

# Building performance engineering

The art and science of  
creating great outcomes



**A good building is all about the people...**

**who design and build it  
who own and operate it  
but most of all who use it**

A good building is simple to create, operate, adapt and ultimately remove; it's cost-effective over its lifecycle; it respects its environment; and it is appropriately functional.

Every building has a role to fulfil – for working, playing, making journeys, learning, healing... for living. Each function has its own technical requirements. But human health and happiness also have a significant bearing upon a building's performance and success.

Success can be measured by outcomes achieved.

Is there a formula for achieving it? We think so, and call it 'building performance engineering'. It's about striking the right balance between science, art and economics, and applying ingenuity for enhanced outcomes.



## Low carbon lesson

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**Project**

Burntwood School, London, UK

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**Client**

Burntwood School and Wandsworth Council

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**Architect**

Allford Hall Monaghan Morris

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**Expertise**

M&E engineering plus low energy and carbon, specialist acoustic and sustainability advice

Burntwood wanted to grow from four inefficient 1950s buildings into a single one – and cut carbon emissions by 20% relative to building regulations while doing it. By playing with building form we maximised daylight while avoiding solar heat gain. Hybrid ventilation allows night time thermal mass cooling. A biomass boiler provides 50% of comfort heating, and solar heating 60% of hot water. The school remained open throughout the build. It has been designed so that energy savings can be cost effectively added in future. Not only is it now a great place to learn, in 2015 Burntwood won the UK's most prestigious architecture accolade, the Stirling Prize.

**30%**  
reduction in carbon emissions

**200**  
more pupils



## More than sport

### Project

Adelaide Oval redevelopment,  
Adelaide, South Australia

### Client

Government of South Australia/  
Stadium Management Authority

### Architect

Cox Architecture with Walter  
Brooke and Hames Sharley

### Expertise

Design management and  
project management

Changing spectator and broadcaster expectations, and innovations in sports event management and economics, led to a dramatic AU\$535M reconfiguration and redevelopment of this internationally iconic and well-loved sports venue. The layout was changed to accommodate the different viewing needs of football and cricket matches, allowing for year-round use. And the project added two new spectator stands, an entrance plaza and a pedestrian bridge across the adjacent River Torrens, linking the Oval to the city centre.

To achieve integrated, fast-track design and construction we introduced BIM to co-ordinate a team

of three architectural firms, four engineering consultants and 20 specialist subconsultants. Modular, lightweight components were used to make rapid progress during short construction windows between sporting seasons.

The overall planning of the stadium and its surrounding spaces also focused on revenues and economic sustainability. Match attendances are now double pre-redevelopment numbers and the reborn Oval has injected an estimated AU\$200M/year into the local economy.



**“The redevelopment of Adelaide Oval was always about much more than football and cricket. The Oval has established itself as a powerhouse in South Australia’s events and entertainment industry and it is continuing to produce major benefits for our state.”**

**John Olsen**

Chairman, Adelaide Oval Stadium Management Authority

# Enhanced outcomes

Schools where children learn better. Hospitals where patients heal faster. Stadia where the play is unforgettable (and the revenues unbeatable). Offices where staff are happier, healthier and more productive. Transport terminals that are, in themselves, great destinations.

They're some of the ways we define enhanced outcomes. How about you?

## Making the money work

New build, refurb, fit-out, adaptation... whatever kind of investment you're making, it is a big commitment. You need value for money and return on capital, not just at the start but over the life of your project.

## Building performance engineering

- cuts resource use and waste
- reduces capital and operational carbon and cost
- optimises designs for enhanced outcomes
- cuts risk and improves certainty
- provides for adaptability, resilience, reuse and recovery

## Preparing for change on and over the horizon

It's about making the most of investment, minimising the costs of operation, repair and maintenance, and maximising financial return. Building performance engineering:

## Starting something good – seeing it spread

Energy and carbon, noise, vibration, fire resilience, waste and air quality... they're just some of the performance criteria tightened by regulation. Add new technology, changing work practices and space uses, increasing demands for a healthy internal environment and climate change, and the only certainty is that tomorrow's requirements won't be the same as today's. We help you anticipate upcoming needs and plan for adaptability to accommodate changes over the horizon.

