

# Buildings London

Yearbook 2017



History and modernity go hand in hand across the London landscape. Whether beautifully restored heritage buildings or audacious new forms that silhouette the London skyline, it is this rich architectural diversity that makes up the fabric of London.

We have the privilege and opportunity to contribute to some of London's most recognisable buildings. Helping our clients to create destinations and introduce vitality to spaces where people and communities can thrive.

Our 2017 Yearbook showcases Arup's commitment to total design with recently completed buildings or those currently under construction. We work in cities all over the world, drawing upon international best practice and bringing this expertise back home to London.

This collection shows that the symbiotic marriage between engineering and architecture produces quality and efficiency for buildings, of all ages and at all scales. We continue to make a positive contribution to the skyline of London and cities worldwide, as these bustling metropolises adapt and evolve.

Nigel

Nigel Tonks  
Buildings London Leader





## Sky Central

## Building S5, International Quarter London

## New Scotland Yard

**Client:** Sky  
**Architect:** AL\_A, PLP Architecture

Greater London TW7

**Client:** LendLease  
**Architect:** Rogers Stirk Harbour + Partners

London E20

**Client:** Metropolitan Police Service  
**Architect:** Allford Hall Monaghan Morris

London SW1A

## White Collar Factory

## 127-135 Sloane Street

## Torre BBVA Bancomer

**Client:** Derwent London  
**Architect:** Allford Hall Monaghan Morris

London EC1Y

**Client:** Cadogan Estate  
**Architect:** Stiff + Trevillion

London SW1X

**Client:** Banco Bilbao Vizcaya Argentaria SA  
**Architect:** LegoRogers

Mexico City, Mexico



# BLOX

# Television Centre

# Brunel Building

**Client:** Foundation Realdania  
**Architect:** OMA

Copenhagen, Denmark

**Client:** Stanhope PLC  
**Architect:** Allford Hall Monaghan Morris

London W1T

**Client:** Derwent London  
**Architect:** Fletcher Priest Architects

London W2

# 80 Charlotte Street

# One New Burlington Place

# 52 Lime Street

**Client:** Derwent London  
**Architect:** Make Architects

London W1T

**Client:** The Crown Estate  
**Architect:** Allford Hall Monaghan Morris

London W4

**Client:** WRBC Development Ltd  
**Architect:** Kohn Pedersen Fox Associates

London EC3



# V&A, Exhibition Road Quarter

**Client:** Victoria & Albert Museum  
**Architect:** AL\_A

London SW7

# La Sagrada Familia

**Client:** La Sagrada Familia Foundation  
**Architect:** Gaudi, La Sagrada Familia Foundation

Barcelona, Spain

# The Design Museum

**Client:** Chelsfield Partners LLP  
**Architect:** OMA, Allies and Morrison

# Southbank Centre

**Client:** Southbank Centre  
**Architect:** Feilden Clegg Bradley Studios

# Science Museum

**Client:** The Board of Trustees, The Science Museum  
**Architect:** Zaha Hadid Architects, Muf Architecture

London W8

# Royal Opera House

**Client:** Royal Opera House  
**Architect:** Stanton Williams

London SW7

London W1



# Daedalus Pavilion

# BLOX

**Client:** AI Build  
**Architect:** AI Build

Amsterdam, The Netherlands

**Client:** Foundation Realdania  
**Architect:** OMA

Copenhagen, Denmark



# BLOX

# Television Centre

# The Circular Building

**Client:** Foundation Realdania  
**Architect:** OMA

Copenhagen, Denmark

**Client:** Stanhope PLC  
**Architect:** Allford Hall Monaghan Morris

London W1T

**Client:** Arup  
**Architect:** Arup

London W1CE

## Simon Sainsbury Centre, University of Cambridge

**Client:** University of Cambridge  
**Architect:** Stanton Williams

Cambridge, UK

## Engineering Building, University of Leicester

**Client:** University of Leicester  
**Original Architect:** James Stirling & James Gowan  
**Architect:** Berman Guedes Stretton

Leicester, UK

## St Anne's College, University of Oxford

**Client:** University of Oxford  
**Architect:** Fletcher Priest Architects

Oxford, UK

# Energy from Waste

**Client:** Clugston Construction Ltd

**Architect:** UMC Architects

Kent, UK

## Blackfriars Pier

**Client:** Thames Water Utilities Ltd  
**Architect:** Arup

## Kuwait International Airport Terminal 2

**Client:** State of Kuwait, Ministry of Public Works, Special Projects Administration  
**Architect:** Foster + Partners

## Cityringen

**Client:** Metroselskabet  
**Architect:** Arup, Cowi, Systra

## Heathrow

Kuwait City, Kuwait

**Client:** Heathrow Airport

## Elizabeth Quay Bridge

**Client:** Metropolitan Redevelopment Authority  
**Architect:** Arup

Perth, Australia

## The Design Museum

**Client:** Chelsfield Partners LLP  
**Architect:** OMA, Allies and Morrison

## White Collar Factory

**Client:** Derwent London  
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## Coal Drops Yard

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London W1T

**Client:** Arup  
**Architect:** Arup

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London W1CE

**Client:** The Crown Estate  
**Architect:** Allford Hall Monaghan Morris

London W4

## 52 Lime Street

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**Architect:** Kohn Pedersen Fox Associates

London EC3



## Guy's Cancer Centre

**Client:** Laing O'Rourke  
**Architect:** Rogers Stirk Harbour + Partners

London SE1

## The Francis Crick Institute

**Client:** UK Centre for Medical Research & Innovation  
**Architect:** HOK, PLP Architecture

London NW1

## Capella, University of Cambridge

**Client:** Kier Construction Ltd  
**Architect:** Fairhursts

Cambridge, UK

## The Design Museum

**Client:** Chelsfield Partners LLP  
**Architect:** OMA, Allies and Morrison

## Science Museum

London W8

**Client:** The Board of Trustees, The Science Museum  
**Architect:** Zaha Hadid Architects, Muf Architecture

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London SW7

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**Architect:** Heatherwick Studio

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**Architect:** Gaudi, La Sagrada Familia Foundation

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London SE1



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**Architect:** Make Architects

## Television Centre

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**Architect:** Allford Hall Monaghan Morris

**London W1T**

## One New Burlington Place

**London W1T**

**Client:** The Crown Estate  
**Architect:** Allford Hall Monaghan Morris

**London W4**



## Coal Drops Yard

**Client:** King's Cross Central Ltd Partnership  
**Architect:** Heatherwick Studio

## 127-135 Sloane Street

London N1C

**Client:** Cadogan Estate  
**Architect:** Stiff + Trevillion

## Canada Square Park Pavilion

London E14

**Client:** Canary Wharf Group  
**Architect:** William Matthews Associates

## Southbank Centre

**Client:** Southbank Centre  
**Architect:** Feilden Clegg Bradley Studios

## BLOX

London SE1

**Client:** Foundation Realdania  
**Architect:** OMA

## Television Centre

London W1T

**Client:** Stanhope PLC  
**Architect:** Allford Hall Monaghan Morris



## 80 Charlotte Street

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**Architect:** Make Architects

## One New Burlington Place

London W1T

**Client:** The Crown Estate  
**Architect:** Allford Hall Monaghan Morris

London W4



# Warner Stand, Lord's Cricket Ground

# Singapore Sports Hub

**Client:** Marylebone Cricket Club  
**Architect:** Populous

London NW8

**Client:** Singapore Sports Hub Pte Ltd  
**Architect:** Arup

Singapore

# Jaguar Land Rover Advanced Engine Facility

# Digital Realty Amsterdam

**Client:** Jaguar Land Rover Ltd  
**Architect:** Arup

Wolverhampton, UK

**Client:** Digital Realty  
**Architect:** Nicholas Webb Architects

Amsterdam, The Netherlands

# V&A, Exhibition Road Quarter

**Client:** Victoria & Albert Museum

**Architect:** AL\_A

**Location:** London SW7

Leading an innovative engineering project for Exhibition Road Quarter, we have created an elegant new entrance space and the world's first all-porcelain public courtyard. Exhibition Road Quarter showcases the best of contemporary design, as well as celebrating the beauty of the Museum's historic architecture. The Sainsbury Gallery provides 1,100m<sup>2</sup> of column-free space with a stunning 36m folded plate steel roof, creating one of the largest temporary exhibition galleries in Europe.

We helped the V&A to remain open and operational throughout the challenging construction period, collaborating on a series of essential enabling works to re-route major services before the main construction commenced.

On track to achieve BREEAM Excellent, the scheme delivers significant reductions in carbon emissions, achieving a 25% improvement compared to Building Regulation requirements. Working within the opportunities this unique site offered, the design capitalises on the thermal mass of the deep basement structure, which provides a stable environment for exhibits displayed in the gallery.

The structural design balanced pragmatism with the use of complex analysis. We collaborated with AL\_A to optimise the geometry and weight of the folded plate roof. 3D analysis was used to predict building movements during excavation. Combined with discussions on how close to construct piles next to existing buildings, where to provide temporary supports and how best to sequence the works. This enabled the most effective use of space whilst reducing risks.

Repurposing the V&A's back-of-house areas into beautiful public spaces was a complex task, as the site is surrounded by three historic listed buildings. Creating The Blavatnik Hall and entrance staircase to the gallery through and under the listed Western Range Building has been an ambitious feat of engineering. The structure, services and public circulation weave through the area where the old and new intersect directly beneath the four-storey 19<sup>th</sup> Century façade. Our solution provides generous daylighting and views through large skylights. Opened to the public on 30<sup>th</sup> June 2017, Arup's engineering design has contributed towards a new urban sensation for London.

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# Warner Stand, Lord's Cricket Ground

**Client:** Marylebone Cricket Club

**Architect:** Populous

**Location:** London NW8

Our collaboration with Populous and BAM led to the Royal Opening of the Warner Stand at Lord's Cricket Ground on 3<sup>rd</sup> May 2017. The previous Warner Stand suffered from poor viewing angles due to shallow inclinations. The design of the new stand addressed these issues by optimising the geometry of each seating tier to maximise the viewing experience.

Working with the client Marylebone Cricket Club (MCC), the team has also created a world-class hospitality venue whilst respecting the architectural heritage and character of the existing buildings, including the Grade II\* Listed Pavilion.

The improved sightlines and upgraded hospitality features, combined with behind-the-scenes improvements to match day facilities, have enhanced this famous establishment, ensuring the viewer experience now matches Lord's reputation for world-class cricket.

The Warner Stand provided an exciting opportunity for the Building Services team to deliver a creative sustainable design, which aligns with MCC's ambitious sustainability objectives. No fossil fuels are used, instead an all electric solution achieves significant carbon savings across all systems including, heating, cooling and cooking. This zero fossil fuels approach sets the trend for future building types. Arup also provided Fire Engineering, Pedestrian Modelling, Acoustics and Biodiversity Consulting services.

Our work on the Warner Stand follows three decades of design. We have contributed to the Grand Stand, Mound Stand and the Media Centre, helping to bring this historic sporting institution into the 21<sup>st</sup> Century, whilst respecting the club's heritage look and feel.

"MCC created a tough brief, requiring a structure which delivered exceptional facilities for spectators, a unique experience for meetings and events and provided an outstanding working environment, while meeting sustainability and accessibility targets. The expertise and knowledge brought by Arup ensured that these objectives were met and delivered a truly world-class building." MCC's Assistant Secretary (Estates), Robert Ebdon.



## Project contact:

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# The Design Museum

**Client:** Chelsfield Partners LLP

**Architect:** OMA, Allies and Morrison

**Location:** London W8

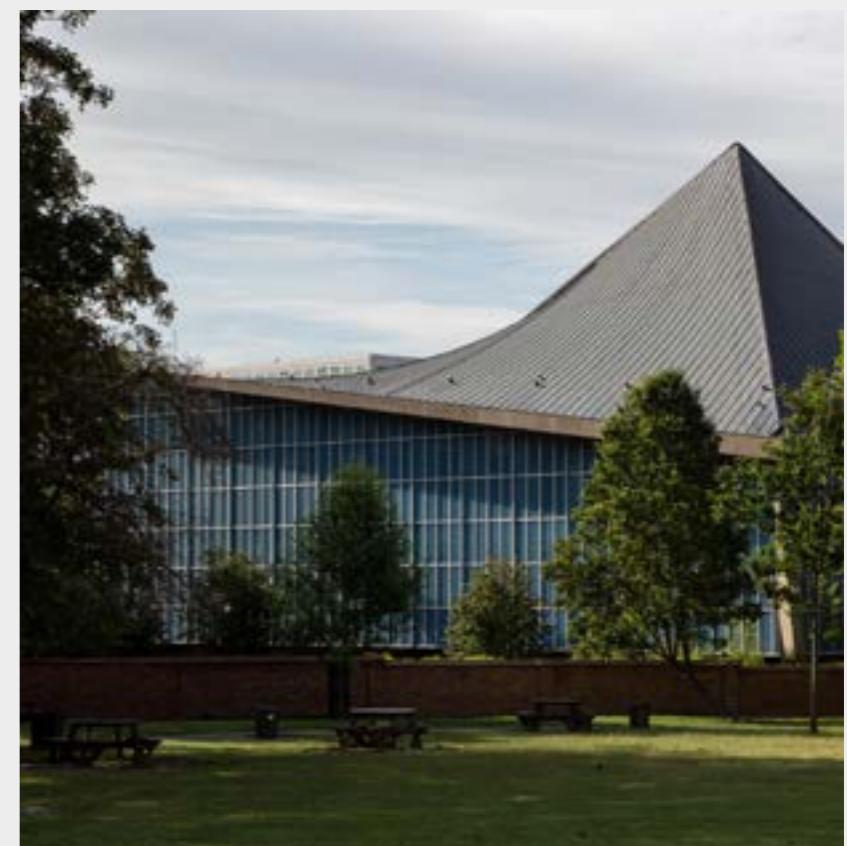
Arup worked closely alongside Allies and Morrison, OMA, together with John Pawson on the development of the Design Museum, in its new West London home.

The £83 million museum will be a world class centre for design. We provided innovative engineering services that enabled the successful repurposing of the former Commonwealth Institute building in Kensington.

Retaining and converting the 1960s Grade II listed building demanded a creative approach to a number of engineering challenges. One of these was to develop a solution to create a new two-storey basement beneath the building's distinctive copper-covered hyperbolic paraboloid roof. The approach involved suspending the 1,500 tonne roof 20m above ground level by temporary works to enable the removal of the foundations, internal structural frame and the new basement to be excavated. Movements of the key supports had to be controlled to within 5mm to avoid damage to this historic roof.

This enabled an increase to the floor plate from 6,000 to 10,000m<sup>2</sup>, triple the amount of space available at the Museum's former home at Shad Thames, Southeast London. The new museum will feature a free permanent collection display called "Designer Maker User", as well as two temporary exhibition spaces, a library, two shops, a restaurant, café and learning studios.

The central hyperbolic paraboloid shell resembles a giant manta ray in full flight. The radiating rafters of the outer warped roof introduce a new dimension with the building appearing to come to life as people move around the upper exhibition space. Its elegant construction was realised using post-tensioned concrete. This same technology was used extensively in the modern interventions. This astonishing roof showcases great engineering design from the past and forms an ideal backdrop for the Design Museum's exhibition space that will inspire and delight all those who visit.



## Project contact:

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# Jaguar Land Rover, Advanced Engine Facility

**Client:** Jaguar Land Rover Ltd

**Architect:** Arup

**Location:** Wolverhampton, UK

The Jaguar Land Rover (JLR), Engine Manufacturing Facility draws upon Arup's half century of experience in the design of industrial buildings. The site for the £900 million plant employing around 1,400 staff, is on brownfield land outside Wolverhampton surrounded by an ecological landscape.

Buildings comprising over 185,000m<sup>2</sup> of space contain north lit machine and assembly halls, which are flanked by office, social support spaces and a community educational centre.

Innovation, collaboration and the wellness of people at the facility is at the heart of its success. Blurring the boundaries between production and offices through visual transparency, clear movement and social spaces, breaks down the barriers of communication between people. North skylights provide day lit spaces throughout the complex. Unusually, glazing strips at ground level provide views to adjacent landscaped surroundings. These vistas provide the visual respite to support personal health, wellbeing and productivity.

As part of JLR's ambition for low carbon manufacturing, the facility is one of the largest to achieve BREEAM Excellent. Sustainable features include natural ventilation, daylit office and production spaces, extensive grey water recycling and the largest rooftop photovoltaic array in the UK. 21,000 photovoltaic panels provide energy to power 30% of the facility, equivalent to 1,600 homes.

Flexibility and resilient adaptability continue to be key drivers for manufacturing facilities. The large span steel roof, based on classic industrial forms, is spaced at 30m intervals and is arranged in a clear hierarchy to provide space for high level modularised services. This design incorporated within the sawtooth roof forms, breaks down the massive scale to humanise the production space.

We provided Architecture, Transport Planning, Environmental, Landscaping, Access advice; together with Civil, Structural, Geotechnical, Fire and Building Services Engineering. This project illustrates a superb and compelling story, further enhanced by our recent RIBA Regional West Midlands Award for Sustainability and Design, in May 2017.



