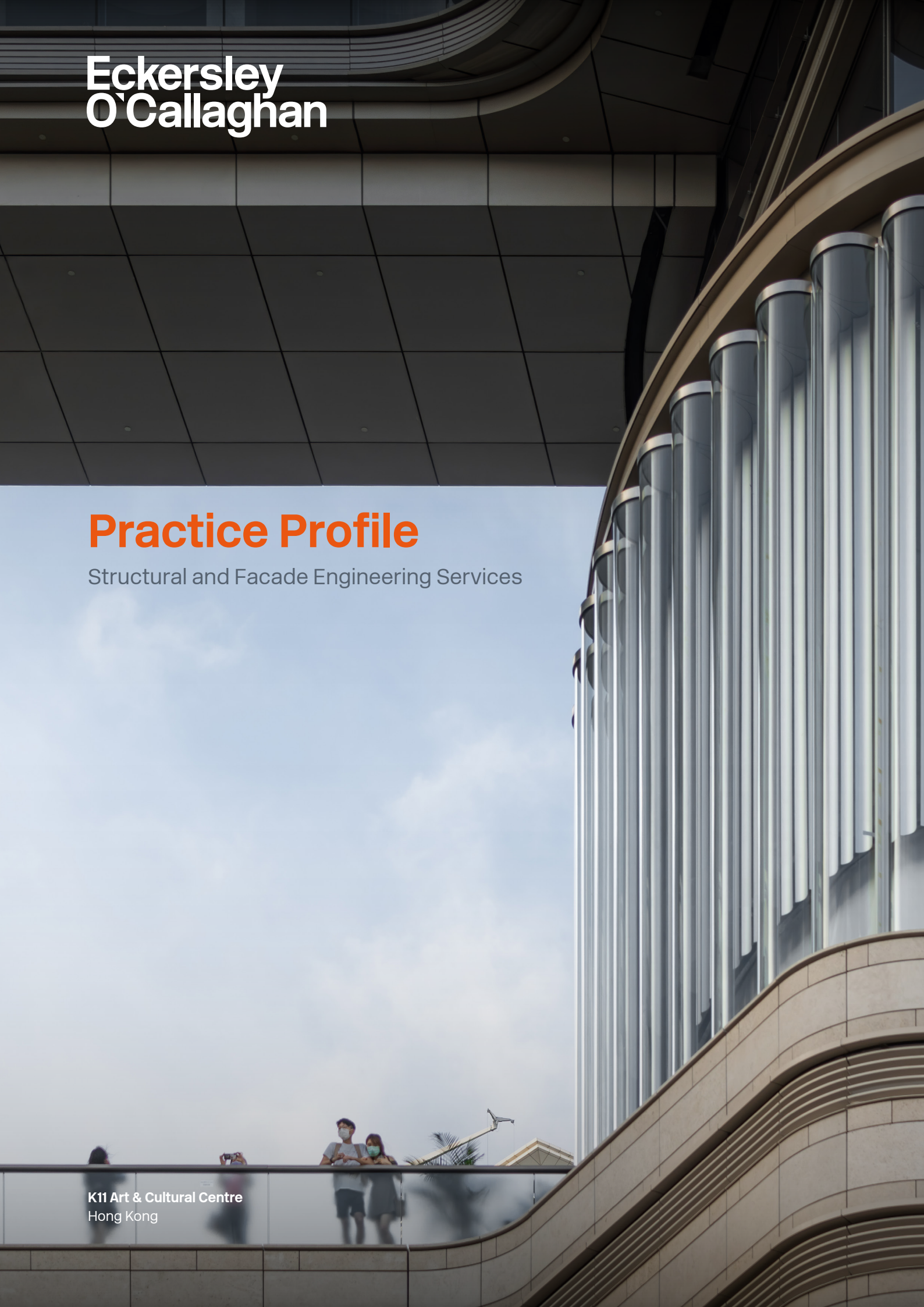
Eckersley O'Callaghan

Practice Profile

Structural and Facade Engineering Services



K11 Art & Cultural Centre
Hong Kong

Contents

About us

"In my experience, I have not come across another consultant engineer that can consistently deliver both the creative and technical integration of thought to yield the outcomes we have achieved."
BJ Siegel
Senior Design Director, Apple

Apple Causeway Bay
Hong Kong

Practice Profile

Eckersley O'Callaghan collaborates with visionary clients on state-of-the-art projects that push the boundaries of what is possible.

Since forming in 2004, our team has grown to 150 across offices in Hong Kong, Shanghai, Sydney, Delhi, London, Manchester, Paris, Milan, New York, Los Angeles and San Francisco.

We have established an international reputation for our creative, yet rigorous, approach to engineering structures and designing facades. We work on a range of extraordinary building projects across the world, from complex structures of timber, steel or concrete, through to bespoke glass designs and specialist heritage projects.

Our innovative work has received some of the highest accolades in the industry, and we are synonymous with pioneering new advances in design and engineering. Our engagement with architecture and industry underpins our pioneering use of materials to realise projects of exceptional quality, efficiency, and elegance.

Sustainable thinking informs all our projects, beginning at the earliest conceptual stages and continuing right the way through to completion.

Awards:

2022 Net Zero Team of the Year
Construction News Awards

2022 Facade Design and Engineering Awards, International Project of the Year, Innovation Award
K11 Art and Cultural Centre

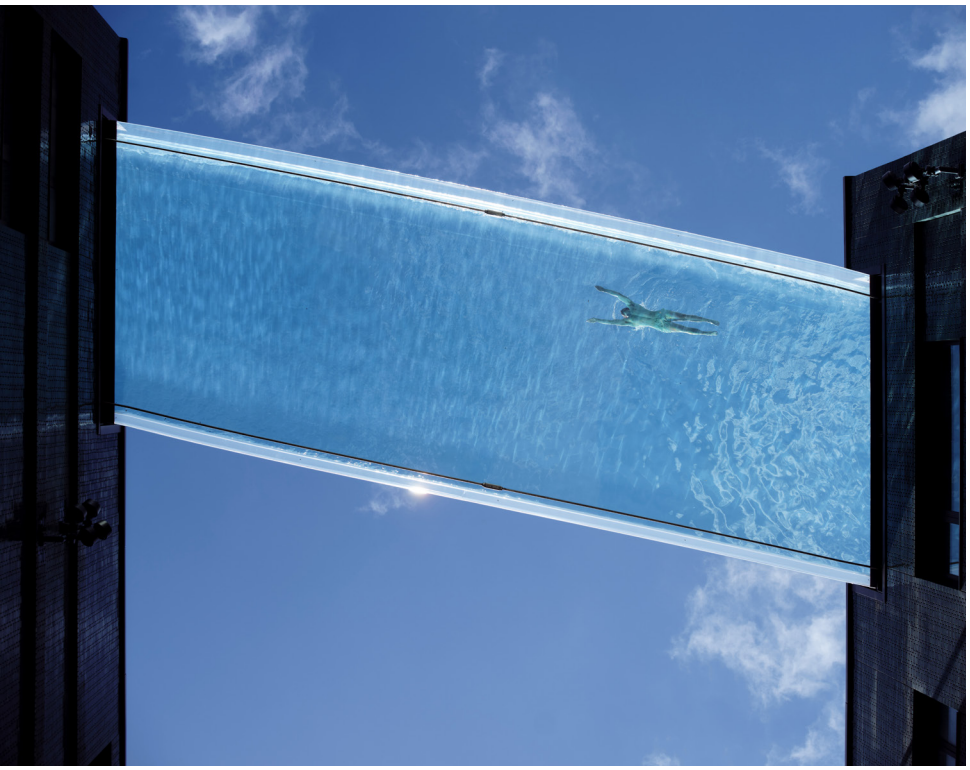
2022 IStructE Award for Transformative Sustainable Design
London South Bank University

2021 Holcim Awards for Sustainable Construction
Atlassian Central - Special Commendation

2019 IStructE Award for Sustainability
La Référence de Ganthier

2019 Construction Consultancy of the Year
Construction News Awards

2018 The Queen's Award for Enterprise
International Trade



Left:
Sky Pool is the worlds first transparent swimming pool suspended 10 floors up between two adjacent residential buildings

Top:
15m tall raised podium facade at Two Taikoo Place, Hong Kong

International Awards

180+
awards since formation

IStructE Awards 2022, Award for transformative sustainable design through minimal intervention - London South Bank University

Construction News Workforce Award - Net Zero Team of the Year 2022

Facade Design and Engineering Awards, International Project of the Year – Innovation 2022 - K11 Art and Cultural Centre

IStructE Award for Construction Innovation 2021 – Apple Marina Bay Sands

IStructE Award for Structural Transformation 2021 – Ashworth Centre and Library Extension - Lincoln's Inn Fields

Holcim Awards 2021 - Commendation - Atlassian Central

Holcim Awards for Asia Pacific 2020 - Bronze - Atlassian Central

RIBA National Award 2021 - Zayed Centre for Research into Rare Disase in Children

AJ Retrofit Awards 2021 - Listed Building £10m and over – Ashworth Centre and Library Extension - Lincoln's Inn Fields

USA Property Awards, Best Architecture Single Residence USA 2020 - Tuscaloosa

AIA New York's 2020 Design Awards - Architecture Merit 2020 - Manhattan West

AEI Excellence Award in Architectural Engineering Integration 2020 - Manhattan West

IStructE Award for Sustainability 2019 – La Reference

World Special Prize Exterior Award, Shops & Stores Category 2019 – Apple Piazza Liberty

World Prix Versailles Award, Shopping Malls category 2019 – Coals Drop Yard

Construction Consultancy of the Year, Construction News Awards 2019

RIBA South Building of the Year Award 2019 – Beecroft Building

RIBA South East Award 2019 – Sevenoaks STC

RIBA London Award 2019 – Alleyn's School Lower | South London Gallery | Coals Drops Yard

Queen's Award for Enterprise: International Trade 2018

IStructE Award for Structural Artistry - Steve Jobs Theater 2018

RIBA National Award 2018 - Freemen's School Swimming Pool

Structural Timber Awards, Education Project of the Year 2018 – Freemen's School Swimming Pool

RIBA South East Sustainability Award 2018 - Freemen's School Swimming Pool

Engineering Consultant of the Year 2016, Building Awards

RIBA National Award 2016 - Investcorp Building

WAF Awards, Higher Education and Research Building 2016 – The Investcorp Building

RIBA North West 2016 – Library Walk

Engineering Consultancy of the Year 2015, Construction News Awards 2019

IStructE Supreme Award for Structural Engineering Excellence 2014 - Apple Zorlu

British Glass Industry, Innovation Award 2014 – Eckersley O'Callaghan

AIA SF Merit Award 2014 – Apple Stanford Mall

WAN House of the Year Award 2013 – Gota Dam Residence

Queen's Award for Enterprise: Innovation 2011

Design Award, Tri-States Design Conference 2011 – Apple Covent Garden

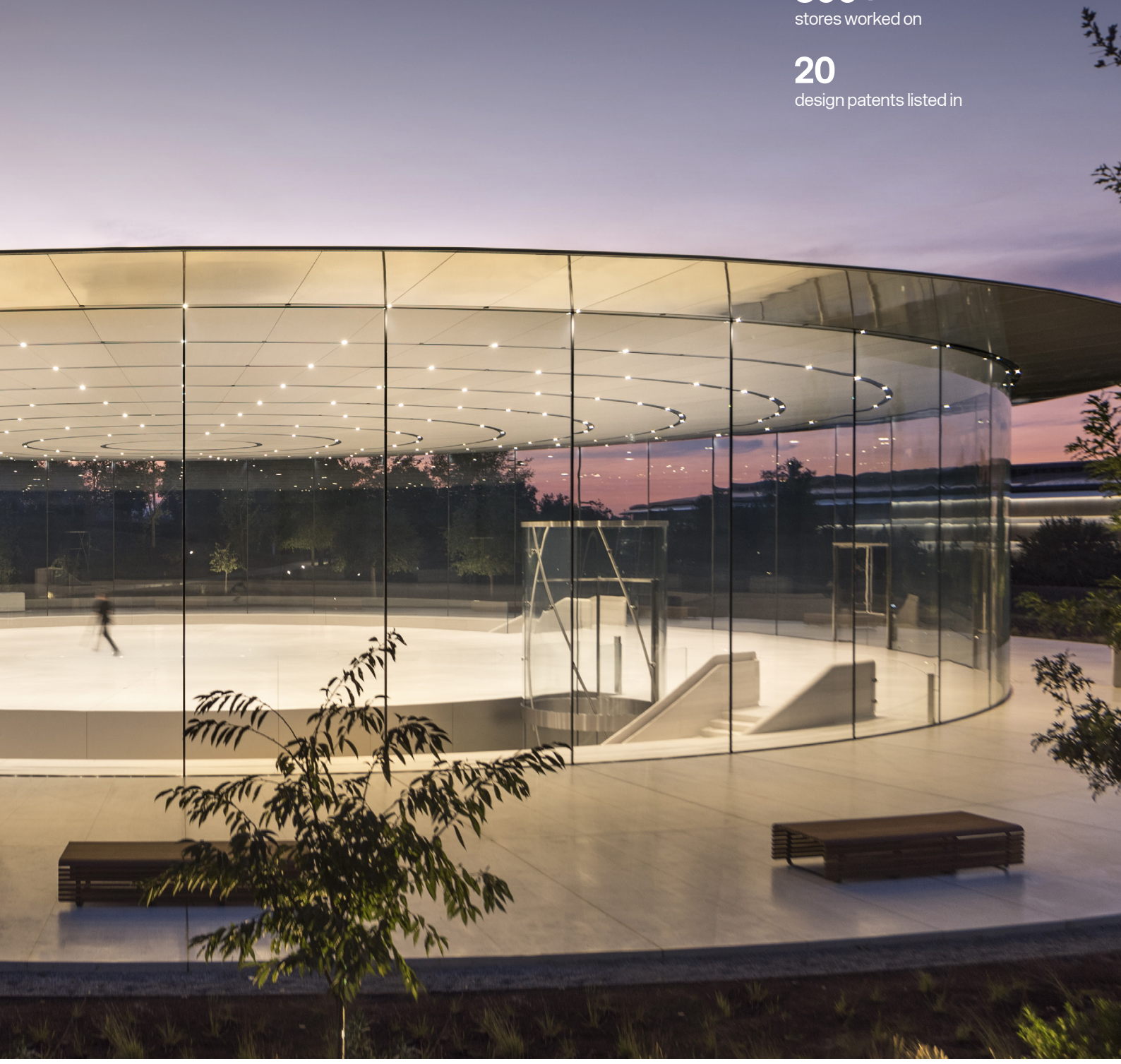
AIA SF, Merit Award 2011 – Apple IFC Shanghai

Expertise

20 year+
collaboration with Apple

300+
stores worked on

20
design patents listed in



Steve Jobs Theater
California, US
IStructE Structural Artistry Award 2018
SentryGlas Innovation Award for Engineering 2018

Working in Hong Kong and across Asia

Eckersley O'Callaghan has over 15 years of experience working in the region.

Hong Kong
Since our first project in Hong Kong, the Apple store in IFC Central, our work has expanded considerably in scale and range. We have been entrusted with some of the highest profile building projects in Hong Kong in recent times including The Henderson, Two Taikoo Place and Apple Causeway Bay.

Our clients include Swire Properties, New World Development, Henderson Land, Hongkong Land, Nan Fung as well as the Architectural Services Department. We have established ourselves as a high-quality engineering consultancy in the market with a focus on facades and feature structures for architectural projects. Our Hong Kong office balances progressive engineering solutions with local compliance and practices in mind, able to draw on the expertise across our international network in a one company approach.

From the 15m tall frameless glazing utilising pre-tensioned rods at Two Taikoo Place and Hong Kong's only closed cavity facade at K11 Musea Art & Cultural Centre, to the curtain wall at 64-70 Wellington Street and multiple facade systems at the Expansion of HK Science Museum and Museum of History; we are equally comfortable engineering both highly bespoke and conventional façade systems which benefit from committed design thinking and attention.

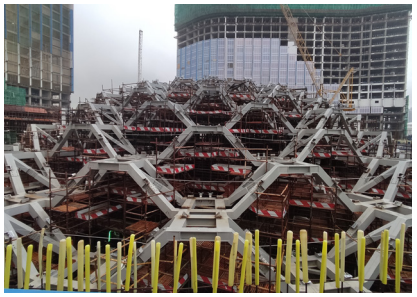
We offer full scope engineering consultancy and specialist scope for features including peer reviews. Our team is highly experienced at preparing Buildings Department submission packages and successfully securing their approval. We provide factory visits and site monitoring, or enhanced QA/QC attendance if required.

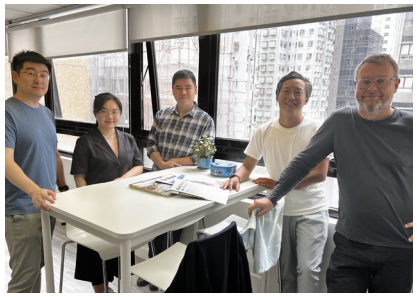
Mainland China and across Asia
From our Asia base in Hong Kong, we service a wide portfolio of projects in Mainland China, Macau, Taiwan Singapore and South East Asia.

We have a registered Shanghai business which allows us to contract with Mainland Chinese clients. We have worked on over 35 projects in Mainland China including all flagship Apple stores, the curtain wall for the Shum Yip Upperhills towers in Shenzhen and major new retail development in Hainan.

Eckersley O'Callaghan Hong Kong Projects

1. Apple Canton Road
2. Apple IFC Central
3. Apple Causeway Bay
4. Repulse Bay
5. K11 Museum Mall
6. Taikoo Place
7. Avenue of Stars
8. The Henderson
9. 64-70 Wellington Street
10. Expansion of Hong Kong Museums of Science and History





Top Left:
Director Yanchee Lau presenting at ZAK World of Facades HK

Top Centre:
Construction at The Henderson Banquet Hall

Bottom Left:
Steelwork at Galaxy Macau Feature Dome

Bottom Centre:
Eckersley O'Callaghan Hong Kong team

Facade Engineering

Our facades group takes a holistic approach to design and engineering, working from a first principles approach.