# Beach life

## Project

British Airways i360,  
Brighton, UK

## Client

Brighton & Hove Council

## Architect

Marks Barfield

## Expertise

Façade engineering

In the 19th century it was piers jutting out to sea that attracted fun seekers to Brighton's seafront. When architect-entrepreneurs Marks Barfield proposed a 21st century attraction – a landmark tower with an ascending/descending observation pod – the holiday town jumped at the opportunity to create the focus for wider urban rejuvenation. The UFO-like pod of the British Airways i360 travels skyward from a sleek glass-clad podium structure engineered by Mott MacDonald. The podium transitions between the sci-fi tower, the shingle beach, and neighbouring, newly restored, Regency pavilions. Its façade is stylishly minimal but engineered to marine standards, to cope with everything that exuberant summertime crowds and raging winter storms can throw at it.





## Strong persuasion

### Project

Northern Line Extension,  
Battersea Power Underground  
Station, London, UK

### Client

London Underground

### Architect

Grimshaw

### Expertise

Civil, structural and MEP  
engineering for the entire route

The 3.2km extension of London Underground's Northern Line to Battersea Power Station will connect the old industrial landmark and its surroundings with the rest of the capital for the first time. Its stations, at Battersea and Nine Elms, are focal points for major development and continue London Underground's long tradition of iconic architecture. They are designed to help attract people and economic life to the area, but must also be affordable.

With architectural partner Grimshaw, we've designed Battersea Power Station with a calm, minimalist aesthetic. Large open spaces and a clearly expressed structure will make the station easy, safe and enjoyable to use. But behind its clean lines the building will be working

incredibly hard – and highly efficiently. Battersea Power Station will sit beneath three buildings. Conventionally, a uniformly strong 'transfer deck', supported on the station structure, would carry the buildings above. However, here the station's columns and beams are tailored to take specific loads, allowing beam depths to be reduced substantially and saving hundreds of tonnes of concrete and steel. We've also cut excavation and concrete use by approximately 30% on the station's perimeter diaphragm wall, by using alternate long and short panels – traditionally panels would all be of the same length. These innovations, along with use of the latest design for manufacture and assembly techniques, have delivered time and cost savings for joint venture contractor Ferrovial-Laing O'Rourke.

# Buildings +

Whatever your ambitions, needs and challenges, and no matter where you are, we'll align the right combination of sector knowledge and expertise.

Mott MacDonald's universe of creative thinkers is centred around our clients – you. We're joined-up across sectors and geographies, giving you access to exceptional breadth and depth of expertise and experience.