## Project contact:

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# Science Museum

**Client:** The Board of Trustees, The Science Museum  
**Architect:** Zaha Hadid Architects, Muf Architecture  
**Location:** London SW7

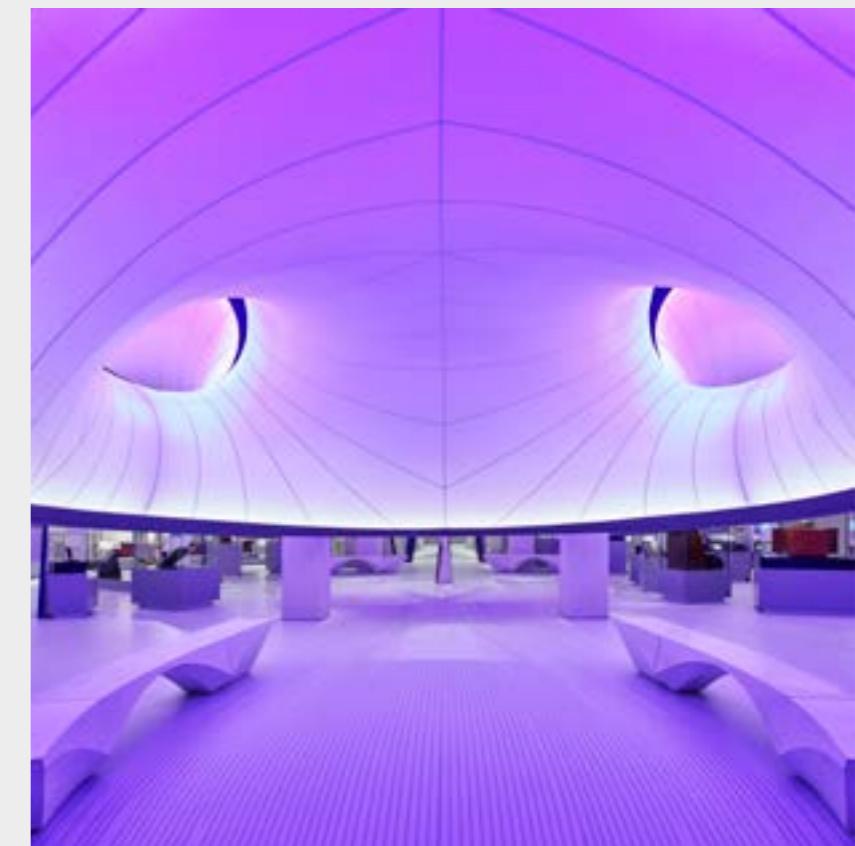
The Wonderlab and The Winton Gallery opened in December 2016, showcasing to the public that the Science Museum has set-out on its transformational journey, which is both imaginative and informative. Dedicated to the power of wonder, the museum encourages curious young minds to discover a variety of science subjects, including; light, sound, matter, forces, electricity, space and mathematics.

The Wonderlab designed with Muf Architecture created a fantastic imaginative space in which engineering is as much part of the exhibition as the formal exhibits. Arup was involved in creating spacious, daylit, naturally ventilated spaces for the museum, opening up and transforming the old interactive galleries.

The Winton Gallery has special resonance for both Zaha Hadid Architects and the Arup team with its exploration of ‘The beauty of Maths’. The gallery spans 400 years of human ingenuity and brings mathematical history to life. We provided Structural and Building Services Engineering together with Lighting Designs for the gallery.

The centre piece is the Handley Page Gugnunc aircraft from 1929. The lighting is arranged to show how air moves around the aircraft, and displays the turbulence patterns over the fabric ‘pod’ installation. The visitor’s experience is at the heart of the gallery and as such, in May 2017, The Winton Gallery received a RIBA London Award. Utilising engineering and lighting techniques to turn complex mathematics and physics concepts into interactive and engaging displays, celebrating sciences, education and the arts.

Arup has also been advising on the museum’s masterplan. This includes the new Medicine Galleries, which will house the Wellcome Trust Collection with Wilkinson Eyre Architects, the Supporters Centre with HAT Projects Architects and the new events spaces with Duggan Morris Architects. Together these projects are central to the museum’s evolution. The engineering behind these spaces is part of a much bigger story. Engineering that will fundamentally enhance the way the museum is perceived and experienced by the public.



## Project contact:

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# Guy's Cancer Centre

**Client:** Laing O'Rourke

**Architect:** Rogers Stirk Harbour + Partners

**Location:** London SE1

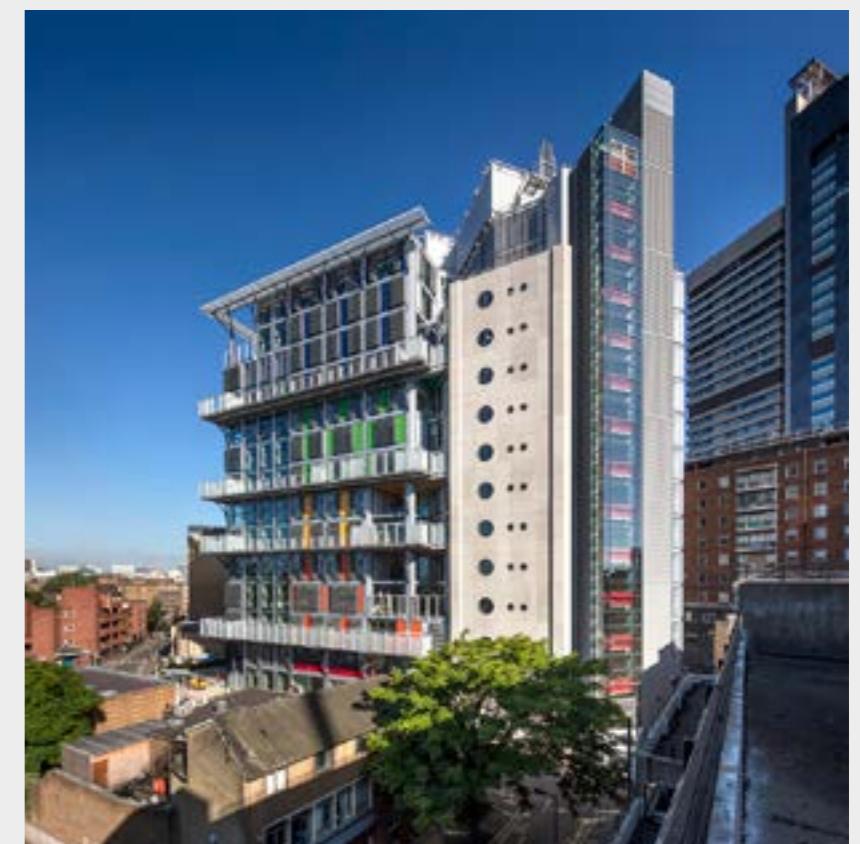
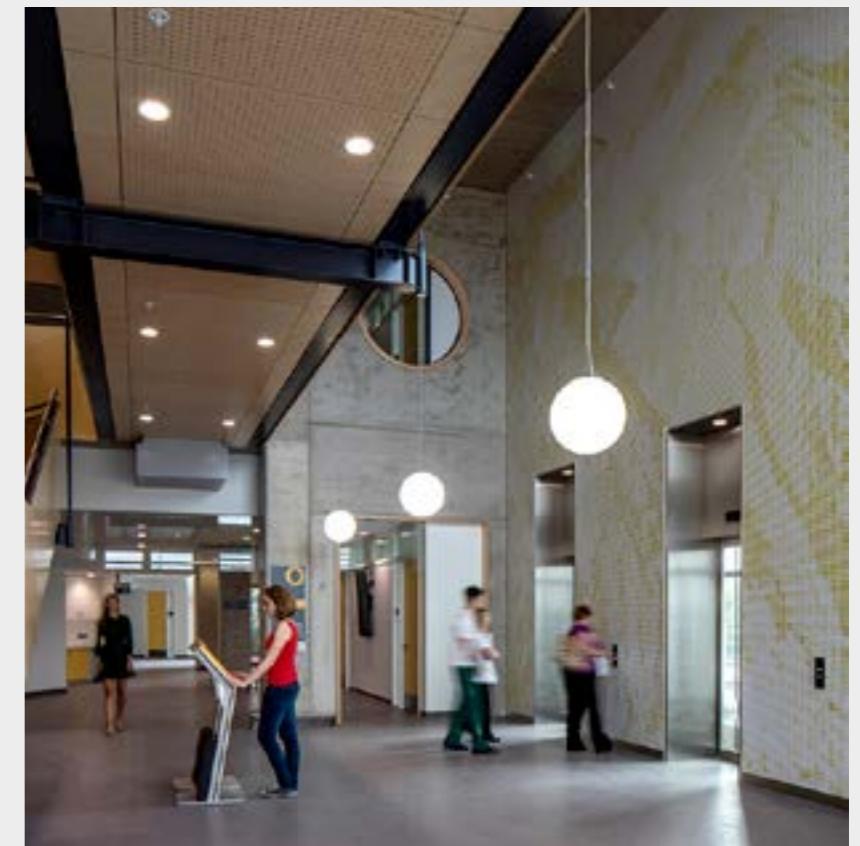
Cancer treatment is rarely straightforward. At Guy's Hospital, cancer patients used to visit up to eight separate buildings accessing different healthcare professionals. The ambition was to improve the experience for patients and their families. The new state-of-the-art Guy's Cancer Centre has been creatively designed around the needs of patients.

The centre is split into four separate 'villages'; Welcome, Radiotherapy, Outpatients and Chemotherapy, each with a distinct identity. The innovative patient-centred layout means people typically visit only one treatment village each time they enter the building. Facilities such as psychological support, blood testing equipment and a pharmacy are all available in the centre, exactly where patients need these services. The new hospital aims to reduce stress, waiting times and late finishes. This enables more patients to be treated whilst offering more radiotherapy treatments.

As a world-class cancer treatment facility, the building includes six linear accelerators (LINACs) for radiotherapy, as well as sophisticated imaging equipment. Heavy LINAC machines are typically sited in basements as a means of shielding staff and other patients from radiation. At the request of patients, Guy's Cancer Centre is the first in Europe to accommodate LINACs above ground, specifically to allow patients to wait and prepare for radiotherapy treatments in naturally lit spaces greatly improving their experience.

Our engineers ensured the suspended floorplates met sensitive vibration criteria for imaging equipment. The use of post-tensioned lattice slabs reduces vibration. The slabs sit elegantly to fit between floors, to invisibly shield the LINACs without disrupting the visually calming treatment spaces. Shielding was incorporated directly above and below these floors. This systems approach integrated services in the reduced-height spaces, above and below for maximum efficiency.

Whilst advancement in cancer care continues, it is encouraging that our technical abilities as engineers can mirror and help the medical profession to deliver new treatments in stunning buildings. Receiving a number of accolades, including the RIBA London Award, Ashden Prize for Sustainability New London Awards, Guy's Cancer Centre is also shortlisted for BCIA.



## Project contact:

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# Coal Drops Yard

**Client:** King's Cross Central Ltd Partnership

**Architect:** Heatherwick Studio

**Location:** London N1C

Autumn 2018 will witness the opening of Coal Drops Yard. This new destination in the heart of King's Cross will create a compelling experience for visitors, workers and Londoners. Offering an exciting array of boutiques, shops and restaurants, Coal Drops Yard is a stunning example of Arup's expertise in re-purposing historic buildings.

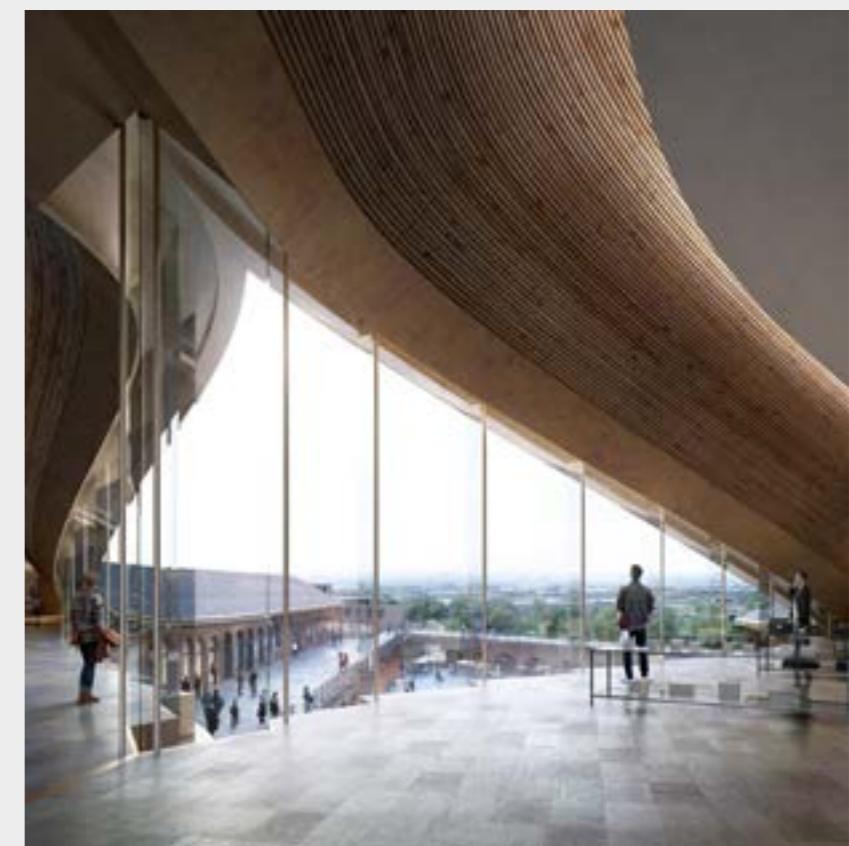
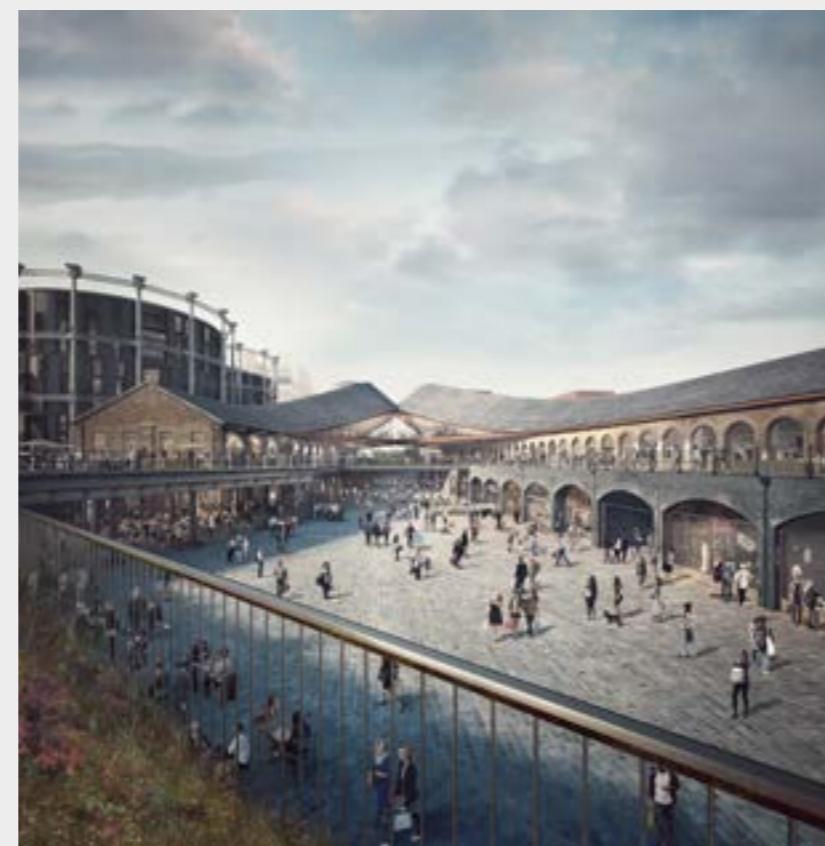
First built in 1850, these historic buildings were used until 1882 as a place to receive and store coal from the north of England. These were subsequently used as warehouses. From the 1980s the Coal Drops housed nightclubs, including the once famous Bagley's, offices and some light industry. Arup has worked closely with Heatherwick Studio to develop the ambitious scheme that has imaginatively reused these heritage buildings.

The sculpted roof has a 50m clear span and suspends a floor through steel hangers. The new upper level and roof structure is supported upon new steel and concrete framing located within the original buildings, which in-turn is supported upon mini-piles squeezed within the internal bays of the coal drops footprint.

Complementing the complex steel frame and enclosing the new upper level is a tapering 8m tall structural glass façade. The façade spans vertically between the slabs and trusses, relying purely on the glass panels arranged in a folded plate geometry. This is bonded with structural silicone to increase the stiffness and load-bearing capacity of the façades.

More than adaptive reuse, and inspired by the circular economy, Arup has pushed the limits of modern codes and assessment references in order to justify much of the existing structure for continued usage, providing a sustainable building that should last more than 200 years.

The project used state of the art surveying techniques, BIM processes and workflows, overcoming many complex design challenges. Providing Structural, Glass and Façade Engineering together with Heritage Building Analysis, Arup continues to contribute towards the regeneration at King's Cross.



