QR3

Quarterly Review

2020
Digital Design

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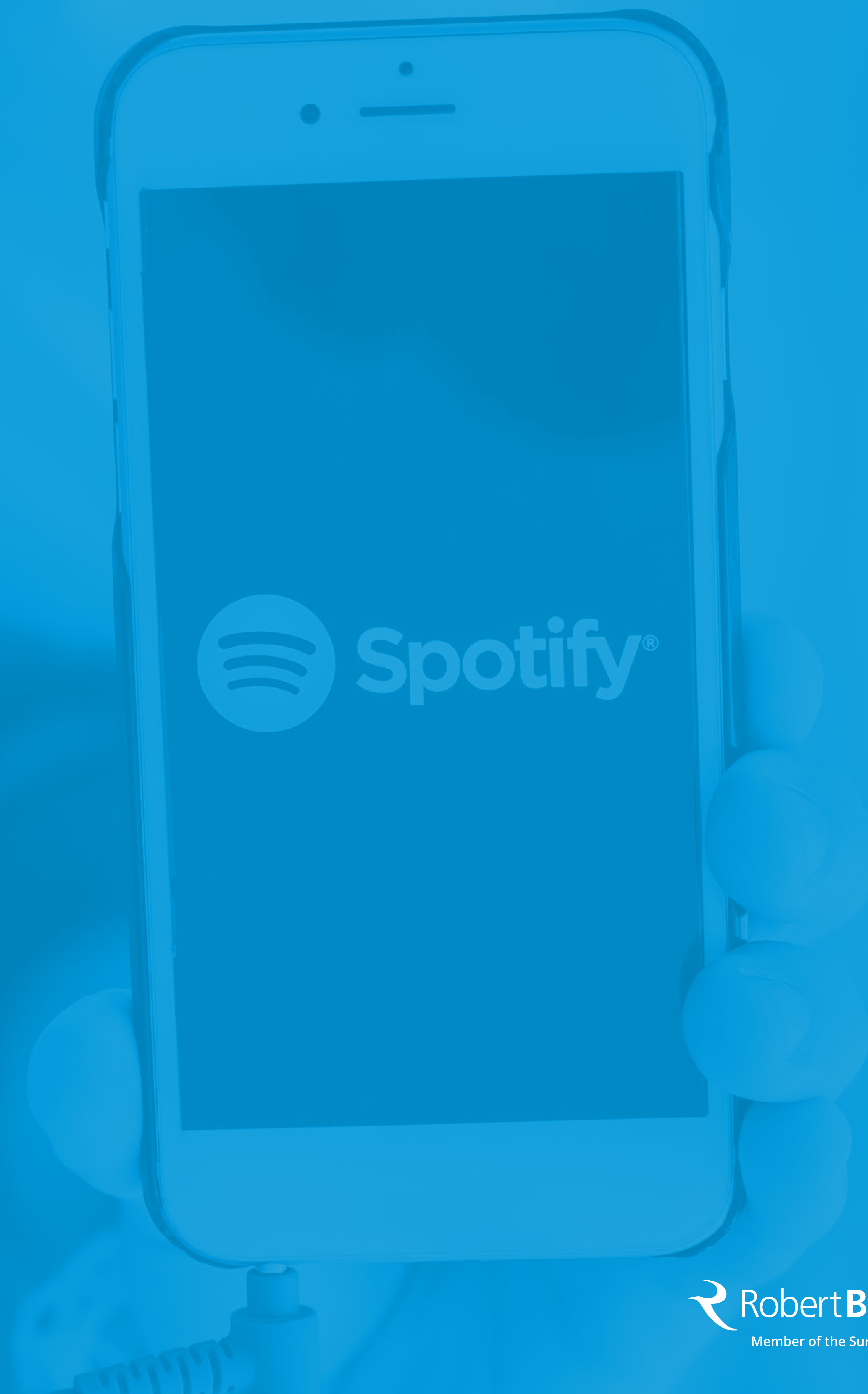
1. The only constant is Change

Have you ever explained to a teenager, what an LP was? Or how this music-storing technology was then ended by the cassette tape? Or how the cassette was then replaced by the CD? Or the year that Sony released the Walkman, and suddenly everyone had a big plastic circular thing strapped to them when they went for a run?

Then the Mini-Disc came along, halving the weight and size? Or when Apple then released the iPod, and suddenly your music wasn't even on anything, it was just a data file, so you gave your US $300 Walkman to your pet dog to chew on? And then the iPod grew from holding about sixty songs, to two hundred, to two thousand? Or how Apple then went and put the iPod functionality inside a phone, so you didn't even need a special device to play music anymore? And then when broadband and Wifi turned up, you could just download and play a song while you were out walking?

" Digital disruption isn't new; just ask anyone who used to visit Blockbuster. The extent and pace of disruption, however – that's a different story "



2. Catch the digital wave

There is a wave of digital disruption sweeping through the construction industry – bringing in new technologies that are changing the way we plan, design, procure and build. This change in the industry is reflective of broader shifts in our world and in society; where change is exponential, where our lives are being systematically digitised, where we are more globally connected and our needs are being increasingly satisfied by accessible technology.

We believe it is imperative that we evolve alongside the technology, drive change in our industry and help shape this evolution. There are major challenges facing humankind; housing shortages, increased urbanisation, wealth inequality, and climate and biodiversity emergency. The recent global pandemic has necessitated an accelerated shift in mindset, and has demonstrated to the construction industry that digitisation, through the adoption of remote communication and design collaboration technology, is both effective and commercially viable. It has also signalled a need to advance component-based off-site manufacturing to provide a safer working environment and a more resilient supply chain.

We need to embrace smarter design, delivery and operations through the effective application of technology to rise to meet these challenges. The beneficiaries of this change will be wide and many. Businesses, clients, industry, society and the natural environment will all reap the rewards; having a direct impact on those who own and occupy buildings, and well as those who use and operate infrastructure, enabling delivery of a better, more efficient and durable product for less cost and less natural resources.

This Quarterly Review considers some of the questions raised by technological advances in our industry; looking at what benefits we are already seeing through the smart application of emerging technology, and looking ahead at the shape of things to come.

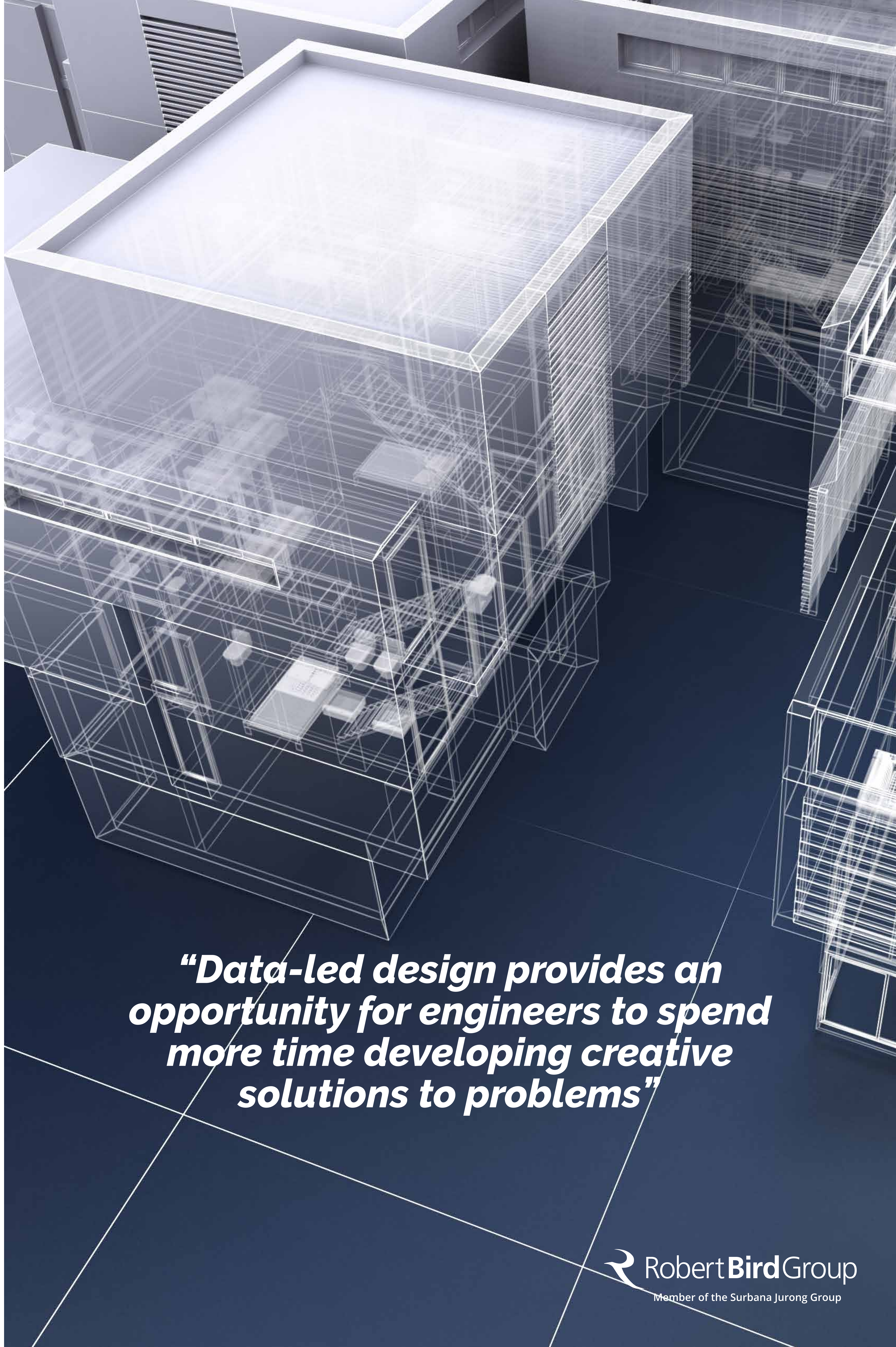
It is our imperative to embrace technology and realise this vision; the challenge has been set, and the opportunities await.

