

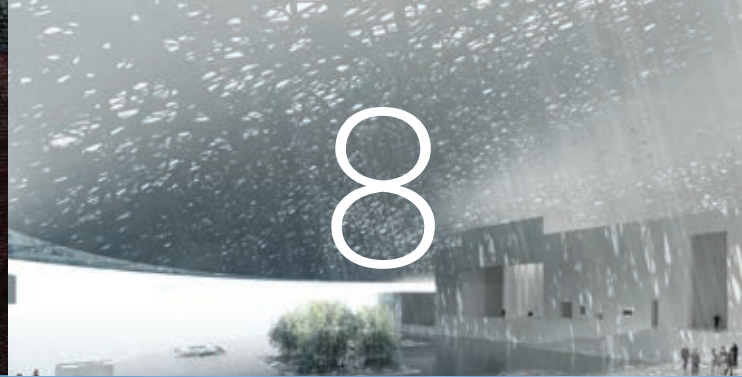
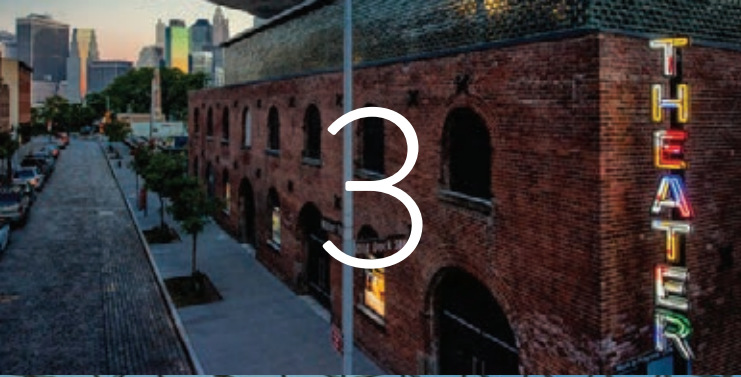
BUROHAPPOLD  
ENGINEERING

# CREATING THE WOW!

CAN OUR ENGINEERING ENHANCE THE POTENTIAL  
OF A CULTURAL VENUE?

HERE ARE SIX EXAMPLES OF HOW IT CAN  
(and 76 more for you to explore)

CULTURAL SECTOR PORTFOLIO



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INGENIOUS DESIGN REALISES A SUCCESSFUL THEATRE WITHIN AN INDUSTRIAL LANDMARK

## ST. ANN'S WAREHOUSE

LOCATION: Brooklyn, New York, NY, USA   CLIENT: St. Ann's Warehouse   ARCHITECT: Marvel Architects   IMAGES: Dustin Nelson



## + EXCELLENT PERFORMANCE

Set within Brooklyn Bridge Park, the restored Tobacco Warehouse is the first permanent home for St. Ann's, a distinctive and diverse theatre company that has been running for over 30 years. The work included preserving the original brickwork and scenic archways, while delivering a state of the art, flexible theatre space.

Preserving the building fabric of the 1860's Tobacco Warehouse presented a number of challenges for BuroHappold Engineering. With the original exterior brick walls forming a key part of the design, we needed to devise a solution to keep the interior spaces at a comfortable temperature in the winter months. Our answer was to install a fin tube system to provide radiant heating at the perimeter of the lobby, theatre and community room, improving the internal environment and acoustic performance.

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### KEY FACTS:

- Seeking LEED Silver certification
- Multi-use 25,000ft<sup>2</sup> theatre and performance space
- Capacity for 300 to 700 people

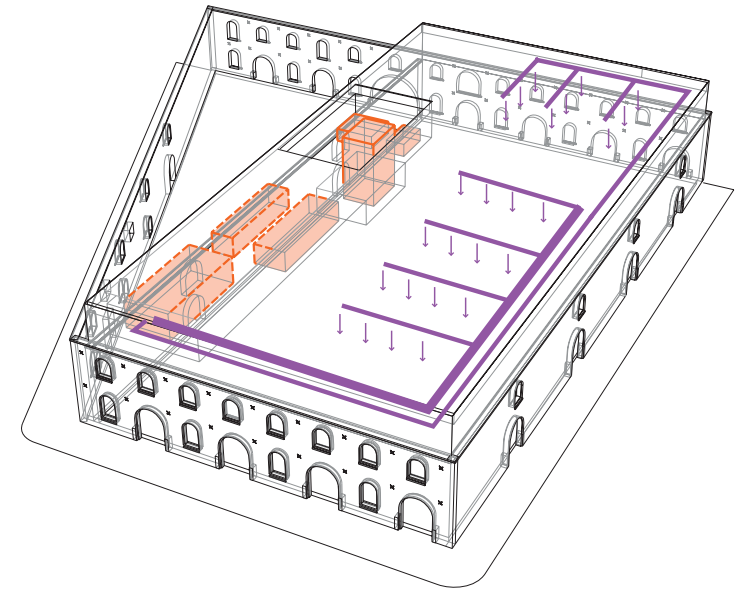






## More than 30% reduction in energy use

This was achieved through energy conservation measures including the use of an insulated roof and triple-glazed windows, high-performance equipment, efficient lighting and occupancy sensors in offices.