## Project contact:

Name

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# The Francis Crick Institute

**Client:** UK Centre for Medical Research & Innovation

**Architect:** HOK, PLP Architecture

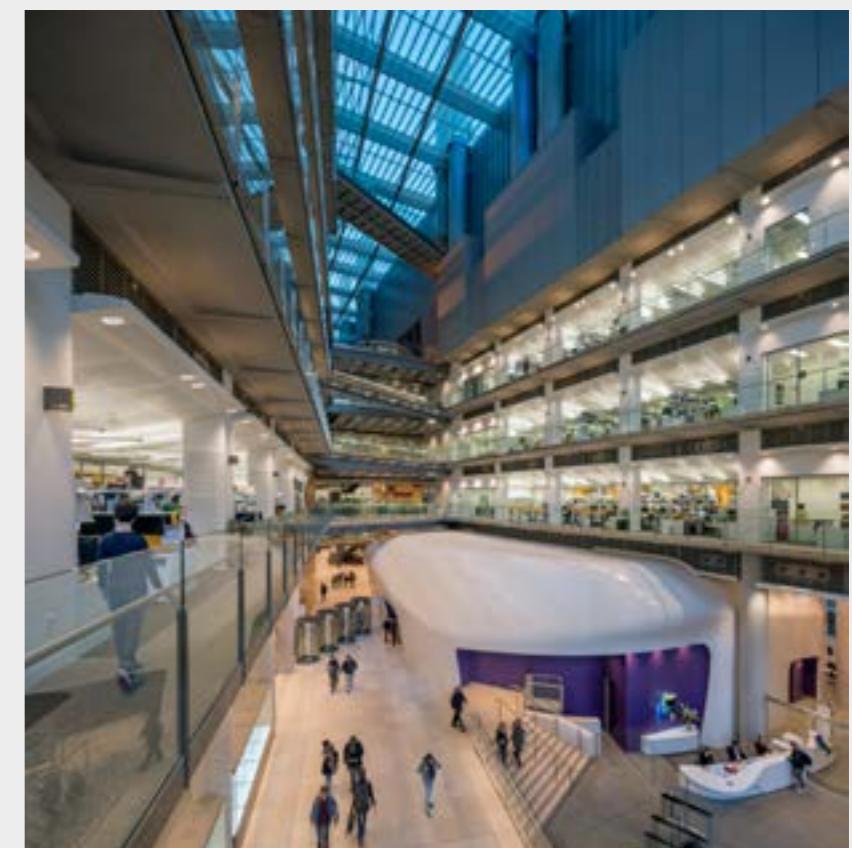
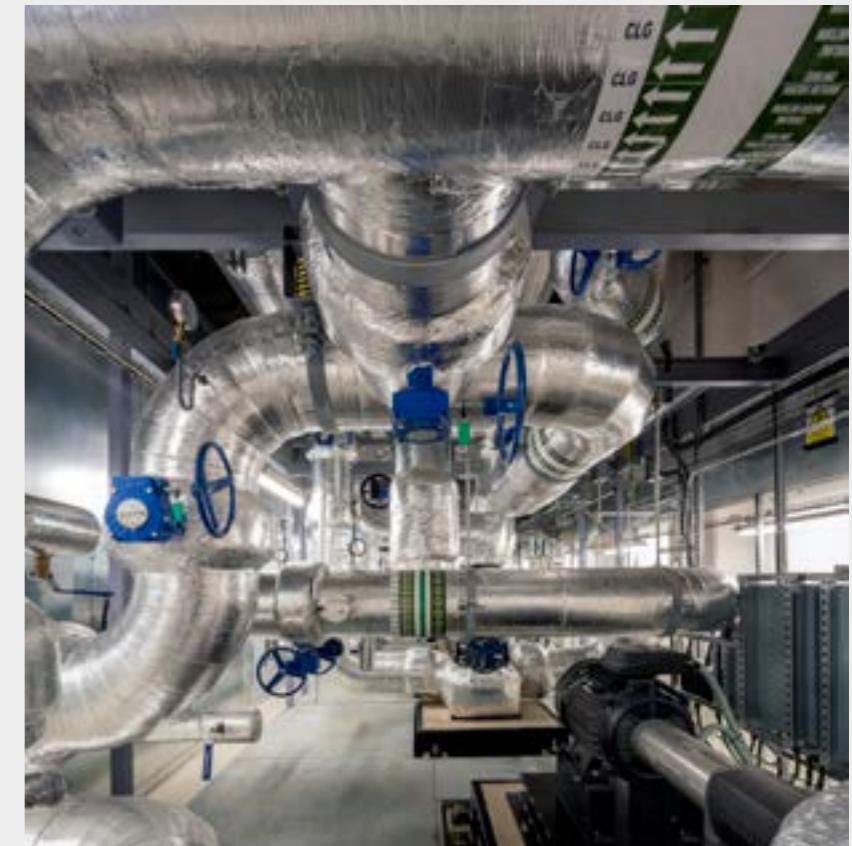
**Location:** London NW1

Officially opened by The Queen and the Duke of Edinburgh in November 2016, The Francis Crick Institute is the largest biomedical facility in Europe. Designed to accommodate the requirements of The Medical Research Council, Cancer Research UK, Wellcome Trust, King's College London, Imperial College London and University College London. The institute is dedicated to understanding the fundamental biology underlying health and disease.

Arup provided Project Management, Building Services and Fire Engineering together with Logistics advice from the outset of the project in 2008. The vision was to encourage a step change from scientists working independently in isolation and instead, foster a spirit of collaboration across teams and disciplines. Mirroring the vision for the Crick, all design partners collaborated together from inception to ensure flexibility coupled with the demanding technical requirements for the building were achievable.

Building Services plant and systems have to be functional and adaptable, and normally fit within the overall architectural form of a building. In this instance, the building services for the laboratory are so substantial that to a large extent, this informed the architecture. The biological research facility is located in the 16m deep basement, along with most of the high-containment laboratories. Large interstitial floors are required to accommodate the sizable heat ventilation air conditioning plant and other services required to support these spaces, while two whole floors of plant at the top of the building inspired the striking roofline.

Since its completion, The Crick has secured a number of awards including; London's Greatest Research and Development Building, awarded by London First and The Best New Place to work presented at the London Planning Awards. Francis Crick at the time of writing has been commended at the RICS Award Ceremony, for Community Benefit and Design through Innovation category, 2017. More recently the Crick also secured BREEAM Excellent accreditation, which is a significant accolade given the building is highly serviced.



## Project contact:

Name

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# Sky Central

**Client:** Sky

**Architect:** AL\_A, PLP Architecture

**Location:** Greater London TW7

Opened in November 2016, Sky Central is creatively designed for flexibility and future business needs. As Sky's headquarters, it is home to 3,500 people. Arup has contributed to creating 'human' spaces over large floor plates in a three-storey, deep-plan building. Our engineering considerations in finding solutions to create a feeling of volume, airiness, with natural light and a generous floor-to-ceiling height, were instrumental in achieving Sky's vision. The striking grid roof is informed by our engineering expertise in timber.

Stairs and ramps encourage interaction and 'chance encounters'. This entertainment company has a prominently-located broadcast studio as well as a range of amenities including, a 200-seat 4K digital life like sound cinema and Waitrose supermarket, 415 seat restaurant and five cafés.

The building achieves the ambitious sustainability aspirations set out in Sky's corporate aims, minimising energy demands through passive means, using efficient systems, and employing renewable energy technologies. A 2,275m<sup>2</sup> photovoltaic array provides 13.5% of the buildings measured peak electrical demand.

A deep raised floor accommodates a wide variety of Sky's data and broadcast relay systems, as well as providing a space for air supply and electrical power. Team areas can be quickly reconfigured by moving floor tiles containing air grilles and power points, maximising flexibility for the sophisticated open plan offices. Meeting rooms and other 'stage set' elements are configured with a 'plug and play' approach.

The Energy Centre located next to Sky Central will meet the heating requirements for the campus. This includes a heating and cooling system linked to the campus's Combined Cooling Heat and Power network, fuelled with biomass.

Sky Central is the most recent and largest of the six buildings that Arup has helped to design and deliver. We are also the designers of the masterplan, utilities and other infrastructure across the site. Lining up a bevy of awards, Sky Central has been shortlisted for BCIA as well as BCO, Estates Gazettes, and Mixology.



## Project contact:

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# Building S5, International Quarter London

**Client:** LendLease

**Architect:** Rogers Stirk Harbour + Partners

**Location:** London E20

Contributing to the evolving destination in Stratford, International Quarter London is located at the gateway to Queen Elizabeth Park and is a joint venture between Lendlease and London Continental Railway.

The first 20-storey office building ‘S5’ will be Financial Conduct Authority’s new headquarters. Once again collaborating with Rogers Stirk Harbour + Partners (RSHP), the design is synonymous with celebrating architectural engineering at its best.

Soffits are exposed in the typical floor plate, with slender columns gently flaring towards the top, to provide punching resistance to the slab. In the Atria, Arup has designed exposed composite deck and cellular steelwork to allow the distribution of services. Secondary steelwork in the atria supports the glazed façade and in part, these span triple height and gently taper.

Flamboyant external staircases extend full height, and the steelwork is set outside of the cladding line. This design will encourage people to use these stairs, thus supporting the client’s health and wellbeing agenda. Each floor plate is between 1,900 and 2,800m<sup>2</sup>, wrapped around a perimeter atrium and split into three-storey ‘villages’. This arrangement maximises horizontal and vertical connectivity and creates a vibrant hub at the heart of the building.

Appointed to provide Structural and Geotechnical Engineering designs, we will also be working on five other buildings, making a significant contribution to this destination. S5 is the first prototype, and as reflected in our work at Chiswick Park with RSHP, we are contributing towards a design methodology which will allow ‘a kit of parts’ approach ensuring efficiency and aesthetic quality are embedded within the masterplan.

The following quote best sums up the ambition, “International Quarter London will be London’s newest and most progressive business district, delivering...a lasting legacy for East London’s economy.” Ian Crockford, Project Director, International Quarter London at Lendlease.

## Project contact:

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# New Scotland Yard

**Client:** Metropolitan Police Service

**Architect:** Allford Hall Monaghan Morris

**Location:** London SW1A

William Curtis Green's neoclassical 1930s building is part of London's Whitehall property estate. Classed as having special heritage interest with a prominent position on the Thames, close to the Palace of Westminster, Arup has restored this building to once again be the headquarters of the Metropolitan Police Service (MPS).

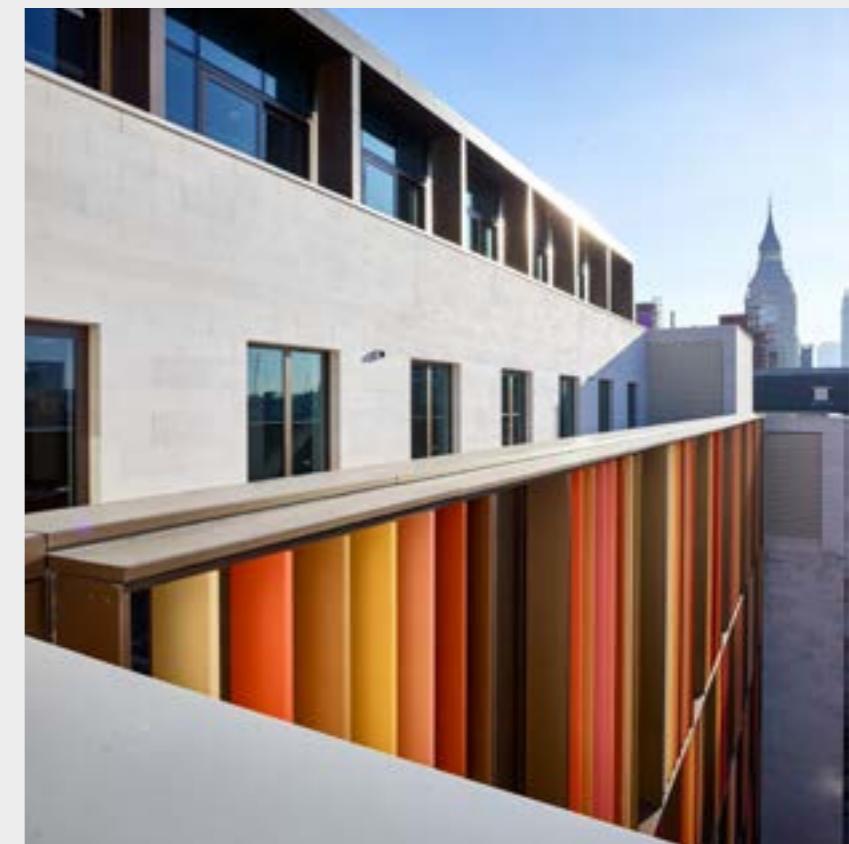
Working with Allford Hall Monaghan Morris (AHMM), we focused on designing high-quality, contemporary offices that support the productivity and wellbeing of MPS staff. Overall, the design encourages greater interconnectivity between departments and many opportunities for interaction.

Early discussions between Arup's Structural, Building Services and Façade Engineers focused on maximising usable floor area. Sensitive modifications to the existing perimeter increased by 30% from 4,700 to 6,400m<sup>2</sup> whilst raising the energy performance to meet stringent requirements.

We maximised floor-to-ceiling heights. A new west-facing glazed façade with architectural shading brings additional daylight deeper into the interior. The project had a demanding timetable. RIBA Stages 1 and 2 commenced in November 2013 with site enabling works beginning in September 2014. Practical completion was achieved in November 2016 and impressively New Scotland Yard opened in March 2017.

Arup's extensive contribution has involved many of our specialist consultants, including Security and AV/ICT experts. The designs incorporate the latest technologies for live broadcast. We also acted as BIM coordinator, responsible for maintaining the digital workflow on behalf of the wider design team.

At street level, a fully glazed entrance pavilion acts as a flexible, introductory space allowing some public access. The innovative curved glazing required rigorous testing to ensure safety and robustness. AHMM and Arup worked closely with the MPS to enable the building to be open to surroundings whilst secure. Receiving a RIBA London Award in May 2017, New Scotland Yard will play an important role in the rejuvenation of Victoria Embankment.



## Project contact:

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# White Collar Factory

**Client:** Derwent London

**Architect:** Allford Hall Monaghan Morris

**Location:** London EC1Y

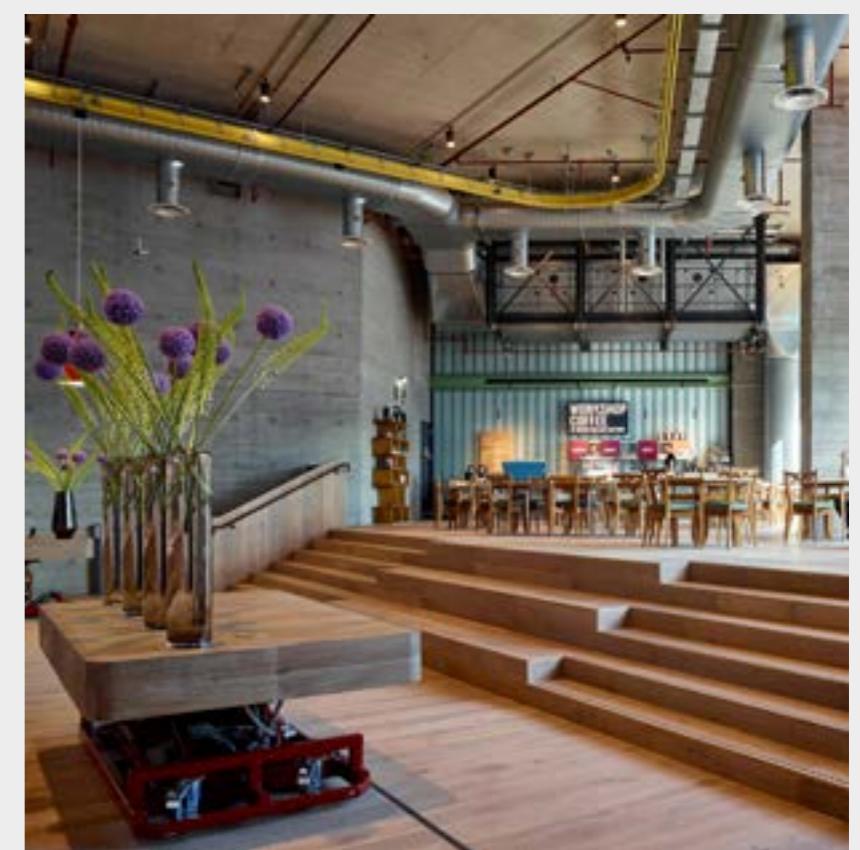
White Collar Factory is the next generation of smart buildings in the heart of London's 'Tech City' district. Arup's innovative design has played a central role in establishing a bespoke office building for a new way of working.

Collaborating with Derwent London and architects Allford Hall Monaghan Morris we have re-imagined new-build office designs for London's commercial property market. The White Collar Factory approach combines the generosity of large flexible, industrial spaces with innovations in technology. The ambition was to provide smarter spaces that anticipate, as-yet, unexpressed needs from London's tenants, rather than simply follow the norm for the established commercial office market.

Largely pre-let, White Collar Factory's occupiers will be mostly technology and creative companies demanding high levels of connectivity, resilience and security from the building's ICT and digital infrastructure, as well as flexibility. People will be able to 'see' in real time how the space they are working within is operating. They will be encouraged to provide feedback, to improve comfort and energy performance, via Arup's tablet-friendly app linked to the building management system.

Five core principles help the design to be 'climate-resilient'; high ceilings, a thermal-mass structure, simple passive façade, flexible floorplates and 'smart' upgradable servicing. By including natural ventilation and other passive systems, White Collar Factory can be operated in ways that limit mechanical heating, cooling and ventilation, including openable windows throughout.

The striking façade incorporates a unitised curtain walling system, which is broken down into three key elements; opaque, fully glazed, and glazed two metre high inward opening windows that are partially shaded by large perforated panels. These are deployed on the building according to each elevation's orientation to the sun. Thus ensuring each elevation is unique. The integrated approach to the design has helped to achieve BREEAM Outstanding and LEED Platinum certifications. The White Collar Factory will, no doubt, be seen as an exemplar in London.



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# Brunel Building

**Client:** Derwent London

**Architect:** Fletcher Priest Architects

**Location:** London W2

Elegantly fronting the Grand Union Canal and sitting above the Bakerloo Line, Derwent London's Brunel Building on North Wharf Road will create a stunning visual marker. Currently on site and working with Laing O'Rourke, Arup is delivering innovative designs for 16-storeys of column-free workspace. A splendid showcase of engineering, the rich palette of materials comprises; concrete walls, long-span precasted fabricated steel floor-beams, precast concrete floor panels and a striking steel exoskeleton.

Before tender there was a period of intense collaboration between the multi-disciplinary design team, further involvement with the contractor led to an ingenious approach to the integration of structures and services. We designed practical yet beautiful connection details. Arup's extensive experience of diagrids was harvested in devising and refining the steel configuration. As the structure penetrates the building envelope, our Façade Engineers advised on the thermal and condensation performance. Shading from the exoskeleton compensates for larger windows, exploiting panoramic views. The diagrid extends beyond the roof levels to create sheltered gardens on the upper floors.

This exciting overt expression of engineering was inspired by solving complex below ground site constraints. Cost effective development of this building required a sophisticated approach to justify the impact on Bishops Bridge, the Grand Union Canal as well as the London Underground line beneath. The engineering solution for the basement box and foundation design was further complicated by a requirement to be shared with another developer on the adjacent site.

We worked closely with the contractor to justify a simple shallow raft foundation. This was the most economical solution for the basement box and foundations. Providing Façades, Structural Engineering together with Geotechnics and below ground drainage services. We are also delivering Access and Maintenance, Transport and Acoustics advice.

Arup's contribution will add to the vibrancy of the area, which has enjoyed significant regeneration over the last two decades. This will be further enhanced by the opening of The Elizabeth Line in 2018.