3. Data-Led Design

Great engineering starts with asking the right questions, and identifying the real problems. Data-led design rises to this challenge, probing deep into client requirements and concept design solutions to identify and address multiple problems with each design variation. We can set parameters around existing constraints, desirable outcomes and objectively evaluate design options.

This has always been at the heart the design process, however digital technology allows rapid solution generation and objective evaluation, enabling more options to be considered and often getting to a better answer, quicker. With sufficient data, data-led design can draw on the experience of engineers, remove solution bias, and free up designers from mundane activities to evaluate new concepts and use their leadership to fully explore the unique questions presented by each project.

Further, we can start to see how a data-led design approach could expand in scope and capability to work across all design disciplines, encompassing a broader range of constraints and parameters to evaluate holistic 'best value'. Applied early in the design process, data can be used to identify projects suitable for redevelopment, refurbishment or re-purposing.



Battersea

Master-planning & Design Leadership

RBG has recently been involved in revisiting the master-planning of the Battersea development to address growing costs associated with site and logistical constraints, to re-position the development and improve the value proposition. We approached this by setting constraints such as ground conditions, existing buried or surface assets, daylight and proximity requirements and access requirements both in the final design but also during construction. With this data we weighed up design solutions against cost, value, programme and risks to derive best value and best project outcome.

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What is Big Data?

Big Data is the process of using large available data-sets to identify trends and connections, often deriving useful patterns or correlations to identify issues and opportunities, many of which are not directly apparent. In construction, big data can be used to predict problems and make process improvements, for example identifying potential for delays, construction errors or design irregularities.

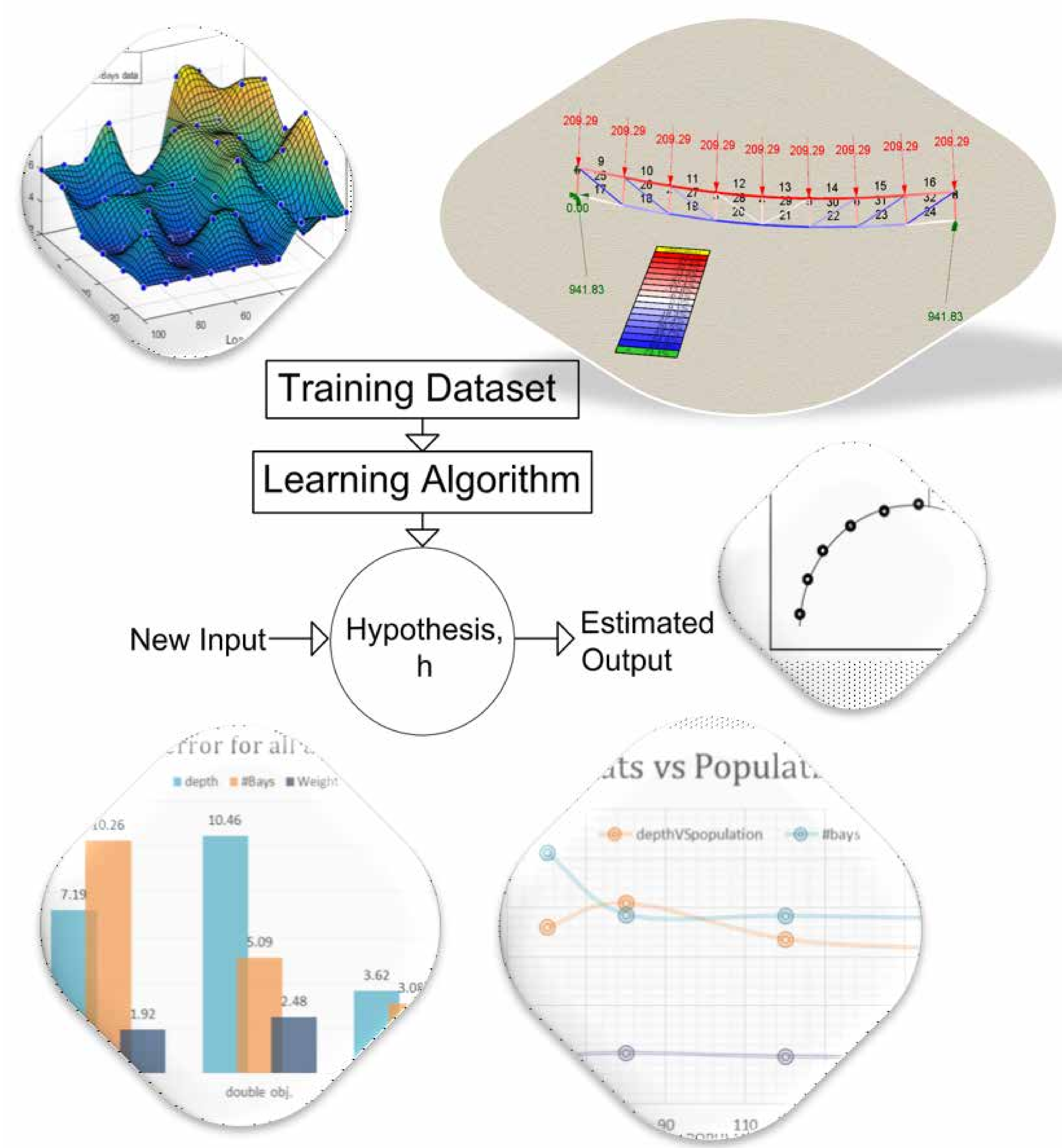
Machine Learning

Artificial Intelligence (AI) applies broadly to refer to any machine (or computer) system that can undertake human cognitive functions. AI includes a range of techniques and can be referred to as Strong (General) or Weak (Narrow) AI. The former seeks to replicate and improve on broad human cognition, whereas the latter refers to very specific cognitive processes (e.g. voice recognition, image processing etc).

Narrow AI is already used by the construction industry, incorporated into numerous technologies, ranging from to semi-autonomous plant to generative design tools. Whilst Strong AI remains a distant dream, the power of computing will continue to drive the use of AI into an increasing range of construction activities.

Machine Learning is a subset of AI and refers specifically to algorithms that learn through experience. The method requires the use of training data to develop a probabilistic model on which future predictions can be based. Deep Learning is further subset of Machine Learning which use multi-layered Artificial Neural Networks to reinforce learning.

Again, Machine Learning is already being used across a range of technologies in construction, including image processing and data-driven design. As we tap into the wealth of existing and future data-sets there is significant potential for Machine Learning predictions to improve quality, reduce errors and minimise construction delays.

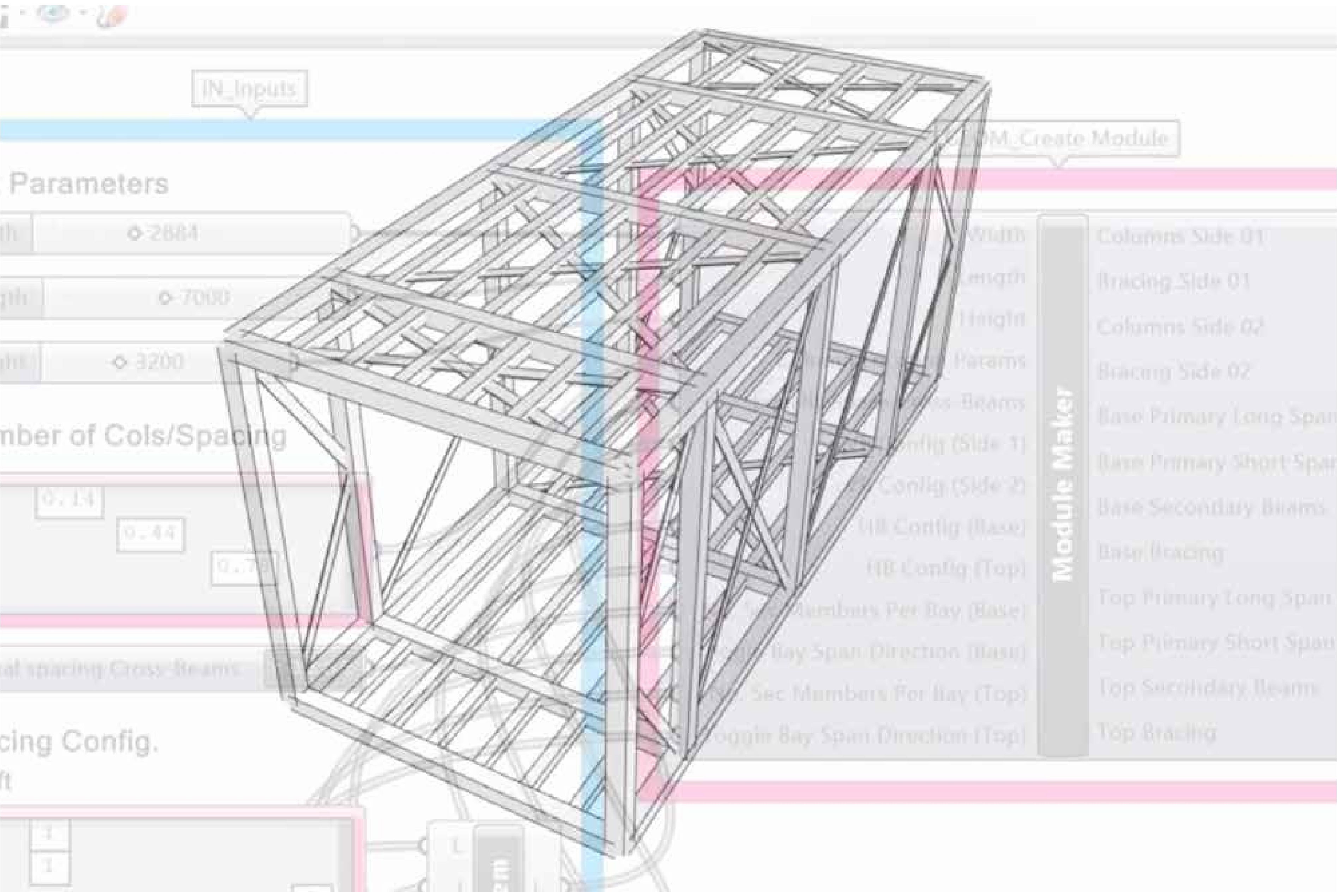


4. Digital Design

Digital design follows the same fundamental process of conventional design; understanding the questions being asked, appreciating the constraints, looking for solutions and iterating to an optimal solution.