As building envelope design becomes more complex due to increasingly stringent energy requirements and material and technological advances, Facade Engineers have assumed a central role in architectural and engineering design teams in recent years.

We offer a full service approach to facades in all material types, using standard or bespoke systems, delivered either as performance-specified or fully detailed design. In addition to structural design and system detailing, we have the tools to assess the facade energy performance and ensure compliance with efficiency targets. Additionally, we maintain a close relationship with industry suppliers to ensure we are aware of the latest technology in materials, manufacture and performance. As a practice, we take a very sustainable approach to design and at the core of this is the re-use of existing buildings. We therefore offer a comprehensive service of existing facade condition survey and reporting, in which condition and remedial works required can be identified and specified. Beyond that, entirely new facade systems can be designed and specified that can be compatible with the existing building structure, giving the building a new sustainable lease of life.

The breadth of our expertise across the discipline includes detailed environmental analysis. This supports our ability to engineer building envelopes that fully, and efficiently, meet all performance criteria.

Left:
Two Taikoo Place, Hong Kong

Top Right:
K11 Art & Cultural Centre, Hong Kong

Bottom Right:
The Henderson Banquet Hall, Hong Kong

Glass Engineering

We are one of the world's foremost engineers and innovators in the field of glass structures.

Our glass projects range from spectacular staircases to some of the world's largest and most iconic glass structures. Many of these projects have pushed forward the boundaries of what is possible in structural glass. Our relationship with Apple spans over 15 years where we have provided engineered over 300 retail stores and are listed in over 20 design patents.

Our services range from conceptual design commissions and assisting specialist fabricators and contractors, through to carrying out detailed design and full concept design to completion services for clients.

We use a rigorous approach to structural analysis making use of the latest digital design tools. Through our detailed analysis of material behaviour, we are able to refine solutions to appear simple, elegant, and effortless.

We are particularly adept at justifying innovative glass structural designs through the various, and often complex, building department requirements specific to the numerous countries we have worked in. We have been invited to sit on many of the standards committees formed around the world to develop more universal codes of practice governing the design of structural glass.

In 2010, our work in glass was recognised with a Queen's Award for Enterprise: Innovation by HM Queen Elizabeth II.

Top left:
The Henderson Banquet Hall, Hong Kong

Top right:
Apple Fifth Avenue, New York, US

Bottom left:
Apple Jiefangbei, Chongqing, China

Bottom centre:
K11 Art & Cultural Centre, Hong Kong

Bottom right:
Apple Amsterdam, Holland

Structural and Civil Engineering

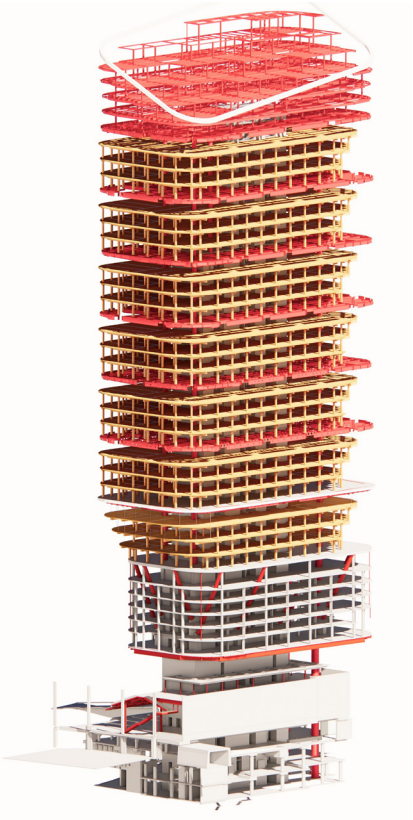
We approach our work by fully interrogating all structural options to identify the most efficient, economic and elegant solutions.

Our work covers all structural materials, traditional and non-conventional. We aim to provide clear options which address the parameters defined by the project and its architecture. Our team is a blend of both analytical and creative engineers, who can make pragmatic decisions as well as design refined details, enjoying a collaborative approach within a design team and beyond with the contractors.

We place high priority on our responsibility to help tackle the Climate Emergency and are committed to promoting low-carbon building design where we have developed a toolkit to monitor the carbon footprint of our design proposals. We have been at the forefront of modern timber design, utilising mass timber, Cross Laminated Timber (CLT) and highly engineered timber in a number of our built projects.

Projects might be in the context of new-build, or refurbishment and restoration of traditional and historic buildings. The extent of our involvement may be to provide creative conceptual design, more detailed work for bidding and tender, or for full input through construction of a project.

We engage with digital design tools and BIM, which are embedded in our workflow. These processes allow us to uncover efficiencies, improve decision making, fully integrate our structures, and enhance delivery. We believe that digital design tools are key to successfully realising intelligent engineering solutions for complex challenges.



Top left:
Tropicalia,
Côte d'Opale

Bottom left:
El Gouna Cultural and Conference Centre, Egypt

Right:
3D model of hybrid timber tower Atlassian Central, Sydney

Building Information Modelling

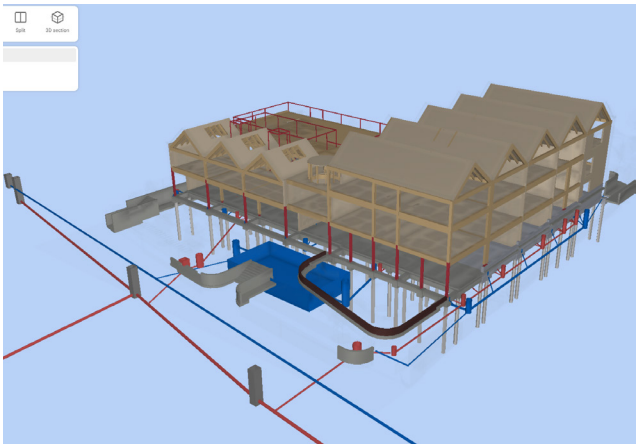
We see BIM as inherently integrated into the way we work, playing a vital role in any building project that we engineer.

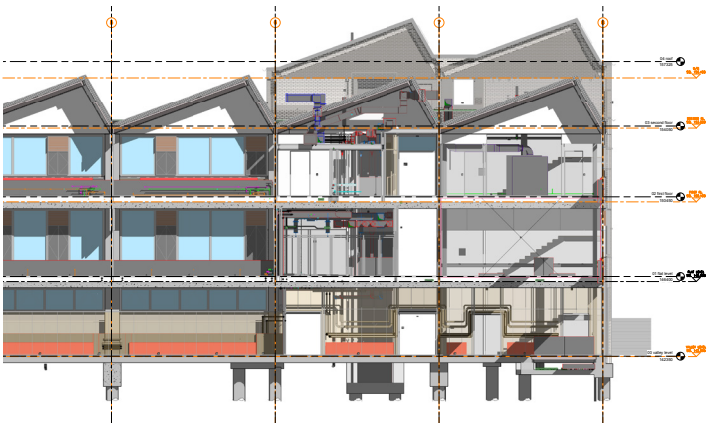
Our expertise in BIM enhances design quality through better collaboration, communication and coordination. It enables us to visualise, explore and integrate all the requirements of the project team to produce efficient engineering solutions for the full life cycle of the building. The BIM model is developed as an information-rich asset for the client.

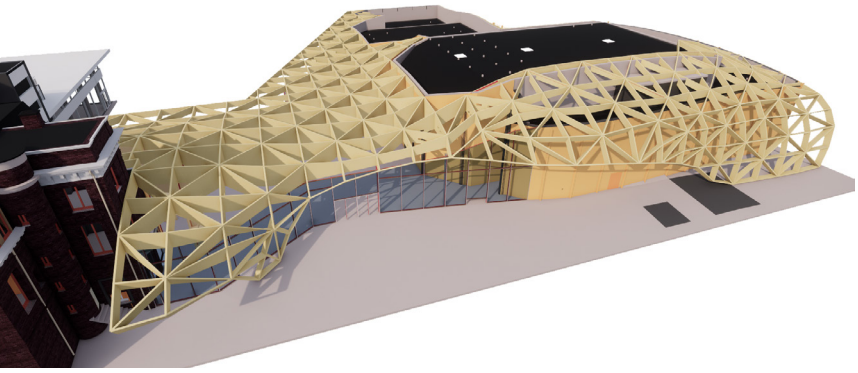
We were early adopters of the BIM approach. We achieve BIM Level 2 as standard - the exchange of CAD models between consultants for combining into a federated model which can be checked and coordinated. We can tailor our service to meet the specific requirements of each project.

Our design process incorporates analysis software which are seamlessly conversant with Revit. Working in conjunction with our bespoke digital design tools, we bring value in our workflow to uncover efficiencies and better solutions. We aim to distil potential complexity into simpler, more rational solutions with buildability, cost and programme benefits.

We use Autodesk Revit as one of our primary tools for delivering BIM. We integrate and exchange smoothly with Revit as well as numerous other packages as required by each project.







Top left:
Advanced BIM modelling allows our engineers to strip back or combine and review individual or multiple layers of the building make-up such as the timber building structure and foundation design displayed here

Top right:
Building section view of integrated MEP services and structural model

Bottom:
Timber gridshell form of Trinum - Mediatheque for Digital Culture in Lomme, France.

Our Strengths

In-depth Material Knowledge

As facade engineers our role to assist in material selection, system detailing and specification to ensure that the facade design is developed to satisfy both the architectural intent and the technical performance requirements. Central to this is working closely with both the architect and industry to research and identify appropriate materials that satisfy the design intent in terms of appearance, geometry and form.

Our team has expertise and delivered project experience in a range of facade materials, including

- Glass and aluminium
- Stone
- Terracotta
- Brickwork
- Timber
- Precast, UHPC and GRC
- Carbon fibre and GFRP

Terracotta

Timber

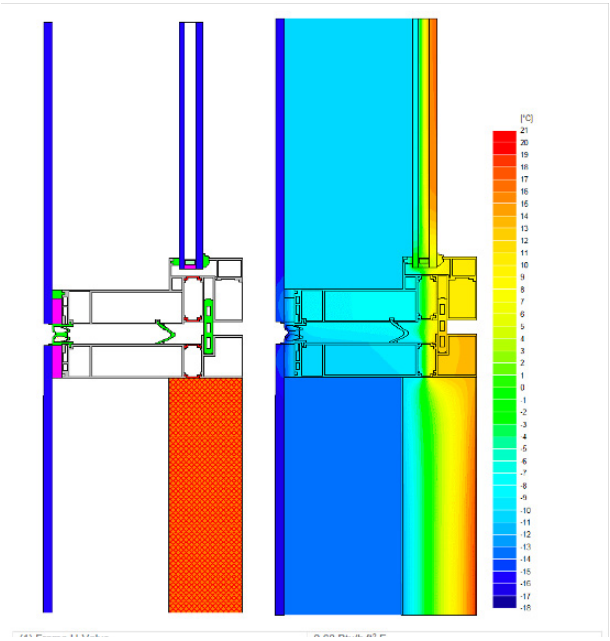
Stone

Rigorous Engineering

Building on our reputation for innovation in structural engineering and glass design, our engineers test concepts analytically and with an in-depth knowledge of engineering principles rather than reyling on simple rules of thumb or past experience. We take pride in our rigorous approach and pre-engineer the facade systems to give us a level of comfort that the final working designs prepared by specialist contractors are deliverable.

Our engineers work across a range of software platforms and are adept at covering the full scope of design challenges involved in facade detailing and design:

- Structural design
- Thermal calculations: U-values, psi-values
- Thermal bridging: 2D and 3D
- Glass design
- Thermal stress analysis
- Heat build-up in shadow boxes



Top left:
Great Ormond Street Hospital

Top centre:
The Black & White Building, London

Top right:
Novartis Institute, Cambridge MA

Bottom :
Thermal Bridge analysis of heat build-up over time in a closed cavaity double skin facade

Buildability

We are very focussed on buildability and procurement, always developing facade system proposals with full consideration of how it will be assembled and installed. This leads us to carrying out option studies on alternative forms of construction and advising the client, architect and cost consultant on the relative benefits of each.

Where appropriate we champion Design for Manufacture and Assembly (DfMA) principles and look to preassemble systems in a controlled environment to improve quality and performance. We collaborate with partners throughout the supply chain - from building owner, to main contractor, to specialist subcontractor - and apply the insights gained to all our projects.

Below:
Construction option studies for a brick, precast and window facade system

Hand laid brick with full span structural precase beam

Hand laid brick with precast rainscreen

Sustainability and building retrofit

We place a high priority on low-carbon building design whether in retrofitting existing building stock or creating the next generation of net-zero or energy-positive buildings. In both cases innovative facade design of exceptional quality is a fundamental ingredient.

High performance facades for net-zero buildings

Net-zero energy buildings require highly insulated facades that reduce the need for mechanical heating and cooling. Using software tools built in-house, we have the capacity to design and deliver high-performance facades through:

— U-value assessment and thermal bridging analysis
— Solar shading optimisation
— Daylight evaluation and glare mitigation
— Detailing for good air-tightness

Embodied carbon evaluation

The external building envelope can make up to 15% or more of a building's embodied carbon in initial construction. Minimising embodied carbon requires selecting materials with a low carbon footprint and ensuring that these materials have a long service life.

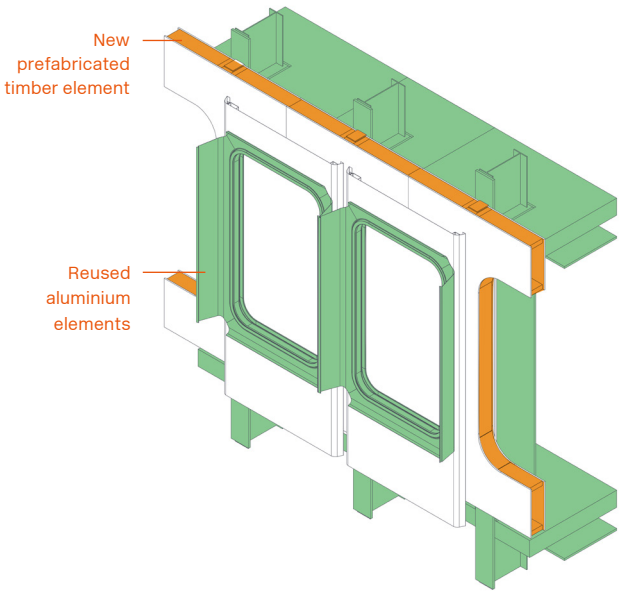
We carry out assessments on all our facades to present our clients with options for reducing embodied carbon. This goes hand in hand with responsible sourcing of products and ensuring healthy materials are specified.

Building retrofit

The reuse and improvement of existing buildings is in many cases a more favourable option than demolition and new build. However, components of a facade are often beyond their design life and need to be upgraded or replaced to make retrofit work from a comfort and energy use standpoint.

We have extensive experience in upgrading existing buildings through facade retrofit and upgrade projects. We design facades that maximize the qualities of their environment to provide optimal energy performance. This involves thermal, solar and finely detailed light analysis. We minimize material quantities, and when working with existing buildings, we seek to identify whether it is possible to repair, renovate, reuse and extend the life of the existing facade rather than building it a new.

65%
reduction in carbon emissions due to material reuse and recycling and use of a bio based system



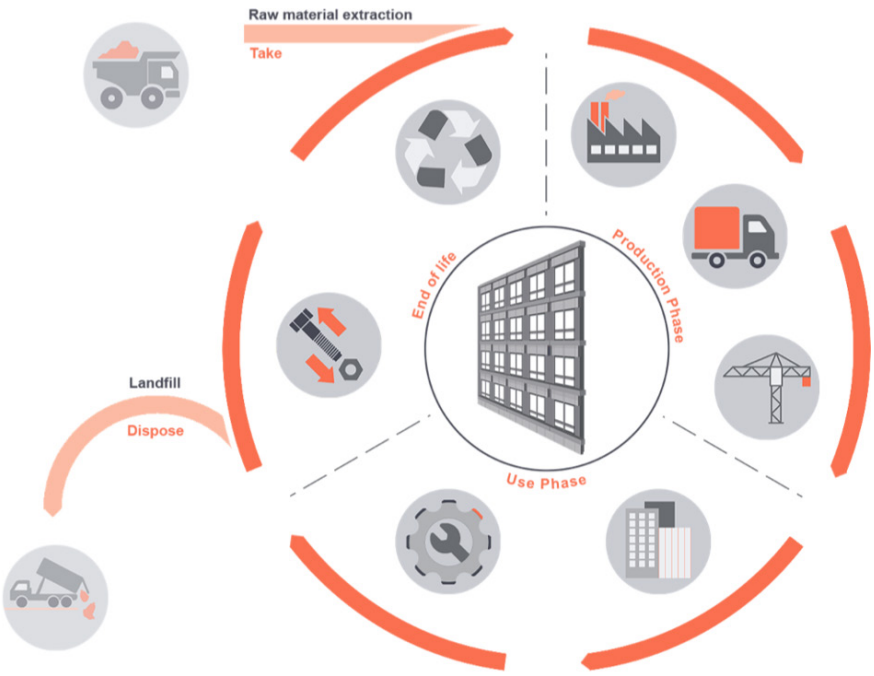
Top left:
UNESCO in Paris forms a pilot circular project of cladding reuse and glass recycling

Bottom left:
Facade glazing panels are knocked out from frames to provide high quality cullet with low contamination risk

Right:
The new facade will incorporate both new materials and retain existing elements of the cladding

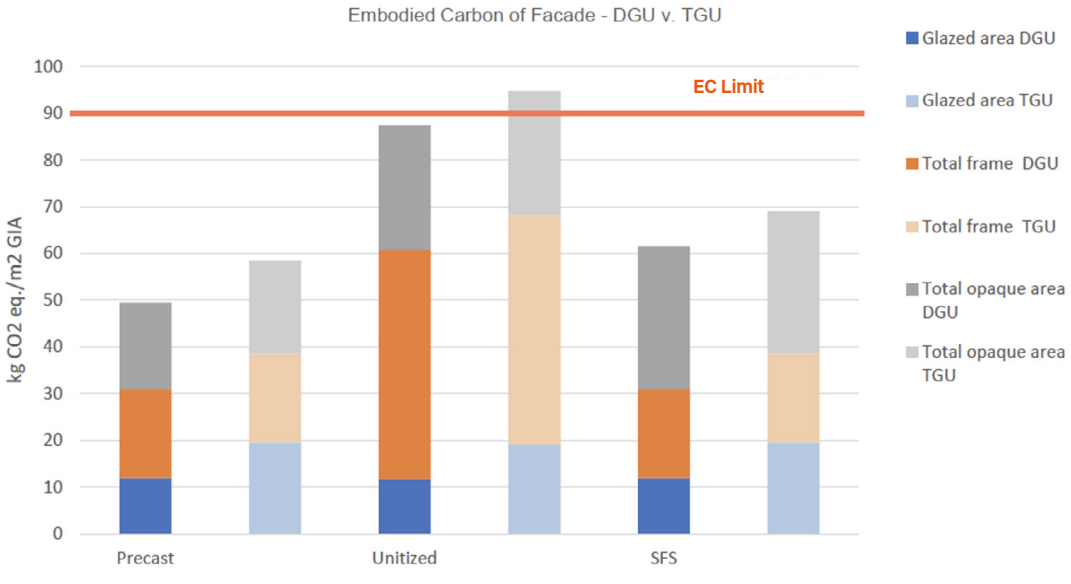
We prescribe low-carbon, biobased and geosourced materials with high recycled content and design “layered” systems that can be easily disassembled. This will allow future adaptation or easy future reuse, to eventually transform buildings into real “banks of materials”.