## Project contact:

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# 127-135 Sloane Street

**Client:** Cadogan Estate

**Architect:** Stiff + Trevillion

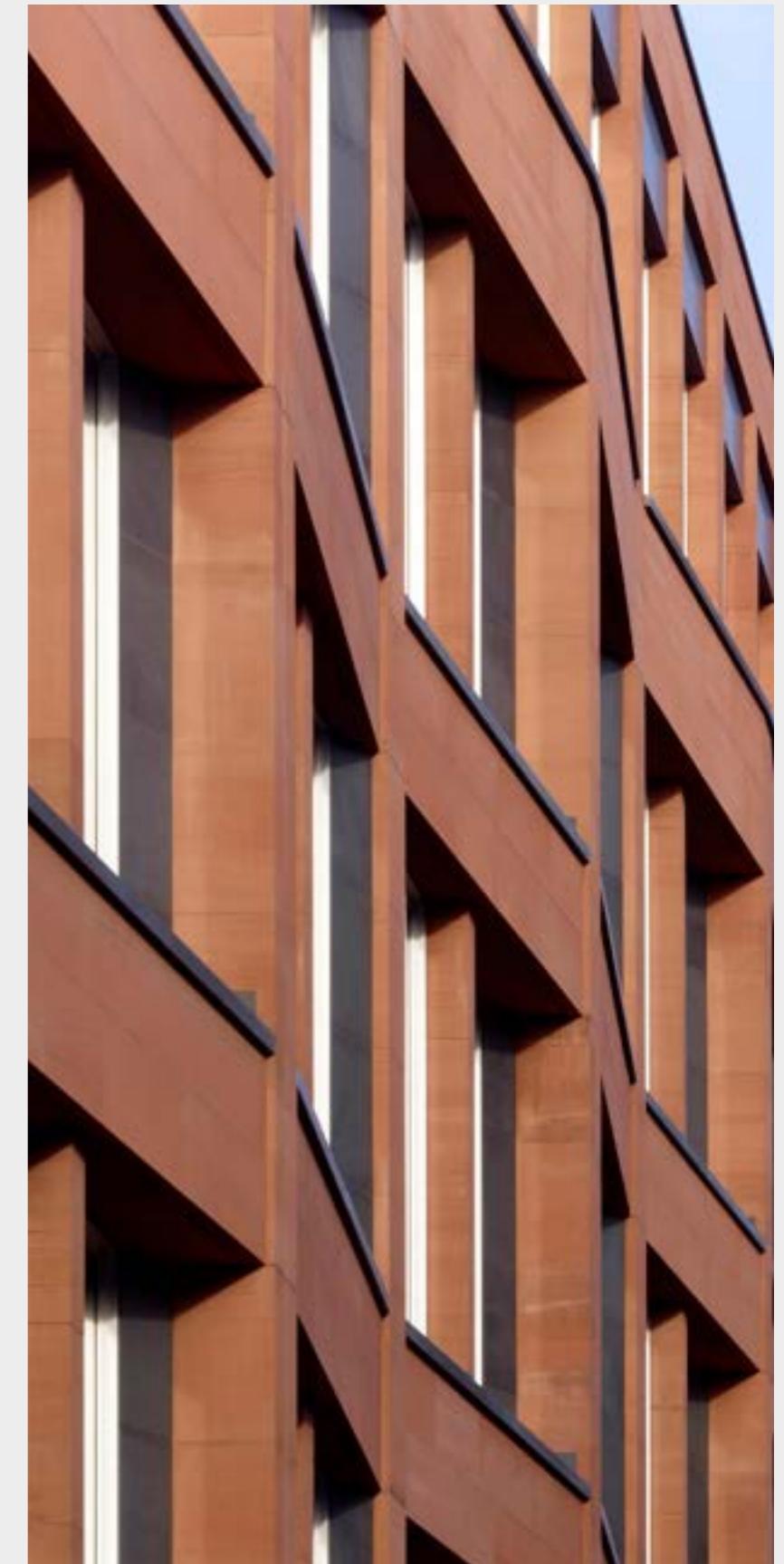
**Location:** London SW1X

127-135 Sloane Street located near Sloane Square, and opposite luxury flagship stores such as Chloe, seeks to create a new ‘village heart’ for Chelsea. Arup has contributed to the Façade Engineering designs for this stunning building, complementing the historical significance and elegance of Sloane Street. Comprising five floors of BREEAM Excellent rated office space, artisan boutiques face Pavilion Road. Central to the development an open-air courtyard, inspired by Corso Como in Milan, creates a green oasis and is home to a new neighbourhood restaurant.

Arup advised on appropriately sourced stones with a pleasing aesthetic. Red Locharbriggs sandstone from the UK was chosen for its colour and texture, which complements the neighbouring buildings. European dark grey lava stone was identified for detailing as it is naturally more robust and durable. The project was highly commended at the Natural Stone Awards 2016 for its detailing and respect for material.

Key to the main Sloane Street elevation is the modulating façade which developed from an earlier saw-tooth pattern. As the line of the stone façade projects outwards at intervals our Façade Engineers developed a steelwork arrangement, to support the cladding. Designing the steelwork before tender enabled a more competitive price, thus helping to reduce costs. Work on site was also minimized by incorporating bracket installation utilising off-site fabrication. The façade on the top-storey elegantly steps back with floor to roof level glass. Arup’s Building Physicists analysed the thermal stresses and developed shading using fritting patterns at the top of each unit to mitigate against solar gains.

Contributing towards Chelsea’s largest retail development for a generation, 127-135 Sloane Street provides an exceptional and inspiring experience for all those visiting, living or working in the area.



## Project contact:

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# Blackfriars Pier

**Client:** Thames Water Utilities Ltd

**Architect:** Arup

**Location:** London EC4V

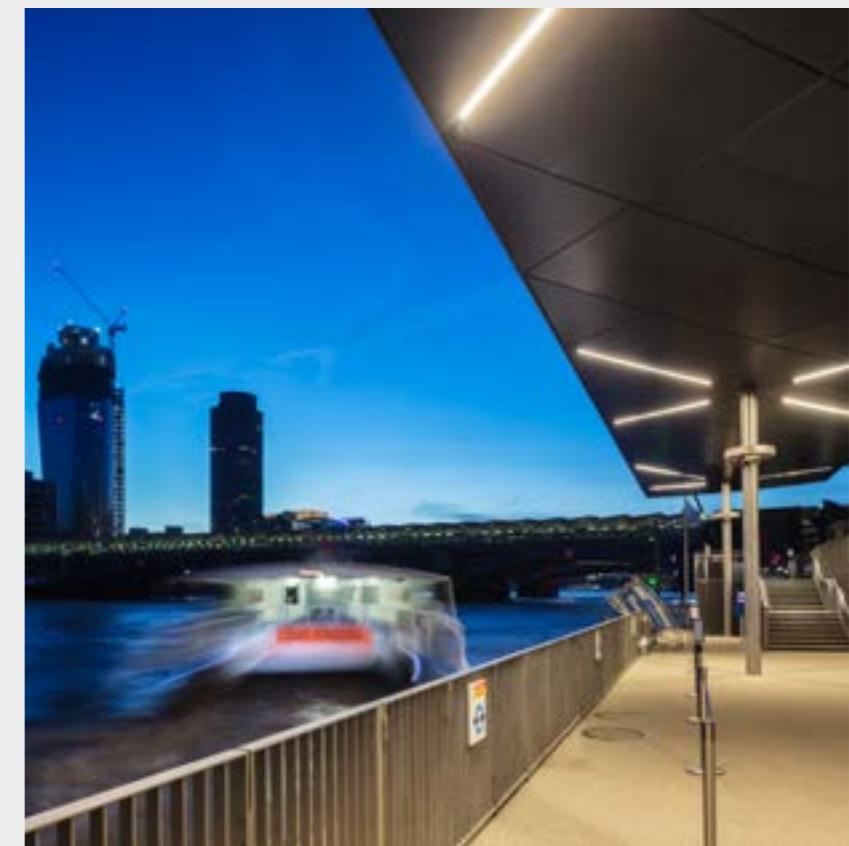
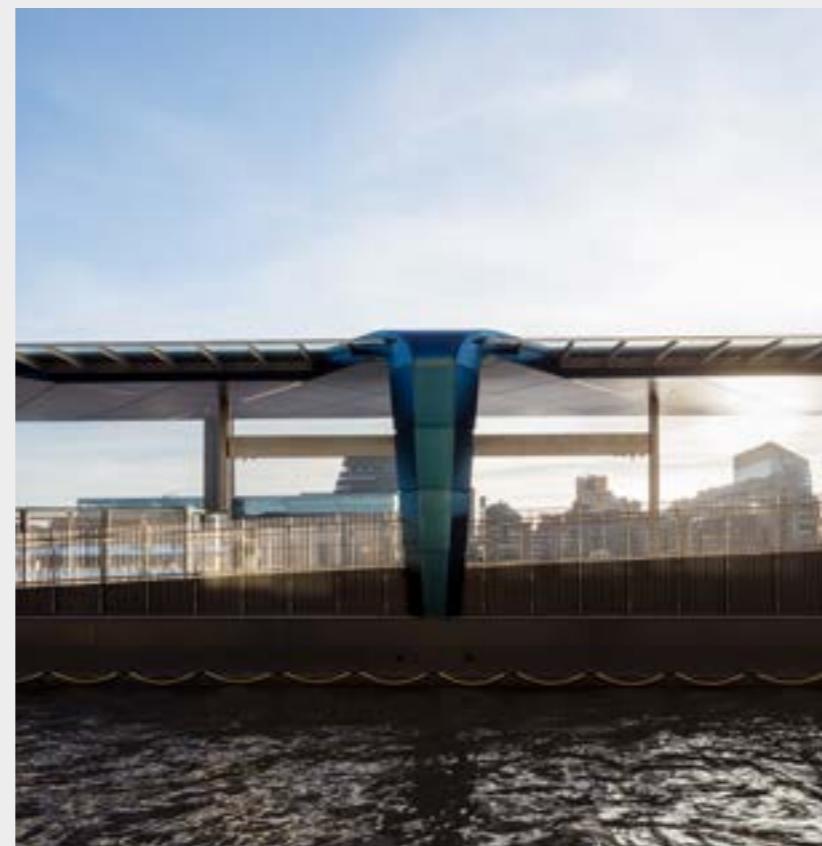
Blackfriars Pier is a fantastic addition for Thames Clipper passengers, allowing two boats to berth simultaneously thus enhancing the capacity of river transport. The elegant 80m pier has maximum visual transparency at all tidal ranges to maintain views to and from the City of London and to complement existing landmarks. Surrounded by both iconic buildings and critical river assets, such as flood defenses and bridges, provided a host of interesting design challenges.

The pier was required to comply with the requirements of both Lloyds Standards for Ships and British Standards for Buildings. The design, planning and delivery of this project required extensive liaison and agreement with multiple stakeholders.

Our designs had to consider for the potential of a ship impact, due to the constrained nature of the river in this location. Innovative grout connections were devised between the bankseat piles and headstock to accommodate the enormous impact loads and to avoid large welds, which would have been very expensive and challenging to construct in a tidal zone.

Unmanned, the pier control systems function automatically. The lighting design required careful integration with the structure and special attention was paid to avoid light pollution into the Thames, as well as limiting glare for passing vessels. The design of the earthing system required an innovative solution, as the pier sits part on-shore and partly in a marine environment. Our design made use of the electricity supplier's earth system for the protection of the equipment on-shore. A segregated and independent off-shore earth was required, to mitigate against the corrosion of the pier structure from stray earth currents, emanating from landside supplies.

We provided Maritime, Architecture, Materials, Accessibility, Landscaping Designs together with Building Services, led by the Arup London Maritime team. Following almost three years of engineering designs by Arup, Blackfriars Pier was successfully opened in October 2016. This successfully marked the completion of the first milestone for the Thames Tideway Tunnel.



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# La Sagrada Familia

**Client:** La Sagrada Familia Foundation

**Architect:** Gaudi, La Sagrada Familia Foundation

**Location:** Barcelona, Spain

La Sagrada Familia in Barcelona is a UNESCO world heritage site and considered one of the most remarkable buildings in the world. The first stone for the temple was laid in 1882, on St Joseph's day, and some 135 years later, Gaudi's original design is 70% built. The ambition is to complete the Basilica by 2026.

The four towers on the Nativity Façade were completed in 1930. On the Passion Façade another four towers were realised in 1976. Currently, the client has commissioned work on the six main central towers, dedicated to the Four Evangelists, Virgin Mary and Jesus Christ. The tower dedicated to the Virgin Mary will rise to 135m and be supported by the earliest parts of the original crypt, finished in 1889. The client approached Arup to advise on the challenge of the 136m tower bearing weight on the crypt.

Working with La Sagrada Familia Foundation, we have developed an innovative approach to the construction of the Virgin Mary Tower. Initial thoughts had been to use a reinforced concrete structure, clad in stone. This solution, however, proved too heavy for the crypt. We suggested that the stone itself, could be the structure providing both a beautiful finish and reducing the weight of the tower by a factor of two. This approach resolved the issue with load capacity of the original designs whilst reducing build cost and accelerating the construction.

Arup engineers designed the stone masonry panels that are pre-stressed using hydraulic jacks, a system of stainless steel rods and anchorages. Pre-stressing provides greater strength to the panels, allowing these to be fabricated remotely, transported to site and lifted into place by crane. This solution also allows the panels to resist stresses imposed by wind and seismic events. The off-site manufacture guarantees a consistently high quality.

Carefully designed connections ensure that when panels are craned into place, these fit together like 'Lego', without further adjustment. Traditionally, these panels would take weeks to build. Installing a panel now takes 30 minutes, saving time and enabling a safer construction process. It is a privilege to contribute innovative 21<sup>st</sup> Century engineering thinking to realise Gaudi's pioneering design.

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# Cityringen

**Client:** Metroselskabet

**Architect:** Arup, Cowi, Systra

**Location:** Copenhagen, Denmark

Danish design is characterized by simplicity, minimalism and functionality. Securing the commission to design 17 new stations for Cityringen, an extension to the metro system in Copenhagen, Arup opted for an elegant and clean approach.

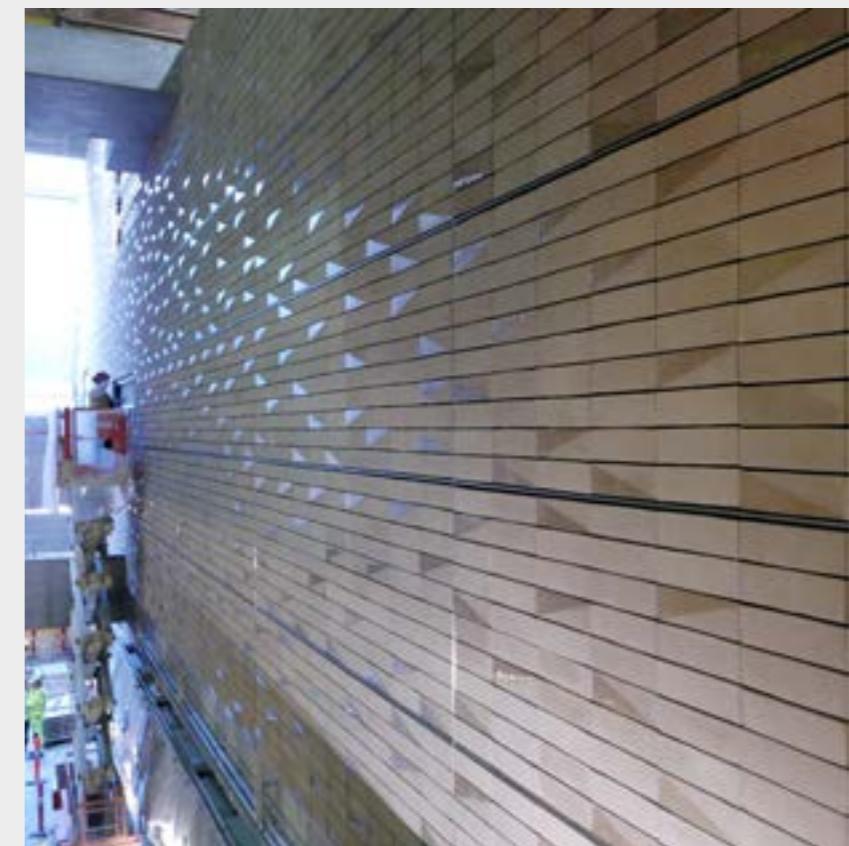
Ambitiously, Cityringen will serve major areas in Copenhagen including the Danish Parliament, Central Station, City Hall, existing major S-train, metro stations and national monuments.

In a city renowned for its population preferring to travel above ground by bike or on foot, we have designed fully day lit stations. The optimisation of the 'Station Box' and its modularity makes it possible to install the new Cityringen stations into the medieval historic fabric of Copenhagen.

The design of each station complements its neighbourhood incorporating ideas and motifs inspired by local surroundings. This design solution also helps people with wayfinding. Enghave Plads Station, by way of example, features brown bricks to proudly reflect the style of buildings in the former working-class neighbourhood. København H, Copenhagen's main station, sports bright red panels, signalling the transfer from metro to regular red trains. The colour is also a nostalgic reminder of the old station building.

Arup is part of a joint venture with Cowi and Systra. We are leading the development of architectural and engineering designs from concept to tender stage. We are also serving as client adviser during the construction stage.

Scheduled for completion for 2018, Cityringen has set new standards for modern metro systems, illustrating that delightful design can be achieved, whilst providing humane and legible spaces.



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# Simon Sainsbury Centre, University of Cambridge

**Client:** University of Cambridge

**Architect:** Stanton Williams

**Location:** Cambridge, UK

Cambridge Judge Business School was founded 20 years ago, on the Grade II listed Old Addenbrooke's Hospital site in the historic centre of Cambridge. Whilst the existing buildings form an important part of the school's identity and character, these no longer provided sufficient space, or appropriate facilities, for its current and future needs.

Arup together with Stanton Williams has been commissioned to enhance, consolidate and expand the school's facilities on its existing site. This will enable the school to operate more efficiently and support future growth. A 4,800m<sup>2</sup> new development, the Simon Sainsbury Centre, will provide space for the expanding Executive Education programme together with additional teaching, office, breakout and dining spaces. Bringing together faculty, staff and students into one location.

Scheduled for completion in 2017, and currently under construction the building connects with the existing facility which currently remains in use.

Working collaboratively to optimise the building form and façade on a constrained site, we have ensured that all office spaces operate without mechanical cooling. Our designs include using natural ventilation in summer and an innovative distributed façade ventilation system for heat recovery in winter. These low energy spaces allow the building to improve on the energy requirements of Part L 2013 by over 25%. The ventilation strategy allows for future flexibility of the internal layout.