In conventional design we rely heavily on experience and test a small number of conceptual solutions with time and resources limiting the number of possible iterations. Digital design methods are far more rapid and are not limited by the number of design iterations. Instead we focus on asking the right questions and defining the appropriate parameters that influence the design through a process of parametrisation. Through a range of software and in-house scripts we explore the design space and find optimal solutions. These solutions, and the parameters that define them, are connected through geometry modelling, analysis software, BIM, visualisation and design output data (such as material quantities and costs) to provide a workflow which can potentially be automated.

Parametric and digital design processes have their origins in the modelling of complex geometry and the challenges of architectural engineering, however the principles can be applied equally to traditional building solutions and routine design processes to arrive at quicker and often better solutions.

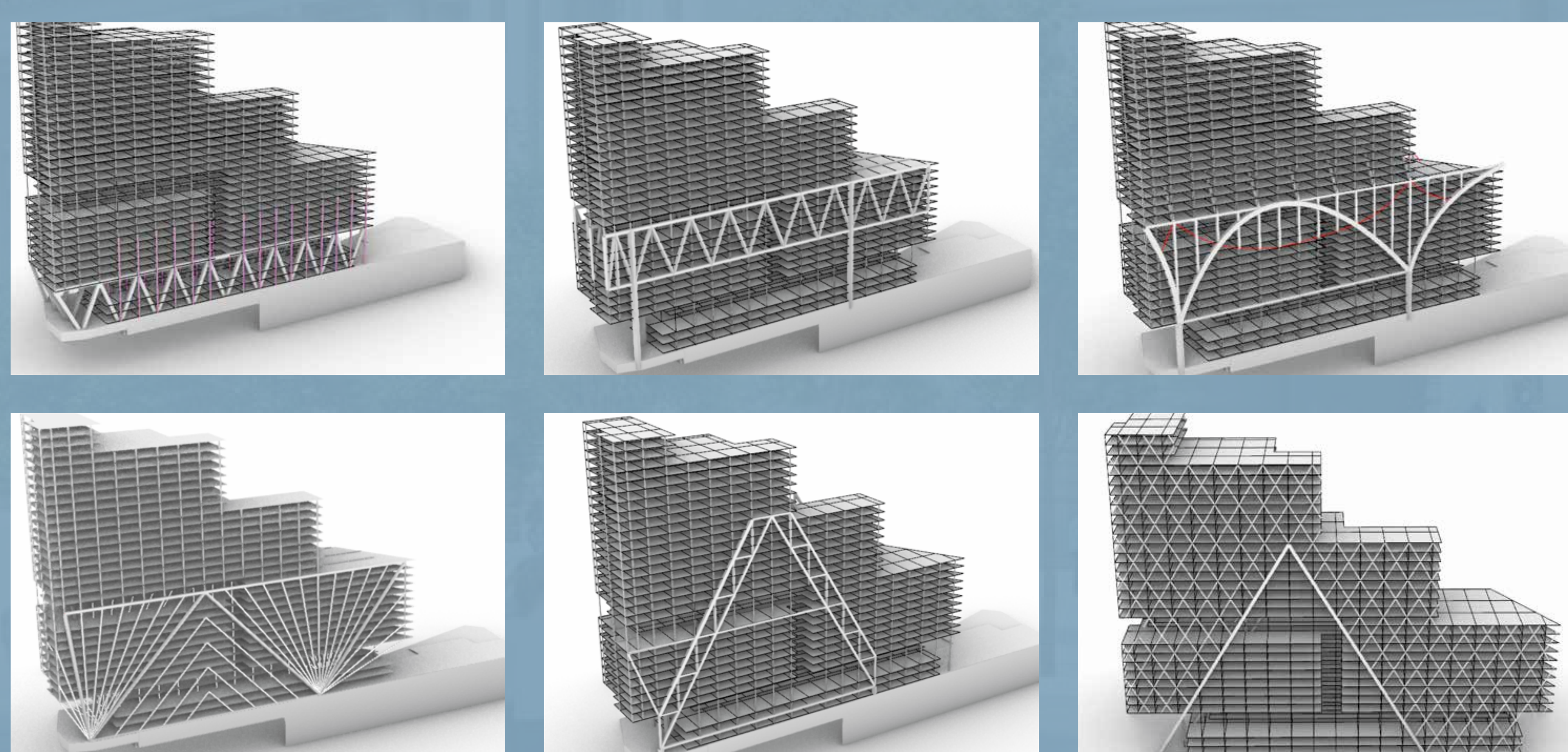


Parametric Design

Parametric Design is a useful concept that sits at the heart of digital design. Rather than drawing a design we set the rules or parameters that define the geometric relationships between design elements. The design is then constructed from these rules. A design developed in this way can be rapidly re-generated enabling many options in a solution space to be evaluated and optimal solutions found. Once set up, a parametric design can also benefit from providing a quick turnaround for design changes and the potential for automated production processes.