Diagnostic studies
We help implement circular economy strategies by identifying opportunities for repair, reuse and recycling. We do this by carrying out diagnostics of existing facades and structures and pre deconstruction studies.



Circularity Principles

A modern facade is made as a kit of parts, with each component having a different lifespan simply stopping materials going to landfill doesn't go far enough and why we should be thinking more about the circular economy of facades by designing systems that can be dismantled and each component reused or repurposed.



Embodied carbon

Embodied carbon assessments are performed on all of our facades to ensure we select the most sustainable option

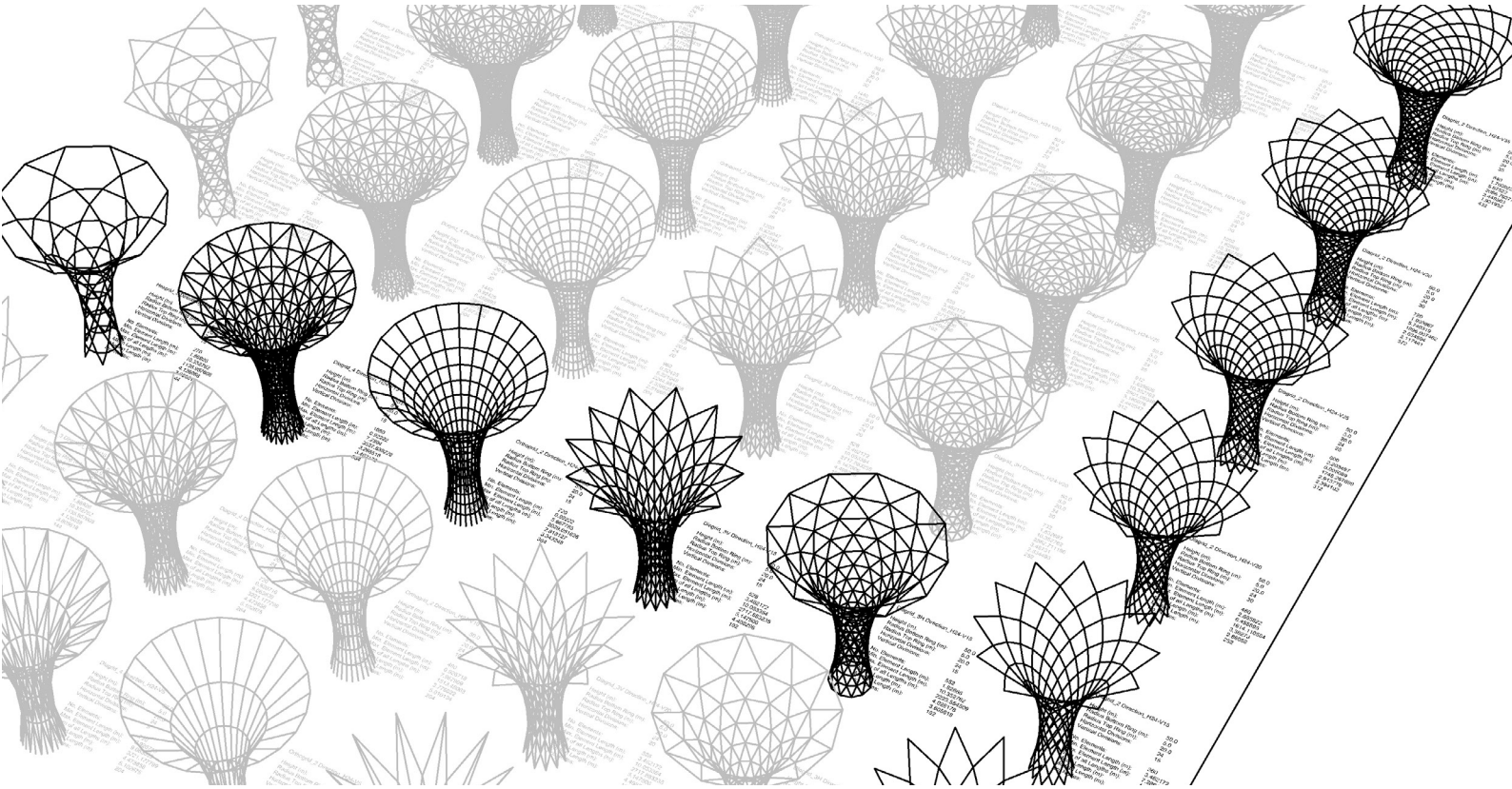
Digital Design

Our leading digital design and skills mean that we can work faster and leaner giving more time to explore options and refine the design.

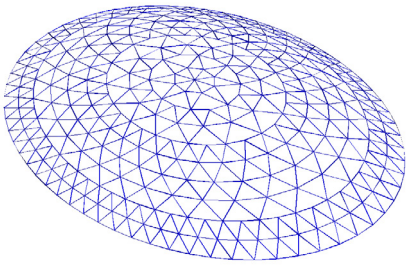
The days of using digital design to simply form find geometry are gone. Through focusing on research and development, we have taken each and every aspect of a building's design and embedded digital design at its heart. From the workflow between disciplines and stages, rationalising geometry, structural optimisation and environmental modelling.

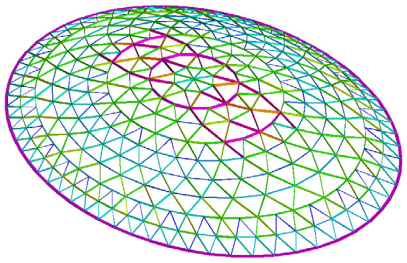
These tools bring value at all stages of a project – from rapid generation and assessment of more concept options, optimising material usage and integration with building services at detailed design stage and extracting digital information to streamline the fabrication process. The information we produce can then be used to maintain a building throughout its lifespan.

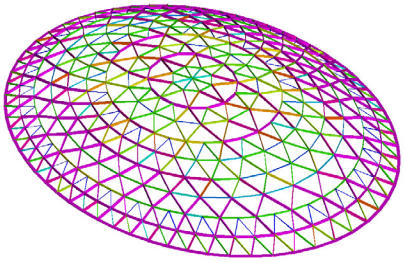
Our Digital Design specialists lead the way in the development of tools and tackle some of the most complex challenges but our engineers regard digital design as a fundamental skill throughout the teams.



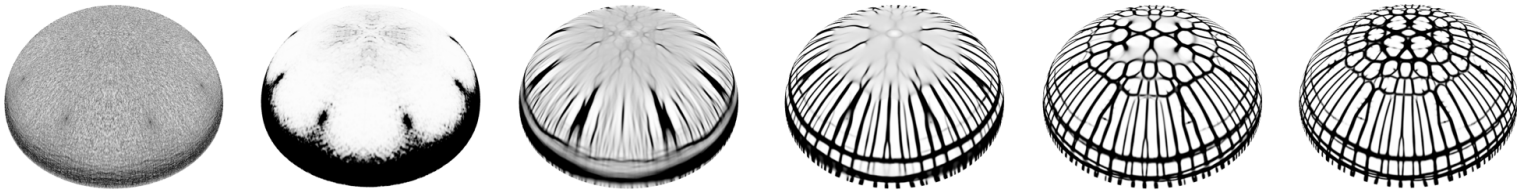
Parametric grid options
Exploring different structural steel column topologies







Automated beam sizing
Used during schematic design to control natural frequencies for a 40m glazed dome on a P&O cruise ship.



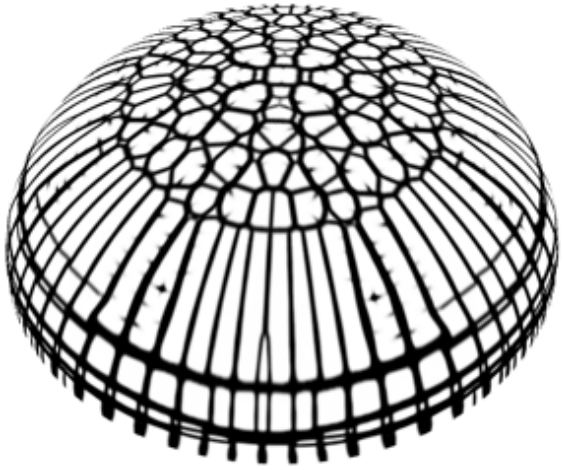
Structural Optimisation

Our digital design services encompass the world of structural optimisation, the holy grail of engineering design - the use of material, only where it is needed.

We use our bespoke computational design tools to find best fit beams and columns depending on their loading, span and support locations.

Our choice of element sizes – panel thickness, beam and column sizes - all have a cost and embodied carbon implication. These digital tools now allow us to solve problems which were previously only accessible from inefficient, monotonous repetition.

Applied early on in the design the benefits which this can bring are numerous; structural weight or cost reduction, increased environmental performance and user comfort, overcoming fabrication limitations, eliminating structural dynamic or frequency issues.



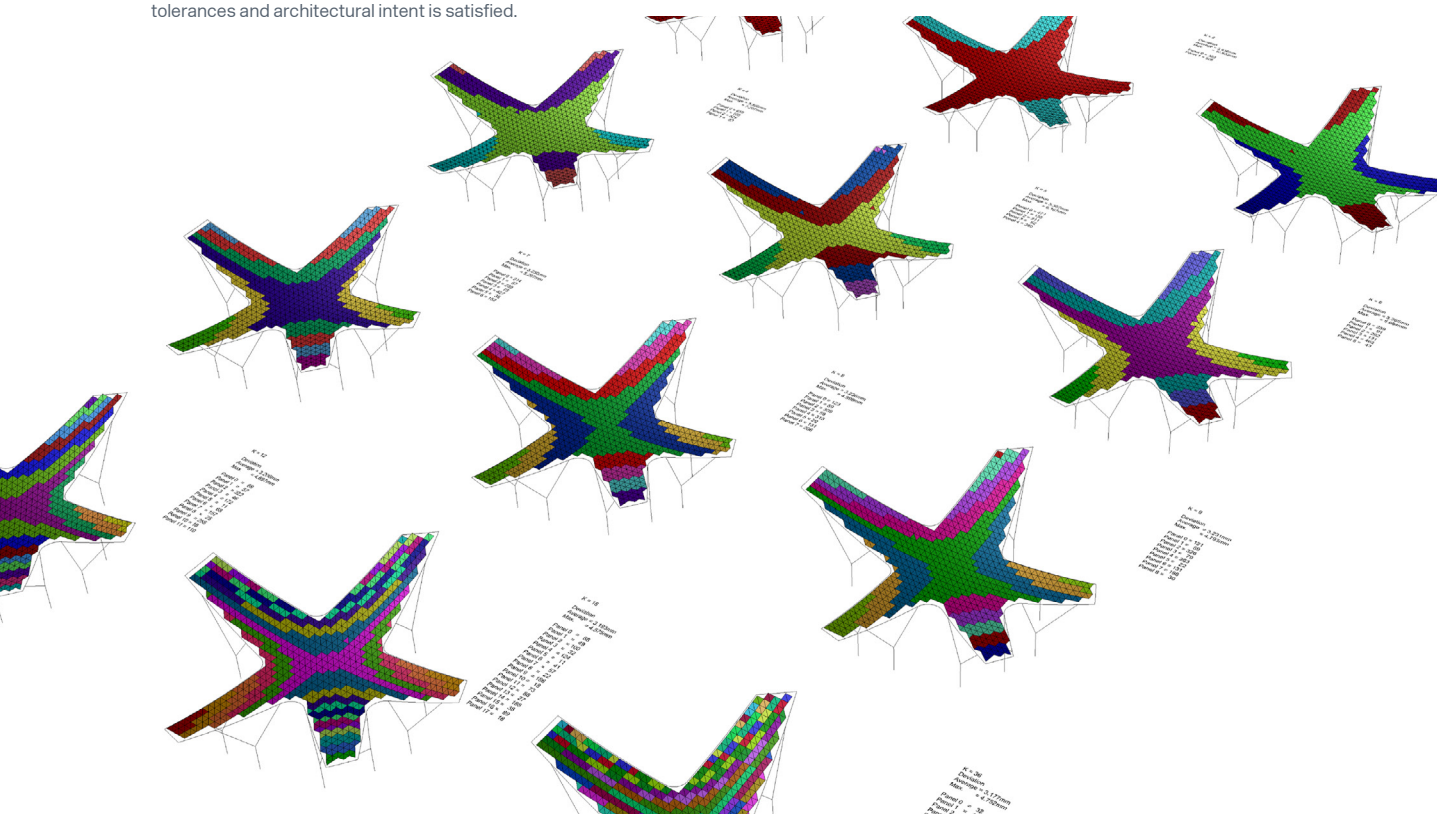
Typology optimisation
Studies carried out to identify efficient structural layout of a steel gridshell dome using topology optimisation

Parametric Workflow

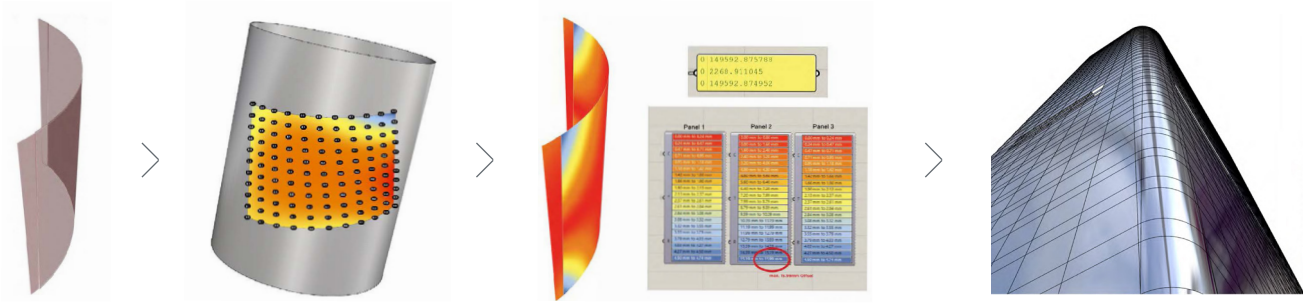
One of the most powerful forms of digital design is simply our ability to use parametric modelling at an early stage of the design process to respond to design changes quickly and explore more options during early design stages.

Our parametric workflows are enhanced by in house developed, custom tools which give us seamless interoperability between geometric modelling software and our FEM analysis package of choice.

Panel Clustering
Clustering algorithms are used to identify how many unique panels can be fabricated to reduce production complexity and cost whilst ensuring tolerances and architectural intent is satisfied.



Geometric optimisation studies
Conically curved corners



Original conical panel

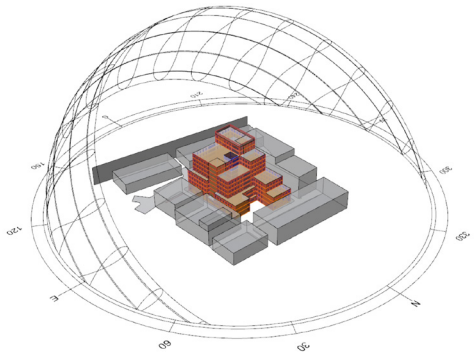
Optimising cylindrical panel:
— Radius
— Orientation of panel
— Cutting shape
— Differences between conical/ cylindrical surfaces

Rationalised glass facade geometry

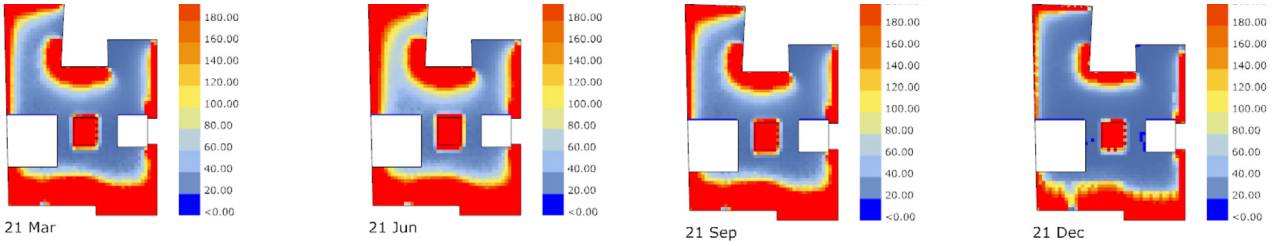
Environmental Modelling

Understanding how we can harness the best and mitigate the worst of the external environment's influence on the internal is a challenge we are strongly embracing. Every building's location and orientation is unique so this requires digital design tools to analyse the specifics of a site and building.