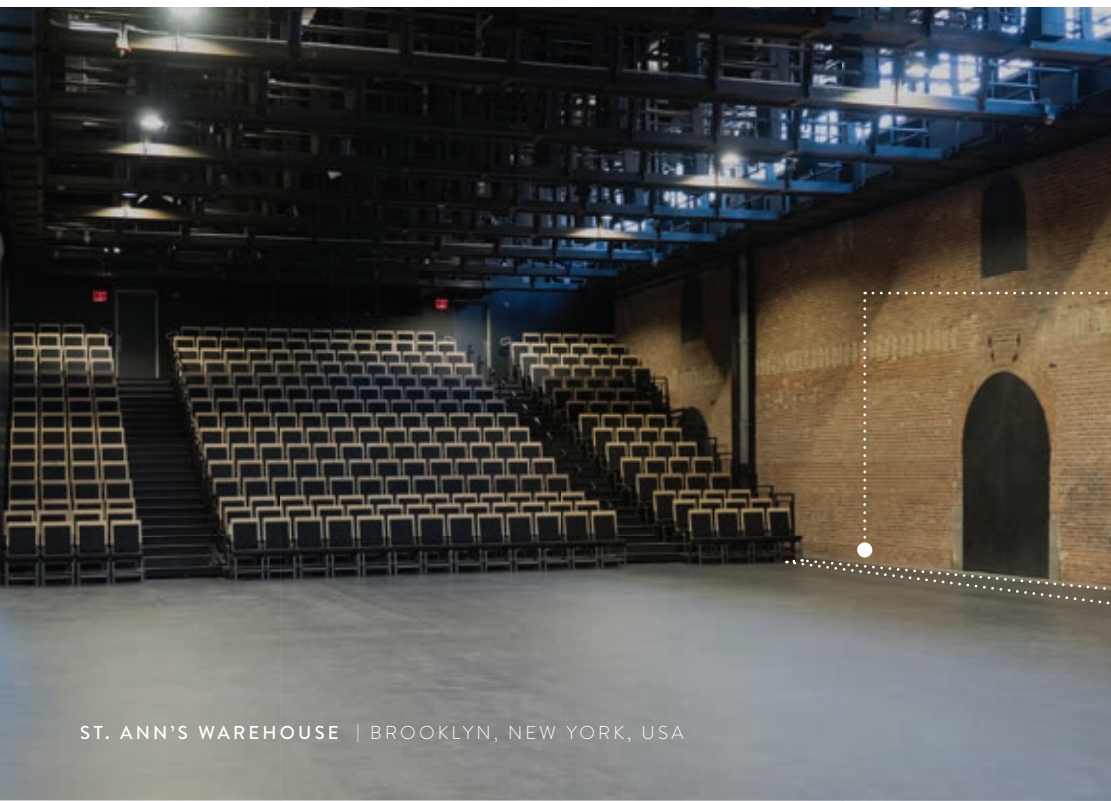
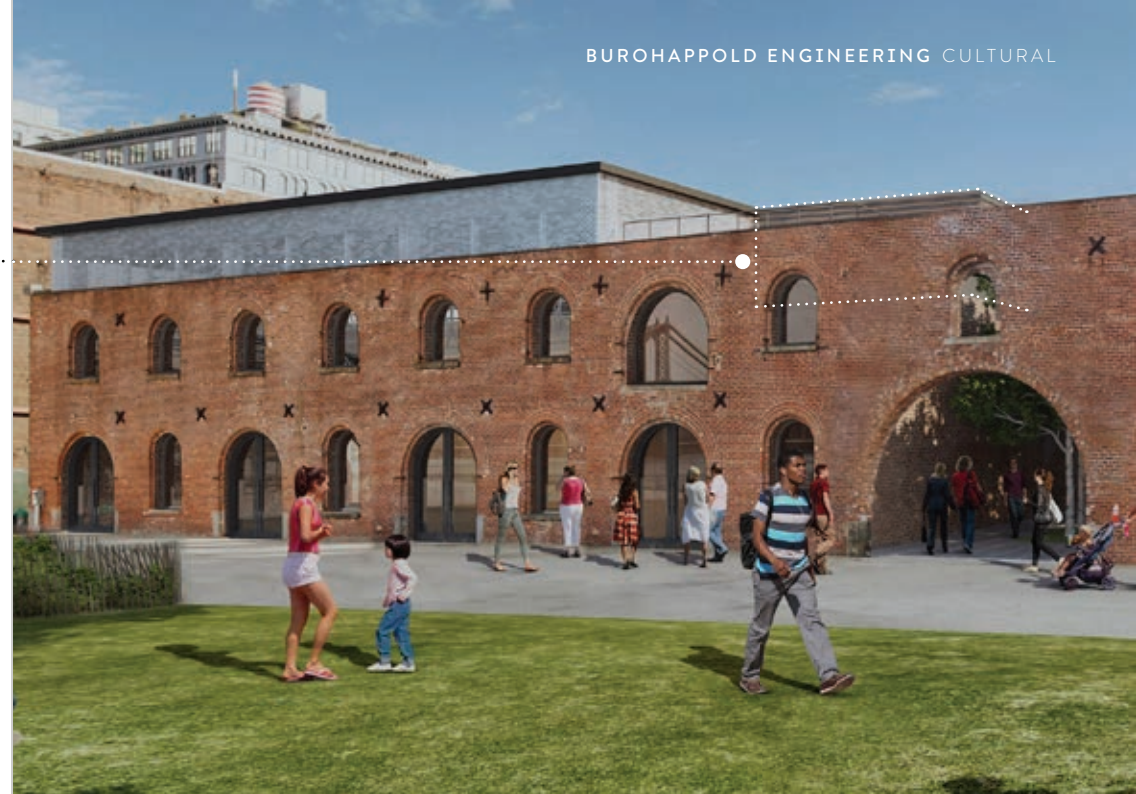


## Flexibility and aesthetics

The overhead ductwork delivers heating and cooling through an evenly distributed grid of 98 supply points throughout the lobby and theatre space. The ducts were carefully integrated into the design of a network of catwalks, AV/lighting cable trays, and other theatrical rigging in order to minimise intrusion into the height of the performance space.

## Resilience

Key electrical and mechanical equipment was moved to the mezzanine and roof, while leaving only the essential plumbing and utilities at the ground level. By elevating equipment and locating electrical outlets higher on the wall than usual on the ground floor, we reduced the amount of time and cost it will take to get the building back up and running after a flooding event.



## Comfort

A finned tube system provides radiant heating along the perimeter of the masonry wall. The system warms the brick and prevents radiant cooling from the brick from affecting the thermal comfort of occupants.



# ENGINEUITY™ PROCESS

Our Enginuity solution for St. Ann's Warehouse focussed on the **Intelligent Reuse of Buildings**.



WORLD CLASS ART IN A WORK OF ART

# LOUVRE ABU DHABI

LOCATION: Abu Dhabi, UAE   CLIENT: The Tourist Development and Investment Company of Abu Dhabi (TDIC)  
ARCHITECT: Ateliers Jean Nouvel (AJN)   IMAGES: AJN and BuroHappold Engineering



## + AN EXTRAORDINARY BRIEF

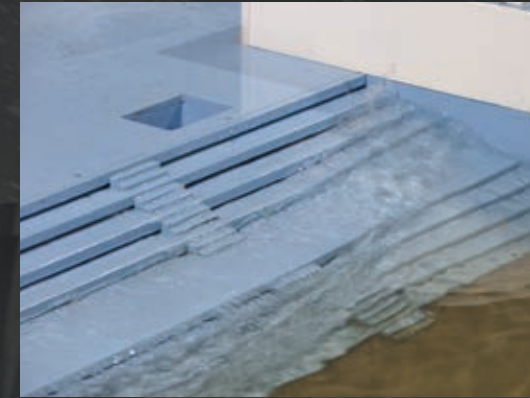
Designed as a 'museum city', the new 58,000m<sup>2</sup> art and exhibition centre boasts a myriad of gallery spaces clustered beneath a shallow domed canopy, creating an expansive yet intimate space in which visitors can meander and mingle at their leisure.

Located in the new Cultural District of Saadiyat Island, off the coast of Abu Dhabi, the intrinsic connection between the new Louvre and the surrounding sea is reflected in the architectural design. Realising this union presented some serious challenges for our team of engineers, who had to conceive and develop a variety of solutions that would give the appearance of a building effortlessly at one with its surroundings, while also providing adequate protection against both the environmental and security issues presented by its maritime location.

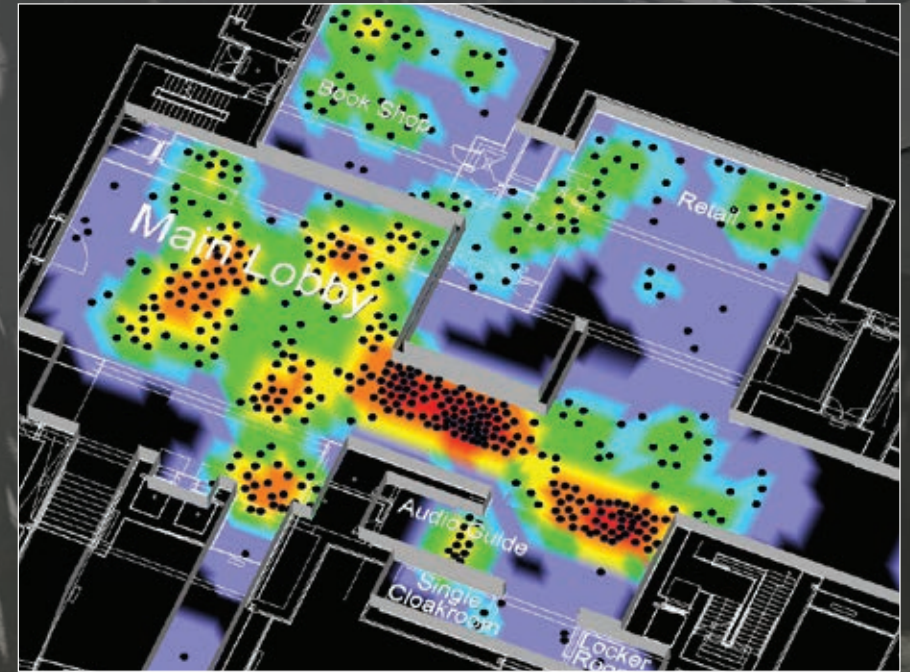
### KEY FACTS:

- Remarkable latticework roof cools exterior spaces and the museum interior
- Low energy and passive cooling and heating techniques used to control temperature and humidity within the museum to benefit artworks and visitors
- Two floors of museum basement space below water level.

