostered connections among practitioners in the field of knowledge management, thereby improving information gathering, analysis, and decision-making processes.

Arup has also harnessed the power of generative AI, specifically a Retrieval Augmented Generation (RAG) application, to enhance our internal knowledge management. We faced significant challenges in efficiently harvesting and categorising knowledge from a large volume of documents in a complex folder structure. This made locating specific information a daunting task that was initially estimated to take six months manually.

By leveraging our RAG application, we reduced the time required for knowledge extraction to just one month. We successfully built a data ingestion pipeline as our project knowledge base for our RAG application. The knowledge base not only stores semantic meanings of words but also captures the contextual meaning of sentences, providing a rich understanding of our project data. The success of this tool opens up future potential for client rollouts.

See the event page for the list of MIKE winners

Participants joined tours to Microsoft (left) and Towngas (right)

Illuminating the path to the future:

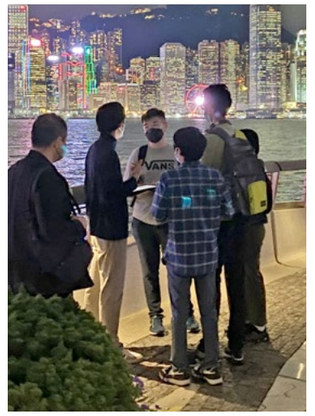
Expertise in lighting and landscape shared at the HKU common core curriculum

Arup is deeply committed to sharing its expertise for societal benefit and inspiring the next generation of engineers and students. This commitment is exemplified by the second episode of the common core programmes offered in collaboration with the University of Hong Kong (HKU).

Building upon the first episode's focus on nighttime lighting, Arup has enhanced the course by bringing in technical specialists from both the Lighting and Landscape teams. These teams work in tandem, particularly in the realm of open space design. With a holistic design mindset, Arup integrates landscape and lighting design elements to craft a multi-sensory and highly inclusive experience for the public. This total design approach not only enhances the aesthetic appeal of the spaces but also bolsters the city's resilience and vibrancy.

Practical learning for HKU students: fieldwork and data collection

In addition to a lecture at HKU, students were provided with hands-on opportunities to assist with fieldwork under the guidance of Arup specialists. Field surveys provided students with a deeper understanding of open space design. They collected data on various aspects of lighting (such as placement, illuminance level, and colour temperature) and spatial design (including seating availability, and pathway width).



Arup specialists lectured at HKU (left) and supervised students during field surveys (right)

Arup brings together its expertise in lighting and landscape to design open space that is safe, useful and welcoming to all

The field surveys were carried out in various categories of designed spaces, including parks, promenades, and commercial and residential plazas. Students were tasked with studying both a traditional and a contemporary space in at least two categories. Comparing the configurations of these spaces allowed students to understand the key considerations during the open space design process, such as accessibility, security, lighting levels, placement of lighting, paving width, greenery, and shading elements.

Through this hands-on experience, students realised the complexity of open space design, acknowledging that there were far more factors to consider than they initially anticipated. This course has garnered enthusiastic reviews from students, a number of whom re-enrolled in this course after completing our initial course on nighttime lighting.

Post-programme analysis: enhancing design workflow at Arup

Arup is dedicated to creating spaces that are accessible and enjoyable for all. Following the course, Arup has conducted a thorough analysis of data collected from field surveys. Workshops were held internally for analysis and idea gathering on how to improve the current design workflow, streamline the logistics of design, and foster collaboration.

Furthermore, utilising the four design considerations that guided students in designing the field surveys, Arup Lighting and Landscape teams developed a landscape-lighting design toolkit, which supports us to create designs that are more centred around human needs.

Arup's collaboration with HKU exemplifies its commitment to fostering a mutually beneficial relationship by nurturing students and enhancing its solutions through a comprehensive design approach.

Read the full story

Arup's vision for climate-resilient railways unveiled at Asia Pacific Rail 2024

At the Asia Pacific Rail 2024, Arup emphasised the need for climate-resilient railways. TC Chew, Arup's Global Rail Leader, discussed the next generation of rail infrastructure and the urgency of making rail networks resilient against climate change. Arup's *Rail Resilience Framework*, a proactive approach to resilience planning, was unveiled. The framework aims to enhance safety and reliability in daily rail services, highlighting the role of transport networks in driving economic growth and sustainable development. The event underscored Arup's leadership in the rail industry and their commitment to future-proofing railways.

Regenerative design: coexisting and coevolving with nature

Arup's Foresight team helps clients understand future trends and contexts with the use of strategic tools and creative techniques to identify opportunities for innovation. Its recently published report, *Regenerative Design: towards living in harmony with nature*, explores how we can restore planetary health and achieve positive outcomes for people and the planet. The report presents three principles: nature-led design, systemic relationships, and equitable change. It highlights examples of regenerative design in action and underscores our responsibility to participate positively in the natural system.

Read the full report

Read the full report

Hong Kong's decarbonisation journey: post-COP28 insights and future steps

Arup's position paper, *Post-COP28 – Decarbonising Hong Kong, lessons learnt and next steps*, underscores Hong Kong's potential to lead in reducing greenhouse gas emissions and adapting to climate change. The paper, drawing from the 'pre-COP28 Race to Transition Asia event series' and stakeholder interviews, highlights the city's achievements and areas for improvement. It suggests actions for stakeholders to accelerate decarbonisation, resonating with the COP28 mantra: Unite. Act. Deliver.

Acknowledgements

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