We aim to create facades that balance spilling natural daylight deep into buildings whilst also limiting excess heat loss or gain. Such competing demands on a facade result in very complex calculations to identify the technological 'sweet-spot', requiring digital design tools to gain the necessary intelligence to tune our facade designs to achieve the best outcome for the building users.

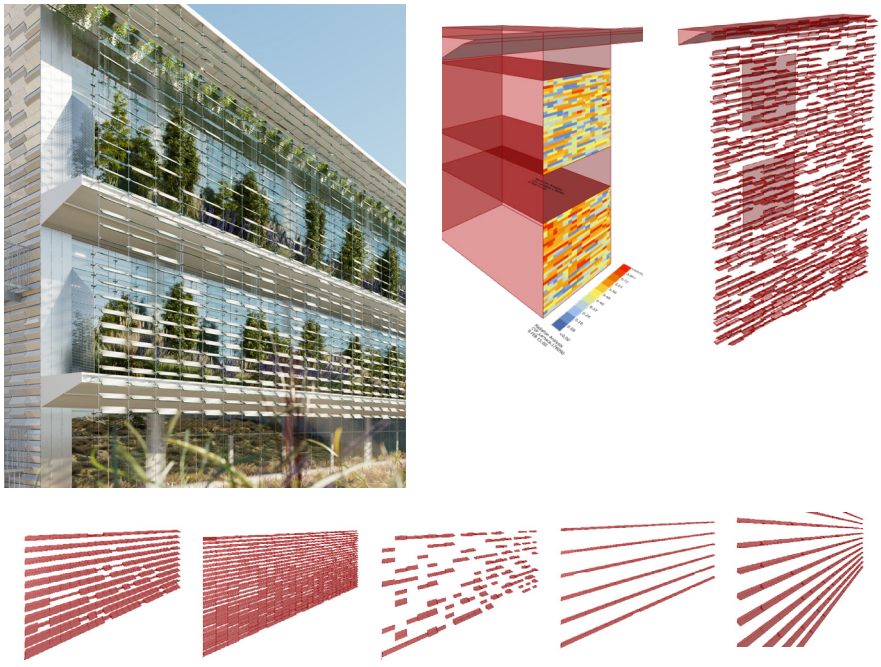


Sunpath analysis
For the daylight study of office building against WELL Gold criteria



Daylight study
For an office building against WELL Gold criteria

Net zero facade
Refurbishing a 1960s office to meet the Green New Deal



Optimisation studies
Optimisation of size and shapes of glass louvres to minimise solar heat gain whilst maintaining high quality daylight inside

Research & Development

We are committed to advancing structural and facade engineering through Research & Development.

Our commitment to research and development is second to none. Annually, we reinvest 10% of our profits in research, while each of our engineers is given a minimum of two hours every week to work on research projects.

We regularly present and publish at technical and scientific conferences around the world, with our new innovations often referenced as landmark precedents. Our ongoing relationship with Apple began in 2004 where we are now listed on over 20 design patents for our pioneering structural glass solutions.

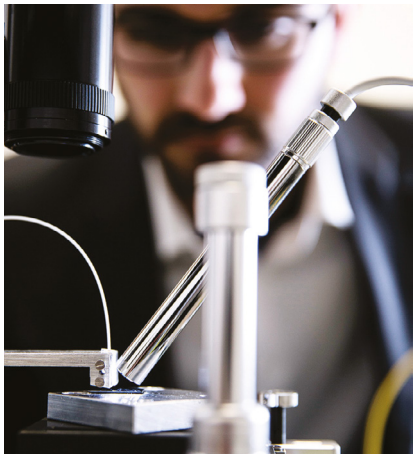
A team dedicated to providing R&D services provides innovative solutions to our clients, including the optimisation of analysis approaches, development of new materials, fabrication and construction techniques, optimising processes and identifying market needs.

Currently our key R&D focus is sustainability and the climate emergency. Our strategy and activity in this area is focussed on developing innovative tools, workflows and products that contribute to the decarbonisation of the construction industry.

This focus has included the development of a REVIT plugin called **EOC ECO$_2$** which we have released to peers and colleagues across the design and construction sector. It's a bolt-on piece of scripted software which gives a breakdown of the embodied carbon output for the structural materials used in a building. In recognition of this we were awarded the Net Zero Team of the Year Award at the Construction News Awards 2022.

"They took the higher ground and have shared their software free of change which is now used by over 120 organisations globally. They adopted a truly inclusive approach. Science backed information is at the core of their mission."

Judges comments
Construction News Workforce Award
Winner of Net Zero Team of the Year



Left | middle:
R&D project with Bodle Technologies to laser construction information almost invisable to the eye on the surface of a glass panel. Crucial information about the type of glass, composite, coatings, frits, when and where it was made will aid demolition contractors to reuse or recycle the glass

Right:
Each year an away day is held to discuss, develop, innovate and set new R&D

Climate Action

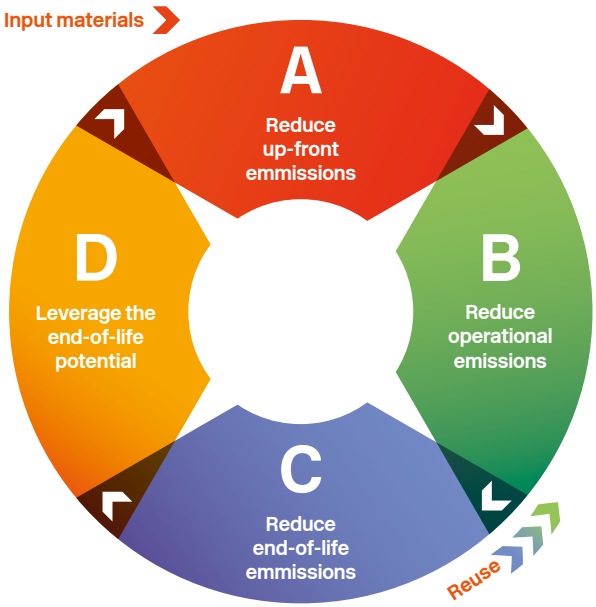
We are pioneers in our field committed to tackling the Climate Emergency by promoting sustainable use of materials, implementing and embedding circularity, resilience and reduced operational carbon into our designs.

We have an integrated design approach to our projects, where we put as much effort into addressing the challenges of climate action as we do to produce fine and efficient designs as well as realizing architectural ambitions.

We approach the sustainability of our projects through the lens of Sustainable Life Cycle Analysis aiming to reduce a projects impact throughout its lifecycle by; reducing immediate, in-use, end of life emissions and leveraging end of life potential.

This approach this allows us not only to tackle the paramount issue of embodied carbon but also incorporate wider sustainability issues such as; resilience, circularity and user comfort. Through this approach we can reach positive and sustainable results at each stage of a project.

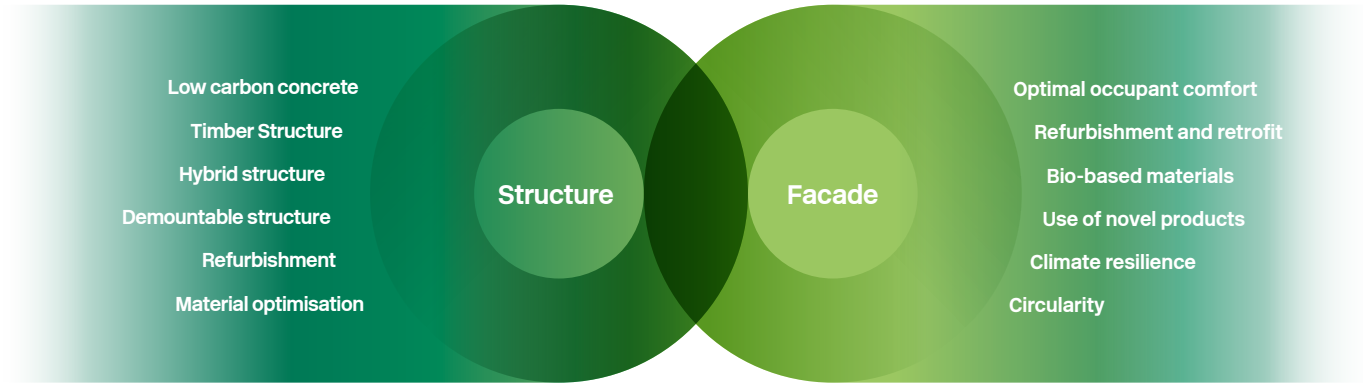
Sustainable life cycle analysis



Climate Action Charter

1. Assess the embodied carbon of all our construction projects
2. Challenge the briefs to reduce their environmental impact
3. Optimise designs to be inherently efficient
4. Challenge the industry and traditional practices
5. Specify low carbon materials and systems
6. Facilitate reduced energy consumption and increased internal comfort
7. Develop resilience strategies
8. Maximise the service life of the buildings and challenge the need for new build projects
9. Integrate circularity principles as a basis of our projects
10. Share knowledge and experience

Integrated low carbon design



Top:
We tackle carbon at each stage of a building's life

Bottom:
Our structures and facade teams bring together key skill sets to tackle the climate challenge through a holistic approach

Project Experience

K11 Art & Cultural Centre
Hong Kong

Apple Causeway Bay

Location: Hong Kong
Client: Apple
Architect: Bohlin Cywinski Jackson | Woods Bagot Hong Kong
Date: Completed 2012
Value: Undisclosed
Services Provided: Glass Engineering

This new flagship Apple Store is located in Hysan Place Mall in Hong Kong's Causeway Bay district. The three-storey store features a 15-metre-tall glass facade, allowing transparent views of all three levels inside.

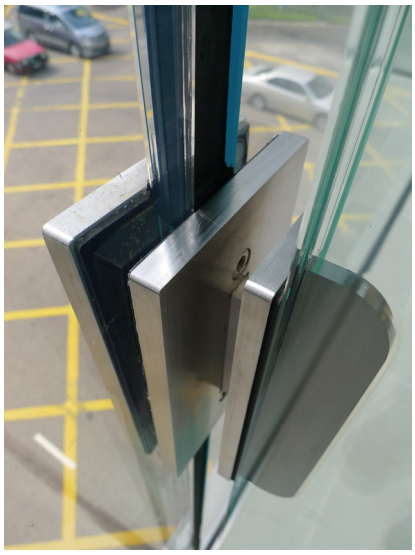
The full-height panels are laterally supported by single piece fins. The panels and fins are among the largest glass elements produced in the world. By reducing the total number of glass pieces in the facade, and therefore limiting the number of connections, we were able to maximise the transparency of the shop front.

This innovative design required permitting from the Hong Kong Buildings Department, which involved full-scale prototyping and testing. Our previous experience of engaging with the department helped to make the process more efficient and reduce the overall permitting schedule.

Top right:
Full-scale prototyping

Bottom left:
Fin connections

Apple IFC Mall



Location: Hong Kong
Client: Apple
Architect: Bohlin Cywinski Jackson | Woods Bagot Hong Kong
Date: Completed 2015
Value: Undisclosed
Services Provided: Facade | Glass Engineering

IFC Mall store is Apple's first store in the area. Eckersley O'Callaghan were responsible for the 9m tall glass facade, glass spiral stair, glass balustrades and internal mall storefront. The structure is suspended 11m above Man Cheung St, with building bridging the street with a 40m span.

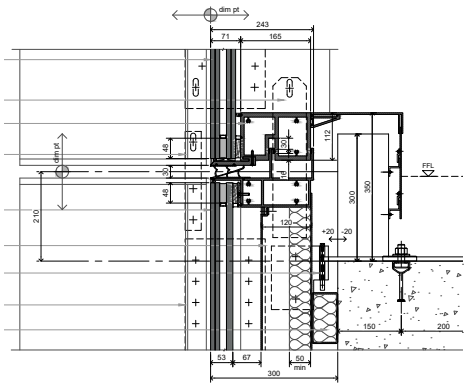
The principle challenges lay in the glass facade. It represented a departure from a bolted glass connection to a new type of encapsulated fitting where the metalwork is bonded into the body of the glass. This led to no visible bolted connections between glass elements and enhanced the minimal appearance of the facade.

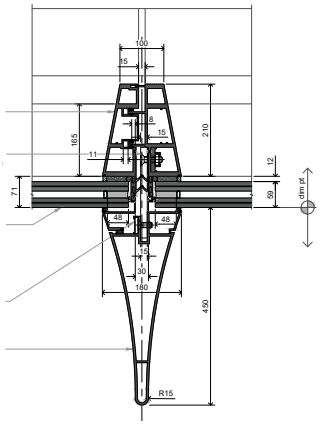
The facade had to be engineered to resist the extremely high wind loads that Hong Kong sees during Typhoon season. Both the facade and the other glass elements also had to be capable of accommodating the significant deflections of the bridge structure.

The proposals lay well outside the conventions of facade and glass engineering in Hong Kong and the strict local construction guidelines led to long negotiations with the building authorities during the permitting process. We provided extensive justification of the design, through analysis and through both large and small scale performance tests.

Top right:
New encapsulated facade connection

Two Taikoo Place





Location: Hong Kong
Client: Swire Properties
Architect: Wong & Ouyang | NBBJ
Date: Completed 2023
Value: Undisclosed
Services Provided: Facade | Glass Engineering

BREEAM Plus anticipated
LEED Platinum anticipated

The new Two Taikoo Place development in Hong Kong features the world's tallest prestressed rod facade and sets new standards in energy performance across the whole **190m-high** glazed facade. We provided the facade and specialist glass engineering services for Swire Properties' iconic new addition to their Taikoo Place development.

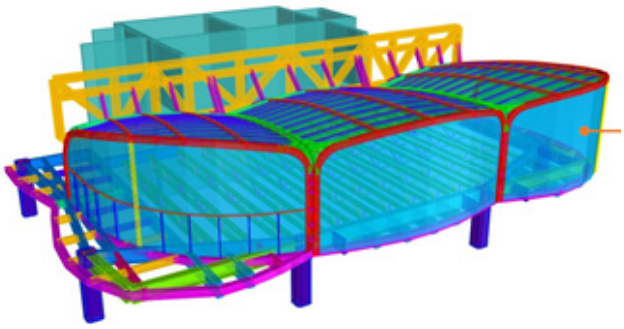
We have used the latest developments in glazing production to ensure high levels of light transmission and designed external shading fins to reduce solar gain. For the glazing, insulated glass units with high performance coatings have been chosen. These measures form part of an energy efficiency strategy to enable the project to achieve BREEAM Plus and LEED Platinum certifications. The facade has been designed as a unitised system with 3m wide units, offering uninterrupted views of the Hong Kong Harbour. Geometric optimisation studies of the conically curved corner panels have been performed to reduce the number of unique panels by 60% to maximise the number of glass fabricators who can supply them. This has resulted in a reduction of cost across the facade without affecting the architectural intent.

The base of the building features a 15m tall podium facade which will be realised in a frameless structural glazed system using integrated pre-tensioned stainless steel rods – the first of its kind in Asia.

Top right:
Curtain wall vertical section detail at slab edge

Bottom right:
Curtain wall horizontal section with external shading fin

Banquet Hall
The Henderson



Location: Central, Hong Kong
Client: Henderson Land Development
Architect: Zaha Hadid Architects
Date: Completion due 2023
Value: Undisclosed
Services Provided: Structural & Facade Engineering

---

2 Murray Road is a Grade A office tower in the heart of Hong Kong's Central financial district. Eckersley O'Callaghan is providing structural and façade engineering services to realise a unique, feature event space at the top of the **200m tower** known as the Banquet Hall.

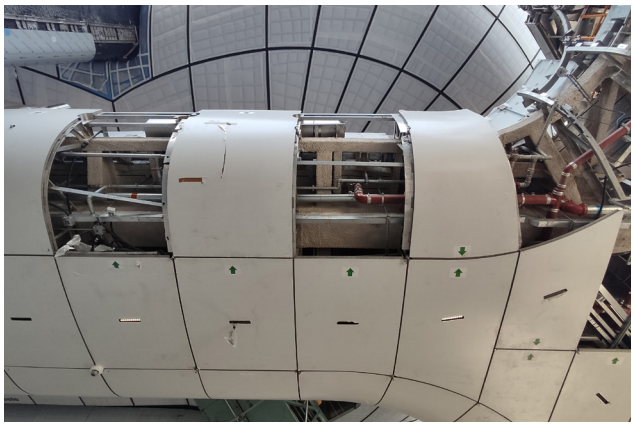
The Banquet Hall is enclosed by a 600m^2 skylight structure – an integrated composition of glass and long-span steelwork that maximises transparency. Without internal columns, 17m long steel beams acting as the primary frame are precambered to limit deflections. Glass beams, acting as secondary structure, support glass roof panels forming the double curved envelope have been rationalised as flat and cylindrical individual panels to improve buildability.

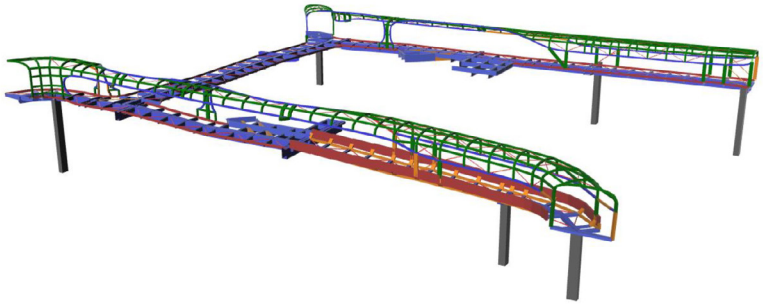
Around the perimeter of the Banquet Hall, 7.5m tall glass walls are frameless, without mullions or glass fins, offering uninterrupted views across the city.

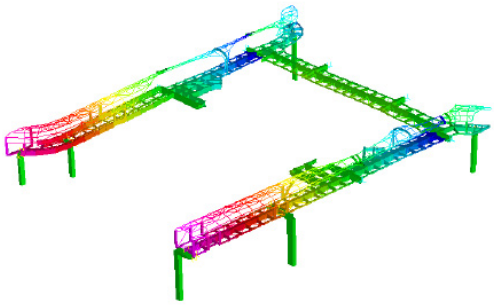
With high design wind loads in Hong Kong, especially at height, the challenge is to minimise element sizes to enable the architectural ambition. The sensitivity to movements and interaction of the structure as a whole has called for highest level of analysis and detailing. The project is expected to complete in 2023.