Our Water Team provided specialist advice on the construction of these pools, using first empirical, and then numerical and physical scale modelling to ensure the tidal flow and water quality augmented the aesthetics of the building without risk of flooding or damage from the saline water.

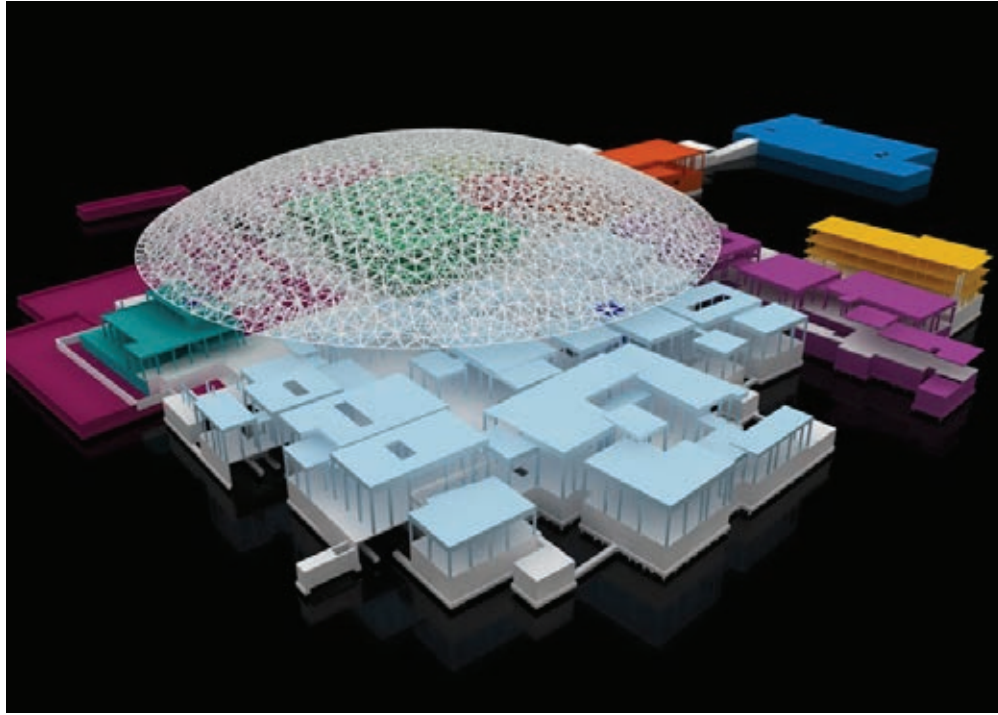






Optimisation of spatial layout and entrance processes. Maximising visitor comfort within design constraints by informing staffing levels and procedures for security, reception, ticketing, cloakrooms and guidebook sales.

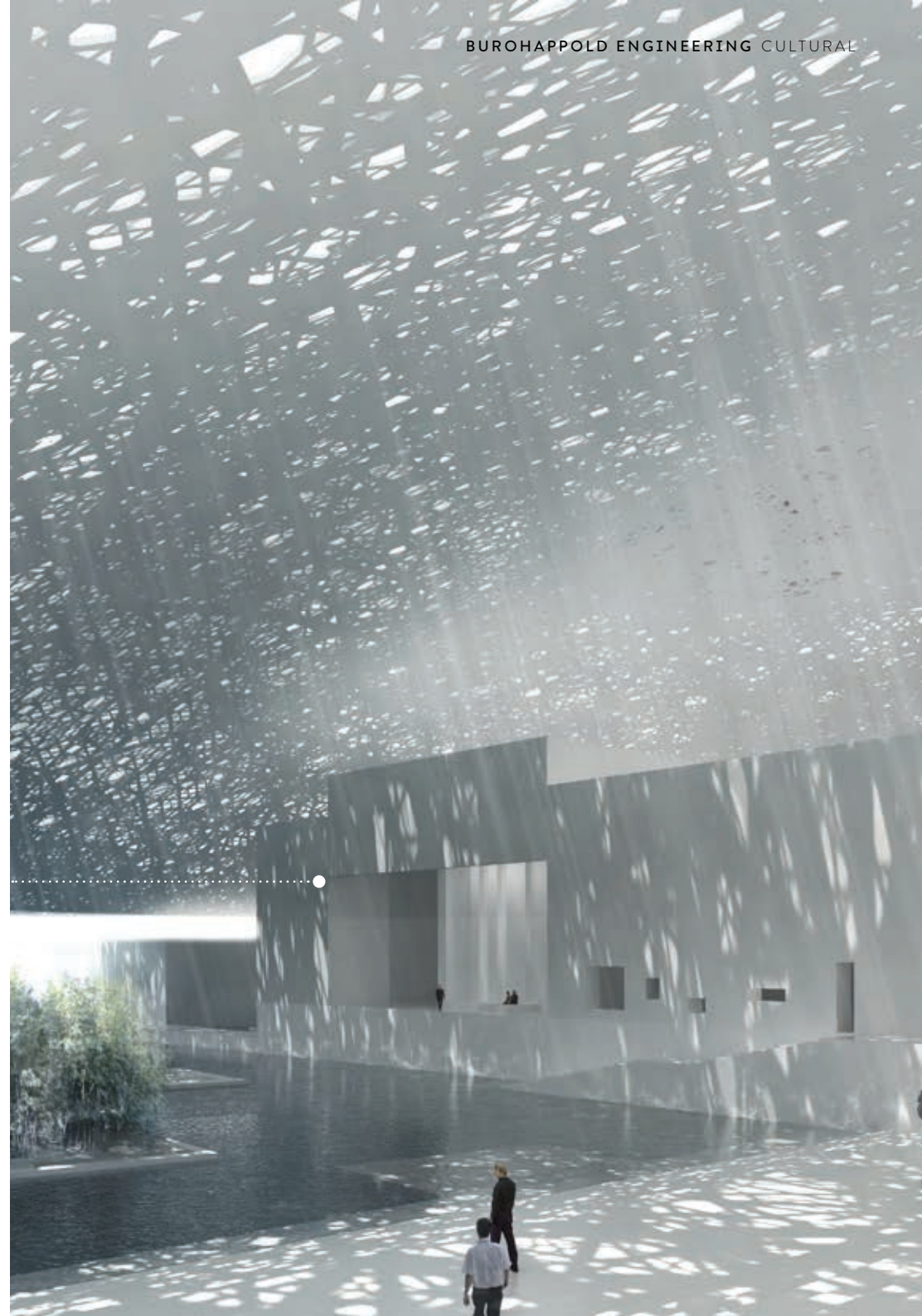




## Integrated 3D design

The permanent exhibition galleries are a series of relatively simple low-rise buildings – however they are positioned in a complex pattern within inlets, tidal pools and ‘islands’. There is no repetition. The buildings are highly serviced and the integration issues are extremely challenging.


We led the spatial coordination process throughout the project using BIM processes and high quality 3D models. We continue to provide site supervision services through construction including BIM support and advice to continue the 3D modelling process ensuring the client receives a final digital model asset to meet their ongoing needs.











Dual use of offshore breakwaters to both attenuate the power of the waves lapping into the port, taking into account the potential impact of future climate change, and serve as a vessel security barrier.

“

The project is based on one of the major symbols of Arabic architecture: the Cupola. But here, it is a modern proposal made evident by its obvious gap with tradition.

The dome is doubled and flat with a 180-metre diameter, offering a perfect luminous geometry drilled in a more random weaved material which creates a shadow punctuated with sun bursts. It shines in the sun of Abu Dhabi. At night, the protected landscape turns into a haven of light under a star-spangled cupola.”

**Jean Nouvel**

Ateliers Jean Nouvel

# ENGINEUNITY™ PROCESS

Our Engineunity solution for the Louvre Abu Dhabi focussed on **Integrated Design**.