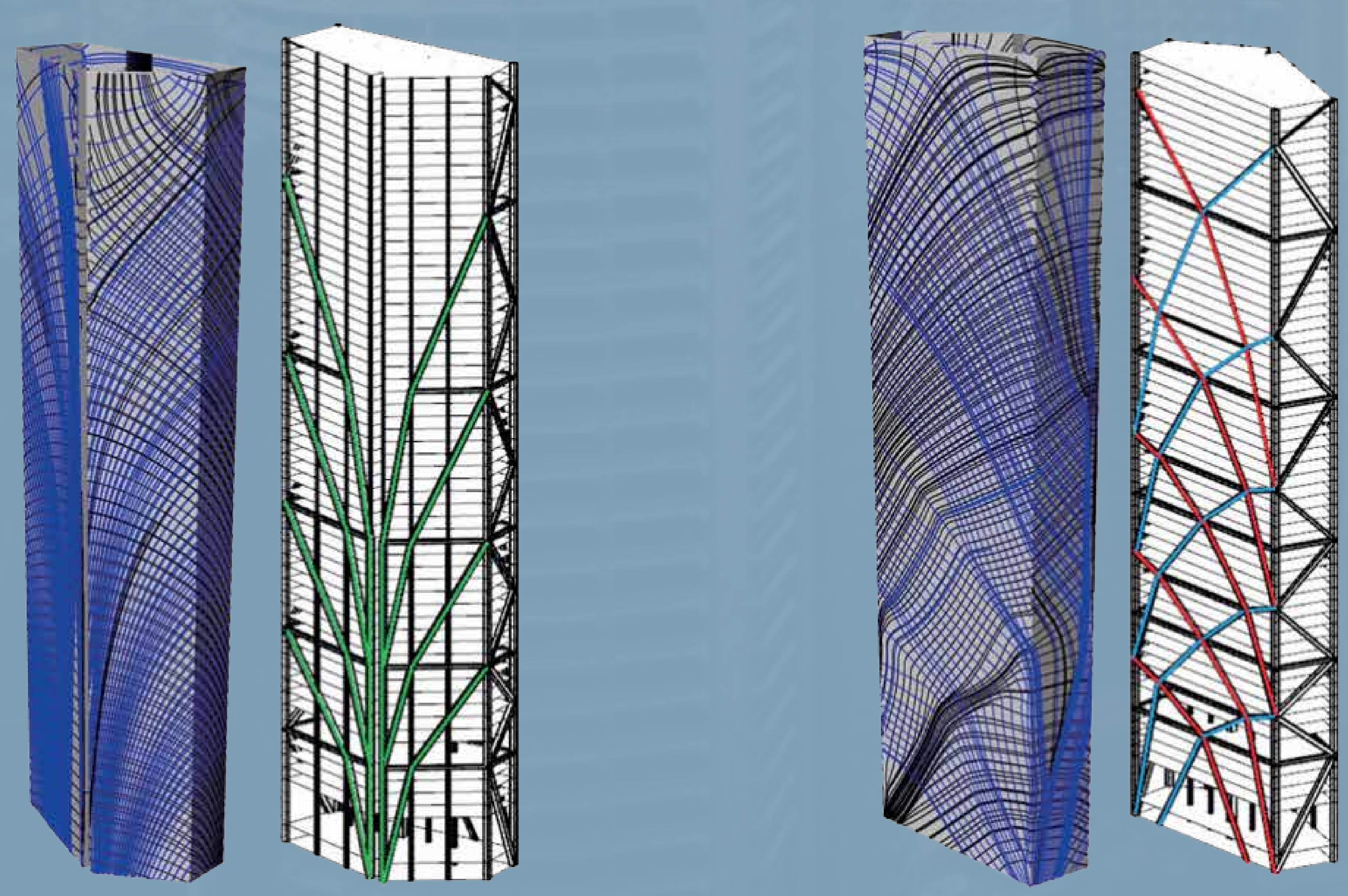
Elizabeth House
Concept design

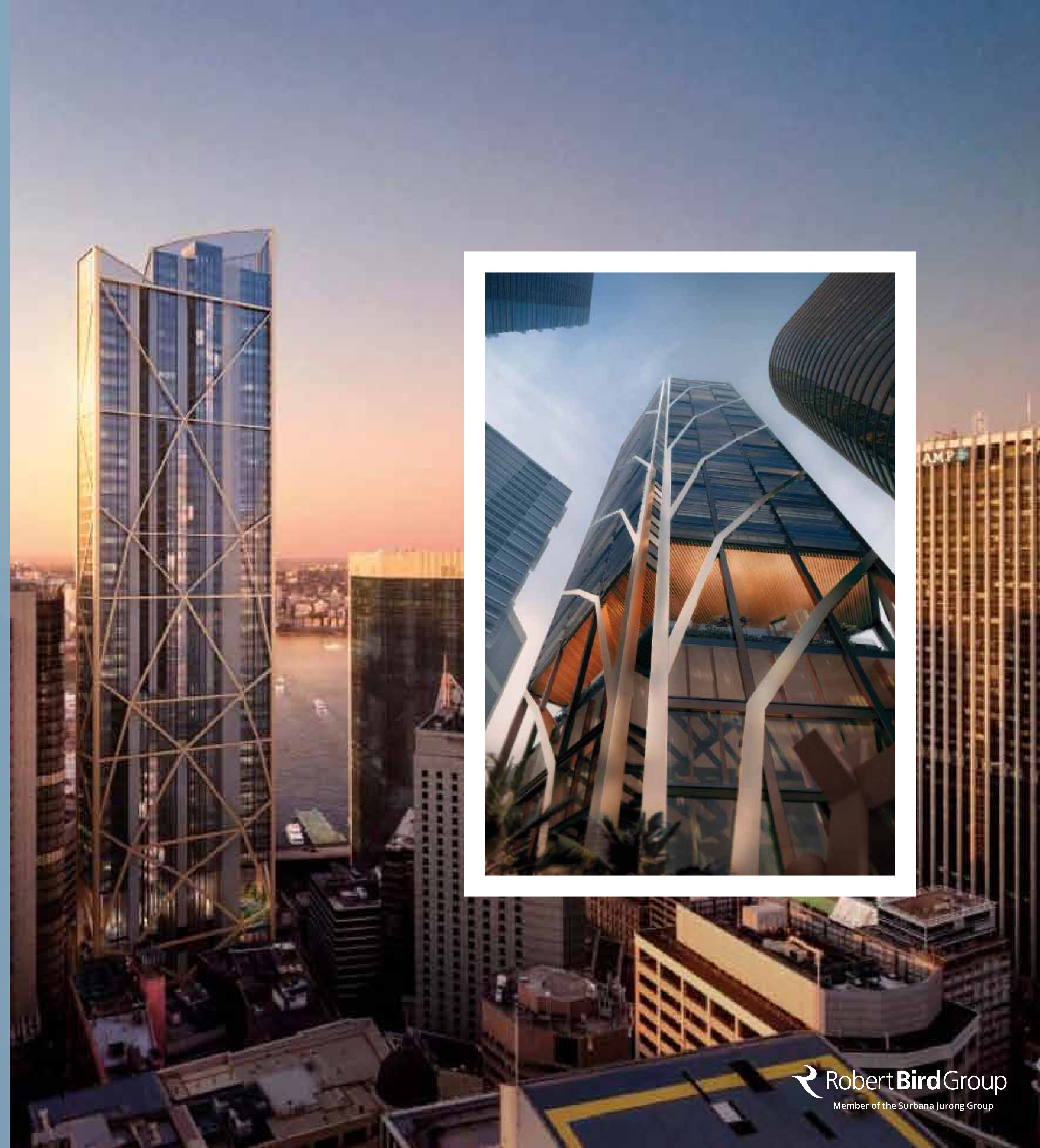
Elizabeth House is a landmark office development in Central London adjacent to Waterloo Station. With many below ground tunnels and obstructions it required a 108m clear span bridge structure to support the 30-storey building. RBG used advance parametric modelling to rapidly derive and test multiple families of concept solutions to evaluate cost, buildability and useable office space. The final solution adopted was able to draw on the best aspects of three of the concept families.



Circular Quay

The design of this landmark building, highly visible between Sydney's iconic Opera House and Harbour bridge, presented both a challenge and an opportunity. The tower's architectural footprint separated both views with a vertical feature recess, and the tower's slenderness demanded an external frame solution. RBG used a parametric approach, coupled with the digital design techniques of topology optimisation and genetic algorithms to derive an exposed feature perimeter frame that expressed the architecture whilst still being highly efficient and buildable.





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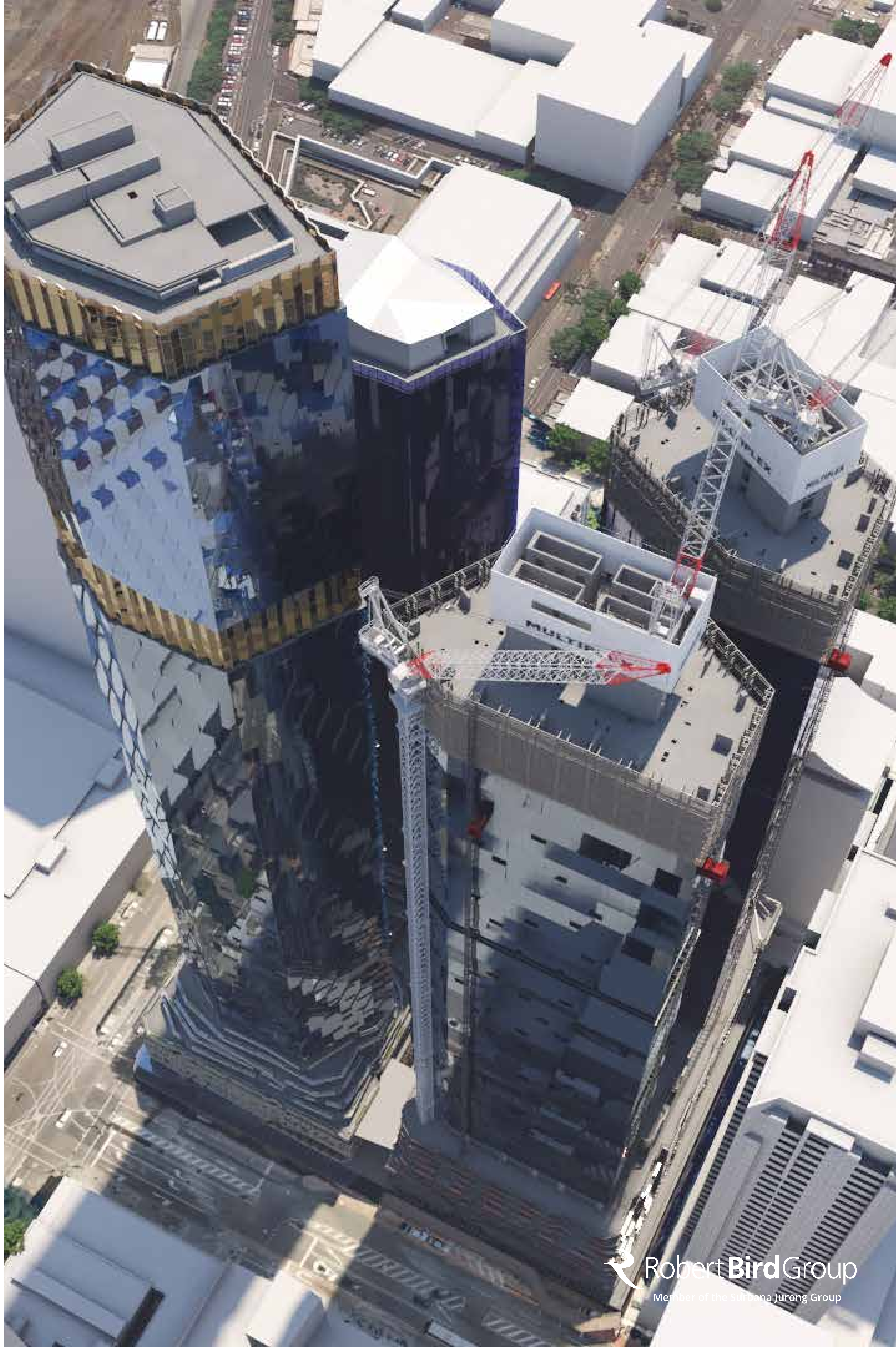
5. Digital Production

Workflows that are built upon parametric and digital design processes can be leveraged to develop highly efficient, automated systems for documentation and digital design production. Software, and the tools and protocols that provide interoperability continue to improve, allowing not just rapid design iteration, but also accelerated routes to design coordination and final delivery. We enhance these commercially available capabilities with in-house tools and scripts to provide tailored solutions that facilitate integration of design and production process from concept through to fabrication and construction.



Midfield Terminal

Erection Stress Analysis

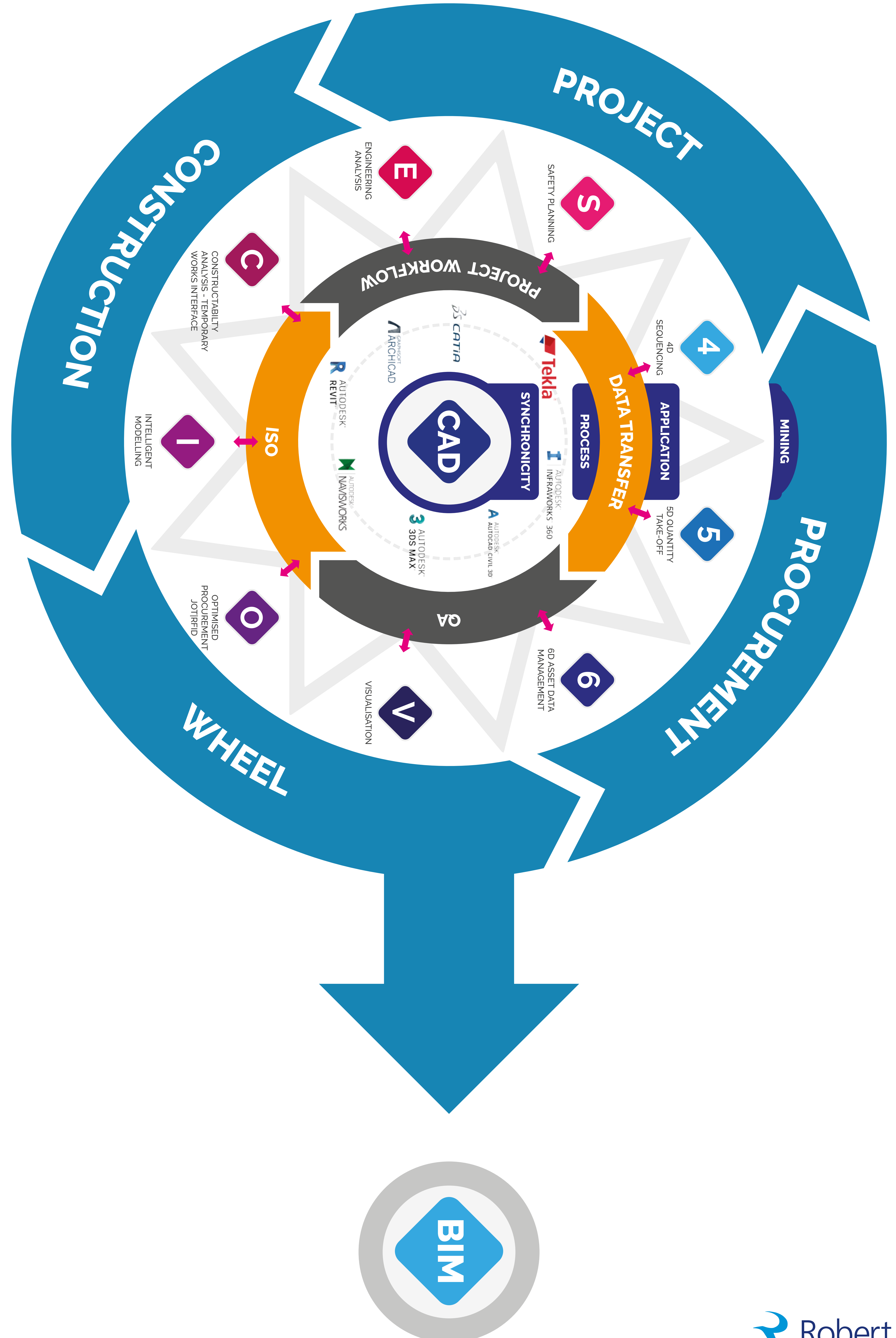
The feature roof of the new Abu Dhabi International Airport Midfield terminal building covers an area of 700,000 square meters and with a clear span of up to 180m, contains the largest internal arches in the world. In undertaking the erection stress analysis of this structure, a sophisticated suite of bespoke software tools was developed by RBG to facilitate data sharing, to automate numerical model creation and validation, to undertake engineering design and to guide decision making during construction.