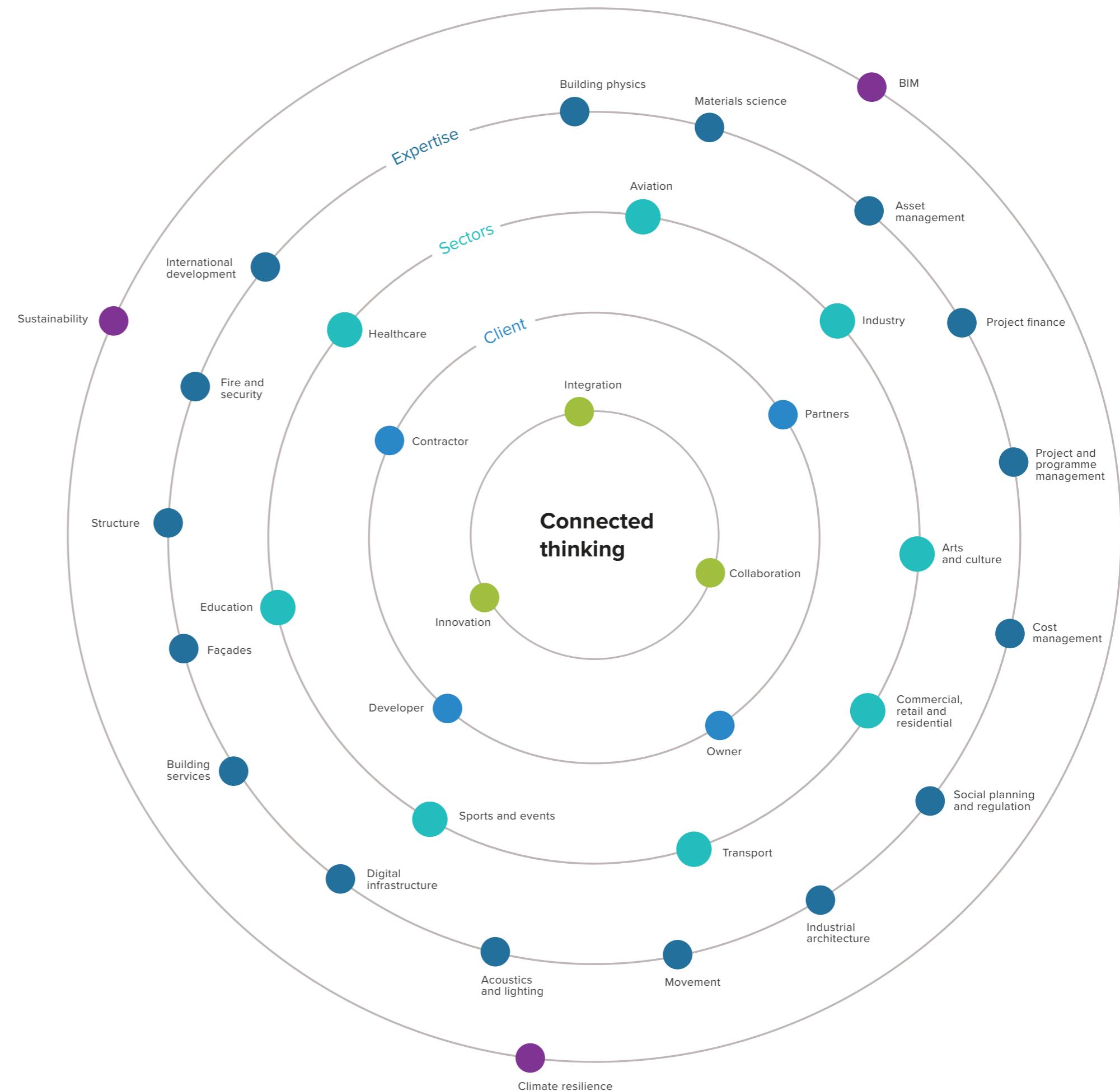
We can offer fully integrated cross-disciplinary engineering, or services in a single discipline if that is your preference. Whatever your chosen procurement strategy, we will always be looking for opportunities to think across boundaries for the benefit of the project.

## Applied ingenuity

You can bring us on board at any stage of the asset cycle and we'll find all practicable means of enhancing its performance in economic, social or environmental dimensions. Or we can work with you throughout the lifecycle of your project, providing the joined-up thinking that's needed for optimum outcomes. It is our understanding of all phases of the lifecycle, from project shaping to through-life optimisation, that enables us to give best-informed advice within any phase.

**"Reaching out through our professional practice networks you can find a world expert in minutes."**

**Randal Jones**  
Global sector leader for the built environment



# Setting your project up for whole-life success

What are your needs, challenges and ambitions? We're out to find the best answer – and it's not always a new building.

Our performance engineering approach applies equally to existing buildings, where the triple bottom line of enhanced value, reduced carbon and fitness for changing lifestyles drives an increasingly urgent need for improvement.

## 1.

### Concept design and master planning

Buildings often work as part of a campus or a wider urban system. We'll use cross-disciplinary and connected thinking to realise synergies and cut demand, bringing materials, energy, carbon and cost benefits for individual buildings and the wider public realm.

## 2.

### Safer by design

Fire and life safety are in our DNA – so whether it's a stadium, a metro station, a highrise hotel or a retail mall, we're in the business of keeping people secure.

## 3.

### Making the money work hardest

Did you know that we are the world's foremost project finance advisor? Our status is built on finding the right financial model to minimise risk and maximise reward over the lifetime of buildings and infrastructure, enhancing through-life value and return on investment.

## 4.

### Advising on procurement strategy

Knowing the service requirements and demands of a building, from cradle to cradle, we can help to ensure you get the right services, when you need them, to meet your changing operational needs and shifts in the world around you. We help you establish processes and protocols to get the most out of digital project delivery.