HOW TO DEVELOP A CULTURAL SANCTUARY  
BLENDING THEATRE, ART AND PUBLIC SPACE

## XIQU CENTRE

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LOCATION: West Kowloon Cultural District, Hong Kong    CLIENT: West Kowloon Cultural District Authority  
ARCHITECT: Bing Thom Architects, Ronald Lu & Partners    IMAGES: Bing Thom Architects, Ronald Lu & Partners



## + SETTING THE SCENE

The venue will provide a platform for the Xiqu communities to interact, develop and produce the finest examples of Cantonese and other Chinese opera performances, as well as attract new audiences, educate and collaborate with and host international cultural programmes.

### Stand out points of engineering achievement

The project will meet the sustainability targets set for the overall district by WKCD A which include BEAM Plus “Gold” as well as specific energy use, renewable energy, recycling, prefabrication and water saving targets.

### KEY FACTS:


- Xiqu Centre will be the first of 17 core arts and cultural venues to be opened within the district.
- World-class facility for the preservation, development and promotion of this important art form of Chinese cultural heritage in Hong Kong.
- Project includes an 1,100 seat theatre, 400 seat theatre, 200 seat teahouse, 80 seat teahouse and support and education spaces.



### Column-free

To realise the vision of a largely column-free public plaza at ground floor level, we have reversed the construction sequence with the roof structure built and lifted into place first before the suspended theatre is hung below.





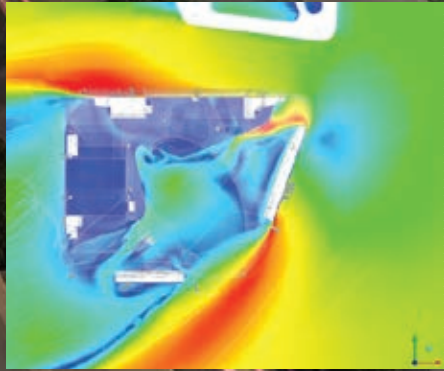
The concept of gateway and pavilion is represented in the openness and door-less nature of the design, welcoming different visitors into the building from all four of its corners.

The 'flow' or 'qi' is interpreted in the fluid movements in the building and the use of curved planes, arched openings and circular paths.

氣

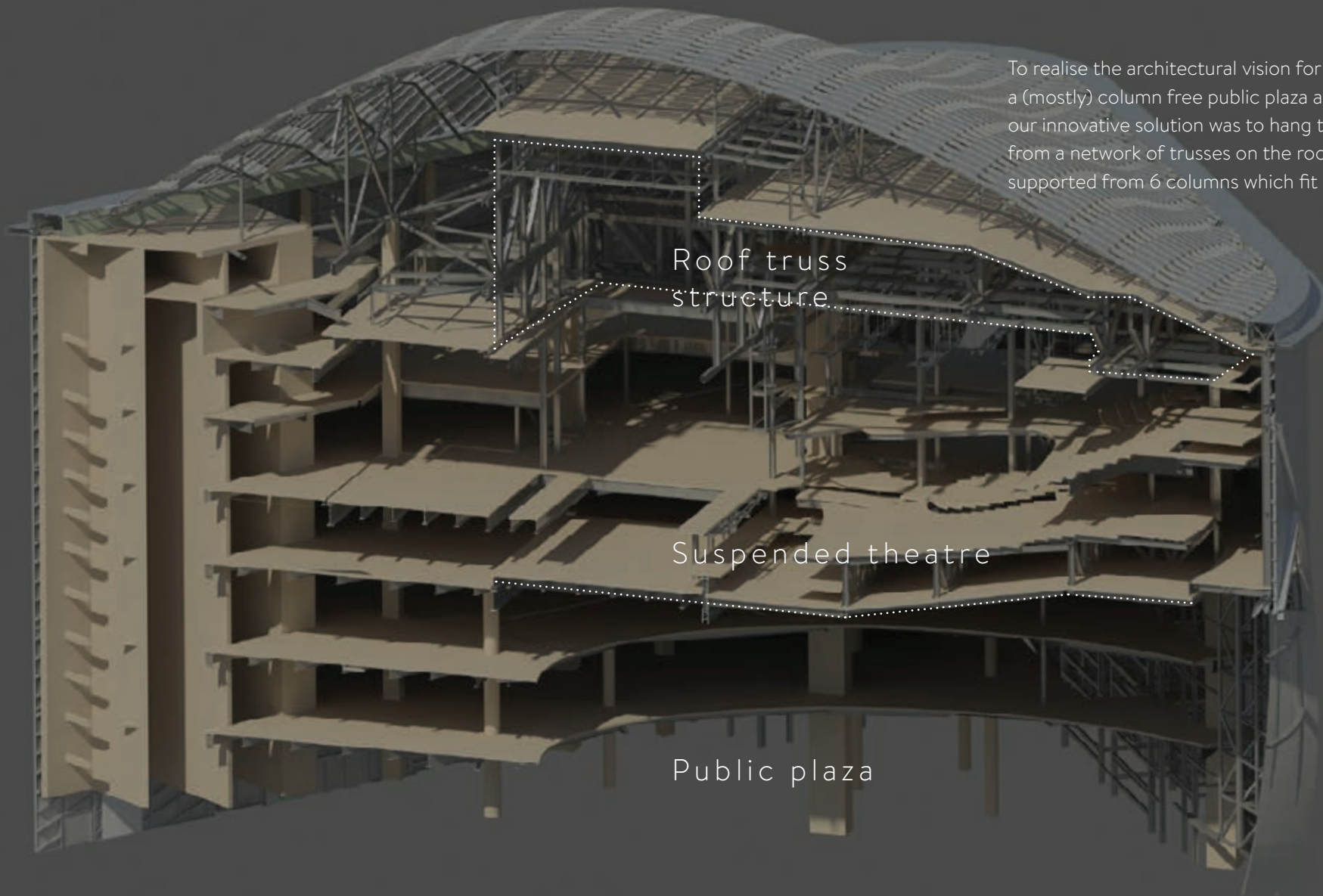
'Qi' vital energy believed to circulate round the body in currents.





The public plaza has been proposed as a space that “breathes”, weather-protected but open to the outdoors. It is not part of the conditioned building mass. As a result, comfort within the plaza is primarily determined by outdoor climate.





To realise the architectural vision for the project to have a (mostly) column free public plaza at ground floor level, our innovative solution was to hang the whole main theatre from a network of trusses on the roof. These trusses are supported from 6 columns which fit around the plaza itself.

