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DELIVERING INNOVATION IN CONSTRUCTION

How Big Data and new technology are transforming project delivery

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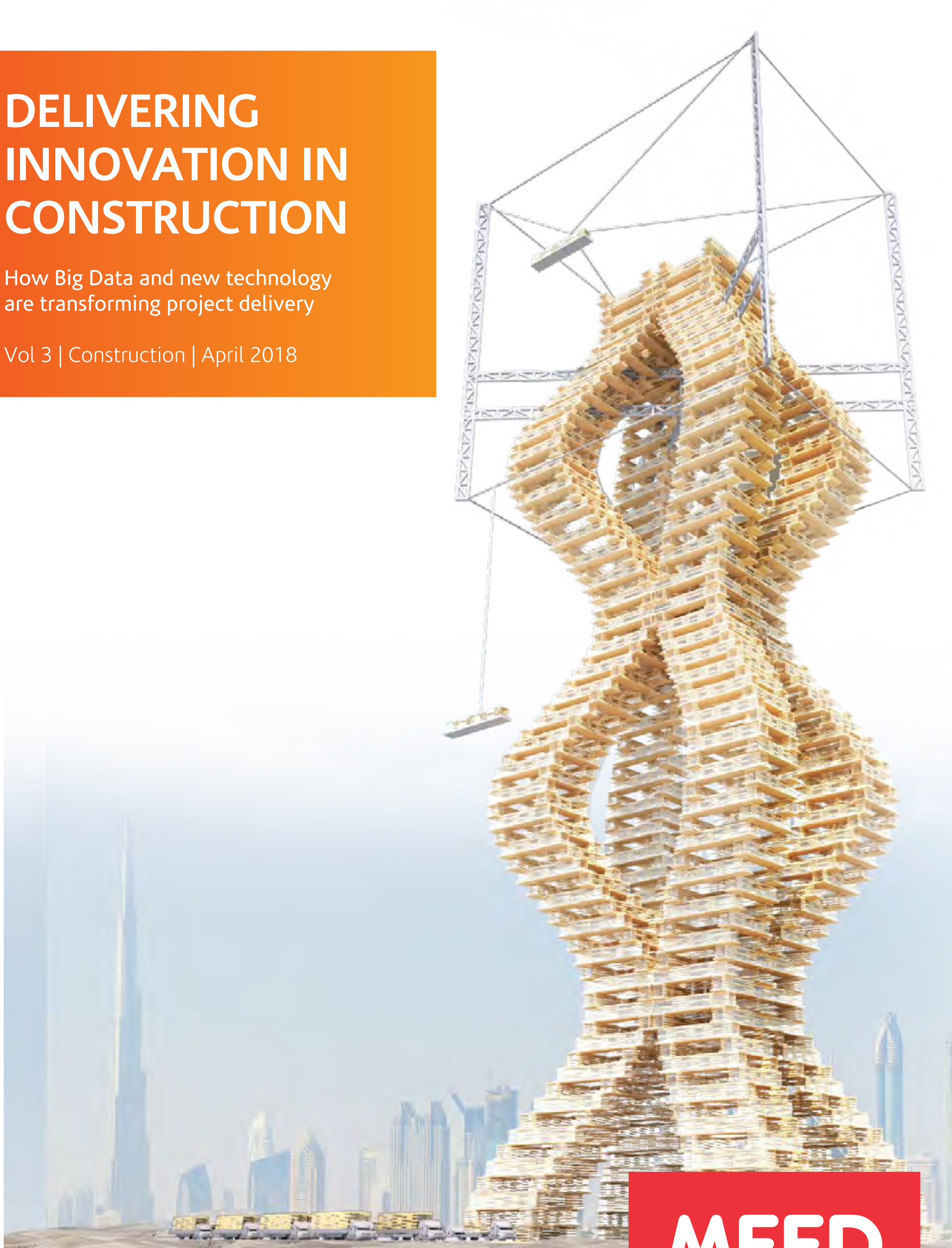

MEED

Middle East business intelligence

EMBRACING DISRUPTION

The construction sector is lagging behind in research and development investment, particularly in digital technology

The construction industry has historically been reticent about technology investment, and the reasons are easy to understand. In the cut-throat world of construction, clients demand the lowest possible price for projects delivered in the least possible time. To win business, contractors must submit the lowest-priced tender bid, eroding their profit margins and leaving them with little left over to invest in long-term objectives.

This lack of strategic investment is unsustainable however. It undermines the competitiveness of construction companies, and results in projects being delivered late and over budget. It is also one of the principle reasons that the construction industry is synonymous with adversarial business relationships and contract disputes.

But things are changing. Around the world, architects, engineers, contractors and asset owners are recognising the benefits of digital technology, and are innovating not only the way in which they deliver work, but also how they work with each other throughout the process. The adoption of digital technology in the construction industry has reached a tipping point and few countries are better positioned to take advantage of this than the UAE.

Research by consultant McKinsey suggests that adoption of new technologies throughout the construction chain could deliver efficiency gains of up to 60 per cent. With some $800bn-worth of major projects planned in the UAE, the gains to the country will be huge. They will allow the UAE to achieve its diversification and employment goals more efficiently, and will empower the workforce to compete in the global marketplace.