Bottom right:
Proposed structural model

Elevated Walkways
The Henderson







Location: Central, Hong Kong
Client: Confidential
Architect: Confidential
Date: Completion due 2023
Value: Undisclosed
Services Provided: Structural & Facade Engineering

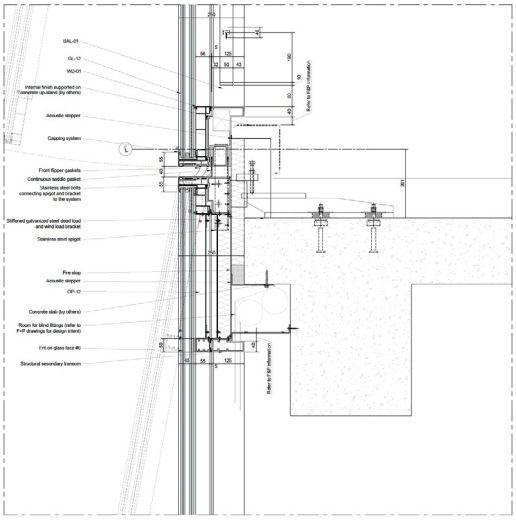
Eckersley O'Callaghan is providing integrated structural and facade engineering on a high-profile extension to Hong Kong's elevated walkway network in Central, connecting into a significant new office development.

These long span bridge structures will introduce a new, modern architectural language to the existing, characteristic fabric of the city.

The bridge steelwork is supported on a series of discrete column locations and weaves through and interfaces with the new office calling for precise coordination. The complex geometry cladding system is fully integrated with the structure to minimise the overall buildup to meet the tight zoning requirements.

Bottom:
Analysis of the walkway's steel structure

Wellington Street



Location: Hong Kong
Client: Wing Tai Properties
Architect: Foster + Partners
Date: Completion due 2026
Value: Undisclosed
Services Provided: Facade | Glass Engineering

LEED Platinum
BEAM Plus (HK)

The Wellington Street project is a new landmark development in Central, Hong Kong. It comprises two towers at **130m and 120m tall** (office and hotel) with retail podiums and public realm spaces at ground level. New walkways will connect the mid-level escalators into the development.

We are engineering over 30 facade types which includes several unitised systems across the project. A key architectural feature is the distinctively transparent glazing for the 'Sky Pavilions' at the upper portions of the towers, utilising double storey 8m tall glass panels to reduce the number of joints.

Carefully assessing the stringent energy requirements and tuning shading coefficients for the envelope zones are fundamental to engineering the 'Sky Pavilions', informing our selection of glass buildup and high performance coatings. This unique approach will define transparent glazing that contrasts with the surrounding buildings in the Hong Kong skyline.

The site is tightly bounded on all sides by narrow streets in this densely populated area, posing additional challenges on the logistics of delivering materials such as glass panes up to 10m tall.

Right:
Unitised curtain wall interface detailing

K11 Art and Cultural Centre

Location: Hong Kong
Client: New World Development
Architect: KPF | SO-IL Architects
Date: Completed 2020
Value: Undisclosed
Services Provided: Glass | Facade Engineering

Facade Design and Engineering Awards, International Project of the Year 2022 — Innovation
MIPIM Asia Awards 2020 — Gold Award

The K11 development project is located in Kowloon, Hong Kong. The all-glass facade for the museum space is located within the sixth and seventh floors of a multi-storey development and wraps around half the building footprint (approximately 170m).

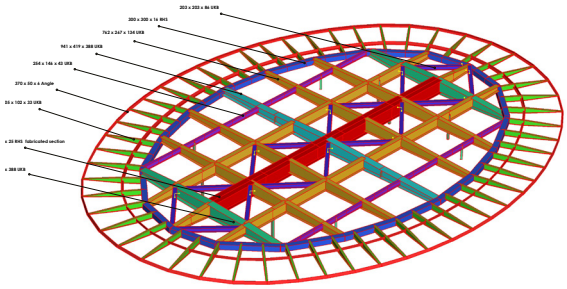
The facade consists of **475 glass cylinders**, each 9m tall with a radiaus of 450mm, encircling the museum. Never before have glass panels of this size been curved to such a tight radius. These cylinders have been fabricated from two half-cylinders, themsleves formed with hot slumped laminated glass, that are then sealed together with silicone.

All panels are base supported, with the panels over the entrance and the openings supported on the adjacent full-height glass cylinders via a mechanical connection bolted through the glass. Movements from the supporting structure are accommodated through vertically-released connection details at the top restraint.

We were challenged to design and engineer the tubular structural glass facade that would span from bottom to top without additional supports, meanwhile meeting the energy and performance requirements of the project.

Bottom right:
Fabrication of tubes
by Seele

K11 Palace Mall Entrance Pavilion



Location: Hong Kong
Client: New World Development
Architect: KPF
Date: Completed 2019
Value: Undisclosed
Services Provided: Glass | Structural Engineering

The structure is the entrance point for all visitors visiting the K11 mall. It consists of **9m tall** IGU glass panels, an elegant frameless glass entryway, a bespoke parabolic mirror-finished internal ceiling and exterior cladding panels.

We were engaged primarily as facade engineer, but we also designed the structural scheme of the steel frame, enabling us to holistically design the pavilion from the outset.

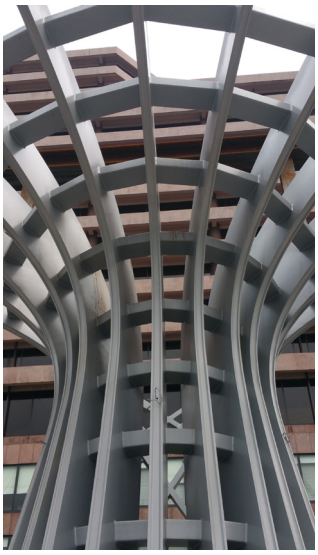
We assessed various structural options for supporting the roof, including the possibility of supporting the roof purely on solid glass walls. Ultimately, we concluded that a concrete encased steel column with a mild steel frame above would best meet the fire requirements of the Hong Kong building department.

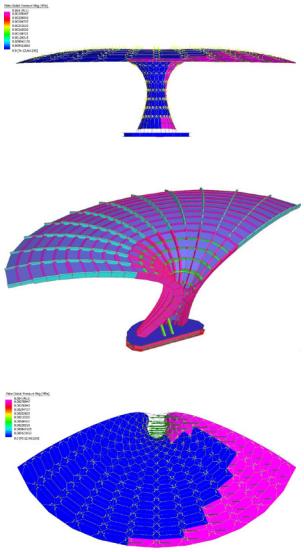
Due to the column layout and especially high wind loads, the roof is extremely sway sensitive, meaning differential movements between the roof and the glass facade were an issue. The structural system was tuned through connection detailing to ensure that the impacts of the differential moments were mitigated.

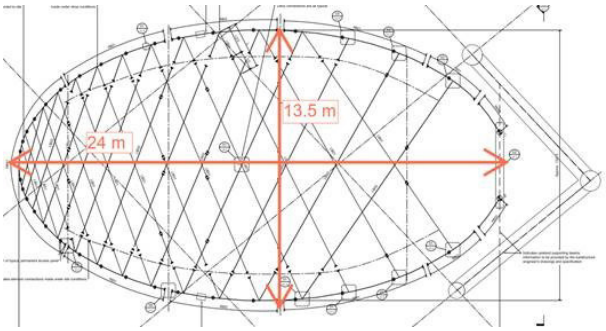
To meet the architect's brief for transparency and the performance criteria of the glass, we undertook detailed cumulative calculations of glass performance coatings and frits which involved significant consultation with a wide range of glass manufacturers. Additionally, we analysed further schemes to minimise the structure at the joints around the facade.

Bottom right:
Analysis of roof structure

Avenue of Stars | Salisbury Gardens







Location: Hong Kong
Client: New World Development
Architects: James Corner Field Operation | LAAB
Date: Completed 2018
Value: Undisclosed
Services Provided: Structural Engineering

HKILA Gold Design Award 2019
HKILA Professional Landscape Award 2020

The Avenue of Stars (AoS) and Salisbury Garden trellises are public realm sculptures which are clad in foliage and lighting elements and located along the Hong Kong waterside to provide shelter from the sun. The structures will comprise of painted mild fabricated steel elements.

The four AoS structures stand at **6m tall** cantileverling horizontally at 7m. The Salisbury Garden trellis is **8.5 tall**. As the structures are exposed and slender, we developed connection details which where economical, feasible and non-visible. This was especially challenging in such tight confines to coordinate structure and services. The installation process is the driver of the design and, as such, we took a leading role.

Our analysis of the architectural intent of the shape informed changes to provide a more aesthetical iconic profile which better suited the context of the site. We geometrically optimised the structural arrangement to avoid 3D curvature without compromising structural performance.

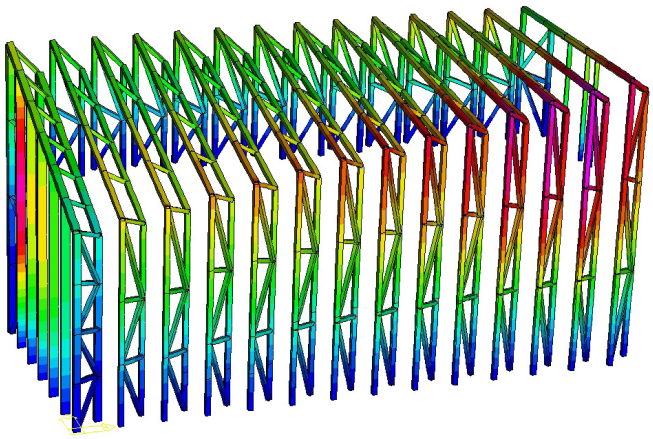
We also rationalised all aspects of the structure with the cost of fabrication and jointing in mind including; louvre layout, orientation and connection details; ring beam orientation and plate curvature constraints. The resulting structure is aesthetically pleasing, economical and follows a strong construction logic.

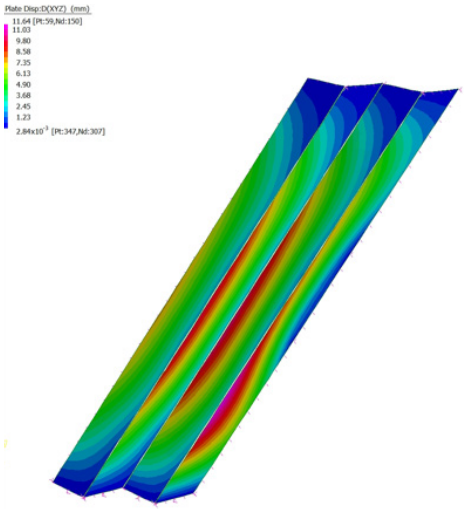
Top:
AoS trellises

Bottom:
Salisbury Garden trellis

Right:
Wind load analysis on trellises

Hong Kong Science Museum & Hong Kong Museum of History





Location: Hong Kong
Client: Hong Kong Architectural Services Department
Architect: Farrells
Date: Completion due 2027
Value: Undisclosed
Services Provided: Facade Engineering

The revitalisation of the Hong Kong Science and History Museums will refurbish and expand the existing buildings to create a new landmark educational facility, The creation of three new annexes and exhibition buildings enclose a new open exhibition courtyard space, whilst the existing museum facades will be fully reclad.

Eckersley O'Callaghan is providing pre-construction facade engineering services - to design and engineer an array of unique facade types proposed for the project, and prepare the associated tender documentation.

The facade typologies on this development include a wide range of systems, including laminated digitally printed artwork glazing, tall glass wall lobby systems, long span curtain walls, complex spiral glass facades, bespoke metal cladding, extruded terracotta cladding and irregular glazed skylights.

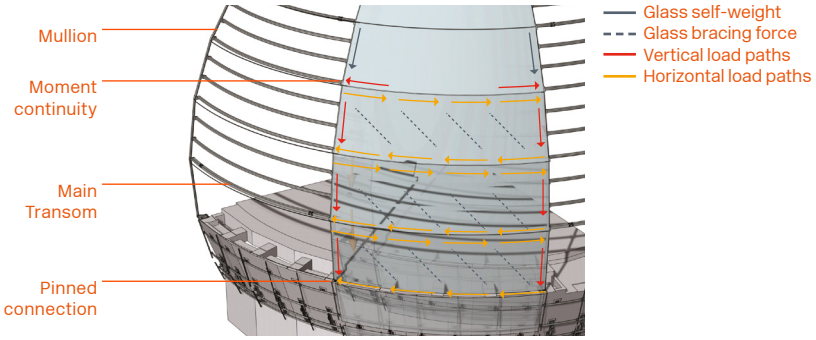
Top left:
New development of Hong Kong Museums

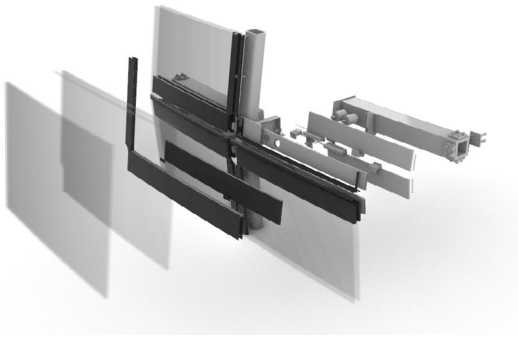
Top right:
Complex spiral glass facade

Bottom left:
Rotunda glass wall detail

Bottom right:
Rotunda glass structural analysis

Apple Marina Bay Sands





Location: Singapore
Client: Apple
Architect: Foster + Partners
Date: Completed 2020
Value: Undisclosed
Services Provided: Glass Engineering

IStructE Construction Innovation Award 2021
Vitruvian Honors & Awards 2021 — Outstanding New Facade

Eckersley O'Callaghan carried out the structural and facade engineering and undertook a site supervisory role for the first-ever Apple Store to sit directly on water, appearing as a sphere that floats on Singapore's Marina Bay.

The sphere itself is a fully self-supported glazed dome comprising **114 panels** of glass with only 10 narrow vertical mullions for structural support – truly a first-of-its-kind. This creates an open, column-free interior. In a feat never before achieved on this scale, we designed the individual glass panels to brace and stiffen the structure rather than use additional diagonal steel bracing or large moment connections at the joints.

We also maximised the size of the insulated glass panels to limit the number of joints, hiding them only where there is structure, and increasing the overall transparency of the building (the largest of these panels measures 10m wide x 3m tall). To give the dome its geometry and to meet the required environmental performance, the panels were designed to be conical in shape with each individual panel 'warm' or lamination bent into shape. Again, this was the first time that this type of bending had ever been used at this scale.

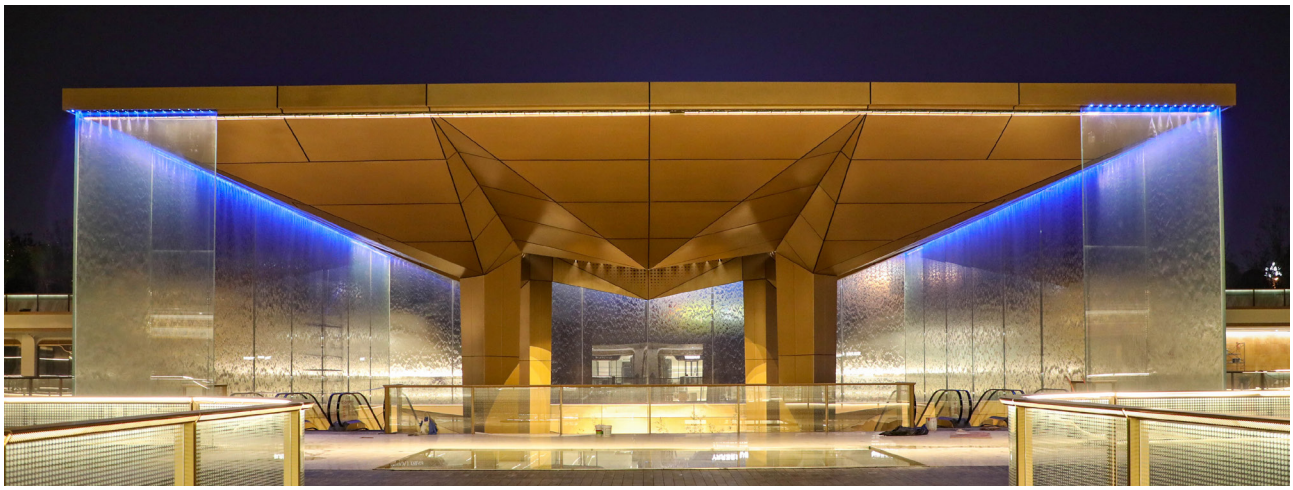
A central circular glass panel, the Oculus, crowns the top of the dome. In the event of a fire, the adjacent glass panels rise to release smoke inside the building. In addition, circumferential baffles around the dome act as glare protection and acoustic attenuation panels. We provided the full superstructure design from concept through to supervision on site and completion.

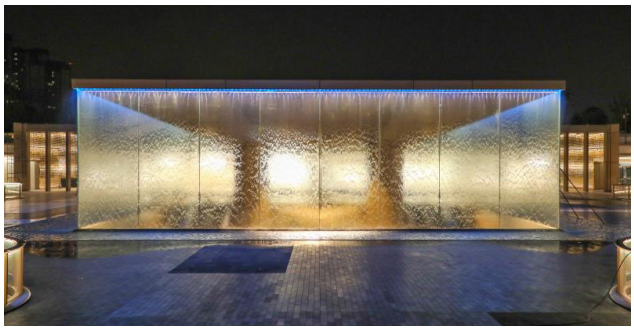
The dome's super slender steel structure was designed to retain its lightweight appearance. The ability to contain the various services (including lighting and sprinkler system) within the cladding and still meet the overall architectural vision was vital to creating Apple's trademark minimalist look inside.