Roof truss  
structure

Suspended theatre

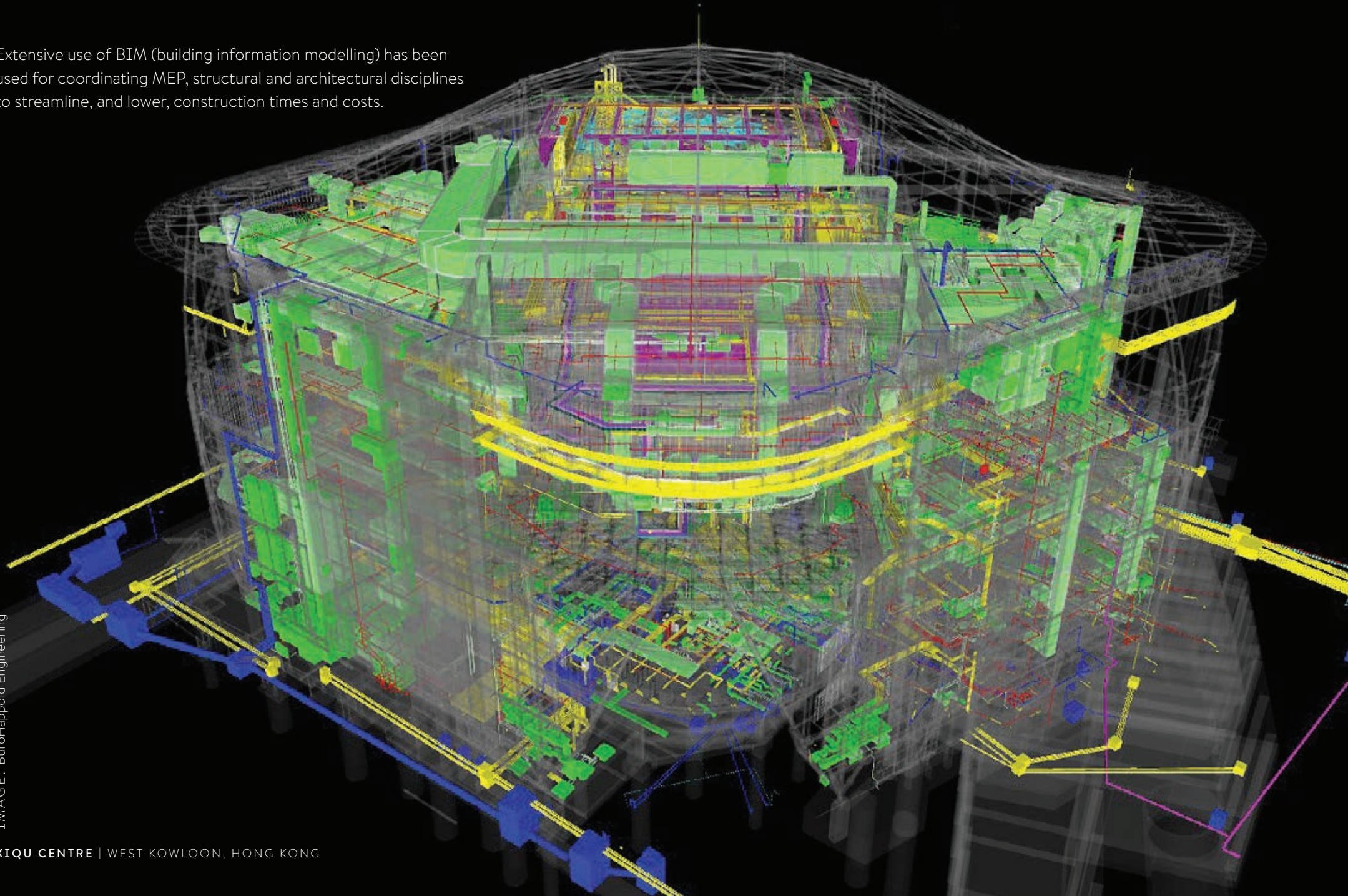
Public plaza



Extensive use of BIM (building information modelling) has been used for coordinating MEP, structural and architectural disciplines to streamline, and lower, construction times and costs.

IMAGE: BuroHappold Engineering

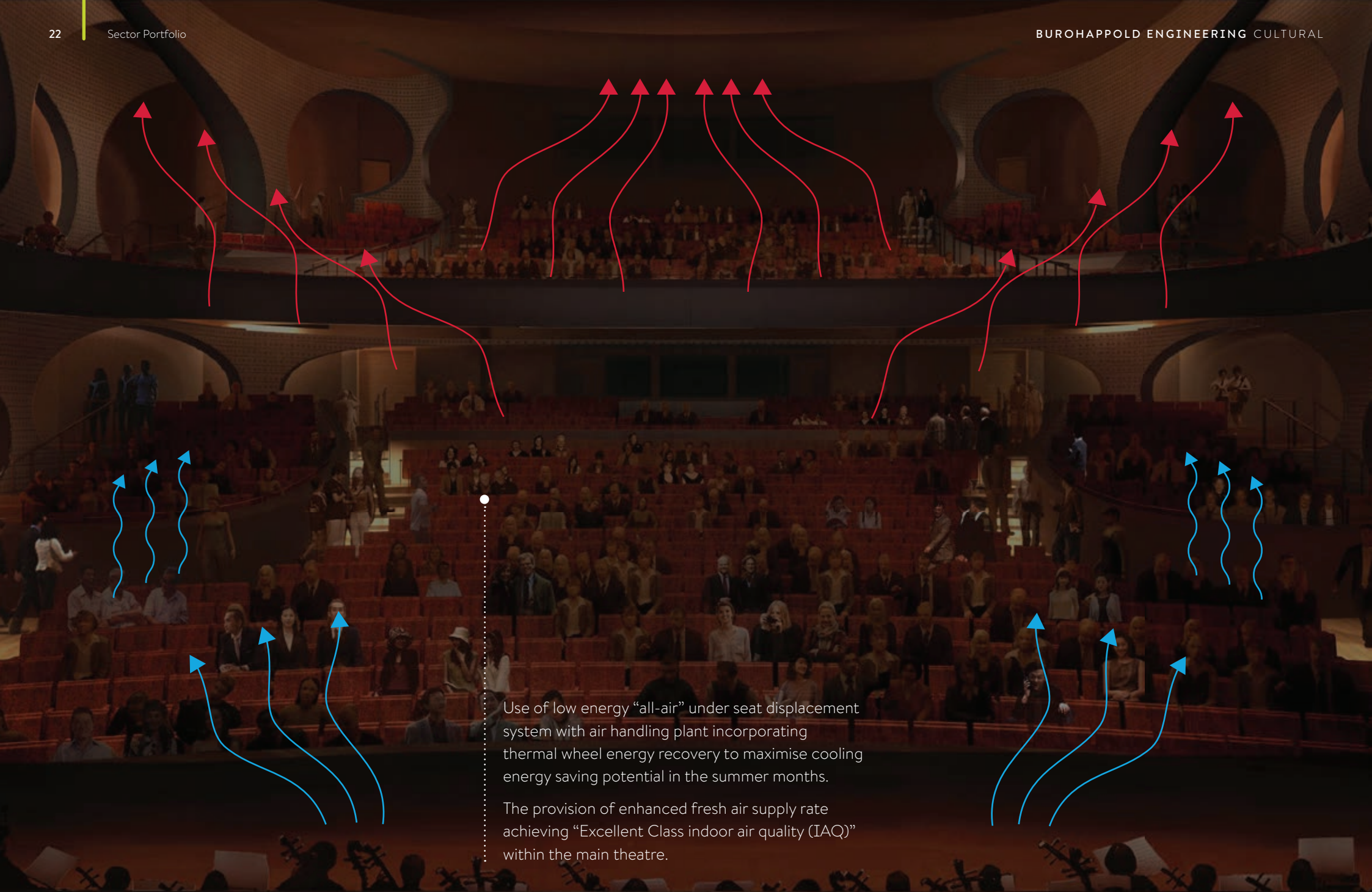
XIQU CENTRE | WEST KOWLOON, HONG KONG











Use of low energy “all-air” under seat displacement system with air handling plant incorporating thermal wheel energy recovery to maximise cooling energy saving potential in the summer months.

The provision of enhanced fresh air supply rate achieving “Excellent Class indoor air quality (IAQ)” within the main theatre.





FASHIONING A MAJESTIC ENVIRONMENT FROM UNDERUSED SPACE

# QUEEN ELIZABETH II GREAT COURT THE BRITISH MUSEUM

LOCATION: London, UK   CLIENT: Trustees of the British Museum   ARCHITECT: Foster + Partners