6. Beyond BIM

BIM (Building Information Modelling) evolved from three-dimensional drawing tools, and whilst this fundamental functionality remains at the heart of most BIM software, BIM is nowadays considered a process that facilitates the sharing of asset data for the full project lifecycle including; geometry, specifications, material volumes, construction sequencing and programming, construction defects, operations manuals and cost and time scheduling.

We use powerful clash detection tools to co-ordinate with other designers, fabricators and contractors and through two-way workflows we communicate directly with analysis tools to realise the benefits of integrated digital design. For refurbishment or renovation projects we extend BIM to incorporate reality capture scans of existing buildings, and we use BIM to visualise and manage live construction data. BIM has also opened up the potential of industrialised construction, reimagining design and construction as an assembly of standard, modularised components, all of which can be realised and evaluated digitally prior to construction.

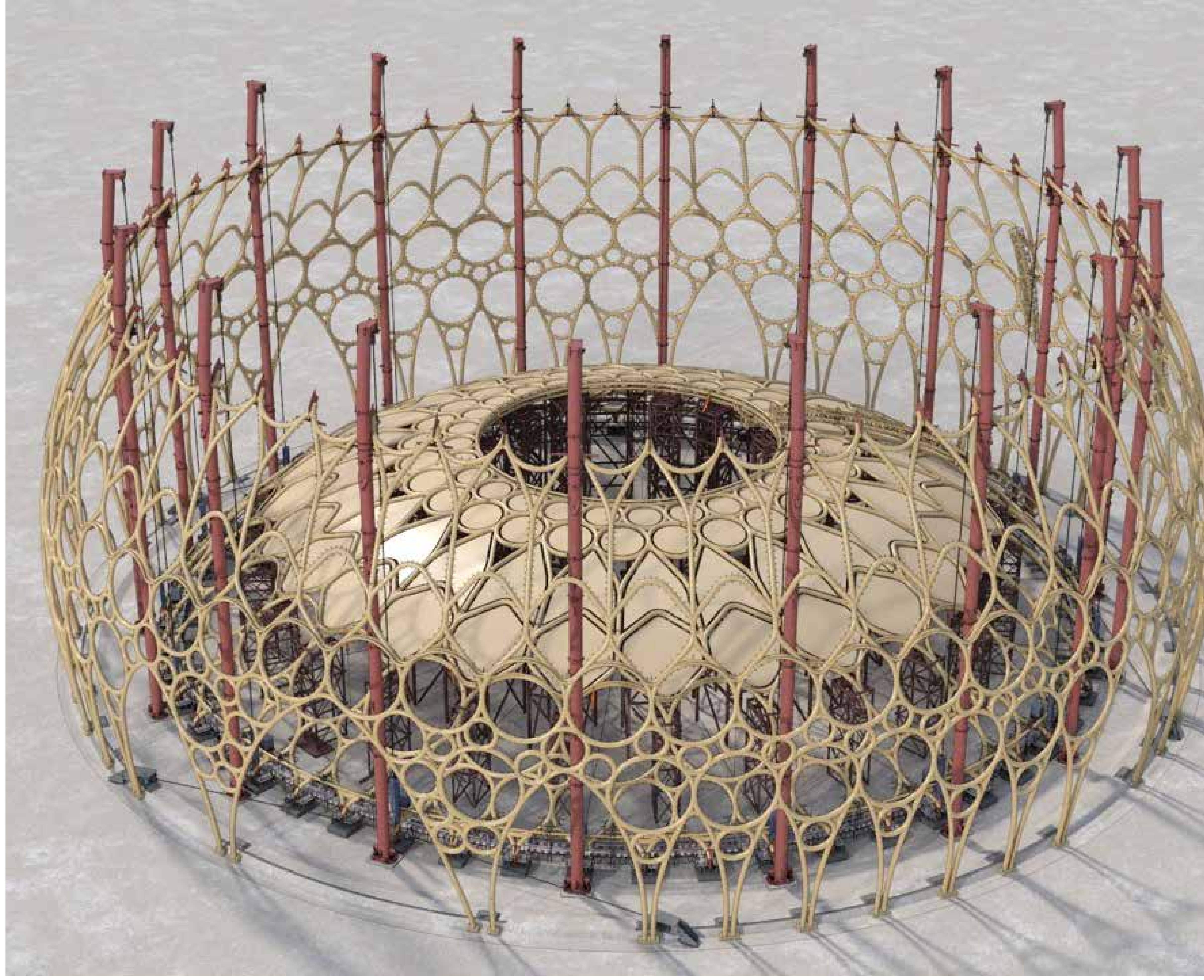
Recent advances in visualisation techniques allow BIM models to be accessed either in fully immersive environments during design and planning or accessed directly on site to help with cognitive and spatial understanding, problem detection and rectification. This is a rapidly developing field, drawing on parallel technologies such as advanced reality capture and unmanned aerial vehicles (UAVs) and robotics. The site of today is rapidly becoming technology-driven, however at the heart of this change is BIM, driving significant opportunities in communication, safety and quality.