In this report – produced by MEED in partnership with Mashreq – we showcase some of the most inspiring innovations being implemented in construction projects around the world. The report provides case studies of how the adoption of new digital technologies is being applied across all the principle stages of the project delivery process, from early-stage design through to the construction and operational phases of a project.

One of the most important messages that recurs throughout the report is the benefit of increased investment in time and money at the front-end of the project process. The involvement of contractors and operators from the start of the design process ultimately produces better projects that run more reliably and are less costly to maintain.

The report looks at technology innovations from machine-learning robots that can continuously improve the efficiency of building processes to the world's first 3D-printed concrete bridge. The report also examines the time, cost and safety benefits of collecting project data through the use of autonomous vehicles and drones to survey and monitor projects in dangerous locations.

Delivering Innovation in Construction provides anyone who is involved in the UAE construction industry with valuable insights into how digital technology can be applied to drive greater efficiency, safety and end-product quality on projects in the UAE.

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Overview

DELIVERING INNOVATION IN CONSTRUCTION

How new technology is transforming project delivery

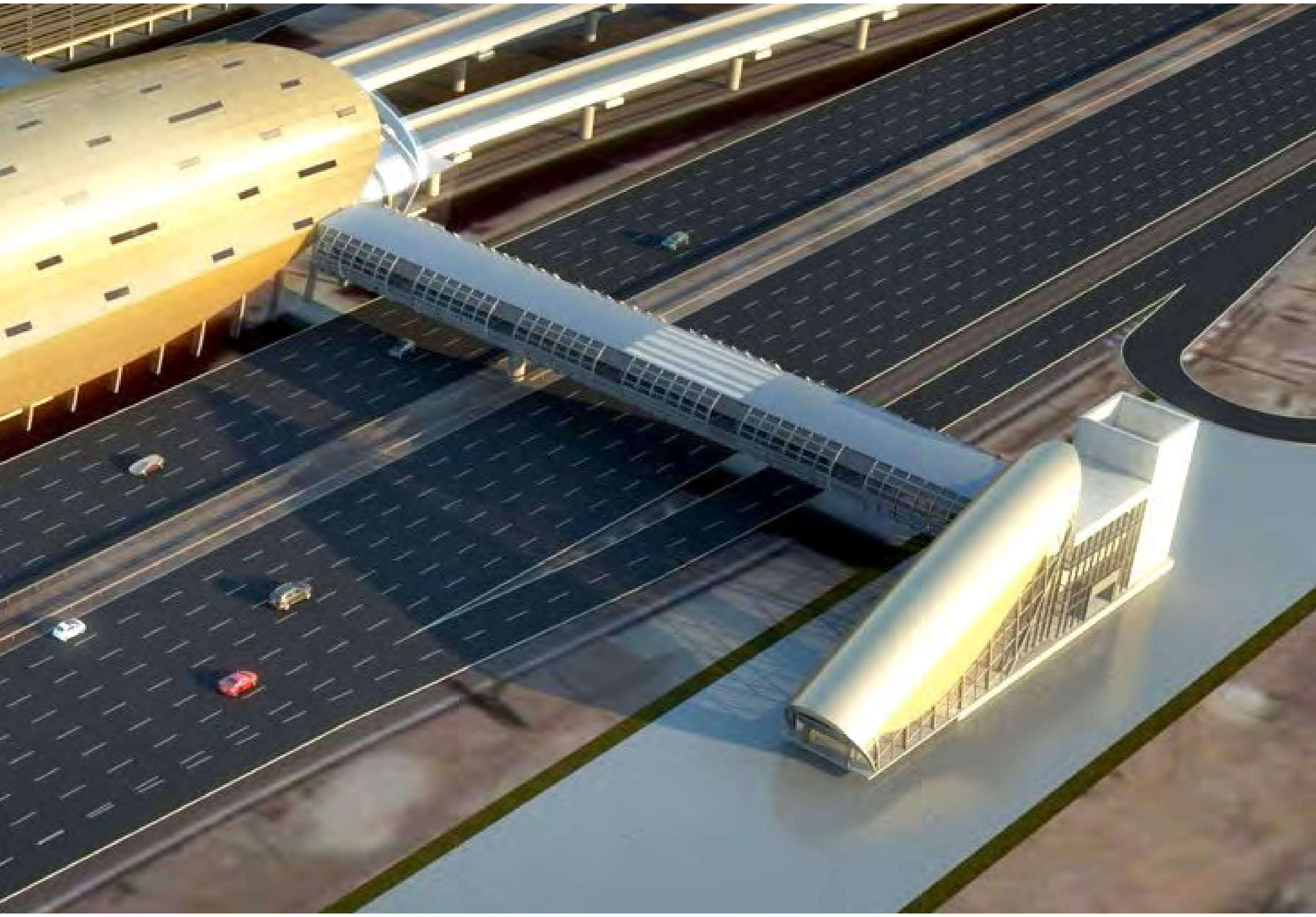
That the construction industry lags behind other industries on innovation and digital transformation is well known. A lack of investment in research and development, slow adoption of new technologies, low productivity and inappropriate risk allocation in contracts are just a handful of the common barriers to change. More fundamentally, there remains a lack of incentives for the parties that can make the biggest impact on a project to take action. Contractors, consultants and suppliers are often bound by lowest-cost solutions, delivered to meet paper-based, transactional performance criteria. In such cases, contractors work to fulfil the contract, not to make better-quality projects.