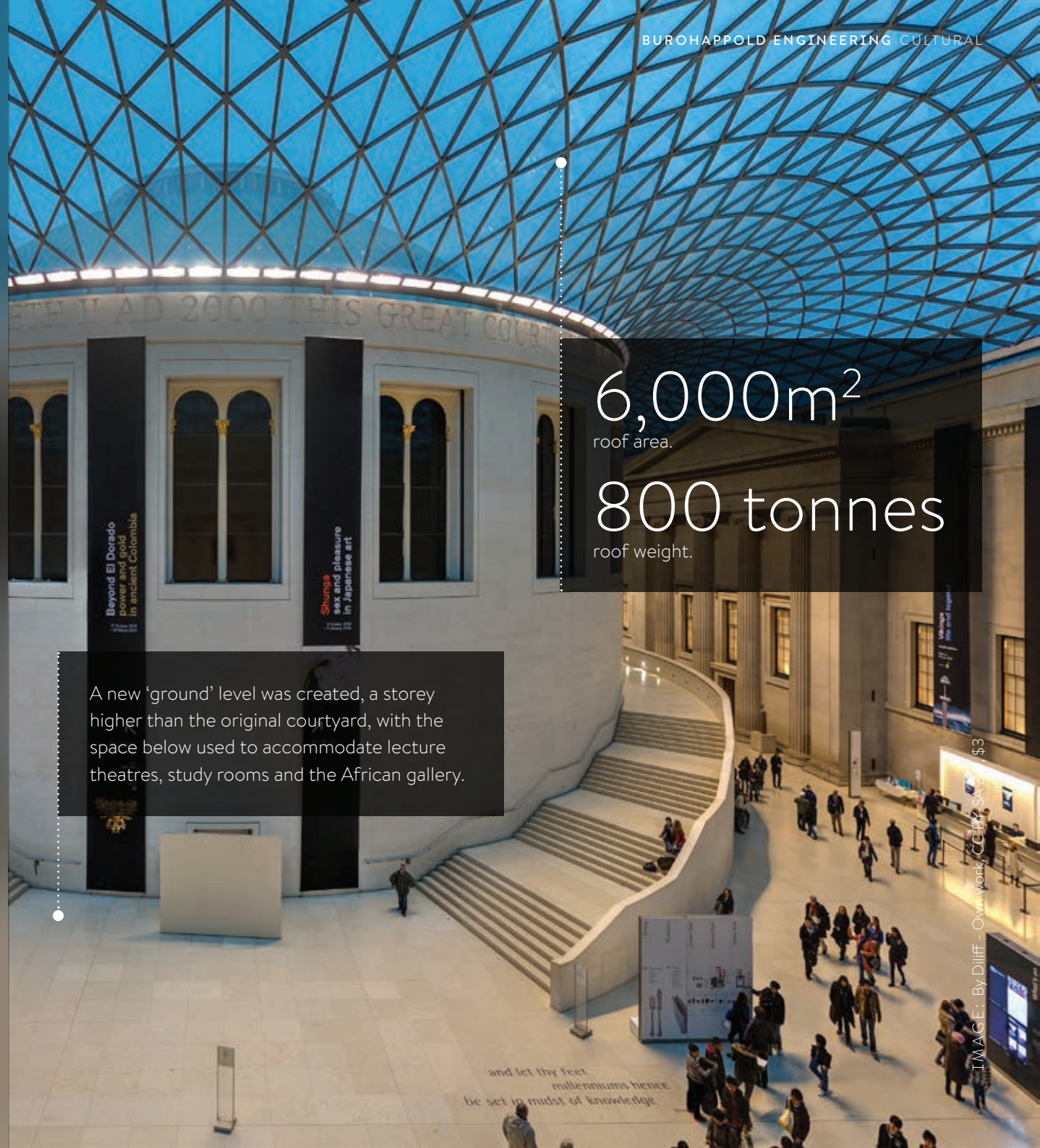
## + ACHIEVING UNITY

The leading attraction in the UK for eight years running has 6.7 million visitors. The British Museum was given a modern sympathetic update to improve visitor experience, and add longevity and continuity to the site.

Designed in 1823 by Robert Smirke, the British Museum's Georgian buildings originally consisted of four wings containing galleries set around a large rectangular courtyard. Since then, the courtyard became filled with extension buildings, including the circular Reading Room and adjoining book stacks (1854-57). Smirke's stone clad museum quadrangle and iron framed Reading Room are now Grade I listed buildings. BuroHappold was commissioned to gather all of these buildings under one roof.

### KEY FACTS:

- Largest covered courtyard in Europe
- Steel and glass lattice work
- Winner of several awards including IStructE Special Structural Award and Civic Trust Awards.



6,000m<sup>2</sup>  
roof area.

800 tonnes  
roof weight.

A new 'ground' level was created, a storey higher than the original courtyard, with the space below used to accommodate lecture theatres, study rooms and the African gallery.



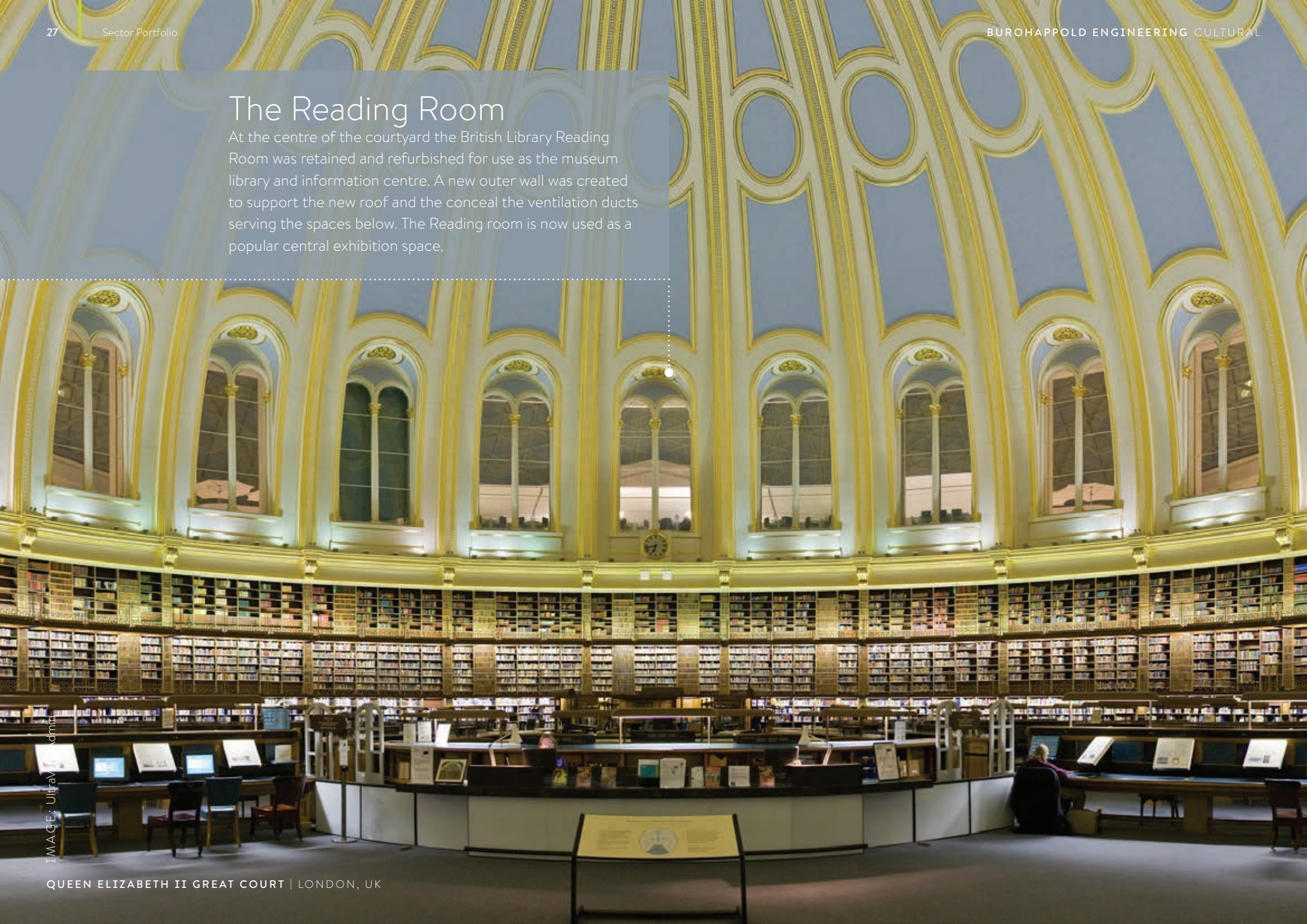
## Business as usual

The huge development and reconstruction took place behind the walls of the British Museum in just 33 months, and without the building having to close to its visiting public.