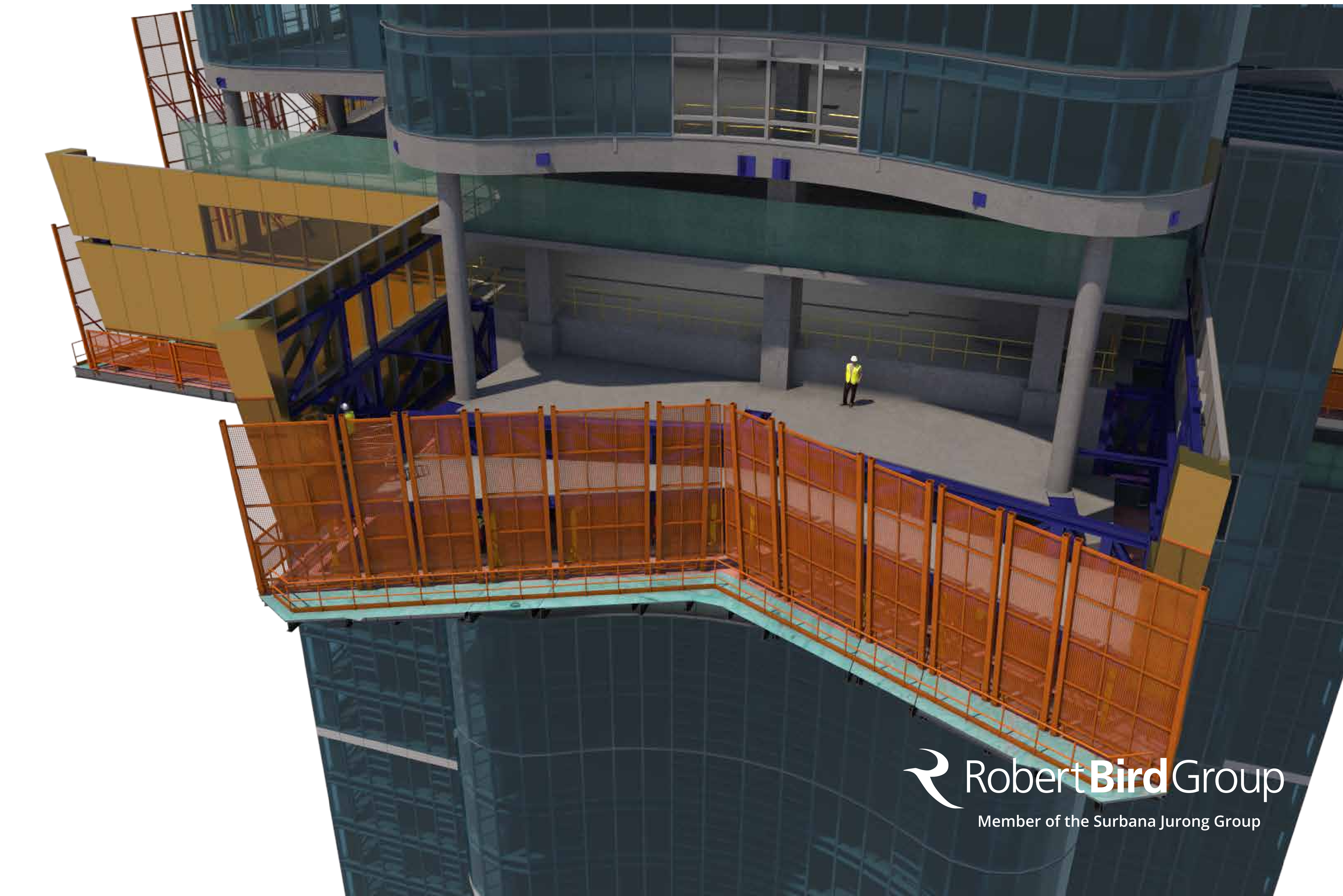


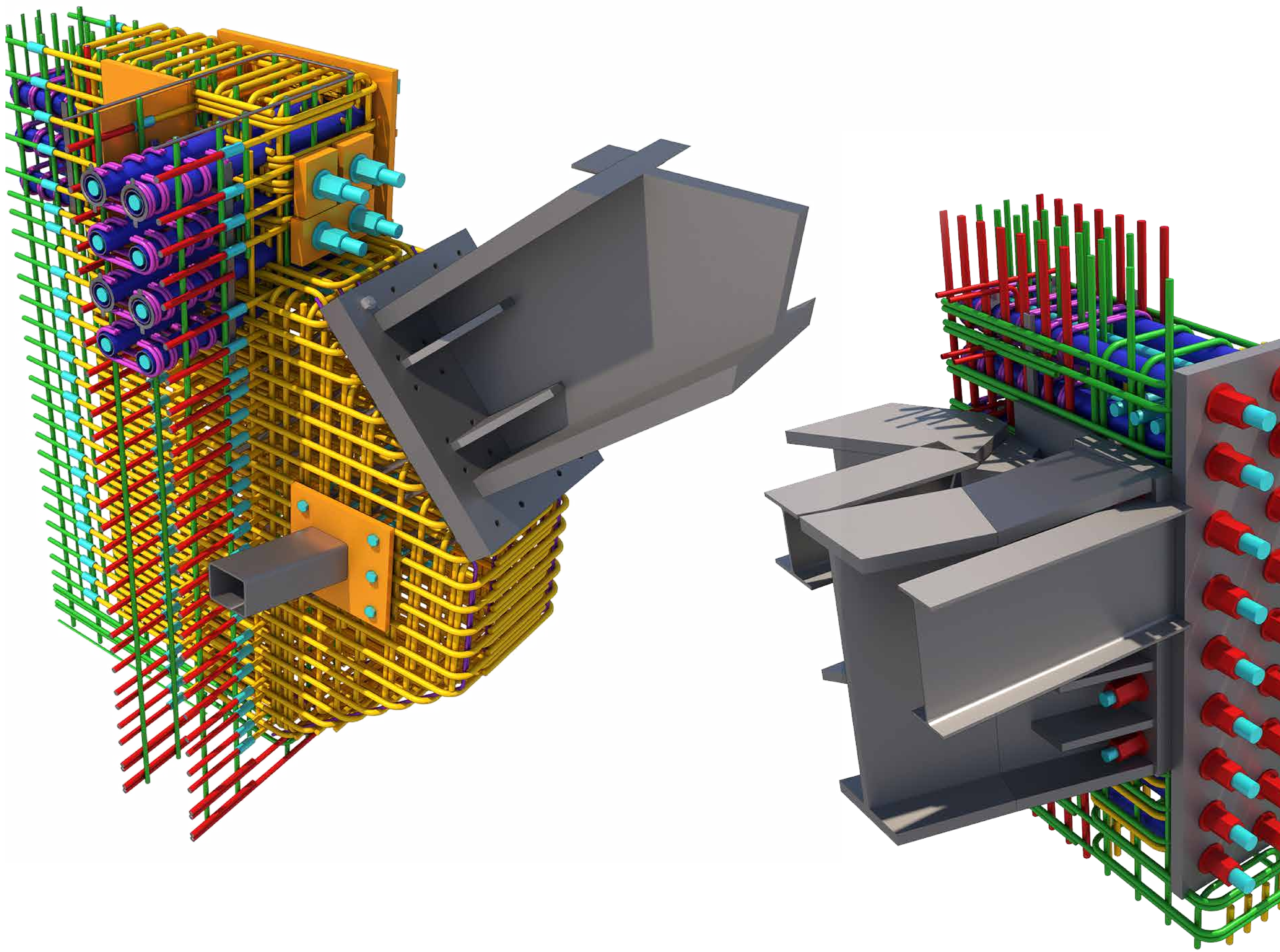
7. Virtual Design & Construction

Virtual Design and Construction (VDC) enables project stakeholders to experience, interact with and collaborate on built assets that are either completed or under construction, in a digitally simulated real-world environment. This encompasses a range of technologies including gaming engines, Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR).

Using our extensive engineering expertise we combine industry-leading visualisation technologies, digital design techniques and data-rich Building Information Modelling to develop bespoke VDC solutions to explore, interrogate, modify and validate complex engineering and construction concepts. We apply VDC to provide insights into both permanent and temporary works designs, and use it to develop virtual construction rehearsals incorporating construction methodologies and erection sequences, programming and scheduling, site and construction logistics, and construction risk management.
We use VDC to provide stakeholders with clarity and confidence, thereby informing better decision making, adding value, and minimising project delivery and performance risk.







BIM Keeps Developing

Building Information Modelling (BIM) is a set of processes and protocols that facilitate the digital visualisation and sharing of asset information to support design, construction and operational activities.

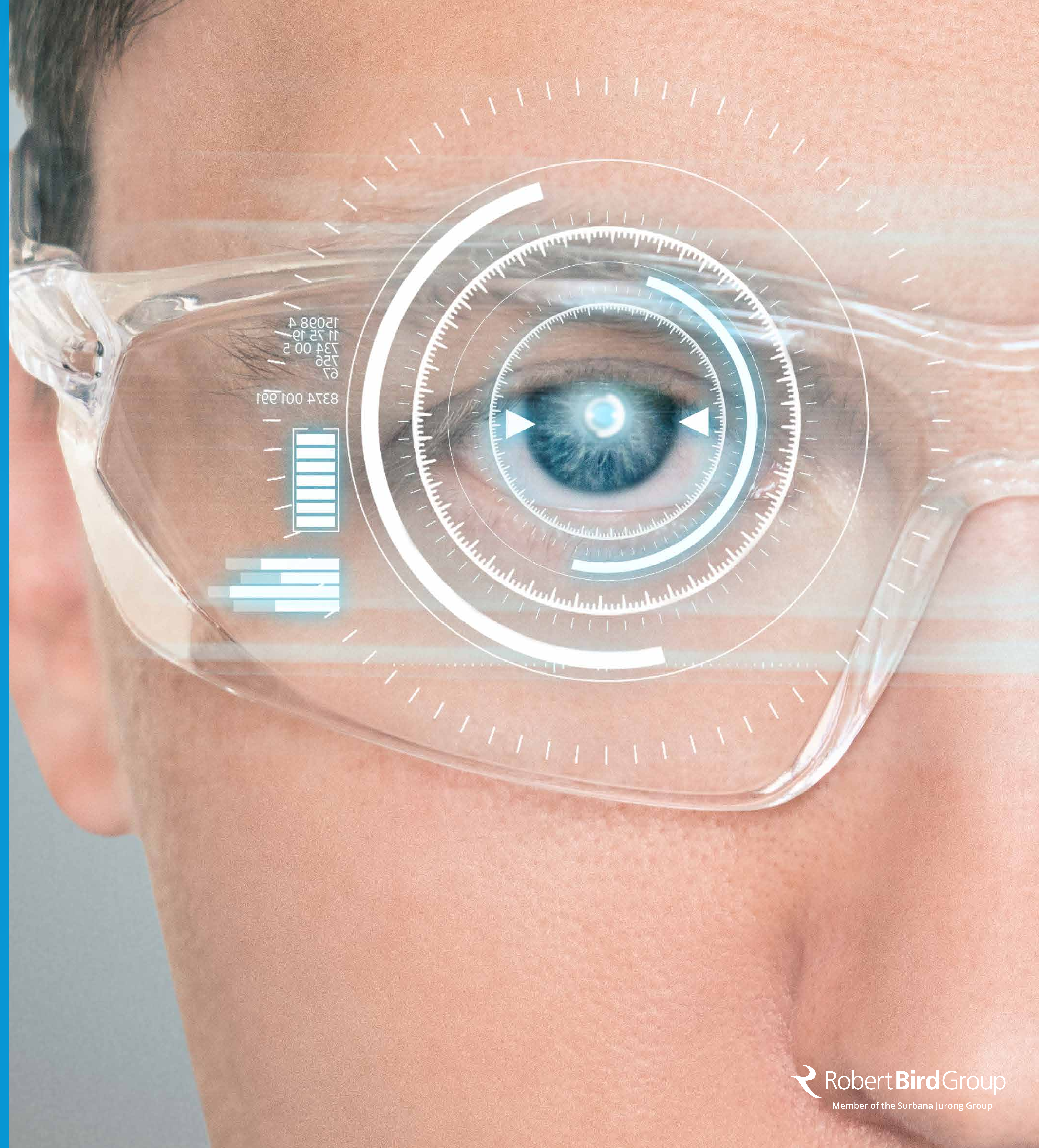
BIM has developed significantly since its formal recognition in the early 2000s into an internationally recognised suite of standards and protocols which facilitate efficient data management and transfer. Leveraging this data, BIM has extended its origins as a 3D modelling tool to include so-called 4D, 5D and 6D BIM representing the quantities of time, cost and carbon respectively.

Many Digital Realities

Virtual reality (VR) provides an immersive environment via an enclosed headset allowing users to interact with digital objects in a virtual space. In construction this technology is used, for example, to walk around digital representations of existing or proposed assets.

In Augmented reality (AR) digital representations are overlayed with physical reality using either a handheld phone/tablet or glasses. Interaction is less immersive but offers opportunities to visualise a combination of digital and physical objects. In construction this is often useful during planning and construction; enabling digital assets to be visualised alongside construction progress.

Mixed Reality (MR) is similar to AR, using either handheld phone/tablets or glasses, however there can be interaction between both physical and virtual environments. For example; it may be possible to measure the distance from an existing wall to a virtual object.