Research by McKinsey Global Institute reported in MEED describes construction as being 'ripe for disruption', with new technologies having the potential to deliver 60 per cent efficiency gains, equating to $1.6 trillion in potential savings every year. At the top of the list for investment is digital technology, with the research demonstrating that construction ranks lowest of 21 other sectors in terms of digitisation and has had only a 6 per cent growth in productivity since the 1940s, compared to 1,512 per cent growth in produc-

tivity in agriculture and 780 per cent growth in manufacturing. But the experience of these other industries shows that there comes a tipping point, where digital capability becomes a requirement for survival.

Digital twins

An example of this is Siemens Building Technologies new headquarters in Switzerland. The firm did not want to perpetuate existing construction processes where contractors deliver a building according to a contract, with the data developed during the construction period simply evaporating. Instead they wanted to capture this throughout design and construction and create a digital repository of data, a digital twin, that would enable the new facility to be cost-effectively managed for the rest of its operational life. This meant using building information modelling (BIM) to its fullest extent, incorporating not only the digital 3D design model, but using it for construction work packages and linking time (4D) and cost (5D) to the model. To achieve this, Siemens Real Estate went out to the market and demanded full BIM enablement. Not all major construction companies were able to comply. In Switzerland's building sector a tipping



point had been reached and Strabag, an Austrian contractor that has invested in BIM for a decade, was ready.

An important lesson for the UAE industry to take from this case study is that Siemens Real Estate undertook this transition accepting that it would need to spend more in the early stages of this project. Innovation does not come for free. But this investment would allow the company to manage its facilities more efficiently in future, minimising the lifecycle cost. Making the crucial link between the cost of new infrastructure and its operational expenditure (opex) is a vital step along the path of transformation. Clients may need to spend more, for infrastructure to cost less.

Design alternatives

At the same time, incentivising contractors to deliver solutions that will result in better, more innovative and more efficient infrastructure is also important. The Siemens project was carried out using a design-and-build contract, which gave Strabag the freedom to help its client create the most cost-effective long-term solution.

Use of design and build also gives the contractor an incentive to value engineer the scheme. As explained in MEED's Mashreq Driving Better Value in Construction Report, this step sees contractors look for design alternatives that can maintain function and performance at lower cost. But under traditional lowest-price contract arrangements there is no incentive for contractors to do this.

The good news for construction in the UAE, and globally, is that the benefits of digital construction have finally been recognised; a tipping point is being reached, and the industry is investing for its own benefit. To date, contractors have told MEED that low margins mean they cannot afford to invest in digitisation. Now they report that they cannot afford not to.

Against this backdrop, MEED and Mashreq Bank have investigated some of the world's leading-edge construction projects where digital transformation is already underway and new technologies are onsite. From 3D printing of the world's first bridge to the development of a universal construction robot, to digital, cloud-based, project management platforms, what these case studies have in common is a commitment from project parties to provide better value in the construction industry, led by enlightened clients who are committed to achieving long-term sustainability.

On the positive side, such commitment is being demonstrated in the UAE at the highest level, from its intent to invest in innovative infrastructure outlined earlier this month, to its targets for 25 per cent of buildings to use 3D printing by 2030. On the path to digital transformation, Dubai's Roads & Transport Authority (RTA) has become a global leader in adoption of BIM.

But to achieve innovation on a large scale, other clients must be ready to work more collaboratively with their supply chains, and to incentivise them to deliver on value, rather than lowest price. Continuing with business as usual will prevent high-level objectives from being realised and see construction remain one of the world's least digital and least productive industries for another 70 years.

BUILDING THE WORLD'S FIRST 3D-PRINTED CONCRETE BRIDGE

Collaboration between the Netherlands' BAM Infra and the Eindhoven University of Technology has led to the world's first 3D-printed concrete bridge

The bridge opened in October 2017

The Netherlands' University of Eindhoven was working on its programme for 3D printing with concrete when Johan Bolhuis paid a visit. A design manager at contractor BAM Infra, Bolhuis saw huge potential in the 3D-printing programme. By printing elements in a certain pattern, connecting them together and then pre-stressing them, these concrete elements could become a bridge.

The idea was born, but BAM Infra needed an opportunity to put the idea into practice. This was provided by the province of Noord-Brabant on its Gemert Noord-Om project, a new peripheral road scheme connecting the N605 with the N272 roads. This involved construction of a new road, a roundabout, two bridges (one 3D printed) and landscaping of the surroundings. The province awarded the project to BAM Infra because it considered the 3D-printed structure to be innovative and environmentally friendly.