## 5.

### Building in adaptability

Through model-based scenario planning in design thinking and choice of construction technology, we can equip your building to be modified over time in response to social, commercial, technical and climatic trends, and retain value.

## 6.

### Defining information requirements

Industry skills in creating, storing and sharing data are still in their relative infancy. We can advise on, and implement, appropriate asset information management, helping you to make better decisions, faster and cheaper – from project inception through delivery and handover into operation, adaptation and eventual recovery and reuse.

## 7.

### Keeping delivery on track

At the start, the end and everywhere in between, we can provide the programme and project management needed to control cost and schedule, secure the right expertise, services and supplies, manage risk and maximise certainty of achieving your goals.



## What you see...

Len Lye was one of New Zealand's most important artists, known internationally for his experimental films and kinetic sculptures. His home town, New Plymouth, commissioned the country's first dedicated single artist gallery to raise its profile as a leading cultural city. Reflecting the intensity, energy and excitement of Len Lye's work we designed a stainless steel façade that is aesthetically simple

but technically ingenious and compatible with local fabrication capability. The curved exterior walls of mirror-like stainless steel have become a New Zealand national landmark. Described as 'a temple for art', the space creates a sensory experience of light inspired by the Lye legacy. It attracted twice as many visitors as anticipated during its first few months, including art enthusiasts and investors from all around the world.

### Project

The Len Lye Centre, New Plymouth, New Zealand

### Client

Patterson Associates for New Plymouth District Council

### Architect

Patterson Associates

### Expertise

Façade design



## Walking the talk

### Project

Department of Environmental Affairs head office, Pretoria, South Africa

### Client

Government of South Africa

### Architect

Boogertman & Partners

### Expertise

Mechanical, electrical, civil, structural, sustainability and fire engineering

The Department of Environmental Affairs, responsible for protecting and improving the environment, needed a new head office that would act as a flagship for its activities. We set out to find ways of exceeding the DEA's own sustainability guidelines. Windows open at night to cool the thermal mass of the building's structure. As the outside temperature

rises, the ventilation pathways are resealed so that the building's structure remains as cool as possible. The building is oriented to maximise natural lighting while minimising heat gain. Sensors dim or turn off electric lighting when there is sufficient daylight, and in unoccupied rooms. The largest rooftop solar photovoltaic array in South Africa meets 20% of the

building's power needs. Rainwater storage and recycled grey water supply 40% of water. Healthy materials were specified for the fit-out. Use of local suppliers triggered job creation and skills development. This was the first government building in South Africa to win 'Six Green Stars' – one of only three in the country – raising the bar for future office developments.

## Air miles ahead

Ever since it opened in 1998 air travellers have voted Hong Kong one of their favourite airports – it's easy to find your way around, offers fast, efficient service, and has spectacular architecture. We embedded these qualities when we designed the main terminal – and again on our design, with Arup, of the new HK\$10bn Midfield Concourse, providing

20 new aircraft parking stands and enabling 10M more journeys a year. We broke new ground in Hong Kong by using BIM to examine 14 layout configurations, weighing capacity, customer experience and airfield operational considerations. The award-winning building was delivered to a fast-track programme and provides leading sustainability performance.

### Project

Midfield Concourse,  
Hong Kong International Airport

### Client

Airport Authority, Hong Kong

### Architect

Aedas

### Expertise

Multidisciplinary engineering; airport systems, people mover and baggage handling systems design; sustainability consultancy; logistics and project management



# Pushing boundaries with digital design

Digital transformation is pulling in expertise from across the supply chain alongside that of the architect and engineer. We've been at the leading edge from the start. The result: better performance at every stage of the project cycle.

**Process mapping**  
From plotting the desired outcomes for your project through to planning the discipline interactions and work stages involved in delivering it, digital technology makes it possible to provide information in a visual context, when and where it is needed, and adapted for all uses.

**Enabling collaboration**  
After decades of frustrated ambition, the tools, standards, working methods and language now exist to create integrated multidisciplinary project teams and fully co-ordinated solutions – for those with the know-how.

## Using brainpower to best effect

Algorithms are enabling basic design operations to be carried out by computers much faster than by humans. Automated fabrication is facilitating fast-track construction using ready-made components and assemblages.