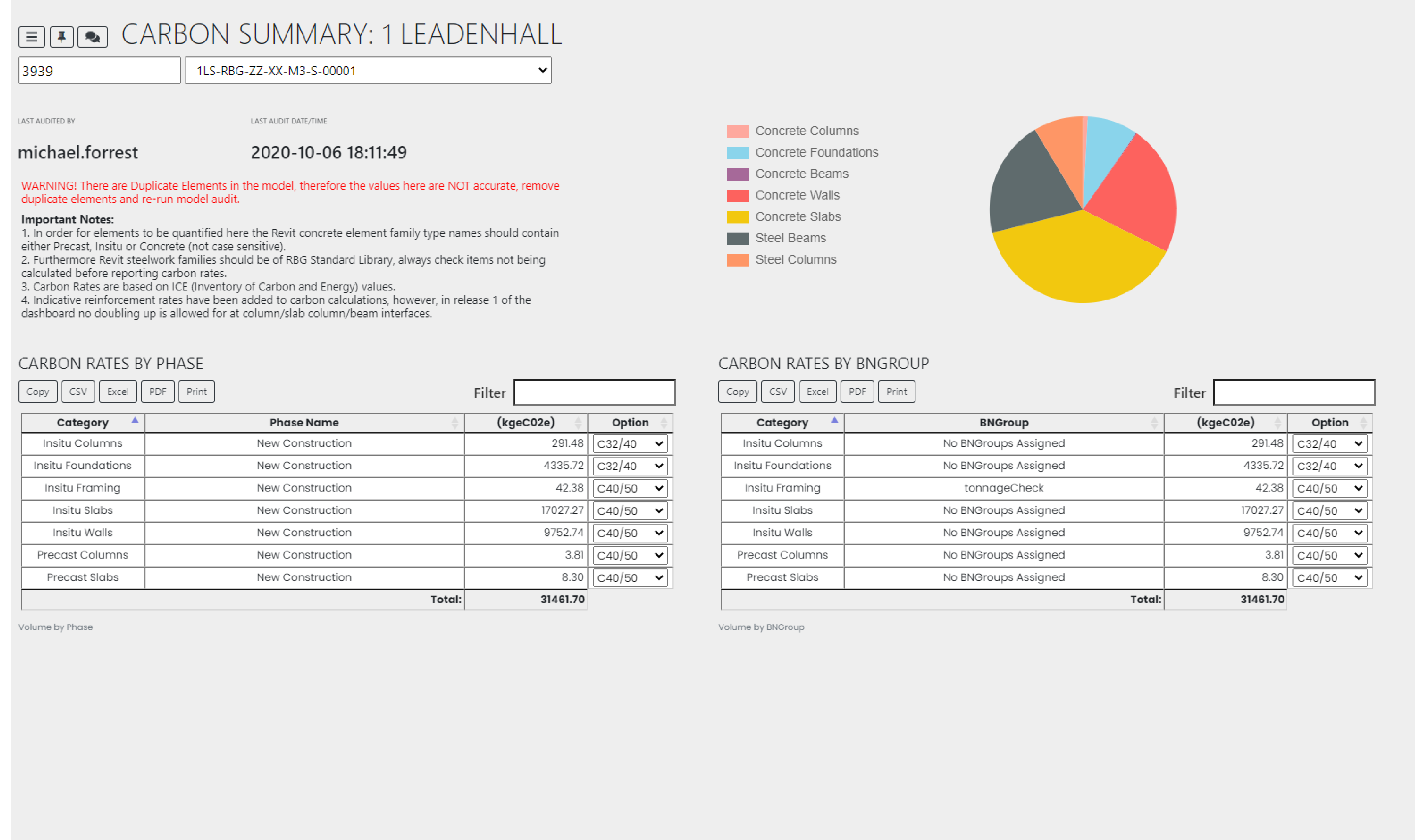


8. Carbon Matters

Whilst Covid-19 has dominated the headlines in recent months, the Global Climate Emergency remains an ever-present issue; touching the lives of many of us in recent years. As professionals and responsible individuals we all have a responsibility to take the issue seriously and change our behaviours and consumption habits.

Fortunately, digital technology has an important role to play in how we respond to the crisis. Our design processes can now readily generate information and metrics such as raw and re-used material volumes and embodied carbon. This data can be used to see in real-time the implication of design decisions on the environment; informing better choices and guiding the setting of design parameters to minimise the impact on the environment. As civil and structural engineers we are mostly concerned with embodied carbon, design efficiency, design life and building reuse; but the same principles apply also to overall energy use..

More broadly, the drive towards circular construction and component standardisation, facilitated by a combination of reality capture and BIM is a responsible way for the construction industry to reduce consumption, re-use existing materials and repurpose what we have already made.



Category	Phase Name	(kgeC02e)	Option
Insitu Columns	New Construction	291.48	C32/40
Insitu Foundations	New Construction	4335.72	C32/40
Insitu Framing	New Construction	42.38	C40/50
Insitu Slabs	New Construction	17027.27	C40/50
Insitu Walls	New Construction	9752.74	C40/50
Precast Columns	New Construction	3.81	C40/50
Precast Slabs	New Construction	8.30	C40/50
	Total:	31461.70	

Category	BNGroup	(kgeC02e)	Option
Insitu Columns	No BNGroups Assigned	291.48	C32/40
Insitu Foundations	No BNGroups Assigned	4335.72	C32/40
Insitu Framing	tonnageCheck	42.38	C40/50
Insitu Slabs	No BNGroups Assigned	17027.27	C40/50
Insitu Walls	No BNGroups Assigned	9752.74	C40/50
Precast Columns	No BNGroups Assigned	3.81	C40/50
Precast Slabs	No BNGroups Assigned	8.30	C40/50
	Total:	31461.70	

RBG BIM
Dashboard

At RBG we have developed our own BIM Dashboard and database to provide a single window for BIM model data. This powerful tool provides valuable insights into modelling maturity, compliance checks and overall model health but also critically captures and collates material volumes and calculates embodied carbon. Access to this data provides design teams with an understanding of material volumes and an understanding of embodied energy throughout design development; empowering them to make informed, data-driven design decisions that add value to projects and are considerate towards the environment.

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9. Digital Twins

The combinatorial benefits of different technologies are being increasingly realised throughout the project lifecycle. Throughout construction, BIM, VDC, reality capture and drone technologies are facilitating an ability to gather live site data through remote sensing or surveying; allowing quality assurance, validation of design predictions and adjustment of construction and fabrication to suit site conditions. In parallel, more powerful digital design capabilities, closer interoperability and integration of BIM and VDC technologies will enable the realisation of the "Digital Twin" – a concept that can apply throughout the full project lifecycle - both during and after construction.

At the heart of this transformation will be the so-called Internet of Things - powered by 5G technology - enabling a real-time flow of data between physical and virtual representations of assets. This will realise the promise of truly "smart buildings", and herald an era of "smart construction" where construction can be rehearsed, and building performance can be evaluated before project funds are committed. Equally during the lifecycle of the project, from construction through to demolition/repurposing performance of the physical asset can be evaluated and predictions made to drive better commercial and environmental decision making.

21 Moorfields

21 Moorfields, a 55m ‘bridge’ building over Moorgate Station in London was designed by RBG and is currently under construction. The steel frame was instrumented during erection to monitor real time deflections, and machine learning algorithms were utilised to predict the final movements and provide adjustments to the steelwork fabricator for components yet to be delivered to site, thus reducing site alterations and speeding up erection.

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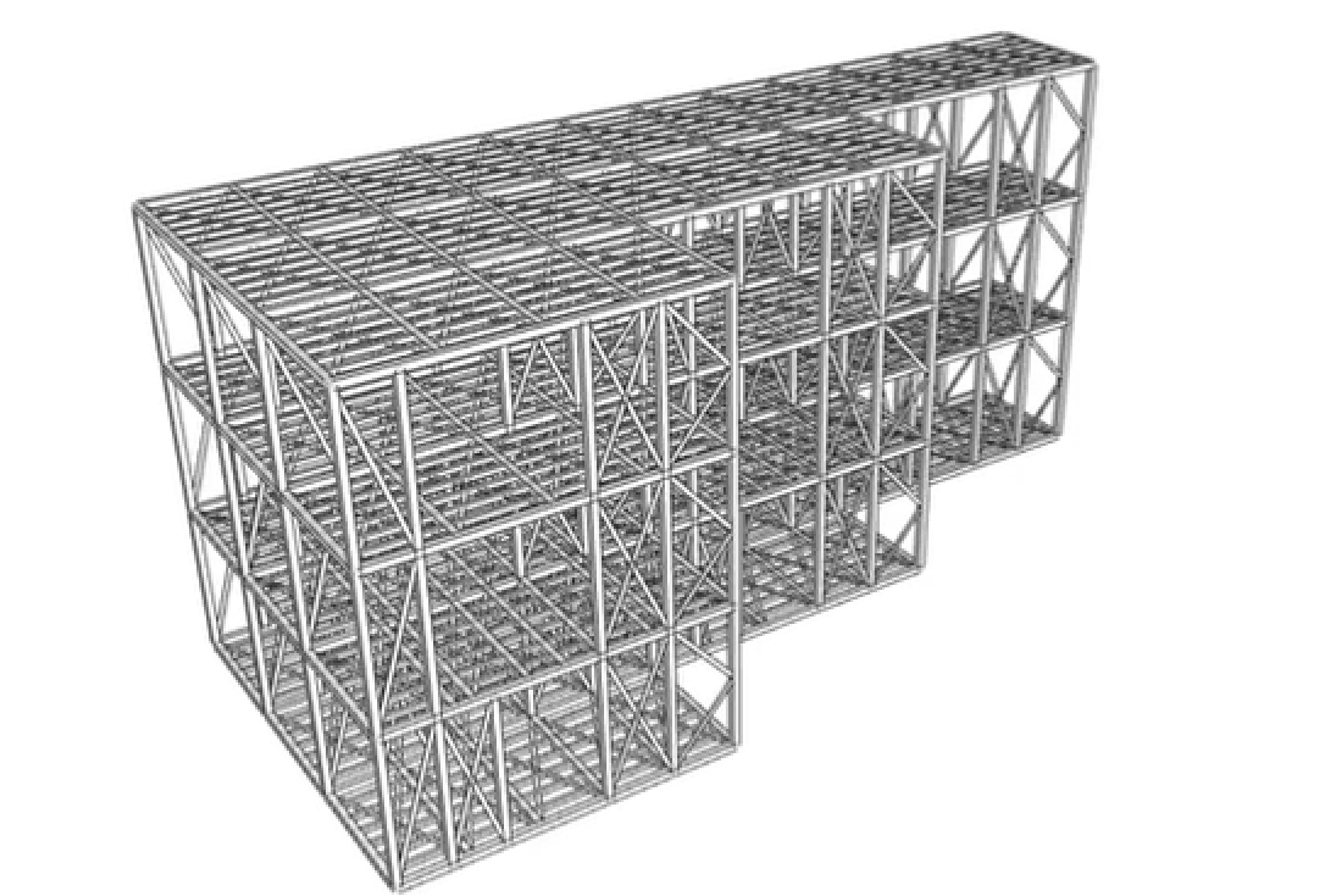
10. Where to next.....?