The body of the 3D-printed part of the bridge is 6 metres long, made from six 1m-long blocks. Each has the same pattern consisting of an element with hollow spaces, instead of a dense concrete block, resulting in a massive concrete saving of as much as 40 per cent. The elements were built up in printed layers of concrete each about 10 centimetres wide and 1cm high. During printing, a 2 millimetre-diameter metal reinforcement wire was added to each layer using a specially manufactured feeder placed alongside the concrete nozzle. The blocks were printed vertically and when complete measure 1m x 0.6m x 4m.

Material strength

After constructing the six elements, the blocks were rotated 90 degrees and connected with an epoxy. They were then pre-stressed between two traditionally manufactured concrete blocks. Dimensions of the blocks were calculated based on the required strength for the bridge and the restrictions of the printer. Based on tests, it was shown that the calculations were accurate and the blocks did not require any formwork to maintain their structure during printing.

The concrete mix is a development from Weber Beamix Saint Gobaint together with the Eindhoven University of

Technology. The mix is designed in a way that it stays fluid while it is pumped. When the pumping is stopped, the material starts to harden. In beginning of the project, the university had never printed higher than 20cm. Another obstacle that had to be overcome was the fact that two pumps were needed to print one element. BAM Infra notes that lots of technical issues were solved by working together as a team.

"The way the bridge was constructed was nothing like the conventional way of building a bridge. No scaffolding was needed and the 3D design from the computer was exactly what you got from the printer. This design can be shared with all parties, including the client, and there is no need for tweaking in the field. This is super transparent and reduces cost"

– Jeroen Nuijten, Innovation Manager, BAM Infra Netherlands

Importantly, the team learned that the way the bridge was produced was very different to the conventional way of building a bridge. The design needed to be exactly right because this was converted to a print-path and that created the structure that was produced and there was no potential for making onsite adjustments.

The design life of the bridge is 50 years, and the team notes it saved 40 per cent in terms of construction material, which also reduces the carbon footprint of the bridge. The exact replication of the design into the 3D printer also minimises failure cost and accelerates the speed of building, all of which is better for the environment.

The world's first 3D-printed bridge was completed in October 2017.

Concrete is printed in 1cm-high, 10cm-wide layers with wire reinforcement added at the nozzle

UNIVERSAL CONSTRUCTION ROBOTS ON THE HORIZON

Robotics is evolving as machines are programmed from design models, feedback loops enable self-monitoring and multi-functional construction machines become a reality

Architectural practice Mamou-Mani's award-winning, tower-building Polibot robot epitomises machine learning at the margins of current artificial intelligence (AI). In January 2017, the firm won a design competition hosted by UK design consultant Arup to use AI to create a machine that could transform construction sites. The initial solution to this was a robot that combines known AI technology but also brings in machine learning, enabling it to self-monitor and self-correct.

Traditional AI relies on what Arup associate Alvise Simondetti describes as an excruciatingly long list of commands that dictate the actions required from a simple robot. The robot has no appreciation of its environment, or ability to learn from its actions. But the recent revolution in processing power is enabling machines to analyse huge volumes of newly available data, and compare this information about its environment to design criteria and thousands, if not millions, of data sets.

Digital model

This ability to self-monitor is what makes the Polibot intelligent. Added to this is its ability to use design criteria from the digital model, rather than rely on a mathematic script-based code created by programmers. This step is described by designers as the 'democratisation' of robotics.

This rendering illustrates how the Polibot could be used at scale on construction of Mamou-Mani's Blockchain Skyscraper

During operation, the model data is used to tell the robot which segments to lift, and where to place them, to create a tower. So far traditional AI, but what pushes the boundaries is that the machine then uses a Microsoft Kinect camera mounted overhead to assess and analyse the position of the segment on the lifting mechanism, and self-correct if it is out of alignment. This feedback loop is the first non-deterministic element of the robot, taking steps along the path to the development of fully learned machines.

Blockchain skyscraper

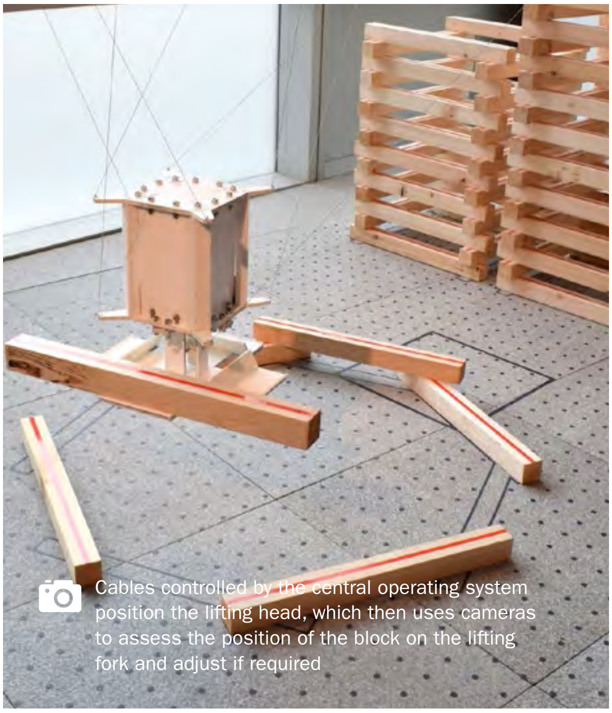
Physically, the Polibot is a simple structure. A central operating system is hosted in a small box attached to the pick-and-place mechanisms, which is suspended from eight cables that use eight winches to move and position the head. The initial prototype is designed for payloads of up to 2 kilogrammes and can build any structure that falls within a 4m-by-4m footprint. However, the team says the machine is scalable and, with larger motors and winch systems, could be used to construct larger structures such as the innovative 600m-high Blockchain Skyscraper designed by Mamou-Mani.