Bottom left:
System to resist loads

Bottom right:
Vertical mullion supporting structure in detail

SKP Chengdu





Location: Chengdu, China
Client: SKP
Architect: Sybarite
Date: Completed 2022
Value: Undisclosed
Services Provided: Glass Engineering

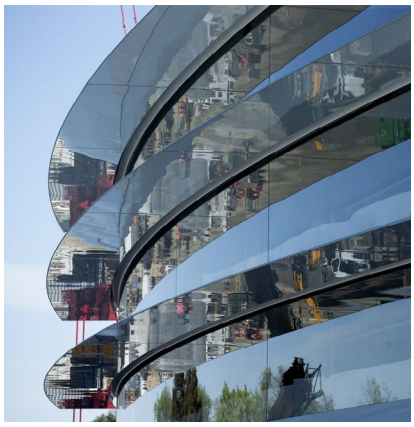
Located in Chengdu, Sichuan Province, China, the development is part of the SKP (Shin Kong Place) chain of high-end shopping centres, which also includes locations in Beijing and Xi'an. Featuring a wide range of luxury brands and designer stores, it also offers a plethora of dining options, a cinema and a series of different parks atop the structures, described as a "botanical patchwork quilt". In addition to its luxurious shopping experience, SKP Chengdu is garnering a reputation for its unique architectural design, establishing itself as a recognisable landmark in the city.

Comprising half a million square metres, this biophilic masterplan is a holistic and collaborative design by Sybarite, realised with James Corner Field Operations, Eckersley O'Callaghan, Arup, Speirs Major, Buro Happold and The Fountain Workshop over a three-year period.

With 99 percent of the buildings below ground level, the store is divided into four main areas: Chengdu SKP, Chengdu SKP-S, K Avenue and G Avenue. At ground floor level, only a few shops are visible interspersed amongst 33 crafted landscapes and scenic spots.

The multi-level store is anchored by the SKP-N department store at the north and the future-focused SKP-S store at the south, which is topped by six towering water-fountains that reach up to **39m high**. A sequence of pavilions, which house key luxury brands, is flanked by these two anchor stores, and separated by canyon-like walkways that are crossed by angled pedestrian bridges. At the centre of the park is a bamboo garden contained within a glazed Central Cube, which provides light and access to the shopping levels below ground.

Apple Park



Location: Cupertino, California
Client: Apple
Architect: Foster + Partners
Date: Completed 2018
Value: $5bn
Services Provided: Glass Engineering

Eckersley O'Callaghan has provided facade engineering for Apple's ambitious new headquarters. The desire for the most advanced office building in the world will house 12,000 employees on one site with ancillary performance space, parking, a fitness centre and an outstanding landscape.

The overall area of the main building is in excess of two million square feet with a construction budget of approximately $5bn, making this one of the largest building construction projects in the world.

A significant feature of the building is the envelope. The **800 glazing panels** are amongst the largest that can be fabricated in the world today, 14m (46') long and 3.2m (11') high, which are incorporated into defining the building's radial geometry. Spanning vertically between the slabs, and defining the floor to ceiling heights, neither mullions nor supporting structure are needed. Vertical joints between the panels are located in front of the columns and are therefore obscured when viewing the landscape from within. In this manner, the sheer size of the glass avoids connection details and maximizes transparency. Feature glass canopies at each floor provide shading around the building negating the need for additional methods to limit solar gain into the building.

As the Client's Representative for all elements of the building envelope, we developed the facade concept with the design team, all glazing details with the architect, and our expertise during the construction phase of the project has managed the procurement and fabrication of the large quantities of glass to the exacting quality required for the project.

Steve Jobs Theater

Location: California, US
Client: Apple
Architect: Foster + Partners
Date: Completed 2017
Value: Undisclosed
Services Provided: Glass Engineering

SentryGlas Innovation Award for Engineering 2018
IStructE Structural Artistry Award 2018

Over the last 15 years, Eckersley O'Callaghan's close relationship with Apple has been accompanied by a rapid evolution in structural glass technology, and the Steve Jobs Theater represents a culmination of these advances.

As a true technology pioneer, it is fitting that Apple's new landmark venue for product launches was designed using innovative technology, some of which has never been seen before on a structure of this scale.

For example, it is the largest structure in the world solely supported by glass, with an **80 tonnes** roof supported by a 7m tall glass cylinder, made up of glass panels, each consisting of four layers of 12mm thick plies, which hold up the roof without any additional support.

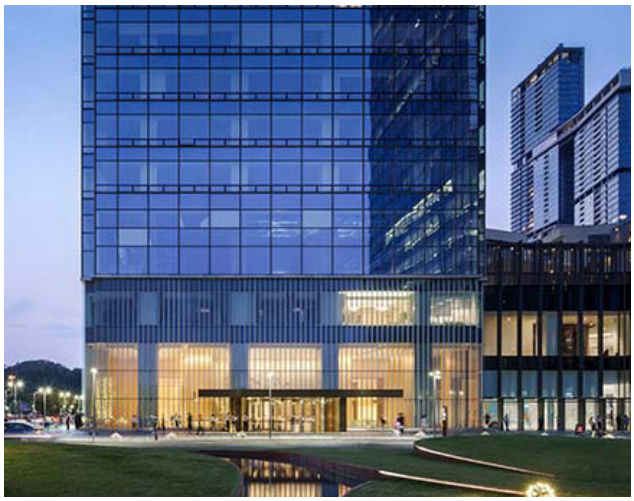
We also designed the structural system so that the conduits, sprinkler pipes, data, audio and security systems in the roof could be accommodated in the 30mm joints between the glass panels.

In addition, the structural criteria were also particularly challenging given the properties of glass with its inherent brittleness requiring detailed analysis to fully justify safe design – not to mention the fact that Cupertino is in a highly seismic zone.

Consequently, we employed several strategies to protect against earthquakes and transfer seismic energy, including curved glass panels fixed at their base with structural silicone into a steel channel. Steel plates were also engineered to deform before the glass breaks, safeguarding the integrity and robustness of the overall structure.

Working closely with Foster + Partners, we also engineered the design of the world's tallest free-standing glass elevator, which stands 12.8m tall and corkscrews on helical guides to facilitate an exit point 171 degrees rotation from entry.

Shum Yip Upperhills



Location: Shenzhen, China
Client: Shum Yip Holdings
Architect: SOM
Date: Completed 2020
Value: Undisclosed
Services Provided: Facade Engineering

LEED Gold Pre-Certified

Eckersley O'Callaghan provided facade engineering services for a glazed curtain wall design for towers 390m and 300m tall, and cable wall design for pavilion building.

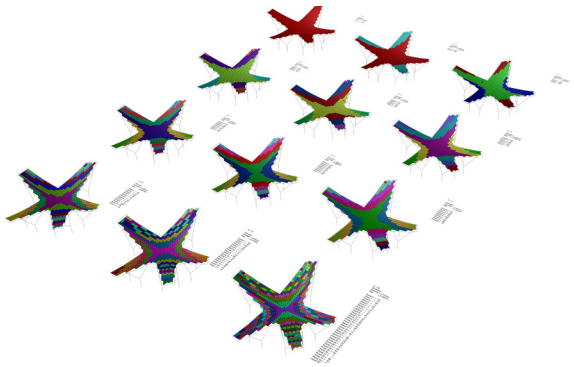
Located in Shenzhen, the People's Republic of China, with a combined facade area of over 1.7 million sq. ft, the Shum Yip office and luxury hotel complex comprises two **80 and 60 storey towers**, with an associated 7 storey Ballroom Pavilion Building.

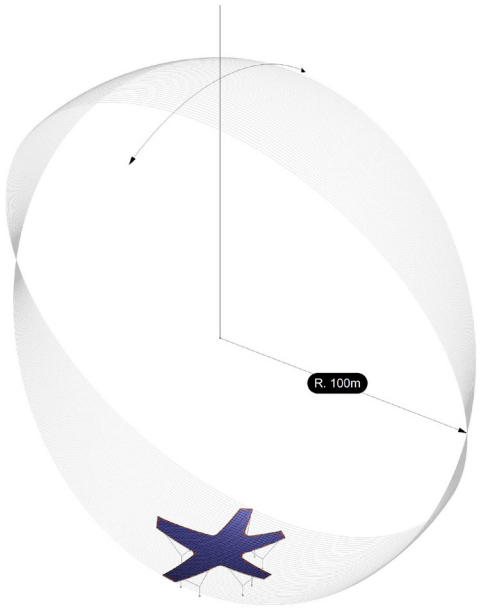
The various building enclosures include a unitised pressure equalized thermally broken curtain wall, a 24' long span butt glazed mullion-less structural glass entrance system, a 49' long span glass fin support glass podium wall with exterior glass louvres, and a sloped custom steel long span glass wall to the Ballroom Pavilion.

We supported SOM with the facade engineering of the systems, ensuring that all of the proposed facade and glass element sizing met the local and National Code requirements of China, as well as the very high typhoon wind loads in excess of 150psf (7.5kPa).

Pre-engineering of the systems ensured that the SOM design intent could be realised by the Chinese facade contractors, preventing defensive pricing, allowing for a fast-track shop drawing process and ultimately a successful project delivery.

Star Pavilion
Lumina 2





Location: Shanghai, China
Client: Henderson Land Development Company
Architect: Gensler
Date: Completion due 2022
Value: Undisclosed
Services Provided: Structural | Facade Engineering

Eckersley O'Callaghan has been tasked with developing a structurally-optimised version of Gensler's architectural concept for an entertainment pavilion in the Xuhui District of Shanghai. It will act as a cultural focal point for a larger surrounding mixed-use development.

The pavilion, which sits over a large basement structure, comprises a 55m wide steelwork lattice canopy supported on 10 Y-shaped steel columns 15m high. The structure's geometric complexity is evident when viewed in elevation; the canopy's upper and lower surfaces feature curves that have been developed from two spheres with different diameters, with the lower curve being more convex. We are also developing the facade design, which will feature an aluminium rain screen cladding system.

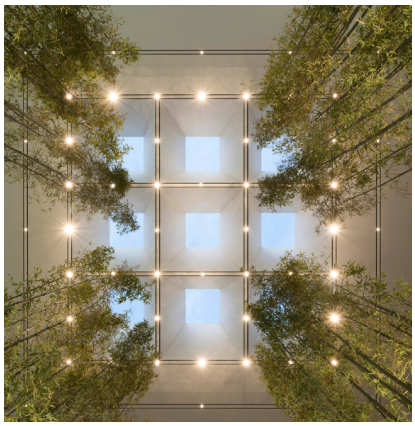
Our design takes into consideration the range of events that the venue will host, allowing for significant additional weight from AV and lighting equipment that may be hung from the canopy. The option of a curtain, which would surround and close off the pavilion for private functions, has also been incorporated.

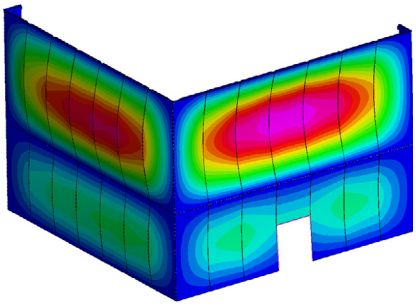
Digital Design tools have been used extensively to rapidly test various structural options, allowing us to identify the most efficient and most elegant design solution. Due to the surface geometry and the panelisation strategy each of the 1,600 panels was a subtly different shape triangle. To reduce the cost of the cladding a bespoke parametric script was developed to optimise the cladding panel geometry using a k-mean clustering algorithm. 1,600 unique panels were reduced to eight unique panels, this significantly reducing the cost of the cladding and the installation time on site.

Bottom Left:
Structural optimisation from parametric model

Bottom Right:
Solar analysis

Apple Sands Cotai





Location: Macau, China
Client: Apple
Architect: Foster + Partners
Date: Completed 2018
Value: Undisclosed
Services Provided: Facade | Glass Engineering

Apple's new flagship store in Macau will see the transformation of an existing casino building into a two-storey retail unit with a floor to ceiling glass facade 16m in height.

Eckersley O'Callaghan has designed a pioneering facade that features 2 layers of stone within the glass build-up to provide a translucent effect. This stone layer stops at the height of the first floor allowing transparency into the store at this level exclusively.

A stone layer in the inner panel face is a known element, however through our close collaboration with glass manufacturer Glas Trösch, we were able to develop the technology to enable a stone layer to be fitted as an interlayer within the laminated glass for the first time. The finless facade spans 16m in height, restrained only at the top and bottom, with a requirement to withstand high wind loads in the typhoon area. This presented additional challenges to ensure that the laminated stone layer would not affect the structural behaviour of the glass.

We performed very refined finite element modelling (FEM) and continuous laboratory tests on glass and stone samples, alongside precise coordination with the glass manufacturer to develop the technology able to achieve the panels.

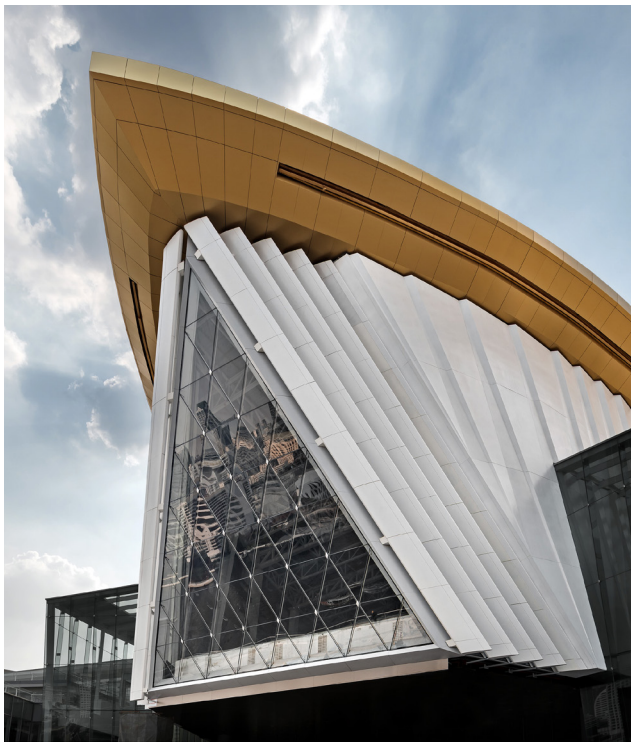
We have also engineered the roof skylight design and staircase.

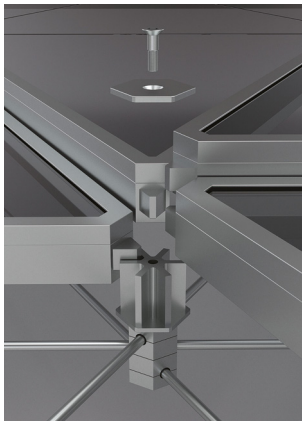
Top right:
Skylight

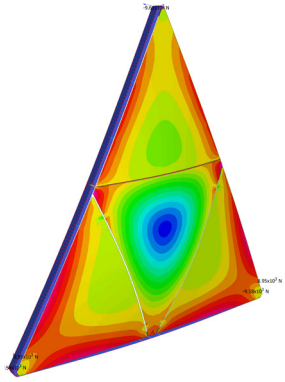
Bottom left:
Investigating samples of stone layered glass

Bottom right:
Glass deflection plot under wind load

ICONSIAM Wisdom Hall







Location: Bangkok, Thailand
Client: SiamPiwat
Architect: Luke Lowings
Date: Completed 2018
Value: £3.5m
Services Provided: Facade Engineering

ICONSIAM is a new national landmark for Thailand and the country's largest ever private property development. The mixed-use scheme is located on the banks of the Chao Phraya River and includes two large shopping centres, hotels, residences and, at its peak, the Wisdom Hall, a museum celebrating Thai history and culture.

Eckersley O'Callaghan engineered the Wisdom Hall's unique triangular cable-net facade, which stands 20m tall and weighs **80 tonnes**, and the building's glazed sidewalls. The cable-net is formed with cable clamps that support up to six glass panels each.

We were challenged to design an A-frame with sides that span over 20m and can support cable loads, while also considering constructability and allowing for the anchorages to be hidden within the cross section. Our solution avoids any internal structural elements, using the external shading fins as the support structure.

The facade consists of 64 triangular panes of glass held in place by 14 tensioned steel cables connected at 21 nodes. As all structural elements and connections are visible, we worked very closely with the architect to realise the design intent of transparency.

The complex assembly of the 20m tall system was largely done on site to account for the significant sizes. The A-frame was welded together and the cable-net tensioned on top of a crash deck. The two lower corners of the frame were attached to the main structure using pins that allowed the whole assembly to rotate into position while being pulled from the apex.

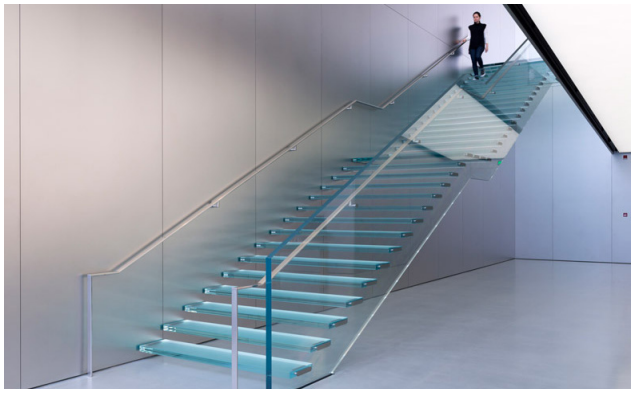
The sidewall glazing is made up of 72pcs of on-site bend glass. Providing contrast to the cable net, the truss structure is positioned externally and is clad with an aluminium skin to provide shading to interior.