Data management and manipulation by 'intelligent' software tools

and apps allows a high degree of autonomous command and control over operations. All of which helps to free human resources for what they're best at – creating and problem-solving.

## Fine tuning solutions

Using parametric and generative design tools at the start of the design process, we can cost-effectively run through numerous permutations of a preferred option. We set out the standards, describe the constraints... and fast-track to optimised solutions for energy, carbon, light, structural form, thermal performance and much more.

## Project

The Core, Science Central, Newcastle upon Tyne, UK

## Client

Newcastle University and Newcastle City Council

## Architect

Faulkner Browns

## Expertise

Civil, structural, building services and fire engineering; environmental certification

# Core skills for millennial entrepreneurs

Newcastle University wanted to build a new business community by providing home-grown, high-tech and green innovation start-ups, conceived within the university's own R&D departments, with the labs and offices they need to grow into successful companies. At the heart of its new campus it desired a landmark

building embodying its would-be tenants' values of innovation, collaboration and sustainability. Technologies include solar thermal hot water, photovoltaics integrated into glazing that generate power at the same time as preventing heat gain, rainwater harvesting and natural ventilation. Floor plate and façade designs maximise natural lighting.

The Core has a wildflower roof and an eye-catching seven-storey living wall – a vertical garden supporting wildlife and biodiversity that also provides thermal insulation. The building is a major hit: Newcastle City Council estimates that it has already created 400 new jobs, contributing an additional £20M to the local economy.



## BIM and bull's-eyes

**Project**

Olympic and Paralympic Shooting Ranges, London, UK

**Client**

LOCOG

**Architect**

Magma

**Expertise**

Total engineering design, sustainability and cost consultancy

Organisers of the 2012 Olympics wanted a shooting venue that was low cost but world class, temporary but distinctive. In an Olympic first, we used one range for two of the four disciplines, cutting the venue footprint and cost by 25%. The structural frame used standard, rented steel trusses and columns, covered inside and out with recyclable PVC fabric. Foundations were lengths of reclaimed oil pipeline. Steel rings mounted on

lightweight frames, braced off the primary structure, tensioned the fabric by pulling and pushing it out of plane, giving the façade its distinctive 'bullet hole' aesthetic. Compared to conventional tensioning, our method halved the cost of the envelope. The rings created apertures for natural ventilation; the fabric's translucency minimised artificial lighting, keeping building operating costs low. We used BIM from concept stage to integrate multiple design

disciplines, suppliers and contractors. Our client allowed 18 months for construction, but using BIM we worked with the main contractor to rehearse construction. Including a two month 'buffer', the venue was completed in six months. Post-games, all components were recovered for reuse. The site was returned to its owner with great memories, but no other trace.



# Contributing to construction efficiency

Whether it's by communicating design intent to site workers, carrying out virtual dry runs of complex work sequences, programming robotic construction plant to achieve super accurate earthworks, or building kits-of-parts in factories, the efficiency of construction is being revolutionised. And we're in the thick of it.

## Embracing offsite fabrication

Designing for manufacture and assembly (plus recovery and reuse) is best considered from concept design stage. Our engineers think about how things go together, using BIM as an enabler and working closely with the supply chain at the earliest opportunity.

## Reducing waste

Throw away materials and energy, or design and build inefficiently, and you're squandering money, carbon and labour, which is why we like lean thinking.

## Taking care of people

Improve safety and you reduce technical, commercial and reputational risk: it brings better project certainty and greater investor confidence. To us it's common sense: safety is good for everyone.

## Controlling change

Planning collaboratively, communicating ideas and checking intent, working through details and sequences, briefing, training... we want our projects to go together right first time, so set out to create the right foundations for success.

## Handing on knowledge

Design and construction generate a wealth of information which is of potentially huge benefit throughout the operational, repair, maintenance and adaptation phases of a building's life. Organised information can inform future projects for continuous improvement. Every client's information needs will be different, so our digital transfer service is about ensuring you get all the right information in the most useful way.