But for now, the firm is focusing on a multi-functional version of the cable robot under a Kickstarter campaign called the Polibot, Universal Building Machine. Prototypes of the machine, which incorporates 3D printing, CNC milling and pick-and-place technologies, are already being tested and the firm argues that these could ultimately replace tower cranes and labourers as fully intelligent site construction robots.

This would require the machine to host millions of data sets that inform its approach to delivering the model-led design, and the more data it has the smarter it becomes. This would be coupled with sensors and cameras to provide real-time environmental information. The launch of this machine is planned for later this year.

"We can generate design options very quickly, but we don't always know which one works best. But when the machine has collected enough data, it can tell us which option has the best performance based on prioritised criteria."

Ping-Hsiang Chen, Project Leader, Polibot



Cables controlled by the central operating system position the lifting head, which then uses cameras to assess the position of the block on the lifting fork and adjust if required

A rendering of one of the thousands of potential iterations of a timber tower built by the Polibot

UNMANNED AERIAL VEHICLES MOVE TO THE NEXT LEVEL

The telecommunications industry has embraced the use of drones beyond site survey data collection, and is using them to inspect and monitor infrastructure

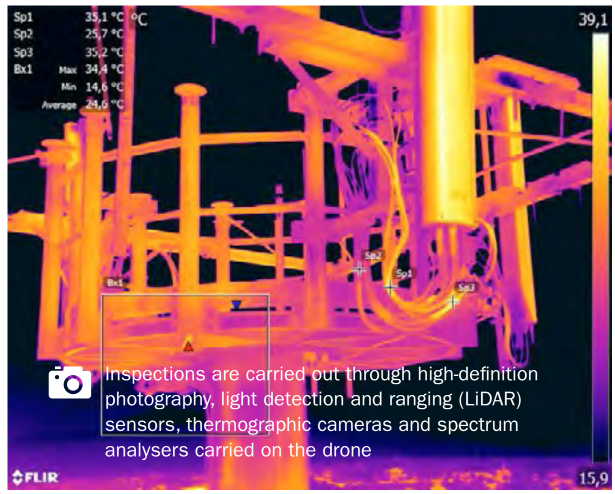
Communications tower inspections typically require the site to be shut down and the tower climbed by an expert rigging team. If the tower is non-climbable, an elevated work platform must be used to allow close-up inspection of the antennas and equipment. Capturing imagery and other information with drones enables significant cost savings, eliminates the safety risks of tower climbs, and reduces the time required to assess tower conditions.

"ProjectWise made it possible to quickly coordinate among the stakeholders, providing telecommunications operators with immediate access to up-to-date information and a huge amount of data, and provides the documentation base to support continuous asset management"

Cristiano De Leonardis, CEO and founder of Seikey Srl

Italian drone company Seikey is using an innovative method for inspecting 11,800 radio base stations (RBS) in Italy for risk prevention, compliance, and the maintenance and development of the 3, 4, 4.5 and 5G networks. Inspections are carried out through high-definition photography, light detection and ranging (LiDAR) sensors, thermographic cameras and spectrum analysers. During an inspection, it is possible to view the data that the drone is acquiring in real-time through project management platform ProjectWise.

Using Bentley software programmes ContextCapture, MicroStation and Bentley Map, data is collected, processed and managed in ProjectWise. A detailed photogrammetric reconstruction takes around 1,700, 40 megapixel photos, up to 30GB of photos for each RBS, and more than 400TB of data for all the RBSs.