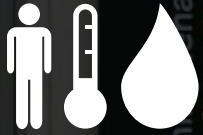


## The Reading Room

At the centre of the courtyard the British Library Reading Room was retained and refurbished for use as the museum library and information centre. A new outer wall was created to support the new roof and the conceal the ventilation ducts serving the spaces below. The Reading room is now used as a popular central exhibition space.







Maintaining environmental conditions with the new spaces was a key design task, not only for the preservation of exhibits but also for the comfort of all visitors.

A range mechanical and passive systems were designed to control conditions from the basement auditoriums and galleries to the restaurant on level six.

To provide the different conditioning requirements for each area, four plant rooms were integrated into the basement of existing quadrangle buildings.

IMAGE: Gidzy

QUEEN ELIZABETH II GREAT COURT | LONDON, UK







IMAGE: AMatthias Süßen (Own work) [GFDL or CC BY-SA 3.0], via Wikimedia Commons



IMAGE: Andrew Stawarz

By opening up the 'lost courtyard' the British Museum also significantly increased their revenue potential by creating elegant, spacious retail and catering spaces, all within the heart of the Grade 1 listed building. In 2000/01 visitor numbers were 5.4 million, with a trading income of £10.7m, but by 2014/15 both figures had risen significantly, with visitor numbers now at 6.7 million and trading income up to £15.4m.

© The British Museum copyright 2015



# ENGINUIITY™ PROCESS

Our Enginuity solution for the Queen Elizabeth II Great Court The British Museum focussed on **Inspirational Design**.





DELIVERING ACOUSTIC EXCELLENCE TO  
AN AWARD-WINNING CONCERT HALL

# THE NATIONAL POLISH RADIO SYMPHONY ORCHESTRA

LOCATION: Katowice, Poland   CLIENT: City of Katowice   ARCHITECT: Konior Studio



## + SOUND STRATEGIES

The new home of the Polish National Radio Symphony Orchestra is one of the most cutting-edge and distinguished cultural sector investments in Poland. This world class, 25,000m<sup>2</sup> concert hall can house an audience of almost 1,800, and the acoustics meet the highest standards as set out by renowned consulting firm, Nagata Acoustics.

### KEY FACTS:

- The orchestra's workplace is a four-storey building containing the concert hall, a chamber room, rehearsal rooms, dressing rooms, recording studios, a canteen and small hotel
- The main auditorium can seat an audience of nearly 1,800. The chamber room can seat 300
- A 1/10 model study and acoustic modelling were used to test acoustic properties
- The hall is acoustically isolated from the outside environment
- Sustainable energy-saving technologies used throughout.

Ventilation louvres integrate discreetly into acoustic wall for improved noise reduction.

BuroHappold were awarded the inaugural Pascal 2015 Award by the Polish Ventilation Association for our HVAC (heating, ventilation and air conditioning) work on this venue.





## Engineering the vision

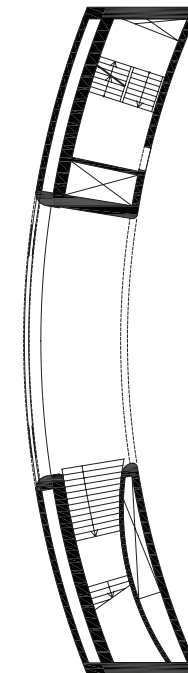
The overriding vision for the building was that not only would it be an acoustically designed masterpiece, delivering a feast for the ears but that the structure itself should be an awe-inspiring sight for all visitors.



IMAGES: Daniel R. Mancew

NOSPR | KATOWICE, POLAND

A stand out structure feature is the extremely impressive spherical wall which towers over the atrium. This very complicated shape was only made possible by a series of complex engineering solutions. These included building the wall in several stages, each separated by hollow cross-section elements in order to control cracking of the concrete, whilst keep it hidden at the same time. Even the special concrete mixture itself was developed by BuroHappold in collaboration with the contractor.





“

The new venue of the Polish National Radio Symphony Orchestra project was the biggest and the most difficult challenge in the history of our studio. This is why, from the outset, it was clear we should partner with the best designers in every discipline. BuroHappold, responsible for structural and building services design, not only brought a team of great experts, but also a wealth of experience in similar buildings around the world.”

**Tomasz Konior**  
Konior Studio

Concert hall facade and roof fixed with use of vibro-insulation to reduce the external noise influence

Deep facade pilasters made of RC concrete with brickwork cladding are efficiently used as vertical shafts. All installations connected with acoustically-proofed rooms have been supported with use of the vibro-insulation hangers.



“

The new venue of the Polish National Radio Symphony Orchestra, forming part of the city's revitalisation, reflects the transition of Katowice from a historical centre of heavy industry to a modern metropolis. The local community has gained a perfect social space within which to meet. NOSPR has also contributed to Katowice's presence on the worldwide music map, helping us earn the UNESCO status of a City of Music.”

**Marcin Krupa**  
Mayor of Katowice

Ventilation plant room moved underground and away from the concert hall for noise reduction. All ducting within concert hall is acoustically isolated.



# ENGINEUITY™ PROCESS

Our Enginuity solution for The National Polish Radio Symphony Orchestra focussed on **Inspirational Design**.  
Click to see the range of BuroHappold specialisms that collaborated to make the vision viable.





HOW SENSITIVE INTERVENTIONS INJECTED FRESH LIFE  
INTO A CULTURAL ICON

# WHITWORTH ART GALLERY

CLIENT: Manchester, UK   CLIENT: Whitworth Art Gallery   ARCHITECT: MUMA   IMAGES: Alan Williams



## + HIDDEN ACHIEVERS

The Whitworth was created in 1889, with one aim: it should act for the “perpetual gratification of the people of Manchester”. This aim remained a guiding principle for the gallery throughout its many years and numerous expansions and reinventions.

### An ambitious plan

Today’s refurbishment and new-build extension, designed by MUMA Architects, is the result of an ambition, not simply to extend the gallery, retaining the very best of the historic building, but also to underline its connection to the park, local community and the university.