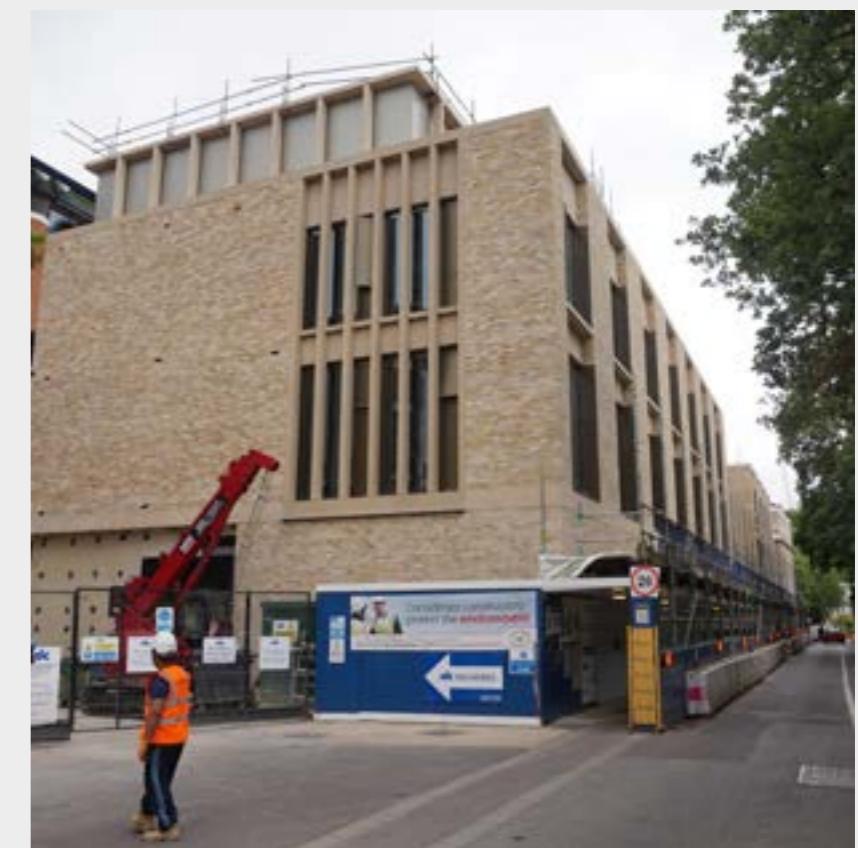
Adoption of 3D modelling at an early stage in the design process has allowed for clear coordination of services. We have also carried out detailed modelling of the building envelope. This work helped to inform the architect's façade design, to prevent overheating and allow optimal placement of photovoltaics together with solar thermal panels.

Arup has a long standing relationship with the University of Cambridge and we are delighted to be contributing towards the Simon Sainsbury Centre, which will continue to inspire future generations of students.

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# Elizabeth Quay Bridge

**Client:** Metropolitan Redevelopment Authority

**Architect:** Arup

**Location:** Perth, Australia

The new Elizabeth Quay development in Perth is graced by a distinctive, dual-arched bridge for pedestrians and cyclists. An artfully meandering structure, designed to delight, the bridge spans a newly-created inlet of the Swan River, its curvaceous form visually linking city and water.

The bridge brings together a waterfront redevelopment that has transformed Perth's previously underused river foreshore, now creating a vibrant promenade, lined with bars and restaurants. Elizabeth Quay Bridge will also be surrounded by a mix of offices, apartments, hotels and shops.

The digital design workflow was a highly collaborative process between Arup's architects and engineers. This collaboration was pivotal in the successful delivery of the project. The team delivered a bridge deck that is only 250mm deep at the edges. This elegance exceeded the client's aesthetic expectations and is a manifestation of the team's ingenious architectural and engineering approach. The bridge promotes continuous pedestrian movement around the quay and links the island in the river to the popular 'bridges' recreational circuit whilst affording spectacular views. The bridge is striking from every angle and gives substance to the MRA's slogan: 'The River. The City. Together Again'. The design of Elizabeth Quay Bridge met the MRA's brief for a simple form, by the use of rationalised modular architecture of fascia finishes, balustrading and timber decking.

In addition to Architecture, Civil, Geotechnical Electrical Engineering and Materials Specialist Consultancy. We also provided Advanced Technology and Research advice, Wind and Vibration Engineering, together with Naval Architecture. Elizabeth Quay Bridge is a stunning example of Arup's total design philosophy.

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# Kuwait International Airport, Terminal 2

**Client:** State of Kuwait, Ministry of Public Works,  
Special Projects Administration

**Architect:** Foster + Partners

**Location:** Kuwait City, Kuwait

Seven years ago the State of Kuwait commissioned Arup and Foster + Partners to design an air terminal that will serve as the Gulf's new regional hub, setting the standard for luxury air travel. Together with Gulf Consult, our local partner, we prioritised mitigating the carbon impact of the building, setting ourselves the challenge to create the world's first LEED Gold passenger terminal, in a desert environment where temperatures regularly exceed 40°C.

Commencing construction in late 2016, we are providing an array of services. This includes Structural Engineering for the beautiful roof; together with our specialists providing Baggage and Acoustics advice. Lighting Designs and Façades Engineering were provided to detailed design stage. Designing an energy efficient new terminal, with a single roof canopy spanning 60m, we are providing the ultimate in comfort for passengers.

The terminal will accommodate 13 million passengers per annum and is designed to increase to 50 million. This requires a building of extraordinary dimensions. The terminal has 28 terminal gates, including eight for the Airbus A380, multi-storey car parks with 4,500 spaces and a transit hotel. We arranged the terminal over three levels for arrivals, departures and baggage claim with minimal vertical changes to produce a passenger friendly environment. Gates extend from a 25m high central atrium and are distributed between three symmetrical wings of 1.2km, therefore walking distances are limited to 600m from centre to end points.

In striving for LEED Gold, the 25m high central dome is supported by a concrete structure which provides thermal mass for passive temperature regulation. The roof incorporates a large expanse of photovoltaic panels to harvest solar energy. We balanced the lighting energy savings from greater daylight penetration with the increased cooling load from solar gain, and shading the façade completely from the summer sun without restricting views. Working in harmony with the climate resulted in an impressive 50% reduction in energy consumption of the terminal's environmental systems, compared to the LEED baseline. In years to come, Terminal 2 will epitomise luxury air travel.



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# Energy from Waste

**Client:** Clugston Construction Ltd

**Architect:** UMC Architects

**Location:** Kent, UK

Energy from Waste is a hugely important growth sector for the UK's infrastructure, as our nation struggles to deal with an ever increasing amount of waste from both household and industry. The new £340 million facility in Kent, will process 550,000 tonnes of rubbish each year, diverting valuable alternative fuel from waste being delivered to neighbouring countries or worse still, being landfilled. Creatively, the facility has also been designed to provide steam for the neighbouring paper plant and generate 43MW of sustainable electricity.

Arup is delivering the building design for this next generation Energy from Waste plant, one of the largest in the UK, in Kemsley, near Sittingbourne, Kent. As the Lead Building Designer, we are working closely with civil contractors Clugston Construction Ltd and process contractor CNIM Group. Over the next 36 months we will work towards the successful delivery of the project. We will provide Civil, Structural and Geotechnical Engineering, in addition to reviewing the building services design.

Commissioned in August 2016, the team has worked with exuberance and enthusiasm on this fast track construction program. By mid October 2016 the first piles were already installed. We are providing a cost effective design for the bunker, the huge concrete box within which the fuel will be stored. Impressively, the size equates to a third of a football pitch dug seven metres into the ground.

The Energy from Waste facility is scheduled to be operational in 2019, and is expected to create around 40 full time jobs. Contributing to the designs of these industrial facilities, Arup is honing its expertise within this sector whilst seeking to shape a better world.

## Project contact:

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# Canada Square Park Pavilion

**Client:** Canary Wharf Group

**Architect:** William Matthews Associates

**Location:** London E14

The addition of a two-storey timber pavilion restaurant within Canada Square Park will enhance the offer of this already bustling green space, which hosts a continuous cycle of events throughout the year. Nestled amongst the Canary Wharf skyline, the intention for the pavilion is to form an extension to the park, especially during the summer months when the façade opens, creating a seamless relationship between the square and the pavilion.

Arup was approached by Canary Wharf Group to design and deliver the Structural and Building Services Engineering and Fire Strategy. Arup Lighting is providing the designs to enhance this new space. We are collaborating closely with architects William Matthews Associates.

The modular scheme consists of a cubic frame that fragments and opens towards the park in an irregular fashion. Large glass sliding doors open onto terrace areas. The use of square timber panels within a frame of the same material, provides a complete family of solutions for all floor and wall finishes, inside and outside the building, including double-span internal areas. A combination of spruce and acetylated timber is used to ensure a long design life to deal with exposure to the weather. The pavilion is fully sprinkler protected and the frame includes a protective char zone in the event of a fire.

Structurally, timber is a much lighter material than its steel and concrete counterparts. This choice of material enabled the pavilion to be built on the existing foundations which also includes a retail offer.

A life cycle assessment has been conducted using the Arup Project Embodied Carbon Calculator. This tool confirms that the pavilion structure's negative global warming potential will effectively offset that of the interior fit-out, resulting in very low overall embodied carbon footprint, when benchmarked against industry-wide building data. Construction of this first-class sustainable building is expected to be completed in early 2018.



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# Capella, University of Cambridge

**Client:** Kier Construction Ltd

**Architect:** Fairhursts

**Location:** Cambridge, UK

In 1719, John Addenbrooke made a generous endowment to establish a hospital in Cambridge. 200 years later, this gift has laid the foundation for a world-renowned centre of excellence in healthcare and research.

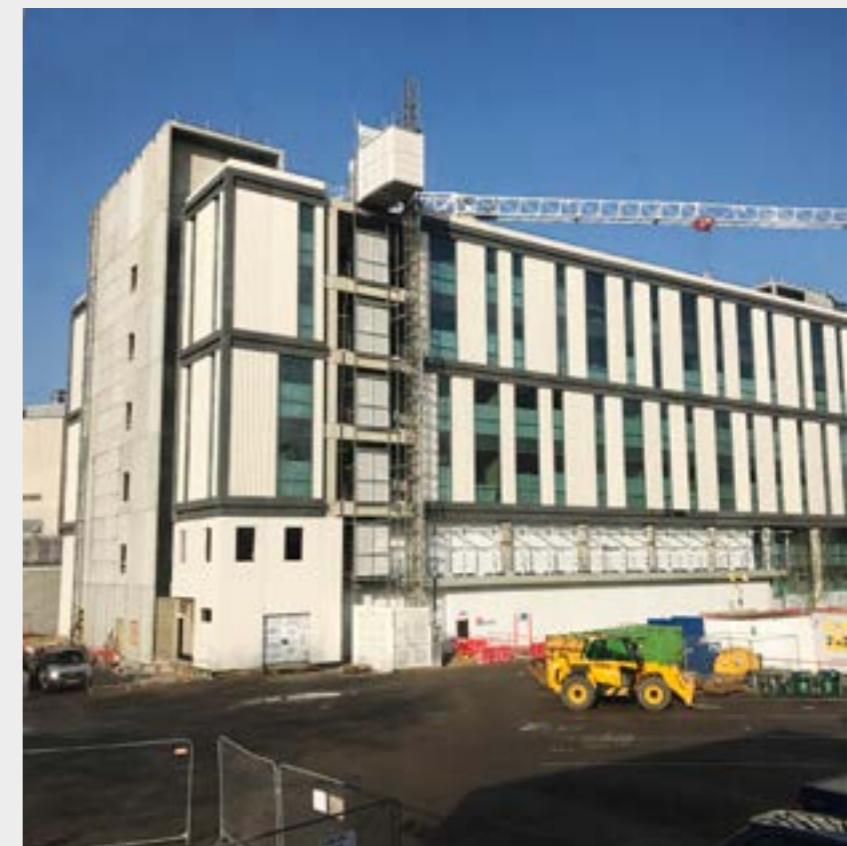
Capella will be a new laboratory for the University of Cambridge and is currently under construction. This new 18,000m<sup>2</sup> biomedical research facility will be located adjacent to the existing Cancer Research UK building, to the west of Addenbrooke's Hospital.

The vision for Capella is aligned with a number of recent laboratory facilities we have delivered across the UK. Capella brings together a large number of medical research groups currently scattered across the city. This will establish a new centre of excellence for research and ground breaking medical treatments. The spirit and trajectory of 21<sup>st</sup> Century scientific research encourages great minds to collaborate. Stimulating the exchange of ideas and helping to foster new medical alliances.

The building will be home to the Cambridge Stem Cell Institute, Gurdon Institute, Cambridge Institute of Therapeutic Immunology and Infectious Disease, Cambridge Centre for Haematopoiesis and Haematological Malignancies. Each of these organisations focus on a particular strain of scientific research, and the work of many of their affiliates interrelates and converges across other disciplines.

As part of the contractor led design team Arup is providing Civil, Structural and Building Services Engineering designs. Arup's engineering designs are showcased as an exemplar BIM Project on the university's estates management website.

Arup's expertise in designing such facilities continues to expand. The engineering designs for Guy's Cancer Centre, The Francis Crick and Sainsbury Wellcome Centre illustrates our knowledge and capability in the field of healthcare and pioneering medical research.



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# Heathrow

**Client:** Heathrow Airport

**Location:** Greater London TW6

Over the last decade, Heathrow has upgraded its airport by focusing on major construction projects, most notably Terminal 5, which opened in 2008 and the significantly enhanced Terminal 2 in 2014.

Arup has provided a breadth of services to bring these projects to fruition, from engineering and specialist expertise to airport planning and operational readiness. These projects have helped Heathrow to continually enhance its passenger experience. Terminal 5 has consistently won the annual Skytrax award for Best Terminal in the World.

It is said global aviation does not stand still. Heathrow recognises this by continuous investment in its existing facilities, to evolve and meet the ever-changing demands. Arup is Heathrow's Programme Designer for two of its four primary programmes of investment, Passenger Experience and Baggage. Since 2014, we have provided an array of Building Engineering Services together with strategic, technical and operational advice to help deliver over 150 key projects across all five terminals and the wider Heathrow campus.

Arup has delivered an extensive range of Passenger Experience Programmes, including; the creation of a new transfer facility in Terminal 3 that caters for 5 million passengers per year, a 20% expansion of Terminal 4's security search capacity and new routes and escalators, which traverse across all levels of Terminal 5.

Heathrow's CEO described the project as "effectively performing open-heart surgery on a live terminal", praising the way in which passenger experience and capacity were maintained throughout.

The next chapter in Heathrow's history is in realising its recently approved expansion plans. Arup's engineers, specialists and project managers are part of the team Heathrow has appointed to deliver the expansion by 2025. These plans are centred on a third runway and a sixth terminal building. The expansion poses significant logistical challenges. Confident in our relationship with Heathrow, we will deliver one of the largest aviation projects in UK history.

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# Torre BBVA Bancomer

**Client:** Banco Bilbao Vizcaya Argentaria SA

**Architect:** Legorogers

**Location:** Mexico City, Mexico

On 9<sup>th</sup> February 2016, Mexico's President Enrique Peña Nieto officially inaugurated the £450 million BBVA Bancomer skyscraper, headquarters for Mexico's largest bank.

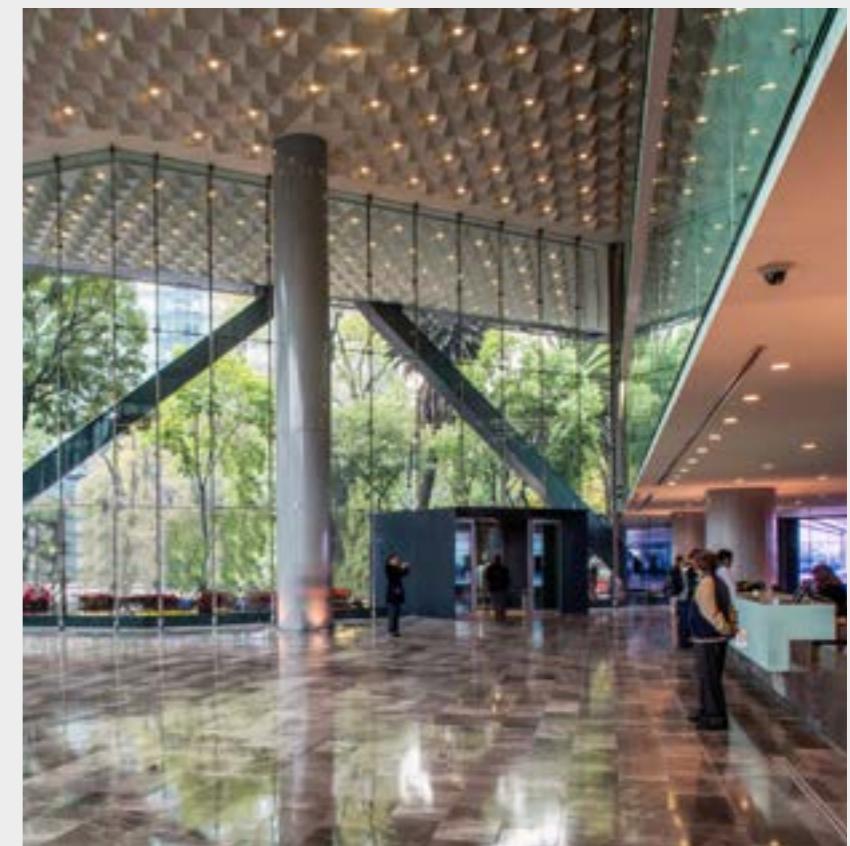
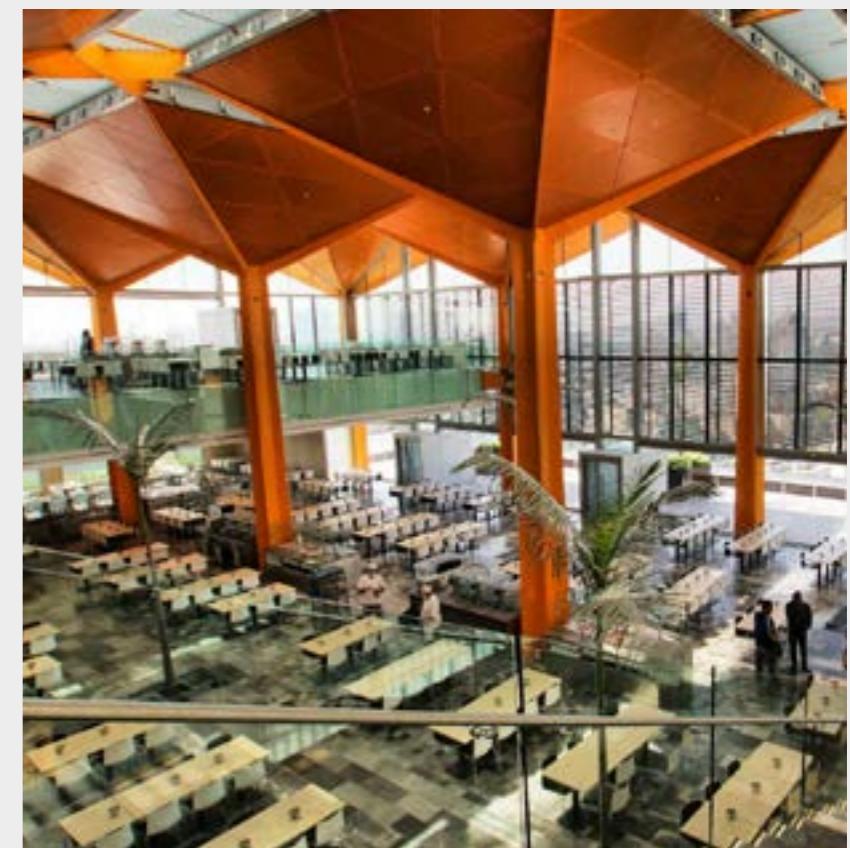
Torre BBVA Bancomer is at the forefront of the development of a central business district in Mexico's rapidly expanding economy. Located on the most prominent site, the building creates a gateway to the central business district of Paseo de la Reforma from Chapultepec Park.