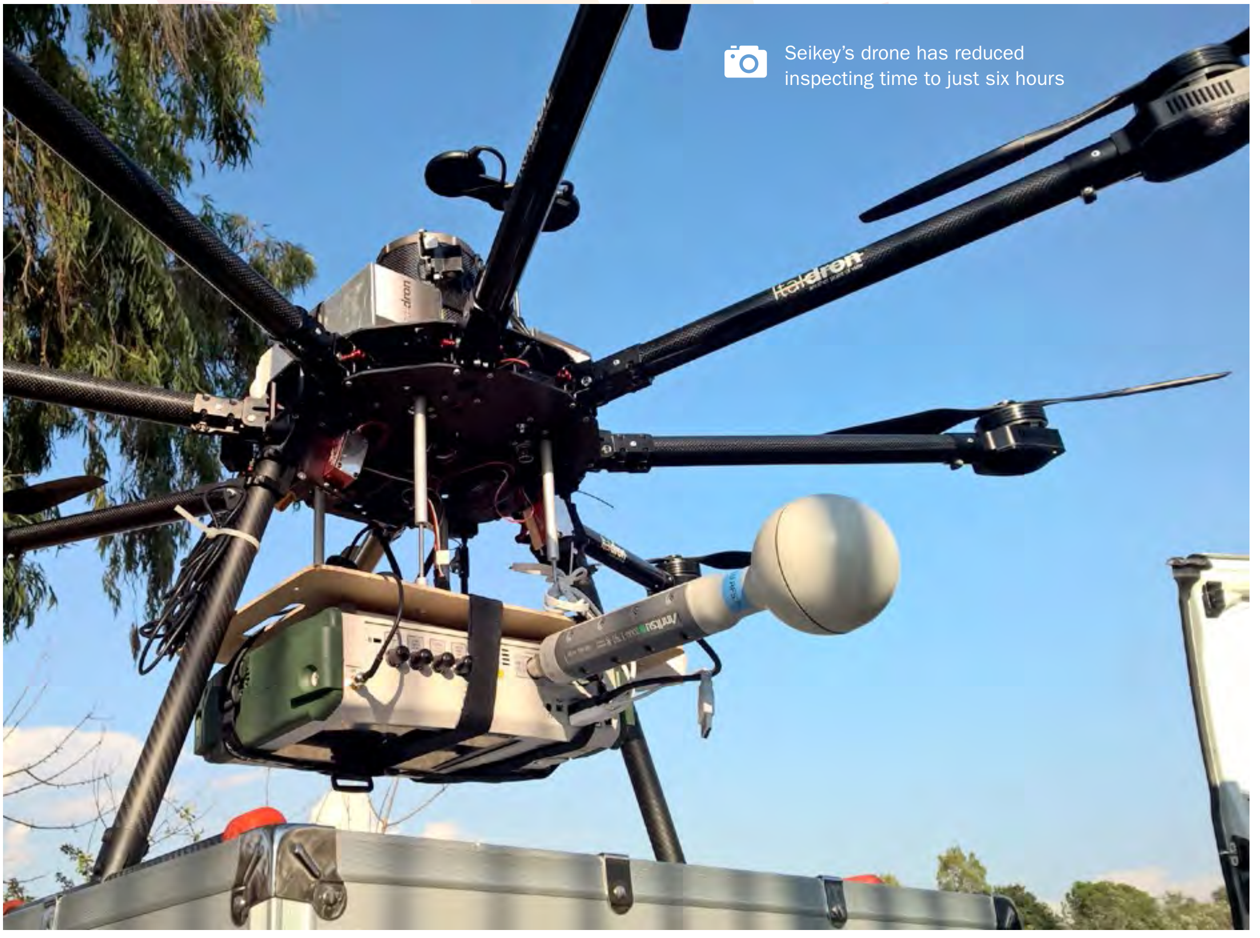
Inspections are carried out through high-definition photography, light detection and ranging (LiDAR) sensors, thermographic cameras and spectrum analysers carried on the drone

Through Bentley Navigator, 3D visualisation provides a comprehensive and realistic view of situations requiring intervention. The management of flight schedules, the collection and preparation of necessary permits, and the management of collected and processed data posed significant challenges. The inspection method led to a reduction in the risk to human life and a reduction in inspection times. While it previously took five days to perform an RBS inspection, it can now be done in six hours.

On the Telstra telecommunications tower in Brisbane, Australia, local cell tower analysis company SiteSee used ContextCapture to create reality meshes for as-built auditing and analysis of the tower. In doing this, it reported a reduction in asset inspection and maintenance costs of 69 per cent, along with a reduction in project delivery lead time of 86 per cent.

Corrosion detection

ContextCapture enabled SiteSee to export a dense point cloud for further analysis in its web-based application for remote site inspection to support automated corrosion detection and antenna identification with model, height, azimuth and mechanical tilt, as well as preliminary radiation hazard simulation within the 3D-reality mesh scene.



Seikey's drone has reduced inspecting time to just six hours

SiteSee also developed a 3D tile viewer that enabled users from field teams, engineering, health and safety, real estate, and asset management to remotely view and analyse assets and run reports. The reality mesh can also be linked to the user's internal asset management system to align records with the data extracted from the reality mesh, bridging the gap between reality and the database of records.

Laser scanning

In the US, Eye-bot Aerial Solutions produces 3D engineering ready meshes of structures, such as the monopole cell tower in Springdale, Pennsylvania. Modelling vertical structures with UAV photogrammetry is extremely difficult when the structure has complex cross bracing that can be seen through. Eye-bot relies on the unique capability of ContextCapture to use photogrammetry and UAV laser scanning to consistently generate accurate models. The models can be used to check for structural deformities and the surface area of components can be measured for wind and ice load calculations, allowing for well-informed decisions that no longer rely solely on the person climbing the tower.