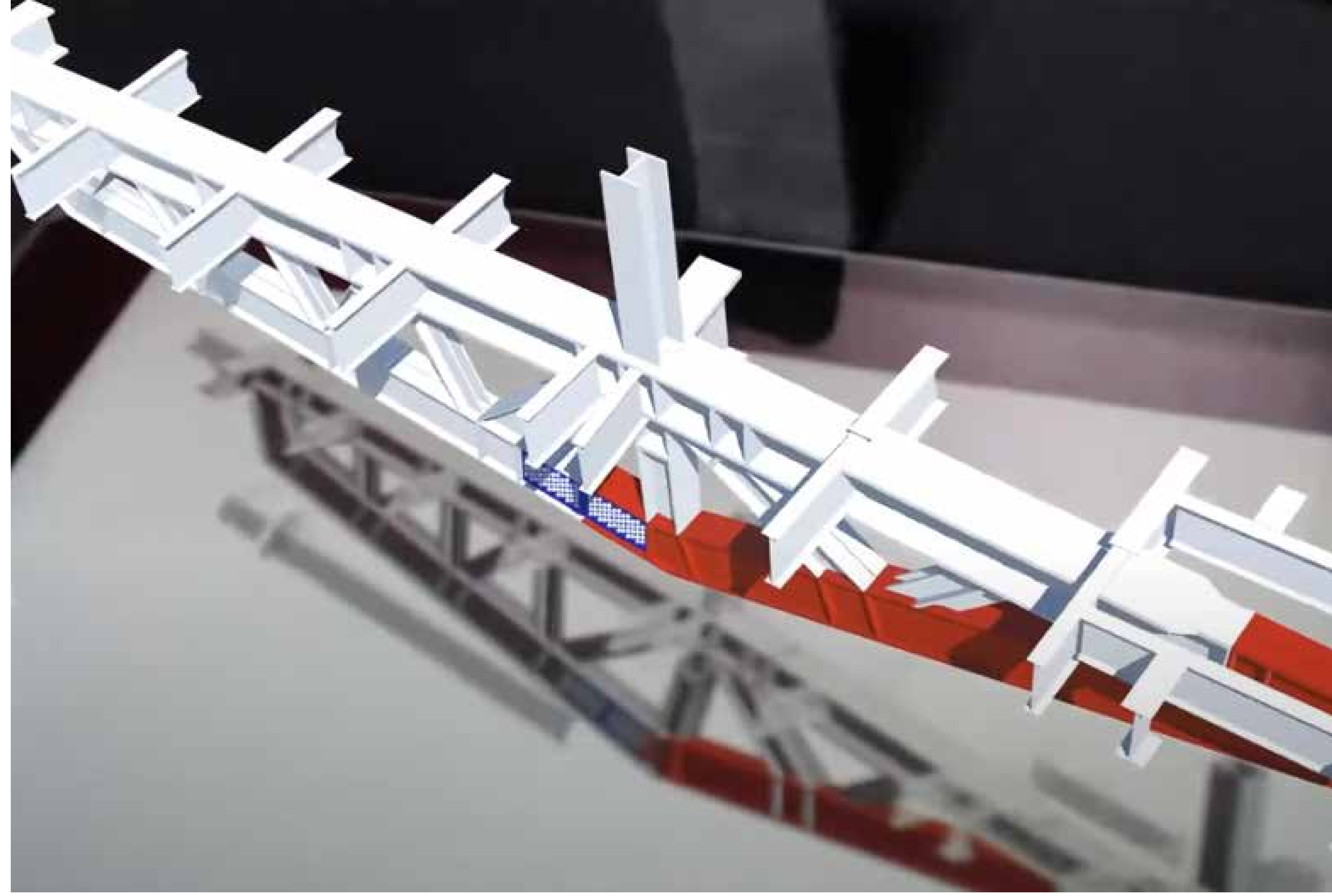
Technology can extend and improve on some of our human capabilities, and is therefore likely it will make some of our existing processes obsolete in their current form. Rather than representing a threat to our profession and industry, it instead presents endless future possibilities; opportunities to improve quality, to create more value and to build more rewarding careers for our people.

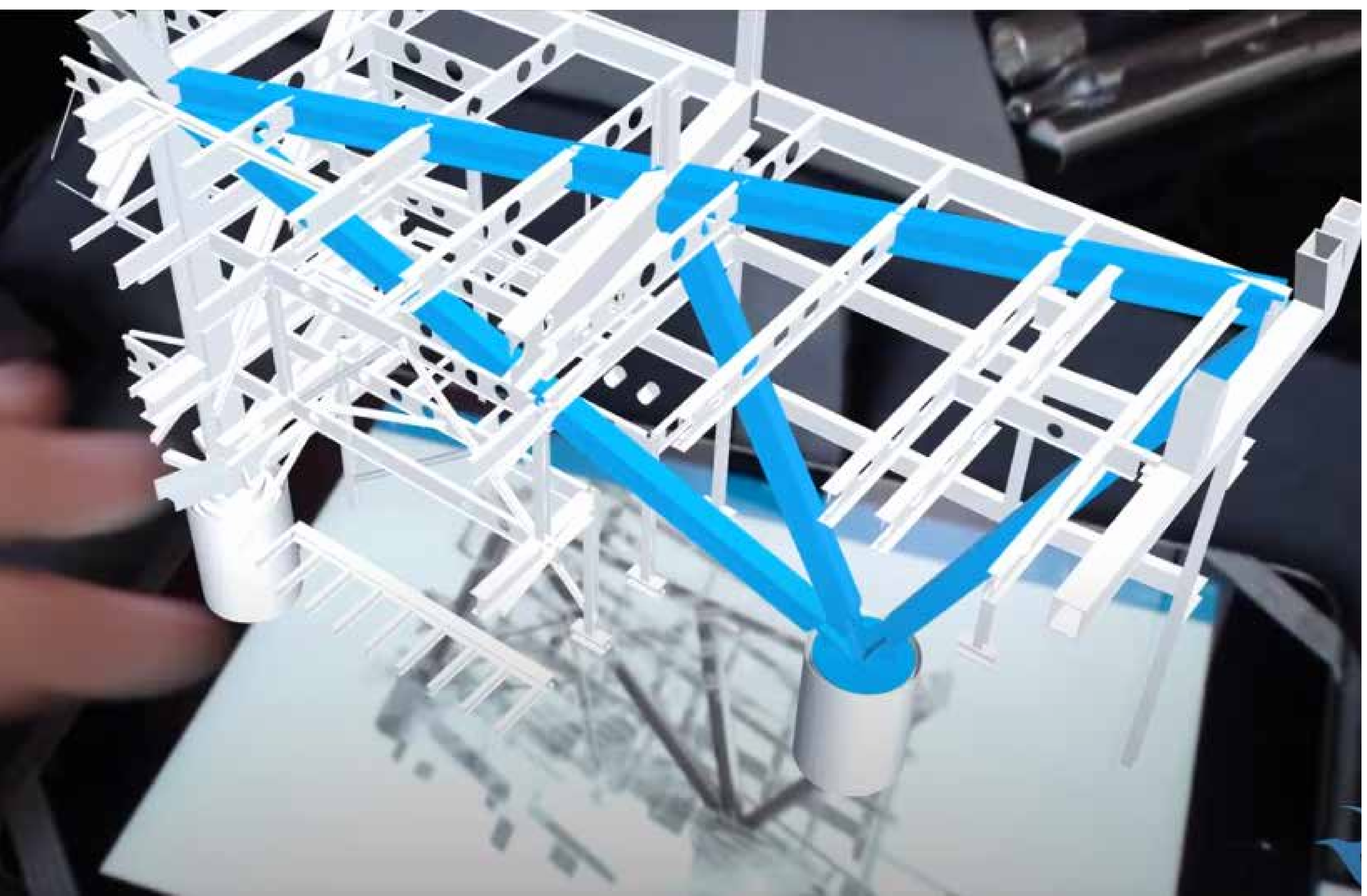
We are on the brink of the next wave of technological change and this evolution will bring about fascinating combinatorial improvements that we have yet to conceive. Artificial Intelligence will enable us to plan and design projects generatively; identifying better solutions faster and delivering projects more efficiently and with greater certainty. Technologies such as 3D Printing and Industrialised Construction will open the door to new architectural forms and ways of building whilst reality capture, drones and robotics technologies will increasingly automate construction sites. The Internet of Things and 5G will allow us to create 'smart buildings' that we can monitor throughout the full asset lifecycle, and "Digital Twins" will enable us to predict how they will behave and perform throughout their lifecycle before they are constructed.

These changes are welcome in the construction industry which, whilst facing societal demands for increasingly complex and larger projects, has become sluggish and repetitive, with low margins, a reputation for poor quality, unacceptable safety and unreliable delivery. These centuries old norms are swept aside by digitisation, presenting a vision of a progressive, socially and environmentally responsible industry of the future.

We are at the heart of this change, helping to drive it forward and we firmly believe there has never been a better or more exciting time to be involved in design and construction for the built environment.





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