At 235m in height, the 52-storey Torre BBVA Bancomer is the tallest completed building in Mexico, with a total construction area of 189,000m<sup>2</sup>. This statuesque tower is designed to house 4,500 BBVA Bancomer head office staff and includes a seven-storey basement, a 12-storey annex, together with an independent ramp structure incorporating a large auditorium.

The LEED Gold-certified Torre BBVA Bancomer is a beacon of sustainability in Mexico City. The design combines traditional elements of Mexican architecture with modern sustainable engineering solutions, including waste and greenhouse gas emissions reduction and water recycling.

The building was designed by Legorogers, which is a collaboration between the architectural practices of Legorreta + Legorreta and Rogers Stirk Harbour + Partners. The building is the culmination of a collaborative process that began seven years ago with a series of hand drawn engineering sketches. Today, these sketches form an integral part of the architecture and client's vision for the project. A symbol of strength as well as an open demonstration of the ability to withstand some of the world's largest earthquakes.

Cementing our reputation in the industry, Arup's structural engineers have designed 17 of the world's tallest buildings. This was included in The Council of Tall Buildings and Urban Habitat findings "100 of the World's Tallest Buildings." as at November 2016.



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# Digital Realty Amsterdam

**Client:** Digital Realty

**Architect:** Nicholas Webb Architects

**Location:** Amsterdam, The Netherlands

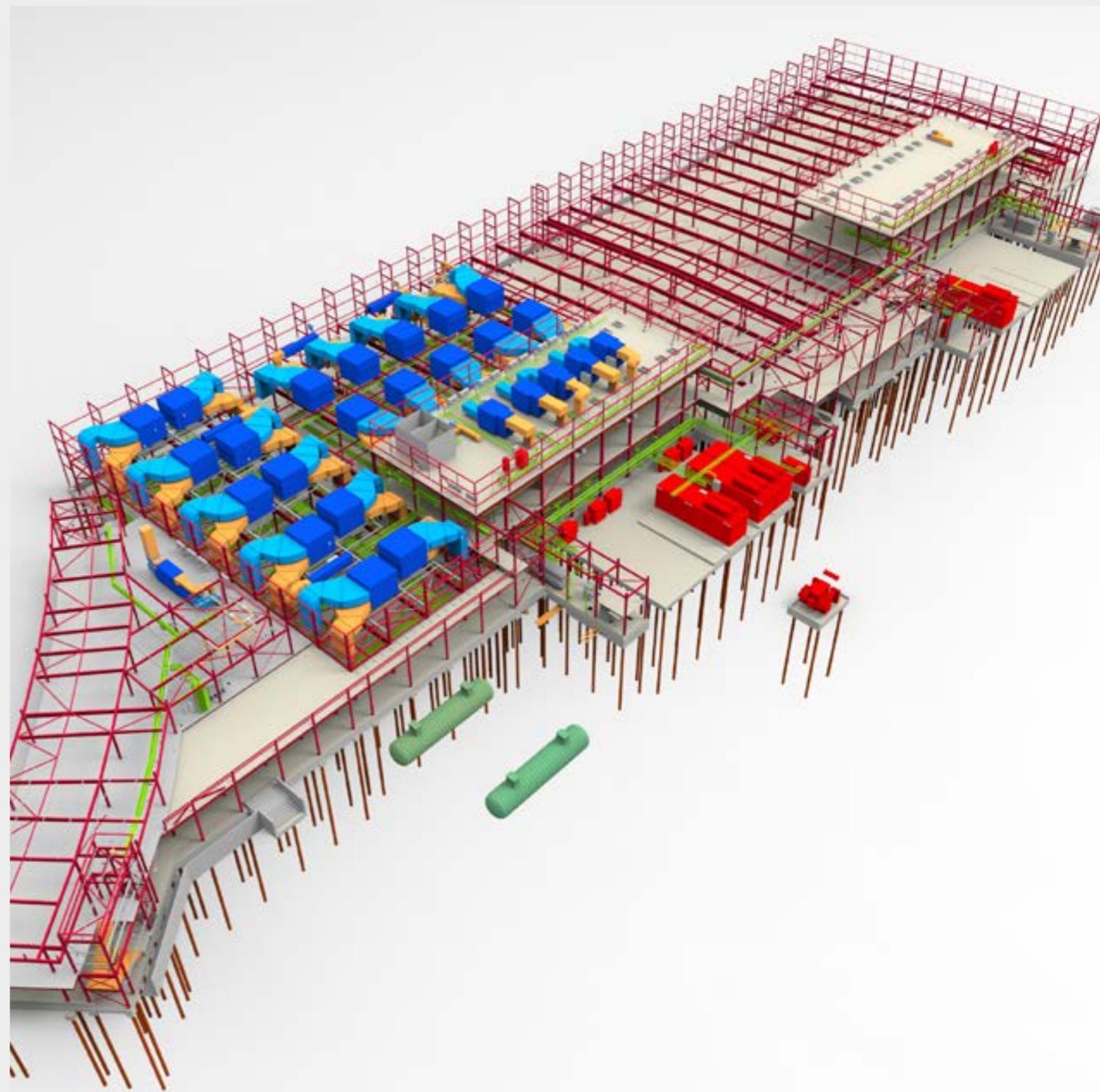
Living in an ever increasingly interconnected world, data centres enable services, customers and partners to connect on a global network. Digital Realty (DLR) is a data centre world leader. In 2017, DLR, will celebrate the opening of its new €60 million data centre in Amsterdam, AMS15. This data centre, together with its flagship office, has been designed to seamlessly blend into its surroundings in the Hoofddorp region of Amsterdam. Six new data halls will add 6,600m<sup>2</sup> of prime ‘white space’ to DLR’s portfolio.

DLR’s business philosophy is to accommodate varying customer demands ensuring flexibility and multi-functionality. Each data hall has been designed for a base IT load of 2MW. Each hall has the capacity to be upgraded to a possible 3MW based on the requirements of DLR’s customers. Our design enables DLR to offer its customers purpose built, bespoke solutions.

AMS15 incorporates highly energy efficient cooling systems. There is a supply of fresh air cooling to electrical rooms. Indirect air cooling is provided to the data halls. In addition there is also evaporative cooling. This approach has contributed to achieving a BREEAM target rating of Very Good.

In a first for data centres, AMS15 utilises a centralised high voltage backup generator system and a distributed uninterruptible power supply. Designed by Arup, in close collaboration with DLR, this scheme provides our client with a highly resilient, cost effective electrical infrastructure. This innovative approach is now being deployed across DLR’s expanding European portfolio.

Providing Structural, Civil and Building Services Engineering designs, we successfully completed Phase 1 at the end of June 2017. Simultaneously we received a second instruction to commence Phase 2.



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# Southbank Centre

**Client:** Southbank Centre

**Architect:** Feilden Clegg Bradley Studios

**Location:** London SE1

The history of Southbank Centre started with the Festival of Britain, held in 1951. The festival aimed at demonstrating Britain's recovery from World War II by showcasing the best in science, technology, arts and industrial design. This was described as "a tonic for the nation" by Herbert Morrison, the Labour Party government minister responsible for the event.

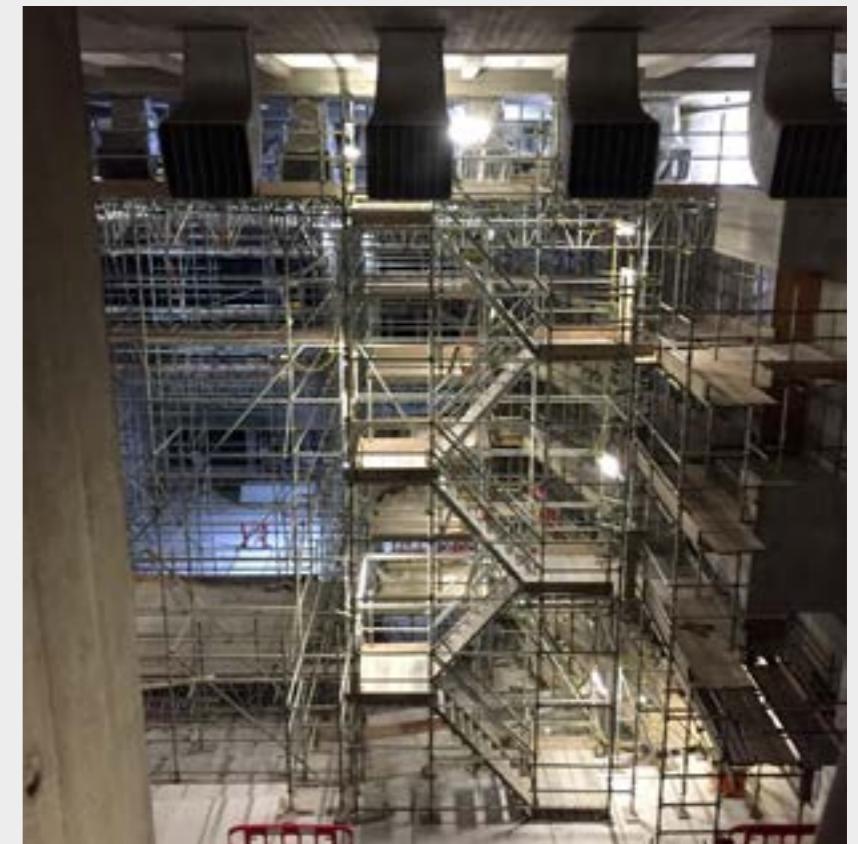
Delivering an array of performances including, orchestra, rock, dance and concerts, the Southbank Centre has secured its position as Europe's largest centre for the arts. After 60 years of use the finishes, services and spaces were in desperate need of an update. Our Structural Engineers enabled and facilitated creative structural interventions to allow for the refurbishment.

Arup was involved in the designs of The Queen Elizabeth Hall, The Purcell Room and The Hayward Gallery together with the interconnecting walkways. As part of our legacy from 1951, we have a set of carefully recorded historical structural drawings and calculations. Studying these records the engineers' generated solutions, which enabled complex and resourceful alterations to the existing structure.

At a conceptual level, we completed quick high level studies that reduced costs and disruption of investigation works. When arriving at the detailed analysis stage, we had the ability to justify less obtrusive and more elegant responses to the alterations.

An illustration of our approach is the new bar that is scheduled to be opened adjacent to Queen's Walk. In this location we have created openings in the reinforced concrete walls to draw in natural light and encourage people to enter Southbank Centre, directly from Queen's Walk.

Our ingenuity in structural engineering has contributed once again to the Southbank Centre. We are delighted to be involved in the rejuvenation of this world famous centre for arts and culture.



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# Royal Opera House

**Client:** Royal Opera House

**Architect:** Stanton Williams

**Location:** London W1

Arup, in collaboration with Stanton Williams, is delivering the Open-up project at the world-renowned, Royal Opera House in Covent Garden. This transformative project is due for completion in March 2018. The existing entrances from both the Covent Garden Piazza and Bow Street no longer fulfilled the Royal Opera House's ambitions to encourage more visitors into this famous beautiful space.

The project seeks to make Royal Opera House more accessible to the general public, making better use of its fantastic location and facilities. The scheme involves the major re-modelling of the Linbury Theatre to create a high quality, 400 seat second house. As part of the works the foyer areas of this Grade I listed venue for opera and ballet will have improved public access, thus enhancing the visitor experience. To enable this transformation the main foyer has been extended onto Bow Street. This allows the foyer to the Linbury Theatre to be flooded with natural light.

We are delivering Building Services and a range of specialist advice, including Acoustics, Fire Engineering together with a bespoke sustainability assessment tool.

A key driver for the project was to deliver all these works to the front of house areas whilst the Main House remained in use. This has only been possible due the close working relationships that have been developed between the client, design team and the contractor. These relationships are paramount to the successful delivery of this project and ensuring that all interventions to live systems are understood, co-ordinated, communicated and implemented meticulously.

The Arup team responsible for delivering this project has been ever cognisant of the Royal Opera House's impressive reputation for never missing a performance.



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# Daedalus Pavilion

**Client:** AI Build

**Architect:** AI Build

**Location:** Amsterdam, The Netherlands

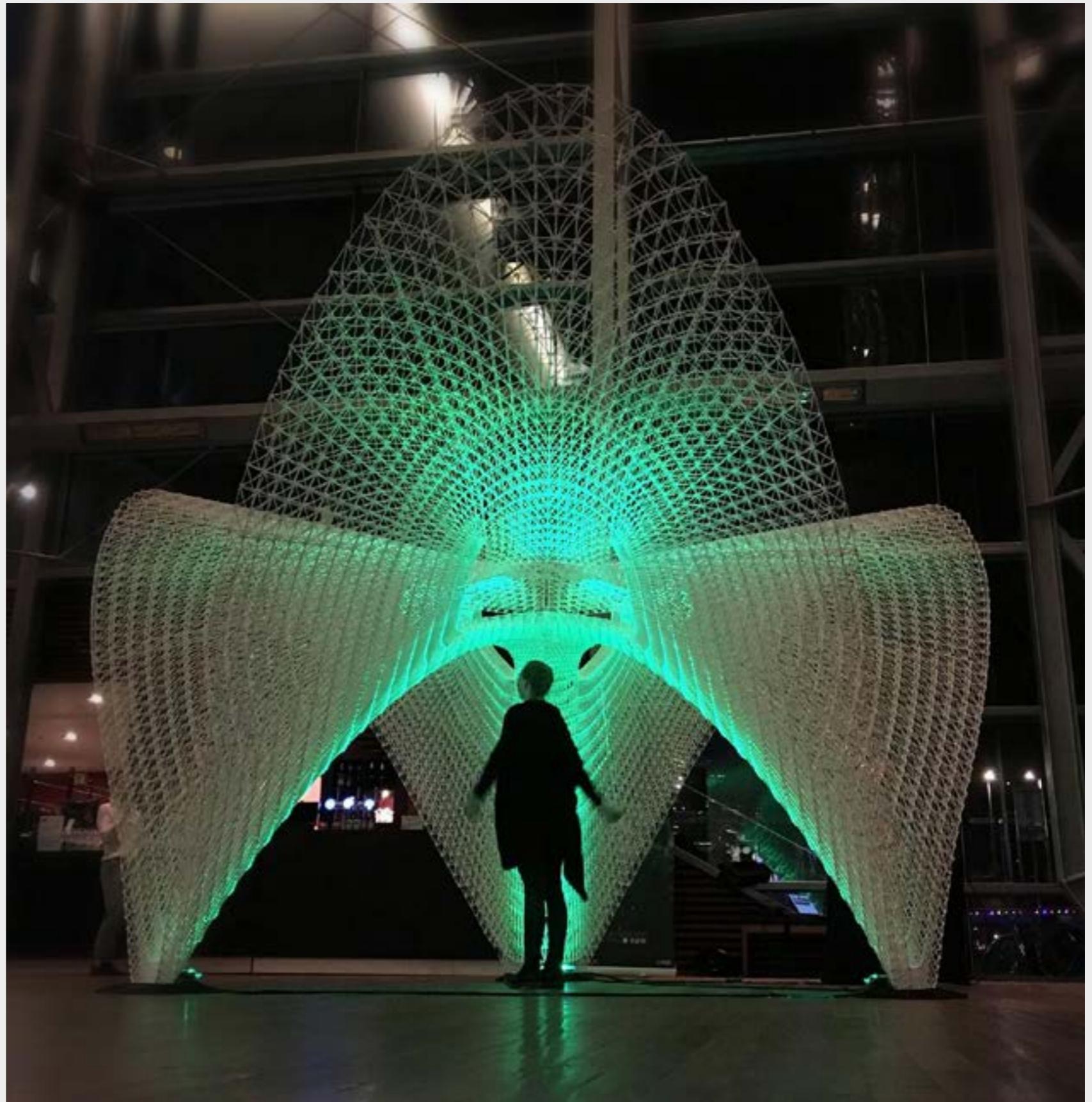
Digital fabrication and 3D printing promise to revolutionise the construction industry by making mass customisation possible, increasing speed and reducing waste. Arup collaborated with AI Build, an architectural and 3D printing company, to explore the scalability of this technology by designing and building one of the world's largest 3D printed pavilions. Daedalus was showcased in September 2016, at NVidia's GPU Technology Conference, Amsterdam.

Standing at a statuesque 4.5m, the Daedalus Pavilion is built entirely by a single industrial robotic arm, supplied by Kuka, a German robotics firm, and using PLA, a corn-based biodegradable plastic. Arup provided Structural Engineering and Design Consultancy. Our talented Lighting Designers provided the creativity to elegantly light this marvellous installation.