Seikey uses drones to inspect the operating parameters of 11,800 radio base stations in Italy for risk prevention

TAKING BUILDING INFORMATION MODELLING TO ITS LIMITS

Siemens Building Technologies' new facility used BIM in 4D and 5D to manage site processes, improve productivity and lower lifecycle costs

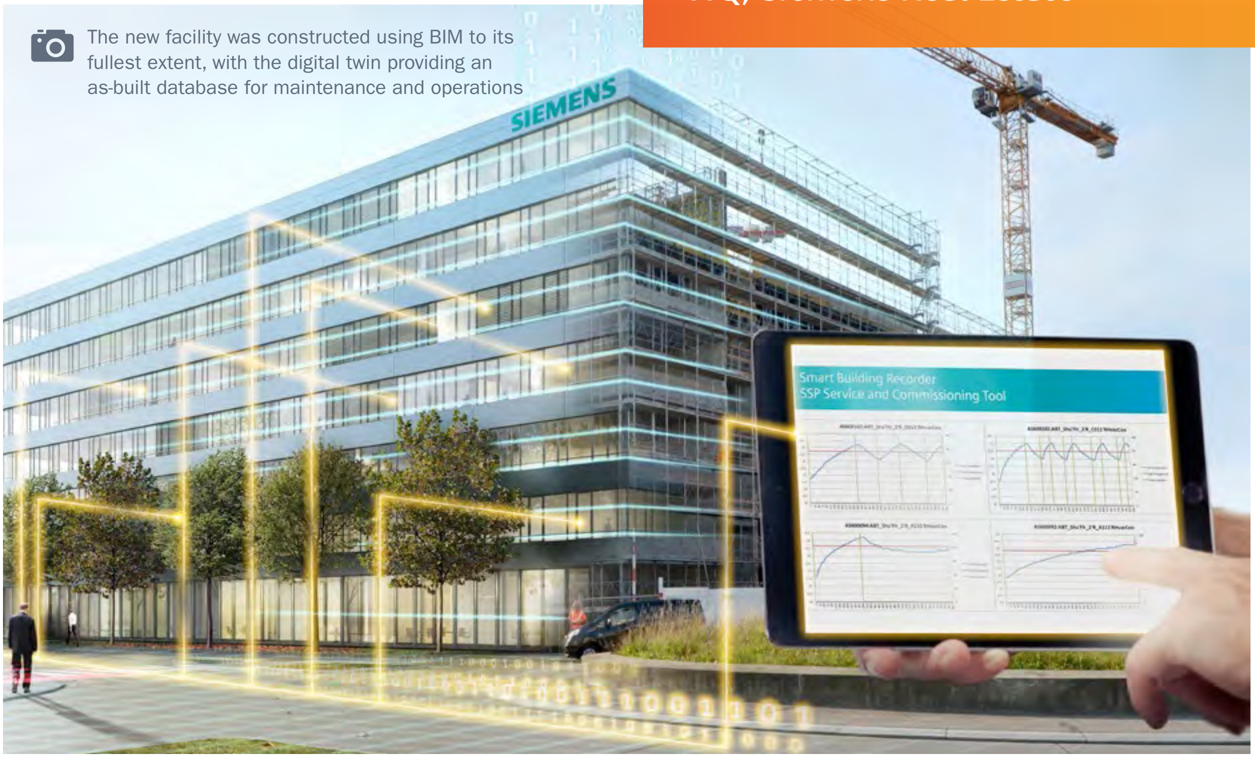
Using Building Information Modelling (BIM) to its fullest extent means extending its reach from design development into site activities and long-term asset management. In Switzerland, Siemens Real Estate has taken a huge leap forward in digital construction by working with Austria's Strabag to digitise construction of its new $124m facility. The new headquarters consolidates group operations, bringing together a production facility previously located 40 kilometres away in Volketswil, and providing modern office and laboratory space.

The result will be two new buildings co-located, each with 18,400 square metres of floor space and 250 underground-parking spaces. Together with the core refurbishment of an existing office building of 13,700 sq m for R&D functions in 2021, Siemens will take up 30 per cent less space than before and overall rental costs to the company will fall by more than 20 per cent.