## Project

Centre Hospitalier de l'Université de Montréal (CHUM), Quebec, Canada

## Client

CHUM, Collectif Santé Montréal, Fiera-Axiom, Acciona, HSBC Infrastructure Consortium

## Architect

Cannon Design

## Expertise

Lenders' technical advisor; construction management

# Friend in need, friend in deed

The biggest PPP hospital project in Canadian history, CHUM consolidates three existing teaching, research, and healthcare facilities onto a single site. It's being built in a tight city centre location, on a rolling handover programme, to exceptionally high standards. We're involved in keeping the project on schedule and cost, with the aim of achieving 'Silver' accreditation under the LEED energy and environmental performance rating system.



# Creating smart buildings for enhanced outcomes

After carefully creating a solution to meet your needs, do we simply hand over the data model and walk away? Absolutely not!

However well designed, outcomes can all too easily be missed if intentions are not translated into actions through construction, commissioning and into operation. We can provide expert advice beyond practical completion to help owners and users get the maximum benefit from the built asset.

## **Buildings for healthier people**

Advances in materials technology have improved the performance of construction products, but many now also release harmful chemicals which affect indoor air quality. We've developed an unusual expertise in auditing materials so we can specify those that safeguard the health of a building's users. Along with deep understanding of light, air, temperature, noise, vibration and spatial design, it's key to delivering better outcomes, measured in terms of human happiness, performance and achievement.

## **Matching best intentions**

We're passionate about closing the performance gap between design intentions and operational performance, working with contractors and operators to guide projects from inception to occupation.

## **Monitoring, listening, analysing and enhancing**

How is your building being used? What do its users – your staff, customers and community – think of it? They are questions rarely asked and the answers are even more rarely known.

Finding out can reveal amazing opportunities to improve performance that yields efficiency, improves productivity and saves cost.

## **Responsive controls**

A sophisticated building often requires skilful management to perform at its best. We can design systems that are easy for building managers to operate – or provide automated controls that respond to occupancy, seasons and weather.

## **Optimising through-life performance**

Time passes and technology evolves, people's expectations and building use patterns change, and the building fabric ages. Whether it's a building designed by us or someone else, we can find cost-effective ways to restore building performance and advance it, by identifying where the real performance issues are.

## **Prioritising investment for greatest effect**

Maintenance is inescapable. The art of asset management is prioritising investment so that you achieve the best performance for your money. We can help you move to condition-based maintenance, using an accurate asset information model combined with sensors and analytics to make sense of the increasing abundance of data.



## **Project**

Houghton-le-Spring Primary Care Centre, County Durham, UK

## **Client**

NHS South of Tyne and Wear

## **Architect**

P+HS

## **Expertise**

Building services engineering

## **Living, breathing, outstanding**

The primary care centre in Houghton-le-Spring is the first healthcare building to achieve a BREEAM Outstanding score. It combines ground source heating and cooling, photovoltaic and wind power, natural ventilation with night cooling, and solar thermal heating. A thermal wall maintains constant temperature, avoiding the need for air conditioning for all but the equivalent of four days per year. Annual energy bills are 38% lower than a standard health building. Our lifecycle maintenance and replacement analysis informed both design and construction.

**"Although there was a capital cost to achieving the Outstanding rating, we set this against the wider financial and health costs of not reducing the impact of our activities and our estate."**