The pavilion was designed to be a structurally efficient form. Arup and the architect collaborated to optimise material distribution, making areas of high forces denser. The result was a highly organic, form-found shape, similar to those observed in nature.

As often happens with installations, the programme was accelerated, astonishingly Daedalus was designed and printed within two months. During the two week printing process, artificial intelligence and computer vision was used to allow the printer to 'see' where the plastic was being deposited and learn from any mistakes, thereby creating a feedback loop for fabrication.

Arup is committed to leading innovation in the area of digital fabrication. We are advocating the benefits that are understood by clients and the wider industry, whilst promoting the environmental credentials that digital fabrication can provide. This project offers a tantalising glimpse of how large scale 3D printing could be used in the future to construct elements of buildings, and the level and quality that is already available for interior fit-out applications. The enthusiasm from our young engineers and designers shone through and captured the imagination of the audiences in Amsterdam.



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# Singapore Sports Hub

**Client:** Singapore Sports Hub Pte Ltd

**Architect:** Arup

**Location:** Singapore

Singapore Sports Hub is Asia's first integrated sports, leisure, entertainment and lifestyle destination. Located on a picturesque 35 hectare waterfront site, the stadium provides a unique attraction of sporting, retail and leisure spaces, providing connectivity between Singapore's expanding city centre and the wider public community.

The Sports Hub is a key project for the Government of Singapore's urban redevelopment and sports facilities masterplan, 'Vision 2030'. This plan promotes a more sustainable, healthy and active society at all levels of participation, nation-wide. Designed for long-term legacy usage from the outset, the venue will set a new standard for adaptability and social integration. By providing premier venues for major sports and entertainment events the Sports Hub now acts as a world class destination hosting superstars, such as Ed Sheeran in November 2017.

Central to the Singapore Sports Hub is the new National Stadium, a state-of-the-art 55,000 capacity venue, air-cooled for comfort and designed with a movable roof and retractable seating to support the widest range of sports and leisure events throughout the year. This will be the first stadium in the world custom designed to host athletics, football, rugby and cricket all in one venue, converting from one mode to another within 48 hours.

With a span of over 310m, the National Stadium is the largest free spanning dome structure in the world. Our designs have created a sublime, awe inspiring events space.

The dome provides cover from the sun and the rain and, extends to create a protective canopy for the 'sports promenade'. As a new cultural icon, the design has focused on creating a close relationship with the city, by opening the interior seating bowl and roof towards the waterfront and the city skyline. This delightful design provides spectators with breath-taking views. Arup's approach and breadth of expertise in designing stadia is perhaps now, best illustrated with Singapore Sports Hub.



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# BLOX

**Client:** Foundation Realdania

**Architect:** OMA

**Location:** Copenhagen, Denmark

Danish philanthropic association Realdania has invested in BLOX to help regenerate the waterfront and strengthen the connection between the inner city and Copenhagen's harbour.

The waterfront area between the Black Diamond and Langebro had been overlooked for many years, and cut off from the city by the heavy traffic on the Christians Brygge approach road.

BLOX will transform the last remnants of the deserted car park adjacent to the water into a lively urban area. Formerly known as Bryghusprojektet, Dutch architectural practice OMA, with Rem Koolhaas, have been entrusted with the realisation of BLOX on the former brewery site with the support of Arup.

BLOX is a mixed use development. Home to the Danish Architecture Centre together with exhibition spaces, a café and bookshop. The mix also includes residential, commercial, retail, leisure, playground and a basement car park. The various functions will create a dynamic synergy. Public areas of the Danish Architecture Centre are designed to create connectivity between the building's other functions.

Arup is providing multi-disciplinary engineering to deliver a complex project on a site within difficult constraints, including construction under and over an arterial route and adjacent to the harbour and canalside. We have worked closely with the client to develop strategies which seek to address sustainability in a holistic manner.

Arup provided design solutions and input into topics including energy efficiency, carbon neutrality and choice of materials. BLOX is aspiring to achieve LE2015 energy target under Danish regulations. Scheduled to open in 2018, we are making a significant contribution including Structural, Building Services and Façades Engineering, ICT and AV from inception through to detailed design.

Waterside regeneration is always complex and rewarding in equal measure. Collaborating on BLOX to revitalise this area of Copenhagen adds to our repertoire of world class regeneration.

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# Engineering Building, University of Leicester

**Client:** University of Leicester

**Original Architect:** James Stirling & James Gowan

**Architect:** Berman Guedes Stretton

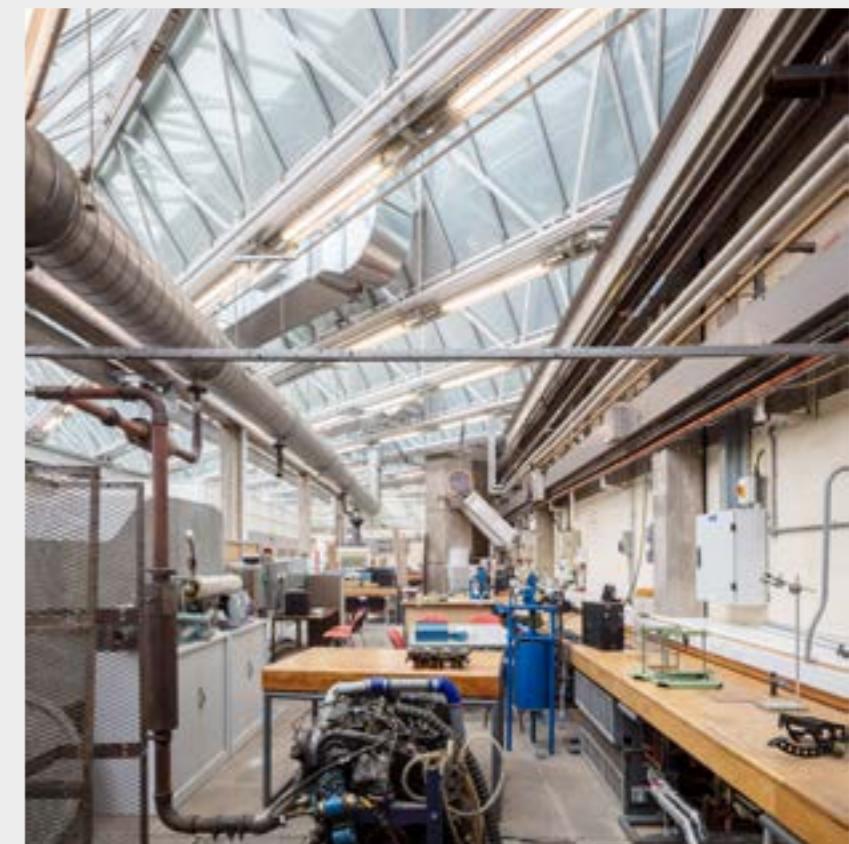
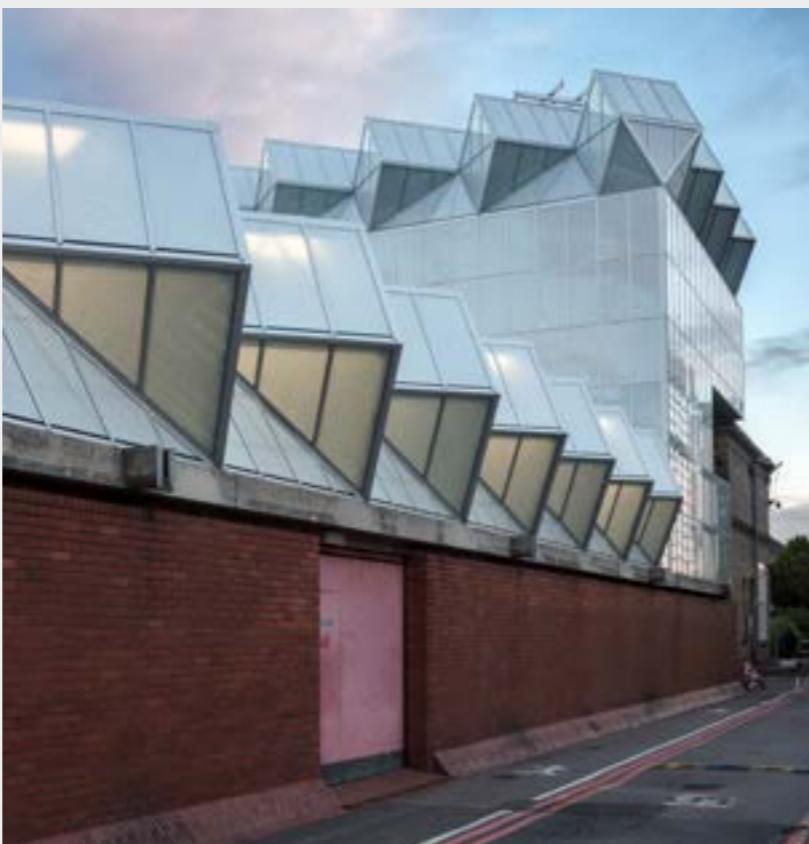
**Location:** Leicester, UK

Stirling and Gowan's hugely influential Engineering Building took the architectural world by storm at its opening in 1963. Befittingly, some 40 years later the building was granted a Grade II\* heritage listing in 2003. After five decades of use, the building was leaky, thermally inefficient and due to its complex shape, many areas were too difficult to access for even basic cleaning and repair. In 2011, Arup was commissioned as the lead and principal designer for the refurbishment of this forerunner of Postmodern architecture. We are providing an integrated conservation-led approach to improving its technical performance, whilst protecting the Engineering Building's unique heritage significance.

Arup sought to celebrate the fine details of the original design, whilst remedying the underlying flaws which made it difficult to maintain and occupy. The striking translucent roof and façade areas have been completely re-glazed. The new envelope is designed to match the original, yet with double-glazed units and insulation throughout. Ventilation, heating and cooling equipment have been upgraded, and a new scheme installed for providing safe access for maintenance.

Our role has also included regular formal presentations to the conservation stakeholders, and monthly inspections to monitor the condition of the building before the construction phase. We were also involved with monitoring the submissions and testing the installation work of the construction team.

Our time on this project has provided Arup a deep understanding of the building, based on several years of detailed involvement in all aspects; Façade Design, Heritage Liaison, Strategic Building Services discussions, and Structural advice. We are now also working on all three of Stirling's 1960s university buildings. Namely the conservation of the Faculty of History at University of Cambridge, and the Florey Building at University of Oxford. Arup is pleased to be associated with buildings designed by James Stirling, who gives his name to the prestigious architecture award the Stirling Prize.



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# St Anne's College, University of Oxford

**Client:** University of Oxford

**Architect:** Fletcher Priest Architects

**Location:** Oxford, UK

St Anne's is an exemplar of total design at one of England's oldest universities. Passion together with creative thought has been given to seamlessly integrate the new modern library into this historical campus. The decision to use Oxford stone on the centre was based not only on its ability to resemble the surrounding aesthetic, yet also its potential to significantly extend the design life.

Arup and Fletcher Priest's total design approach to the servicing strategies and harmonious integration with the structure has achieved more than 30% savings over and above the Part L (Conservation of Fuel and Power) Building Regulation. The aggregation of these creative interventions across all disciplines has achieved environmental efficiencies yet the approach has ensured we remain committed to delivering the architectural vision and adhere to client requirements.

For example, a selection of windows in the façade have been designed to be opened, allowing natural ventilation that will further enhance user satisfaction by increasing occupant control, yet also achieving additional energy savings. The passive capillary mat heating and cooling system offers high levels of people comfort with low energy demands. The structure and the exposed, acoustically treated plastered soffits are used to increase the thermal mass therefore, reducing the cooling loads and energy consumption.

Internal tubular steel columns serve a dual role supporting the floors, combined with acting as supply air ducts for the tempered and de-humidified air.

Arup selected building materials known for their minimal environmental impact. European timber from sustainably managed forests has been used to craft the roof structure and window frames. The structural frame has incorporated cement tubes in place of less sustainable alternatives where possible. These ideas have led to securing BREEAM Excellent.

Providing an impressive array of disciplines, including Structural, Geotechnical and Building Services Engineering together with Specialist Acoustic advice, our contribution towards this historic institution is a striking example of integrated design.

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# Television Centre

**Client:** Arup

**Architect:** Arup

**Location:** London WC1E

The redevelopment of the iconic 1960s BBC Television Centre continues apace and involves unwrapping the former broadcasting headquarters to form a new neighbourhood in west London. Each building is distinctive, with new-build designed for commercial use, and other existing and listed structures that have been redeveloped to create a variety of residential accommodation. Complementing the mix of uses the site will also offer a cinema, extensive retail and restaurant space, together with hotel and enhanced public realm.

The famous ‘doughnut’ building is being repurposed to provide over 400 high-end apartments. A new outer crescent of homes will mirror the inner ring, separated by public gardens. Elegant townhouses will be situated at the western end of the site.

Arup has been assisting Stanhope since the initial stages of the project, initially undertaking feasibility studies of the site prior to purchase and now delivering multi-disciplinary design on each of the buildings as well as working on the masterplan. This ensures that buildings ‘plug in’ to the infrastructure seamlessly, delivering maximum impact and value, both to the buildings and site-wide amenity.

Construction on Phase 1 is well underway and new homes, offices, retail and leisure will be ready for use in 2018. Phase 2 is currently at scheme design stage and will add five further residential plots to this historic London site.

Arup is providing an impressive array of disciplines including; Civil, Structural, Building Services, Geotechnical, Façade and Fire Engineering; together with advice on Sustainability, Infrastructure, Access & Maintenance, Wellness and Logistics.

Our relationship with Stanhope continues to strengthen through this significant urban regeneration project. Delivering this high profile transformation and creating a new destination for people to work, live and enjoy at White City.



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# The Circular Building

**Client:** Arup

**Architect:** Arup

**Location:** London WC1E

Participating in the prestigious London Design Festival, we once again showcased Arup's thinking. This time designing a temporary installation at the Building Centre that explored the impact of the circular economy on the built environment.

The Circular Building prototype was designed and delivered by Arup, Frener & Reifer and BAM, with support from The Built Environment Trust. Together with our partners we explored how the circular economy could benefit the industry, reflecting on the commercial, social and environmental opportunities of employing circular principles. We questioned whether it was possible to design a building where, at the end of its life, all its components and materials can be re-used, re-manufactured or re-cycled. Asking this question tested the capability of the supply chain and profoundly altered the design and construction priorities. Supplier engagement was critical, with both designers and suppliers challenged to think differently about materials and construction processes.

We explored some of the challenges the industry faces when incorporating circular economy thinking, including the impact on design, procurement, construction, operation and deconstruction of the building. This prompted conversations between the designers, contractors and the wider supply chain around the ownership of assets and new business models. Taking a life cycle approach is critical to achieving true circularity.

In building this prototype the multi-disciplinary team has learnt that there needs to be a significant step change in the design process, how components are assembled and the inherent value that we create over the life of the building.

At the time of writing, a number of speakers from Arup have been asked to present the learning from this prototype at industry events, such as Green Sky Thinking 2017. In addition, two of our partners, Accelor Mital and Acoya have also referenced the Circular Building as part of their corporate sustainability learning.

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# 80 Charlotte Street

**Client:** Derwent London

**Architect:** Make Architects

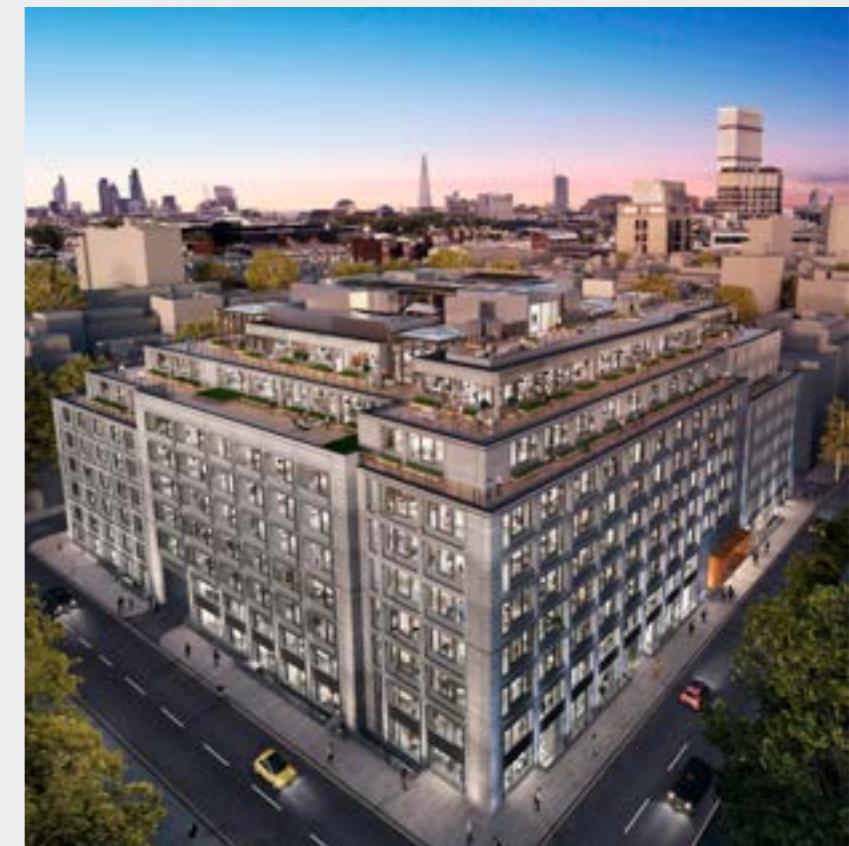
**Location:** London W1T

At the heart of Fitzrovia, Derwent London is investing in an imaginative commercial and residential development. 80 Charlotte Street will be completely independent of on-site fossil fuels, relying on all electric heat pumps to provide heating and cooling to the building, whilst also recycling waste heat where possible. These ambitious sustainability targets will bring the added advantage that when the national grid is decarbonised, 80 Charlotte Street will not be dependant on carbon and fossil fuels. Arup's engineering designs have truly future proofed the building.

We are providing multi-disciplinary advice including Structural, Building Services, Civil and Fire Engineering together with Security Consulting and BREEAM Assessment. 80 Charlotte Street is designed to be multi-let with separate entrances and large, flexible floorplates with beautiful terraces. The occupiers will also be encouraged to access a new pocket park. Arup will take 41% of the main building which comprises 28,700m<sup>2</sup> offices and 1,300m<sup>2</sup> of retail space.