### The ‘slow conservation’ strategy

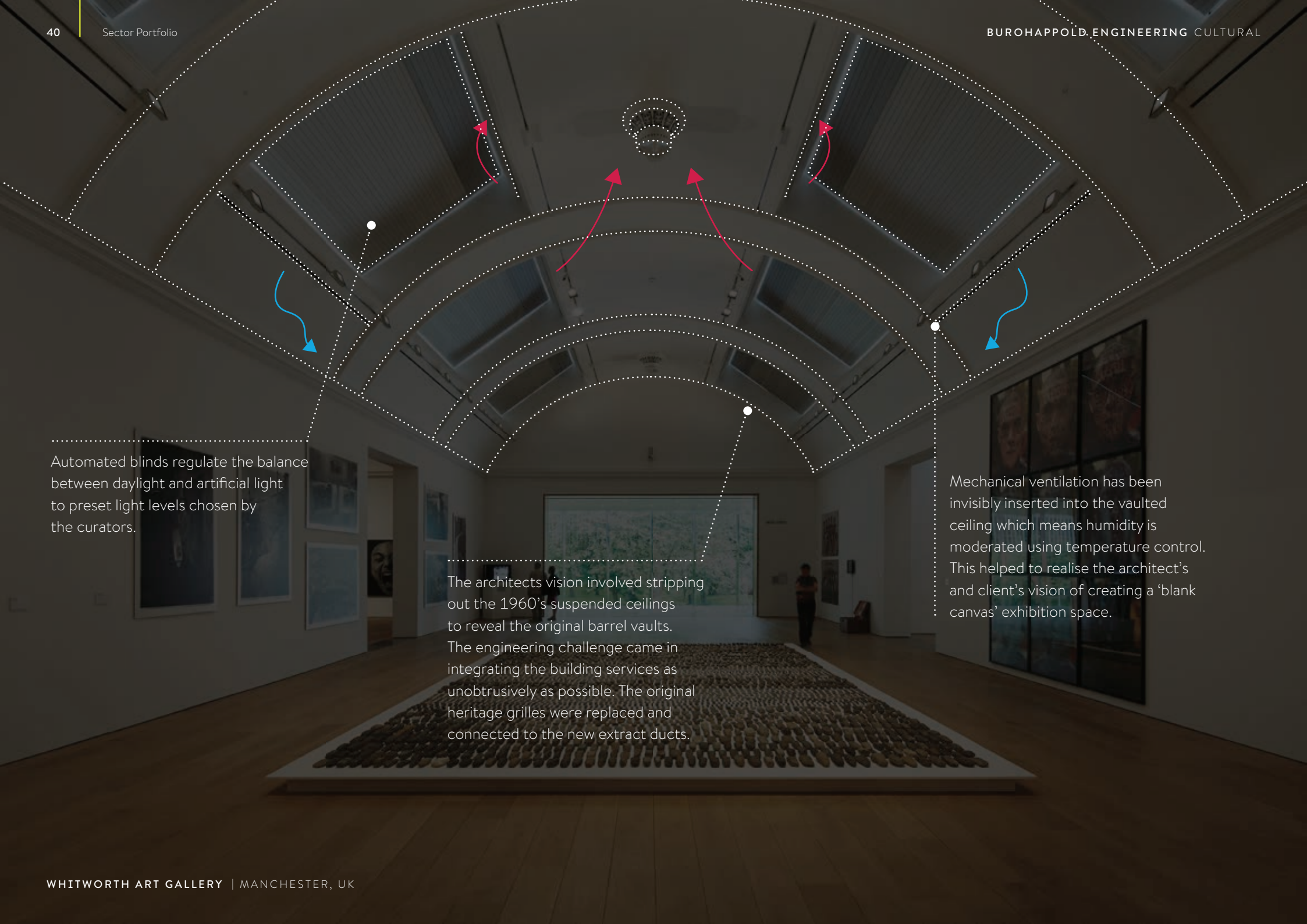
Part of the engineering challenge was to reduce the overall carbon footprint despite its significant expansion, whilst preserving the building’s architectural heritage. BuroHappold engineered an innovative ‘slow conservation’ strategy using the landscape and buildings to shelter the gallery and collection stores. As a result, temperature and humidity can be controlled without the need for mechanical cooling and humidification; this greatly reduces energy use and running costs to be realised.











Automated blinds regulate the balance between daylight and artificial light to preset light levels chosen by the curators.

The architects vision involved stripping out the 1960's suspended ceilings to reveal the original barrel vaults. The engineering challenge came in integrating the building services as unobtrusively as possible. The original heritage grilles were replaced and connected to the new extract ducts.

Mechanical ventilation has been invisibly inserted into the vaulted ceiling which means humidity is moderated using temperature control. This helped to realise the architect's and client's vision of creating a 'blank canvas' exhibition space.







The 'brise soleil' facade and high performance glass minimises the heat from the sun entering the building, whilst maximising daylight and views, combining architectural expression with the engineering purpose. To achieve this BuroHappold conducted in depth solar exposure research and analysis.

18,000 kWh per annum

Solar panels hidden on the roof contribute over 18,000kWh per annum to the building's hot water.

The roof top projector allows for dramatic external visual exhibitions. This has been carefully camouflaged into the penthouse louvre.









Renovations have been carried out sympathetically to the original 1889 building. Services have been hidden within other features, for example, these benches hide ventilation tubes that bring fresh air into the building.

The art garden works hard, hiding earth tubes close to the surface. These pre-cool the air in summer and pre-heat it in winter, before taking it back into the building. This saves in the region of 4800kWh per annum in heating and 5500kWh per annum in cooling. The garden also hides ground source heat pumps extracting heat for the building from deep underground.









The café is a pavilion in the park and a place from which to look back into the galleries. Solar shading is provided by mirrored dots printed onto the glass which also work to reflect the park from the outside and fade out towards the bottom to give a clear view from inside to out.

The sustainability strategy meets the challenges of increasing the building area by over 30% whilst at the same time reducing the overall carbon footprint by 10%.

We concealed natural ventilation openings along the bottom of the new corridor and café glazing.



To date, collections have been stored in various locations around Manchester but have now been brought in house. To create this space the redundant cooling equipment was removed from the basement and it was further excavated. We implemented a passive-first conservation strategy in accordance with the PD5454 guide for the storage and exhibition of archival materials.



#### **RIBA awards winner: 2015**

Winner of the RIBA North West Award, the RIBA North West Conservation Award, the RIBA North West Building of the Year 2015 and winner of the RIBA Stirling Prize BBC public vote.

Also winner of the ArtFund prize for Museum of the Year 2015.



# ENGINEUNITY™ PROCESS

Our Engineunity solution for the Whitworth Art Gallery on **Efficient and Green Design**.





- +Aberdeen Art Gallery
- +Bath Abbey Footprint Project
- +Bristol Aero Collection
- +Cutty Sark
- +Glasgow Riverside Museum
- +Halifax Library
- +HOME
- +Ickworth House, West Wing
- +Imperial War Museum
- +Keighley Central Hall
- +Leeds City Museum

- +Library of Birmingham
- +Liverpool Central Library
- +Loch Lomond and the Trossachs National Park Authority
- +London Transport Museum
- +Marlowe Theatre
- +Masterplan for the London 2012 Olympic and Paralympic Games and Legacy
- +Metropolitan Arts Centre (MAC)
- +Millennium Dome

- +MOSTYN Gallery
- +MOSTYN Gallery (Lighting Design)
- +Museum of Liverpool
- +Palace of Westminster
- +Queen Elizabeth II Great Court, The British Museum
- +RAF Museum Hendon
- +Rambert
- +Royal Shakespeare Theatre
- +Savill Building
- +St George's Bristol

- +Stanbrook Abbey
- +Stihl Treetop Walkway
- +Temple Precinct Renovation, Roman Baths
- +The Piece Hall
- +Theatre Royal
- +Transforming Tate Modern
- +Victoria and Albert Museum, Furniture Galleries
- +Whitworth Art Gallery
- +Woolwich Civic Centre

- +Academy Museum of Motion Pictures
- +Corner Glory Art Installation
- +Levitated Mass at Los Angeles County Museum of Art
- +Long Beach Aquarium of the Pacific
- +Natural History Museum of Los Angeles County Los Angeles Exhibit
- +Manhattan Beach Library
- +Stud Wall Art Installation
- +Tongva Park and Ken Genser Square

- +Cleveland Museum of Natural History
- +Crystal Bridges Museum of American Art
- +Euphony at Nashville Music City Center
- +Navy Pier
- +Perot Museum of Nature and Science

- +Boston Museum of Fine Arts
- +Colby College Museum of Art, Alford-Lunder Family Pavilion Building
- +Isabella Stewart Gardner Museum
- +Curtis R. Priem Experimental Media and Performing Arts Center, Rensselaer Polytechnic Institute
- +National 9/11 Memorial Museum Pavilion
- +Parrish Art Museum
- +Queens Central Library, Children's Library Discovery Center
- +Queens Museum
- +St. Ann's Warehouse
- +Sperone Westwater Gallery
- +Sterling and Francine Clark Art Institute
- +The High Line

- +Contemporary Museum Wroclaw
- +Copernicus Science Centre
- +Museum of the Polish Army
- +The National Polish Radio Symphony Orchestra
- +Sluzew Cultural Centre
- +Memorial to the Murdered Jews of Europe
- +Mercedes Platz
- +Zaryadye Park Cultural Centre

- +Al Ain Oasis
- +Louvre Abu Dhabi
- +Atturaif
- +Tuwaiq Palace
- +10KSA Human Chain Event

Yinchuan Art Museum+

Polish Pavilion at the Shanghai Expo 2010+  
Nanjing Youth Olympic Centre (YOC)+  
Yuhang Cultural Arts Centre+

Tsim Sha Tsui Cultural Centre+  
Xiqu Centre+

# OUR CULTURAL PROJECTS WORLDWIDE



BUROHAPPOLD  
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WE MAKE THE VISION VIABLE

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