**Stephen Naylor**

Head of estates, NHS South of Tyne and Wear

## Cool jewel

### Project

Indian Heritage Centre, Singapore

### Client

Singapore National  
Heritage Board

### Architect

Greg Shand Architects

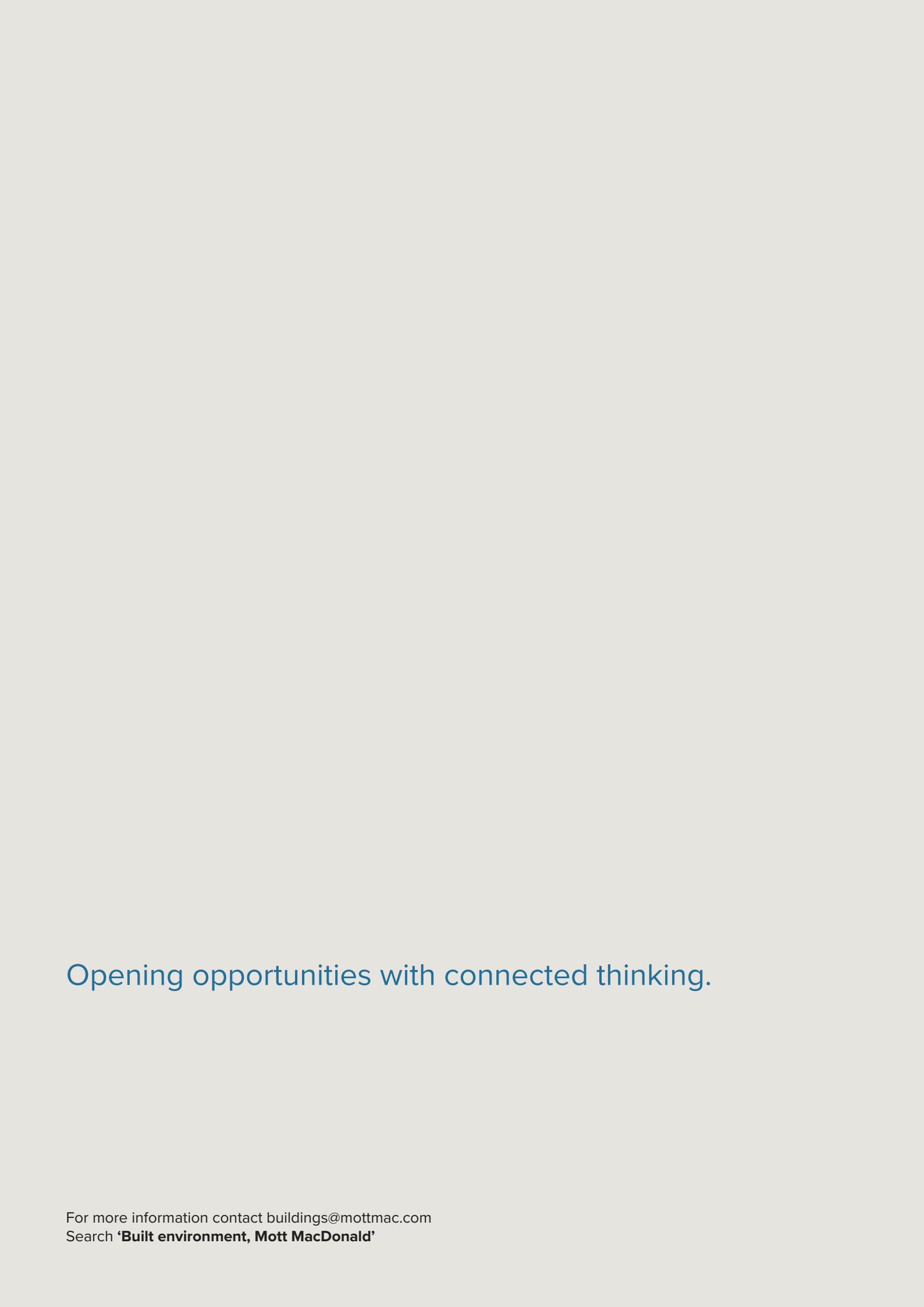
### Expertise

Building services design,  
sustainable design consultancy  
and façades advice



When the National Heritage Board embarked on creation of a museum to celebrate the culture of Singapore's Indian community, it set the goal of achieving a 'Gold Plus' award under the country's Green Mark sustainability rating system. Safeguarding centuries-old artefacts in Singapore's humid climate requires precise 24 hour environmental control. We achieved this by designing a ventilation and dehumidification system with innovative dual heat exchangers that are 44% more efficient than a conventional heat pump solution. At night, a 'super-dehumidification' process

produces very cold water for a short period before being shut down. The chilled water enables continued temperature and humidity control. We worked with the architect and façade consultant to improve building envelope performance by incorporating a double-skin façade that reduces thermal gains and solar radiation. And by persuading the gallery consultant that halogen exhibit lighting could be replaced by LEDs, we delivered a 24% saving in lighting energy. Overall building energy use was reduced by 28% and annual operating costs cut by SG\$45,500.



Opening opportunities with connected thinking.

For more information contact [buildings@mottmac.com](mailto:buildings@mottmac.com)  
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