A flamboyant expression of engineering, the services and structure are completely visible and have been designed in collaboration with MAKE. Every detail is considered to ensure an exceptional quality whilst also celebrating the symbiosis between architecture and engineering.

Derwent London continues to take a fresh approach to regeneration by identifying the unique qualities of each property, in the case of 80 Charlotte Street, the listed façade will be retained. Derwent London brings a savvy understanding of tenant requirements, and of course, an emphasis on design. We are delighted to be contributing towards this significant project and working with such an enlightened client who actively encourages 'a leap of faith' on every collaboration.



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# One New Burlington Place

**Client:** The Crown Estate

**Architect:** Allford Hall Monaghan Morris

**Location:** London W4

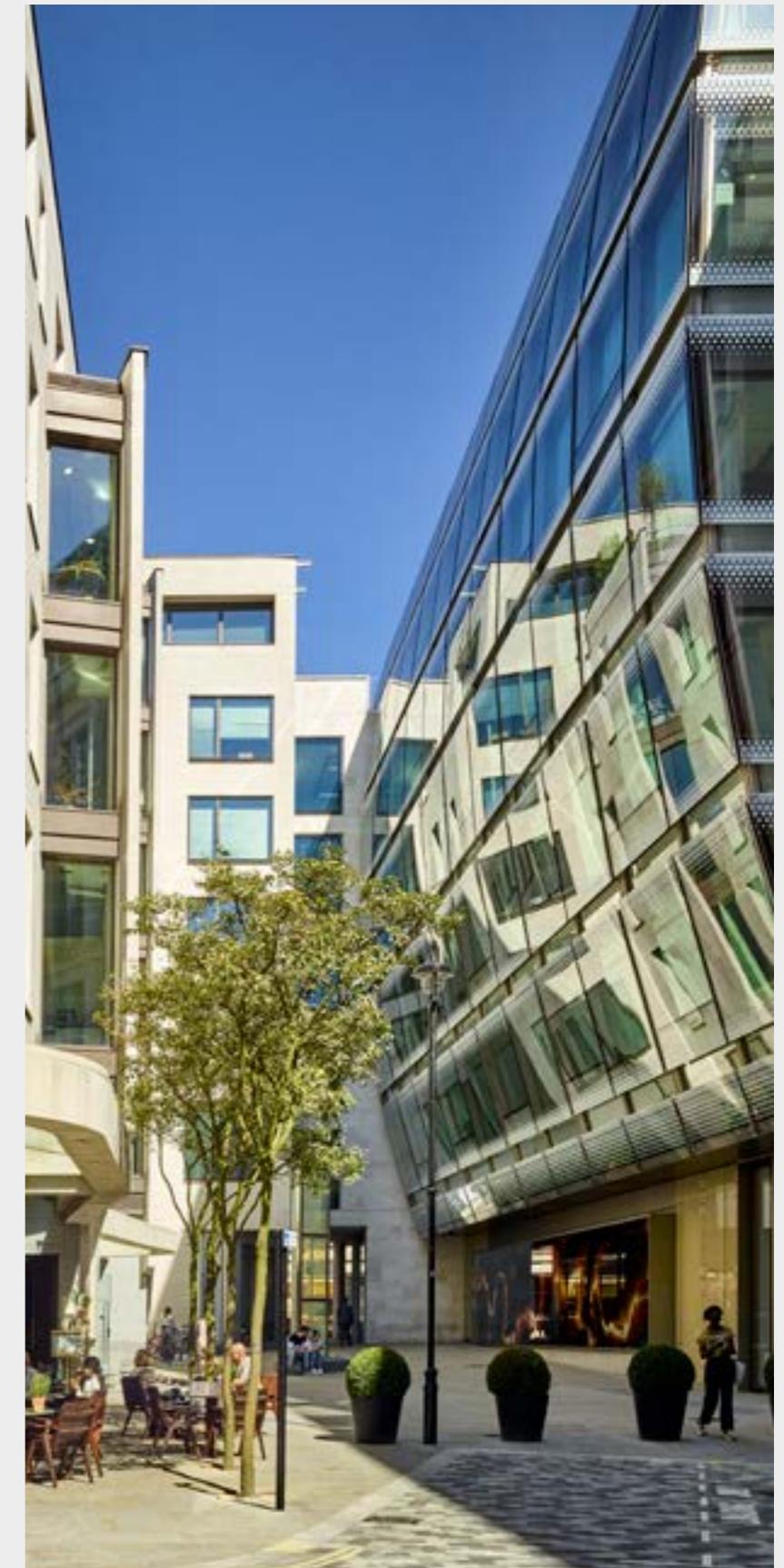
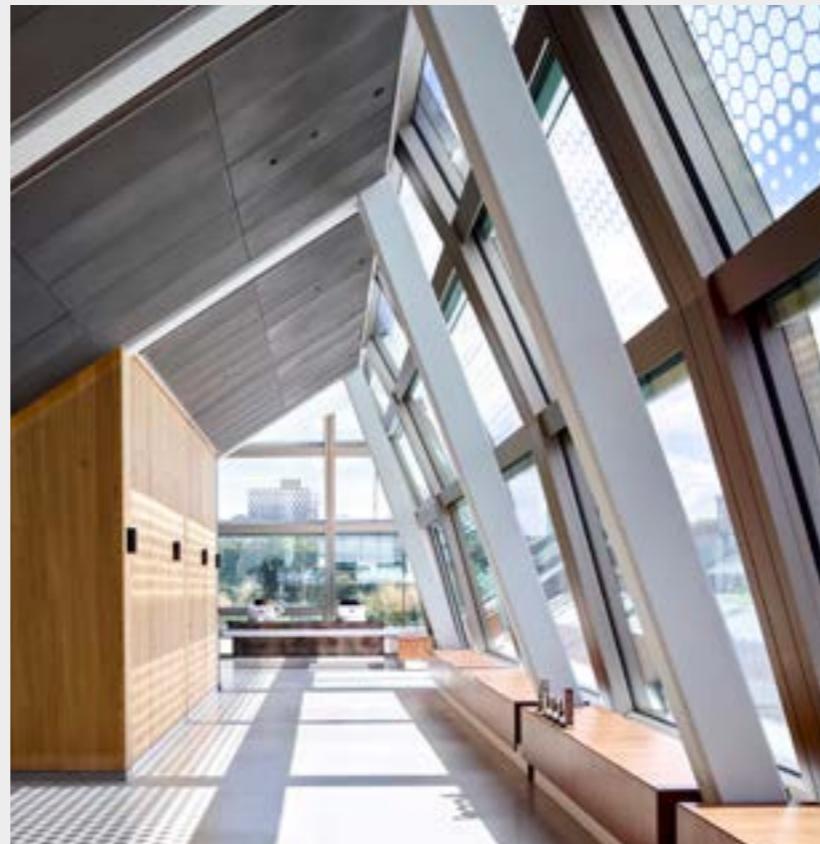
In the heart of London's West End sits One New Burlington Place. An elegant development, showcasing a boldly designed, curved, fully glazed building behind retained and restored Portland stone façades.

To reach its full commercial potential, the original design featured narrow cavity, double-skinned façades. Maintenance, however, usually takes place from inside the building and can be disruptive to operation. After exploring various options, our Façade Engineers recommended a closed cavity system which provides a relatively maintenance-free façade.

This system uses sealed units that have a constant supply of dry, clean air pumped in. This prevents condensation and dirt forming within the cavity reaching temperatures that could damage some materials. The system has other advantages, internal shading is protected from weathering, wind and dirt. The system also provides good solar and thermal performance whilst efficiently integrating the building services with the façade to monitor conditions in the cavity.

There are limited suppliers within the industry and even fewer precedents. The client, contractor and design team, who collaborated previously on 10 Burlington Street, visited exemplar projects in Europe to help better understand this new technology. Our Building Physicists methodically assessed and reduced the identified risks, controlling the heat issues by using fritting on the external skin in combination with a solar control coating, which was verified by our thermal analyses.

With curved building envelopes, complex interfaces can make achieving a weather tight façade difficult. Careful detailing of the glazing and handset stone has produced a high performance façade, enhancing this impressive building. One New Burlington Place is a testament to the dedication and collaboration of the whole team.



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# 52 Lime Street

**Client:** WRBC Development Ltd

**Architect:** Kohn Pedersen Fox Associates

**Location:** London EC3

Affectionately known as ‘The Scalpel’, 52 Lime Street will be the new European Headquarters for W. R. Berkley, providing 30,000m<sup>2</sup> of prime commercial lettable space. This fantastic new addition to the City of London comprises 35-storeys and is located opposite The Lloyds Building.

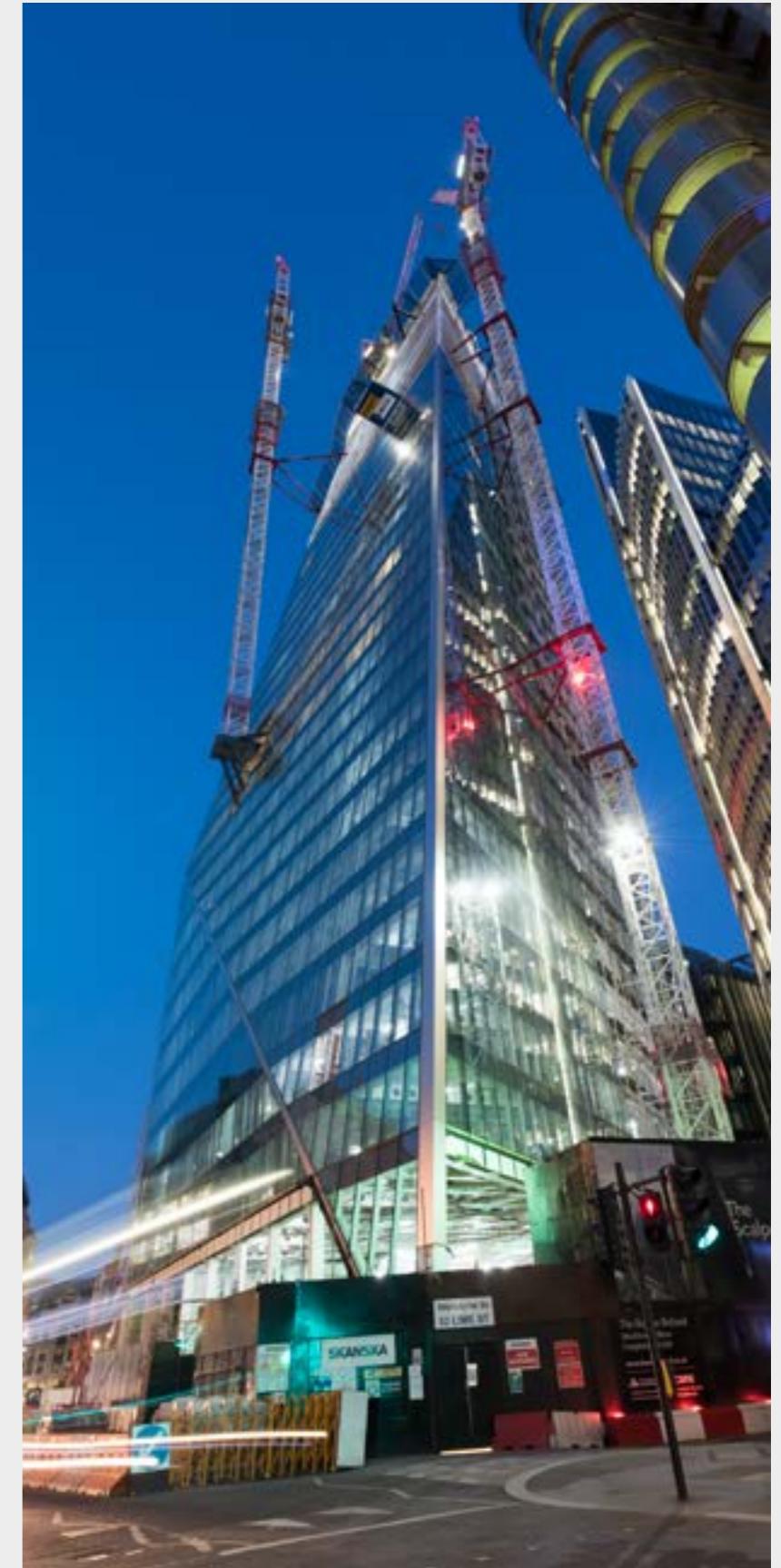
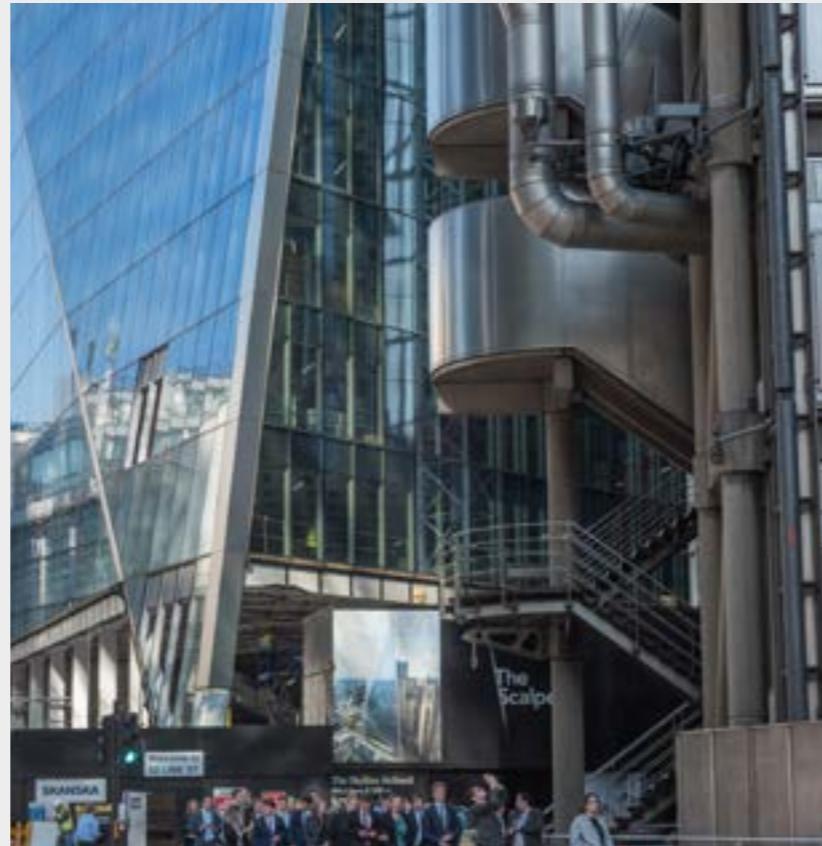
The incisive form of the building, designed by leading architectural firm Kohn Pedersen Fox, will be an exciting addition to the City of London’s skyline. The core of the building is offset to the south, providing large uninterrupted floor plates meeting the developers aspiration for an efficient and stylish workplace.

Our structural engineers sought new efficiencies by harnessing the potential of ‘mass customisation’. We created a script which enabled every beam in the building to be uniquely engineered and used the BIM model to deliver data directly to William Hare, steel fabricators. This use of digital technology led to saving 700 tonnes of steel compared with a traditional approach, reducing costs by more than £1.4 million and removing 1,300 tonnes of embodied carbon dioxide.

One special aspect of The Scalpel is hidden in its lateral stability system. Seven viscous damper units are built into the system and absorb the energy of motion. Therefore, even on an unusually windy day, people working in The Scalpel will be comfortable as the lateral accelerations will be limited.

Arup’s highly creative Building Services and Façade Engineering designs achieved low CO<sub>2</sub> emissions and BREEAM Excellent 2014 accreditation. The 25% operational carbon savings have been achieved through an efficient Building Services Design, a high performance façade together with low energy lighting. Careful detailing and coating selection of the glass provides the appearance of a fully glazed façade. The double glazed unit skin represents a simple, yet cost-effective solution, efficiently controlling solar gains, whilst helping to achieve greater daylighting distribution.

In the vicinity of this historic location, Arup has also contributed towards the engineering designs for The Lloyds Building, St Mary Axe, Heron Tower and more recently The Leadenhall Building.



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**2007**  
Chiswick Park



**2008**  
Serpentine Pavilion 2008



**2009**  
Sky Studios



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**2010**  
Evelyn Grace City Academy



**2011**  
Heron Tower



**2012**  
London Aquatics Centre



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**2013**

The Shard



**2014**

The Leadenhall Building



**2015**

Canary Wharf Crossrail Place



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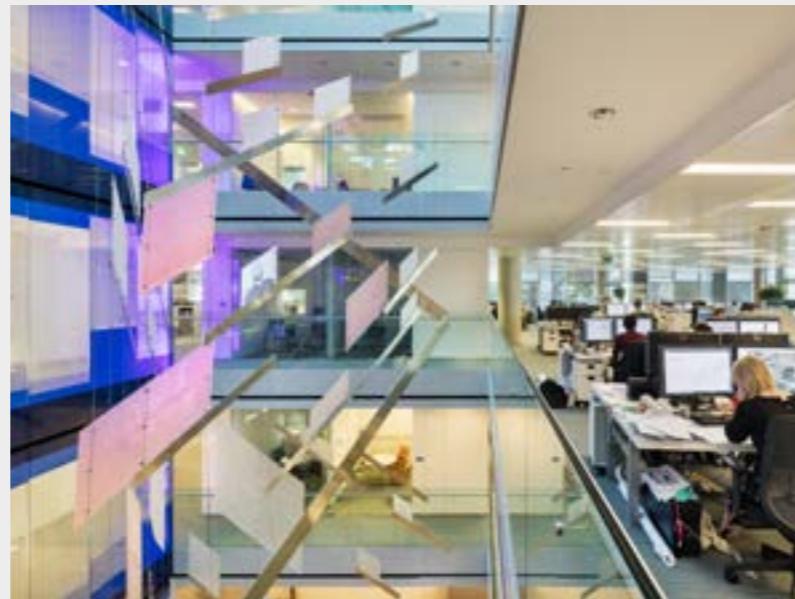
**2016**

The Francis Crick Institute



**2016**

The Heart of Arup



**2017**

Lord's Warner Stand