Top right:
Installation of cable net facade

Bottom centre:
Supernode connecting and supporting 6 glass panels each

Bottom right:
Local analysis model showing the glass frame stresses

Apple Westlake



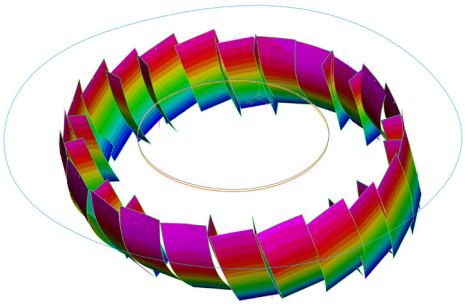
Location: Hangzhou, China
Client: Apple
Architect: Foster + Partners
Date: Completed 2015
Value: Undisclosed
Services Provided: Facade | Glass Engineering

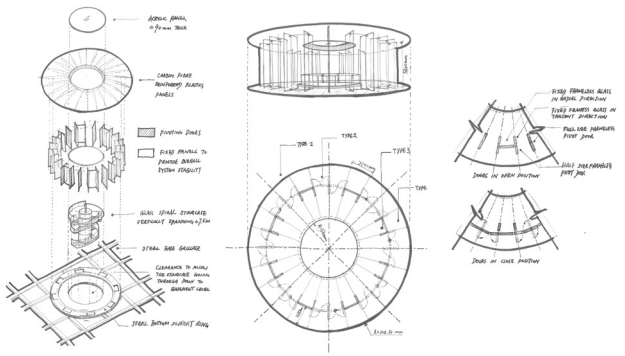
Apple Hangzhou is one of the largest Apple retails stores in Asia. Eckersley O'Callaghan engineered the design of the structural glass facade which stands at **15m tall**. The 11 double-glazed panels and are amongst the largest panels of glass fabricated at the time. The panels are supported by glass fins to achieve maximum transparency.

The design features a floating glass staircase and a dramatic cantilevered floor, which extends 12 metres from the rear wall like a diving board, tapering from 1.2 metres to just 10 centimetres. This upper floor creates a 9 metre high space intended to evoke "a sense of space and calm"

The feature glass staircase adopts new laminated insert fittings that we have developed in collaboration with glass processors Sedak and the Architect.

Apple Kunming





Location: Kunming, China
Client: Apple
Architect: IDA
Date: Completed 2016
Value: Undisclosed
Services Provided: Structural Glass Engineering

IStructE Structural Artistry Award 2017 — Commended
ENR Global Best Projects, Retail 2017

Eckersley O'Callaghan has engineered the pavilion and staircase for the new Apple store located in the Shuncheng Mall Plaza in Kunming, China. The pavilion combines glass, CFRP, and acrylic – unconventional construction materials – to interact and perform together as an efficient and elegant structural system.

The unique challenge of the project was incorporating the 24 opening glass doors around the perimeter of the structure. The structural system includes 8 sets of **5.4m high glass 'U-columns'**. These are laminated, fully tempered glass with SentryGlas interlayers.

The 'U-columns' support a carbon fibre reinforced polymer (CFRP) roof (20.9m diameter) with a central oculus of clear acrylic (8.3m diameter) above a glass spiral staircase leading down into the subterranean store.

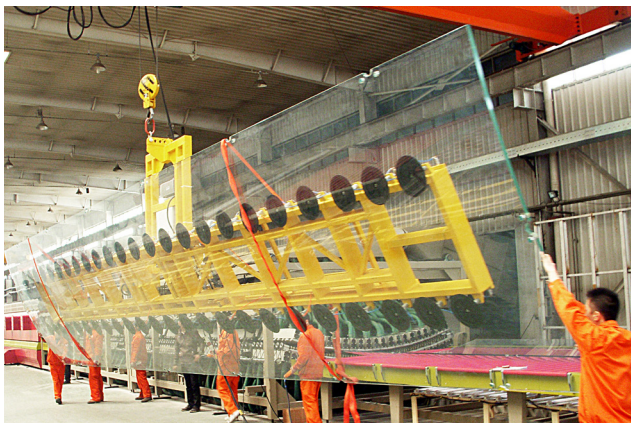
The 24 glass doors (16 swing and 8 pivot) are located between the fixed 'U-columns' and are mechanically operated. When the doors are open, the arrangement enables customers to enter the store from all directions.

Detailed consideration, technical analysis and testing was required to justify new innovations including the titanium fittings for the doors. The sensitivity of the structure to the movements of the supporting concrete slab is accommodated by careful detailing which responds to the exact performance requirements.

Top right:
Finite element analysis of seismic load

Bottom right:
Sketches of structural system

Apple Pudong



Location: Pudong, Shanghai
Client: Apple
Architect: Bohlin Cywinski Jackson
Date: Completed 2010
Value: Undisclosed
Services Provided: Glass Engineering

American Institute of Architects SF, Merit Award 2011

Eckersley O'Callaghan has provided the glass design of a revolutionary new Apple retail store standing at **13m tall** in the form of a cylindrical glass tower. With a 5m radius, the pavilion illuminates the entrance to the store inviting the customer onto a spiral glass staircase which leads down to the subterranean retail experience.

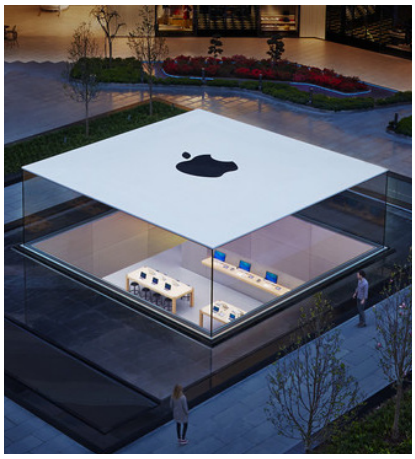
The design team worked intensively with fabricators in china to develop the first of it's kind production facility to make 13m tall curved, toughened and laminated panels of glass in one piece, far exceeding anything of this nature previously made, either flat or curved. The glass fin columns which stiffen the structure and run full height internally are also made in one piece with laminated-in fittings for tying to the curved wall panels.

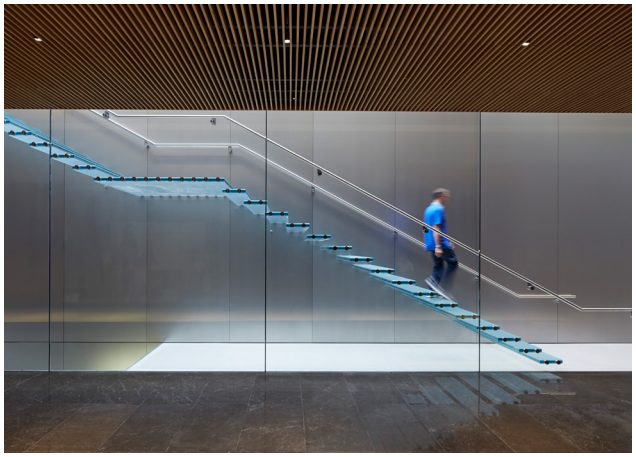
Glass ribs were designed to form a "skeleton" from which the gravity loads are taken down to the plaza slab. Full height, curved, external glass elements form the "shell" which transfers stability loads. Steel fittings were carefully detailed to connect the ribs to the external glass elements at each interface. The roof is supported by radial glass beams, spanning onto a curved glass central beam.

We have designed the spiral glass stair case to cantilever from a second glass drum inserted into the centre of this structure which appears to float down to retail space below.

Bottom right:
Production facility
created for the project

Apple Zorlu





Location: Istanbul, Turkey
Client: Apple
Architect: Foster + Partners
Date: Completed 2014
Value: Undisclosed
Services Provided: Glass Engineering

IStructE Supreme Award for Engineering Excellence 2014
IStructE Award for Retail or Commercial Structures 2014

For the Architect and Engineer it is the distillation of a desire to achieve the ultimate and simplest solution.

The architectural form of Apple's new flagshire store is a result of the purest structural approach possible given the limits of material fabrication today.

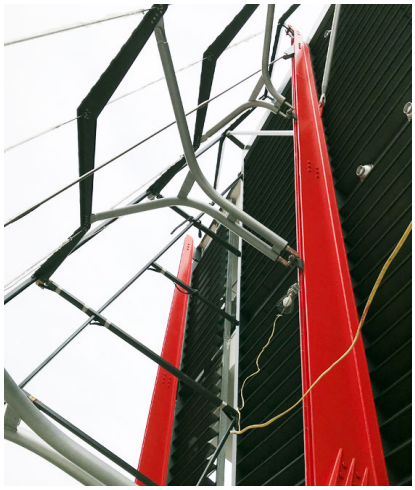
Eckersley O'Callaghan engineered a solution of single panels of glass for the walls and a single element for the roof held all together with silicone - no fixings to mar their integrity and transparency.

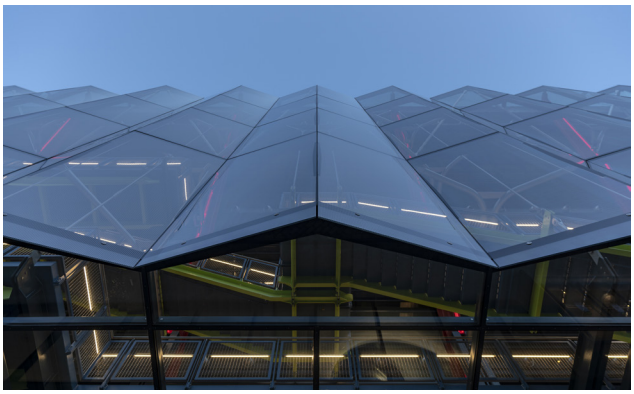
The journey to this solution explored many ideas and solution's, the team continuing to strive for the best solution in terms of architecture, engineering, urbanism, function, design.

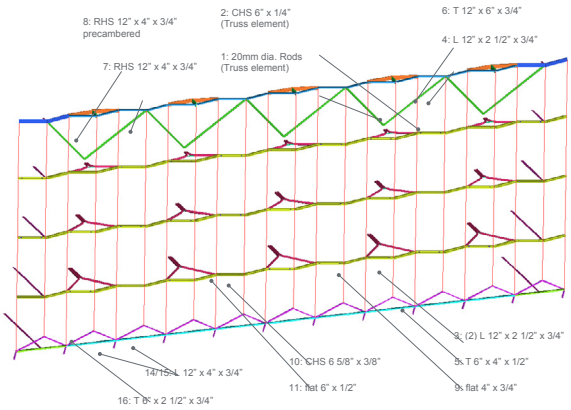
The four glass walls are **10m wide x 3m tall** and are formed of 3 x 12mm fully tempered glass laminated with Sentry Glass interlayer. The roof is a single Carbon Fibre Reinforced Plastic (CRFP) panel with a complex 'precambered' shape to ensure the soffit is completely level throughout when installed. The external form rises to 210mmin the centre to facilitate water run-off. It is a constant 60mm at the edges where it meets the wall panels.

The structure acts as a lantern illuminating the plaza at night and flooding light into the basement store during the day. We have also engineered the glass staircase leading into this retail area.

International Spy Museum







Location: Washington DC, US
Client: International Spy Museum
Architect: Rogers Stirk Harbour + Partners
Date: Completed 2018
Value: Undisclosed
Services Provided: Facade Engineering

AISC IDEAS^2 Award 2022
ENR MidAtlantic's Best Project 2019 —
Cultural /Worship

The new International Spy Museum at L'Enfant Plaza in Washington DC features an iconic facade, which draws its inspiration from espionage and spycraft. Working with Rogers Stirk Harbour + Partners, Eckersley O'Callaghan designed a folded structural glass veil, suspended in front of the black box exhibition space to add a deceptive visual layer.

To meet the stringent budget, we rationalised the original curved glass design into folded plate glass panels that stand 17 feet high. A lightweight stainless steel structure stitches together the geometric folds, resulting in a thinner build-up of glass and lower costs.

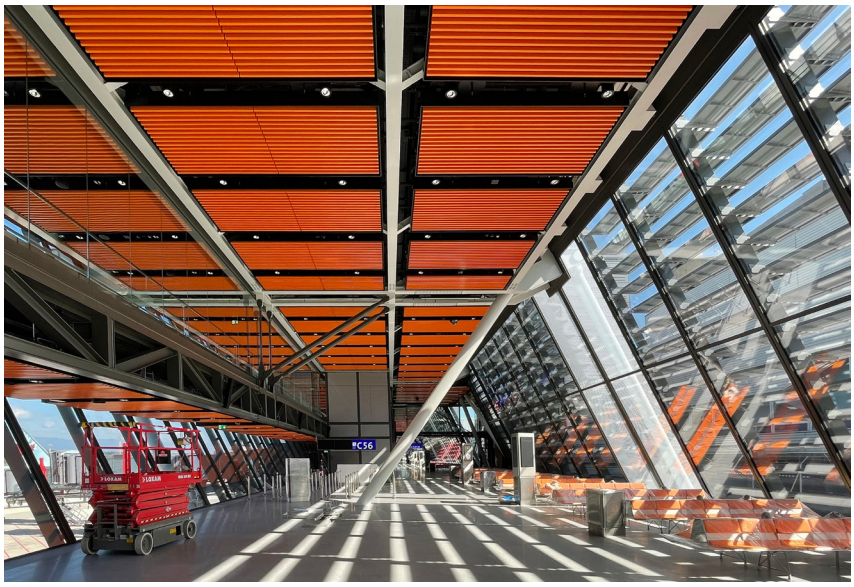
At 140,000 square feet, the new museum building more than doubles the exhibition space for the world's largest collection of espionage-related artefacts, with new resources for educational programming, a lecture theatre, and a multifunctional rooftop event space with sweeping views of the city, where we have engineered the glazed facade.

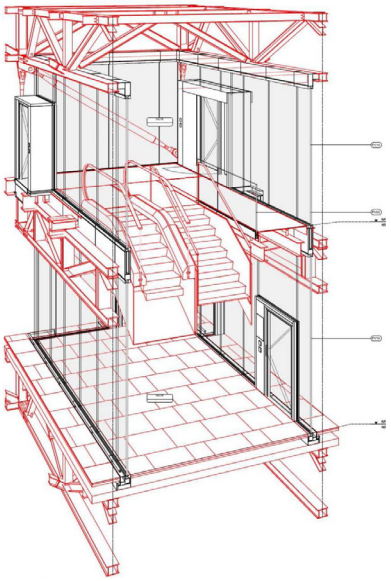
Eckersley O'Callaghan also designed the facade for the ground floor lobby, which comprises of an aluminium curtain wall bonded by four-sided structural silicone.

Top right:
Veil stainless steel structure

Bottom right:
Preliminary facade structure analysis

Geneva Airport





Location: Geneva, Switzerland
Client: Geneve Aeroport
Architect: Rogers Stirk Harbour + Partners
Date: Completion due 2021
Value: £250m
Services Provided: Glass Engineering

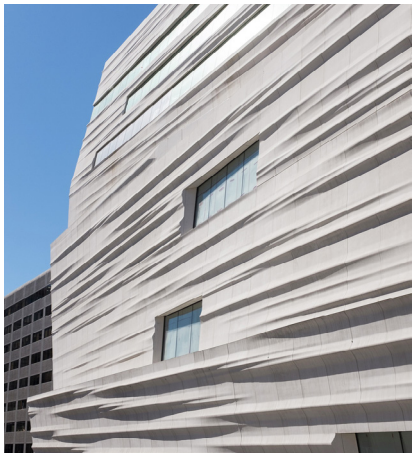
The new East Wing at Geneva Airport will vastly improve the services offered to passengers. The wing comprises a passenger processing area, departure gates, and a mezzanine with the capacity to accommodate airline lounges. Eckersley O'Callaghan is designing the internal glazing elements that form part of the fit-out package. This includes feature glass enclosure passenger valves, glass-formed passport control booths, glass barriers and balustrades.

We have collaborated with the architect in developing a design and drawings for tender. Our work has allowed the Design Team to realise a consistent language of details across the various interfaces, while utilising the latest glazing technology and products to achieve a light and transparent design aesthetic.

One specific challenge involved the design of the passenger valves which reach up to 4m tall and require fire-rated glass. It was important for us to explore and understand the possibilities in terms of fire-rated systems, which needed to be fire tested to strict requirements. Through close coordination with manufacturers and suppliers, we were able to review a range of options and highlight the risks associated with each.

Top right:
Passenger valves

SF MOMA



Location: San Francisco, US
Client: San Francisco Museum of Modern Art
Architect: Snøhetta
Date: Completed 2015
Value: Undisclosed
Services Provided: Facade Engineering

LEED Gold certified

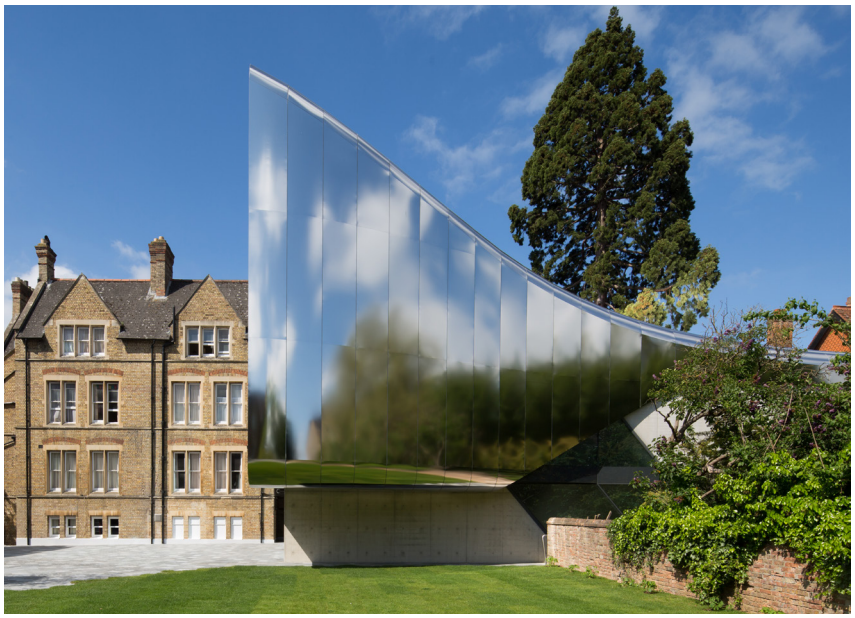
The **10-storey** expansion structure for the San Francisco Museum of Modern Art almost doubles the gallery's size, and almost triples its available exhibition space. Eckersley O'Callaghan provided engineering consultancy services for the building's distinctive rippling facade.

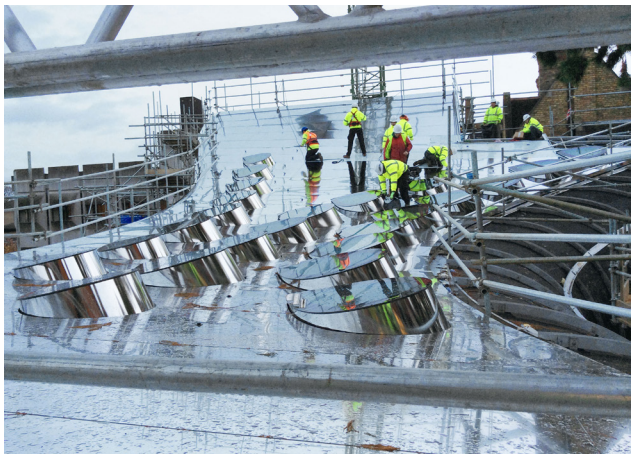
The facade consists of a mix of solid and glazed surfaces, with over 700 uniquely shaped fibreglass reinforced plastic (FRP) panels attached to a curtain wall system. SF MOMA is the first building to be clad in FRP at this scale.

Embedded into the surface of the panels, silicate crystals react to the changing daylight. The glazed elements include tall frameless panels specially designed to accommodate seismic movements.

We assisted in rationalisation of the glazing and solid wall, FRP construction, and evaluation of the contractors' proposals to achieve the design intent in a cost-effective solution. Through fabrication and installation, we carried out quality assurance monitoring to ensure that design quality was maintained.

Investcorp Building
St Antony's College





Location: Oxford, UK
Client: St Antony's College
Architect: Zaha Hadid Architects
Date: Completed 2015
Value: Undisclosed
Services Provided: Facade Engineering

RIBA National Award 2016
RIBA South Award 2016
Higher Education & Research Building Award, World Architecture Festival 2016

Eckersley O'Callaghan was the Facade Consultant for St Antony's College, Oxford University, during the construction of a new extension to the Middle East Centre building.

On behalf of the College, our role was to provide compliance monitoring over the design and build construction team through final contractor design, fabrication and installation.

The building doubles the space available for their library and archive, and also provides additional study space and a new 117-seat auditorium.

It is clad in a complex facade with doubly curved stainless steel panels. Large glazed facades form the two ends of the building; these employ double-glazed units with custom frit patterns on multiple layers.

The building interfaces with two historic buildings and makes a striking intervention to a traditional Oxford Quad.

Atlassian Central

Location: Sydney, Australia
Client: Atlassian
Architect: SHoP | BVN
Date: Completion due 2026
Value: Undisclosed
Services Provided: Structural | Facade Engineering

Council on Tall Buildings and Urban Habitat Awards 2023 — Future Project
World Architecture Award 2021 — Future Office Project
Holcim Awards 2021 — Commendation
Holcim Awards for Asia Pacific 2020 — Bronze

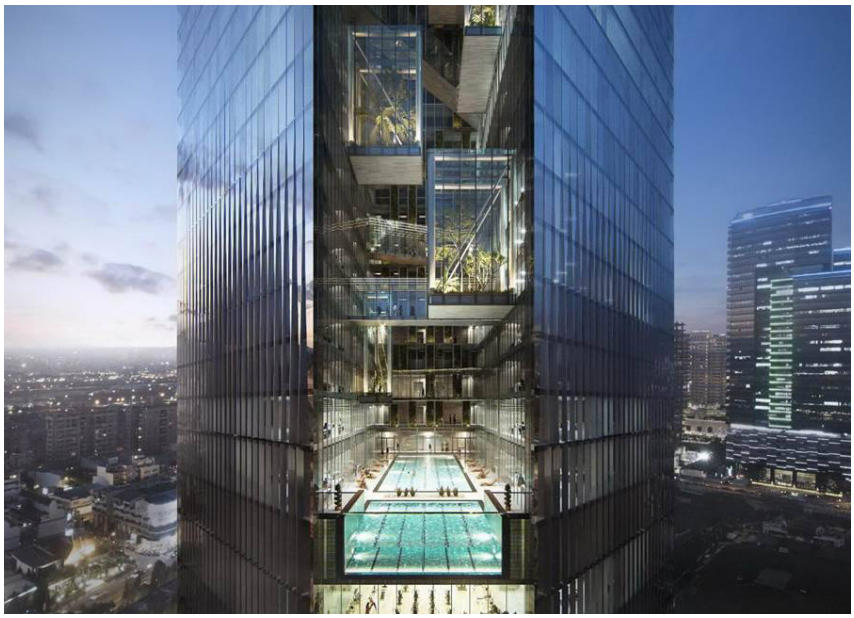
We are providing the structural and facade design for the world's tallest hybrid timber building in Sydney, Australia. The new approximately **40-storey high building** is being designed in conjunction with New York-based architect SHoP, who will work in partnership with Australian firm BVN and will provide a new headquarters for technology giant Atlassian.

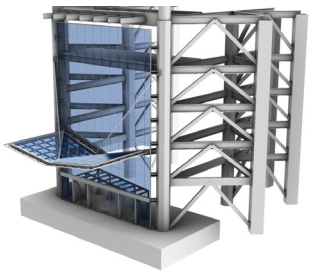
The groundbreaking design of timber, with a glass and steel facade will include a mix of outdoor and indoor spaces and will use an energy-efficient approach that features natural ventilation and large planted terraces giving access to nature. The building is leading edge in its application of Mass Timber Construction (MTC).
In line with Atlassian's commitment to operate on 100% renewable energy and reach net zero emissions by 2050, the project will target:

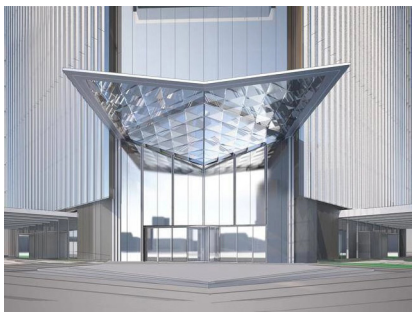
- 50% less embodied carbon in construction compared to a conventional building
- 50% less energy consumption compared with a new conventionally operated building and solar panels in the vertical facades, to generate green power on-site
- The building will operate on 100% renewable energy from day one and include solar panels built into the facade.
- Measuring at approximately 180m this will be the tallest commercial hybrid timber building in the world. The tower includes a steel exoskeleton that supports the mega floors between neighbourhoods.

The current design also incorporates an electricity-generating facade system with self-shade capabilities to reduce direct heat gain internally. Combined with the use of mass timber, the innovative facade enables the project to leverage Sydney's temperate climate to help reduce carbon emissions and generate on site energy.

Taichung Bank







Location: Taichung, Taiwan
Client: SKLF
Architect: AEDAS | YSL
Date: Completion due 2023
Value: Undisclosed
Services Provided: Glass Engineering

The new Taichung Bank Tower in Taiwan will form a new icon on Taiwan's skyline and provide the headquarters for the bank as well as five-star hotel accommodation. The over 200m tall tower has a large internal slot cut into its perimeter into which a number of 14m tall by 6m deep, glass boxes cantilever up to 180m high. At ground floor, a 20m x 10m V-shape glass cladded cantilever out canopy – described visually as a shining diamond – interrupts a high clarity but flexible 30m x 20m cable glazed facade.

From Tender to construction, Eckersley O'Callaghan carried out full design calculations and typical construction drawings for the architectural setting out of the main entrance, which includes the complex steel work structure for the main canopy and cable façade design, and the cantilevering glass boxes. Each element has complex design requirements including design for frequent typhoon weather and earthquake loading.

The challenges which the team have overcome include:

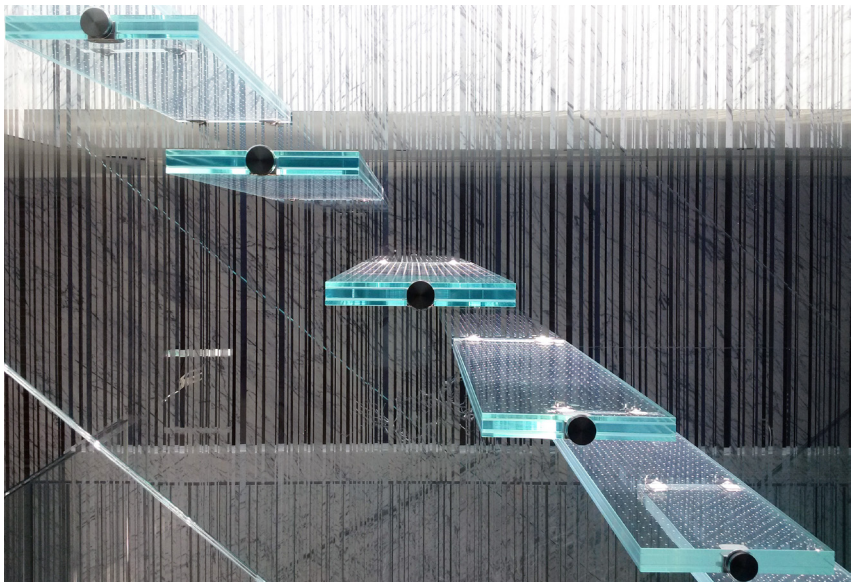
- With no roof over the slot, all the protruding glass boxes are subject to the onerous external environment. High corrosion-resistance has been required particularly at the bolted connections. Due to their height and position in the building, all the glass panels in the boxes need to be able to be replaced by the building's maintenance crane unit and as such they are subject to strict weight limits. We carried out FEA of the glass panels with imposed displacements to reduce the build-up when possible.
- For the main entrance cable-net facade and canopy, we took ownership of the architectural setting out, coordinated with the architects to express their design intent, all while staying within the contractor budget and allowing for interfaces with the main structures. We carried out a large displacement stage analysis of the cable facade to provide most accurate pretension and did a detailed analysis of the glass warpage in the corners and joints design.
- We also carried out a detailing strategy to allow for rationalization of the fabrication and assembly while not compromising the architectural intent. At an early stage, to ensure the complex elements would remain within the limited budget, we collaborated extensively with all parts to improve design.

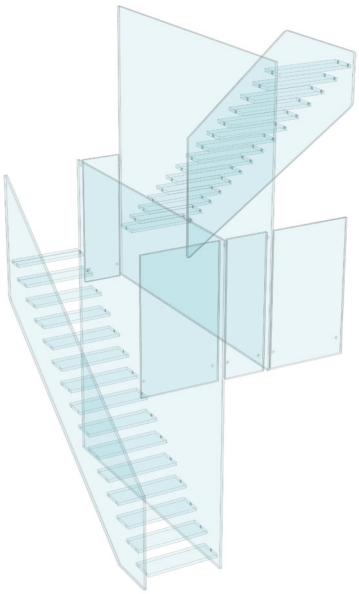
Right:
Glass boxes

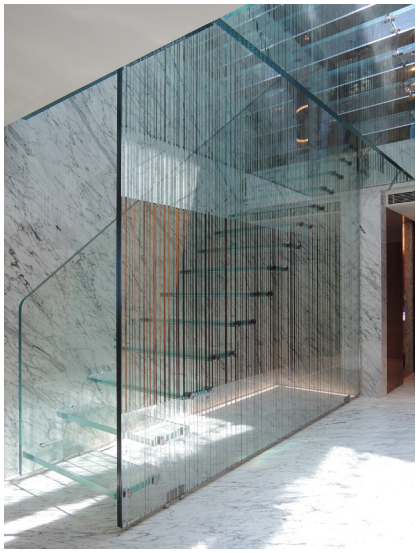
Top Right:
Cable facade architectural setting

Bottom right:
Main canopy

Repulse Bay





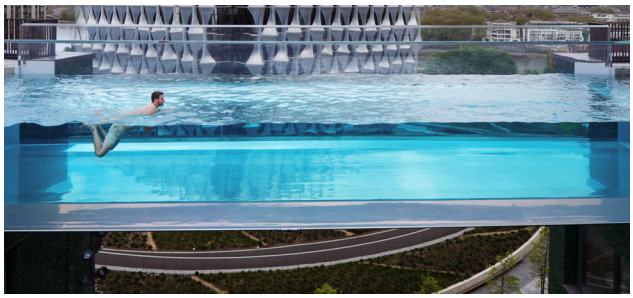


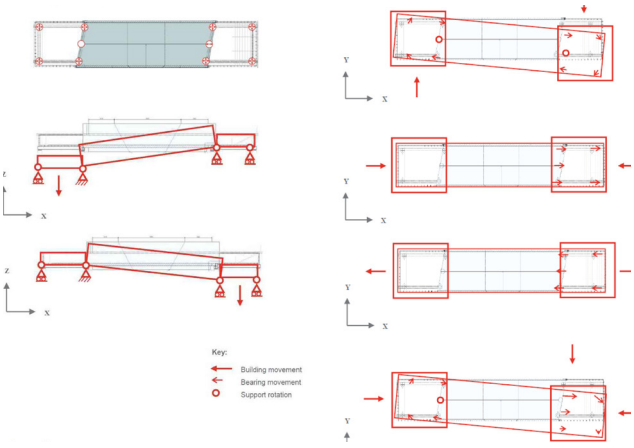
Location: Hong Kong
Client: Private
Architect: Carpenter Lowings
Date: Completed 2015
Value: Undisclosed
Services Provided: Glass Engineering

The staircase serves the 2 floors of this exclusive private apartment and allows access to the roof terrace.

The design was to create a central sculptural screen with simple outer stringers. The central screen was a triple laminate and utilised sputter-coated glass to create the distinctive mirror striped pattern.
The fittings that connected the glass treads to the staircase were minimised as far as possible so as little interruption was given to the central screen as possible.

Sky Pool





Location: London, UK
Client: EcoWorld Ballymore
Architect: Hal Architects
Date: Completed 2021
Value: Undisclosed
Services Provided: Structural Engineering

The world's first fully transparent swimming pool, Sky Pool is a lightweight structure that bridges the 10th floors of two residential buildings which form part of developer EcoWorld Ballymore's Embassy Gardens development in south London.

Constructed in clear acrylic, the side walls of the pool are 180mm thick, 3.2m deep and its base is 360mm thick. The whole pool weighs 50 tonnes and contains a total of 150 tonnes of water (100 tonnes of which is carried by the acrylic 'bridge').

Because of its size, Sky Pool was constructed in separate sections with transparent bonded joints cleverly designed to maximise the bond area and avoid areas of high stress.

While Sky Pool forms the spectacular centrepiece of the new Estate, allowing swimmers a dizzyingly clear view of the park 35m below, Eckersley O'Callaghan addressed some significant engineering challenges when developing the structural solution for this project. The side walls, for example, form deep beams capable of spanning the 15m distance between the buildings, whilst carrying the weight of the water, and resisting the hydrostatic water pressure on the sides and the wind loads.

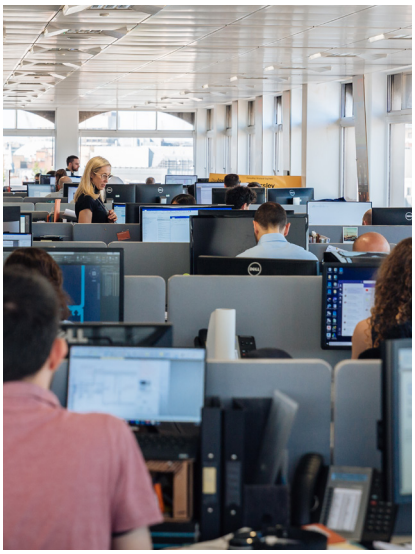
In addition, the two buildings are subject to normal movements, which are inherent to buildings of this scale including wind sway and foundation settlement. The pool structure deals with these movements by avoiding rigid connection at both ends; it slides on bridge bearings whilst maintaining watertightness.

An additional 5m length of pool sits over the buildings at each end – constructed in stainless steel – to make a total length of 25m. They are tied together across the acrylic by two high strength, spring-tensioned, stainless steel rods 38mm in diameter which sit beneath the pool.

A bonded acrylic structure also offers less intrusive joints and connections and greater transparency. The refractive index of acrylic, close to the value for water, will also result in much less distortion when viewing through the water or from outside.

Bottom right:
Accommodating
building movements

Offices



Hong Kong
Eckersley O'Callaghan Asia Ltd
Unit 1301, Bangkok Bank Building
18 Bonham Strand West Road
Sheung Wan
Hong Kong

+852 9799 8812
hongkong@eocengineers.com

Shanghai
Shanghai Eckersley O'Callaghan
Structural Design Consulting Co Ltd
Unit 903 Shanghai Baohua Center
355 West Guangzhong Road
Shanghai 200072
PRC

shanghai@eocengineers.com

London
Eckersley O'Callaghan Ltd
236 Gray's Inn Road
London
WC1X 8HB
UK

+44 20 7354 5402
london@eocengineers.com

Manchester
Eckersley O'Callaghan Ltd
63 Newton Street
Manchester
M1 1ET
UK

+44 78 3443 4870
manchester@eocengineers.com

Paris
Eckersley O'Callaghan SARL
7 Boulevard de Magenta
75010 Paris
France

+33 1 49 29 76 26
paris@eocengineers.com

Milan
Eckersley O'Callaghan S.r.l
Via Ferrucci 22
20145 Milano,
Italy

+39 023 459 9436
milan@eocengineers.com

New York
Eckersley O'Callaghan&Partners LLC
26 Broadway, Suite 1306
New York
NY 10004
USA

+1 646 756 4731
nyc@eocengineers.com

San Francisco
Eckersley O'Callaghan Inc
954 Powell Street
San Francisco
CA 94108
USA

+1 424 272 8484
sanfrancisco@eocengineers.com

Los Angeles
Eckersley O'Callaghan Inc
555 Rose Avenue
Los Angeles
CA 90291
USA

+1 424 272 8484
losangeles@eocengineers.com

Sydney
Eckersley O'Callaghan Pty Ltd
Level 3, 11 Buckingham Street
Surrey Hills
Sydney NSW 2010
Australia

+61 4816 74523
sydney@eocengineers.com

Delhi
Eckersley O'Callaghan India Private Ltd
2nd Floor
B-49 Sector-48
Noida 201303
India

+91(0) 120 4203399
delhi@eocengineers.com