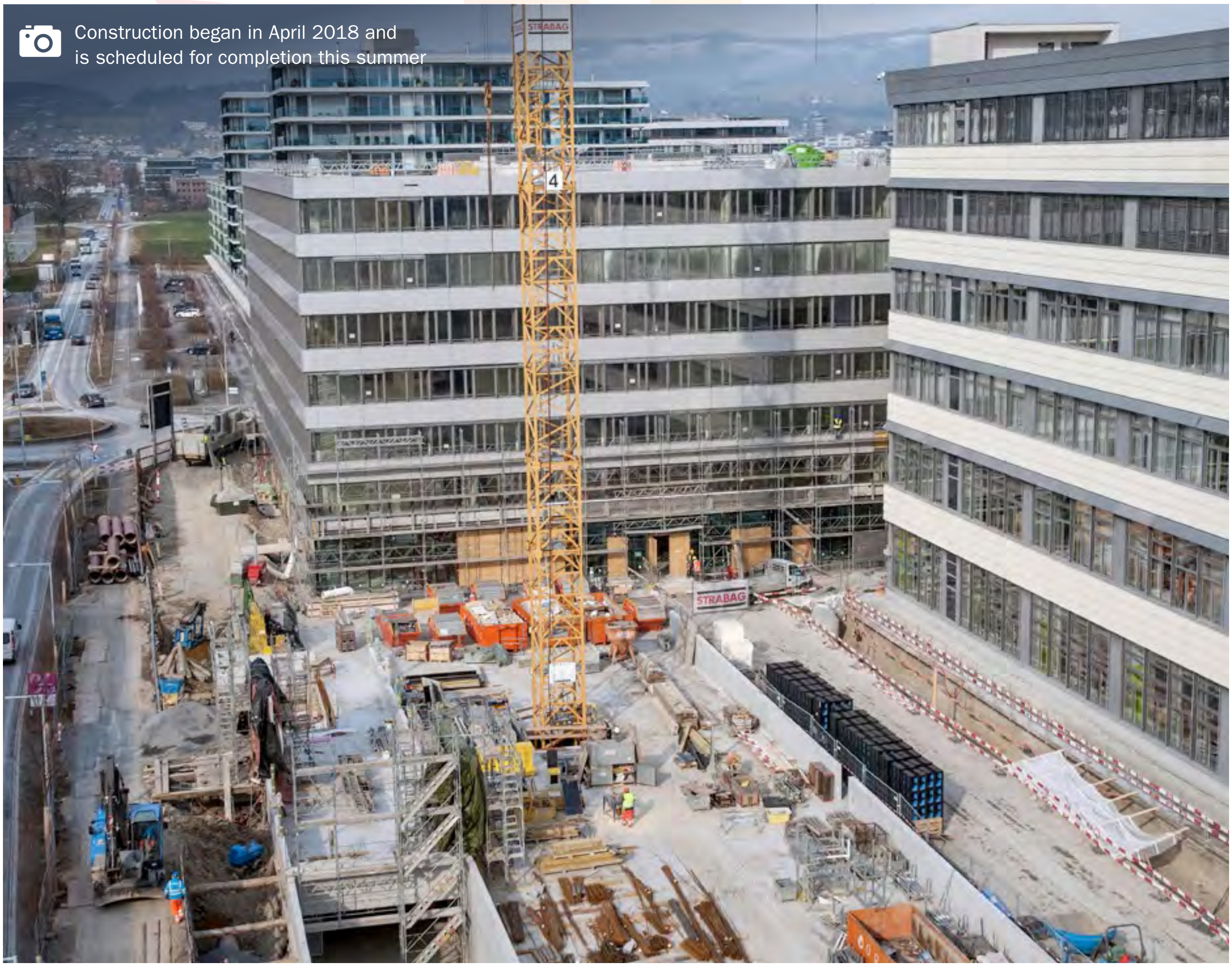
Construction began in April 2016 and Siemens specified the use of BIM throughout the project. Christoph Leitgeb, project manager from Siemens Real Estate, explains that a range of responses came back, providing a reflection of the maturity of the local market in terms of BIM preparedness. Some contractors told Siemens that incorporating BIM would add more than $1m to the price; for others it was already part of their business model. This included Strabag,

"We could do things as we have always done them in the past or we could look to the future. We decided to do the latter."

Christoph Leitgeb, Project Leader, Siemens Building Technologies' new HQ, Siemens Real Estate



The new facility was constructed using BIM to its fullest extent, with the digital twin providing an as-built database for maintenance and operations



Construction began in April 2018 and is scheduled for completion this summer

which had not only been using BIM for a decade, but was able to use it to manage site processes including time and cost – so called 4D (time) and 5D (cost) BIM.

Using the model to prepare work packages and compare progress onsite to the model improved transparency on the project compared to traditional approaches, and reduced management time. Monthly progress meetings were informed with site pictures recorded by contractor personnel using hand-held devices to provide daily updates of activity. Such measures also reduced unnecessary paperwork.

Digital transformation

During construction, the site team also built an object database, which is to become the digital as-built model used to operate and maintain the buildings. Extension of BIM into these six dimensions makes this a pilot project for both Siemens and the industry, as it seeks to harness true digital transformation.

The scheme is scheduled for completion this summer and many lessons have been learnt. One of which was the use of a closed BIM model. Utilising Strabag's existing expertise and systems meant using the Autodesk suite of software was specified throughout the project.

This use of a single data format meant that the team was dependent on the capabilities of one software vendor. This is in contrast to an open BIM model, where project teams can use non-proprietary Industry Foundation Class (IFC) files to update the consolidated model.

Cost savings

Siemens Building Technologies' BIM expert Wolfgang Hass explains that this is an important lesson for future projects, along with the need to create standards around the format of the as-built data repository, better known as the digital twin.

Financial benefits from the project are yet to be measured, but the team is expecting these to exceed industry statistics as outlined by the US' Stanford University of 10 per cent savings due to prevention of clashes on site, 40 per cent lower costs due to the prevention of change orders, and a 9 per cent saving in the lifetime operational costs.

HONG KONG, ZHUHAI AND MACAU BRIDGE

Digital technology and offsite fabrication were used to reduce costs and accelerate construction on a critical section of this iconic bridge project

The Highways Department for the Government of Hong Kong Special Administrative Region (SAR) is building a mega-size sea crossing to link Hong Kong, Zhuhai and Macau. Vehicles will enter and leave Hong Kong through new boundary crossing facilities on a 150-hectare reclaimed island and the revolutionary project includes 50 kilometres of bridges and tunnels.

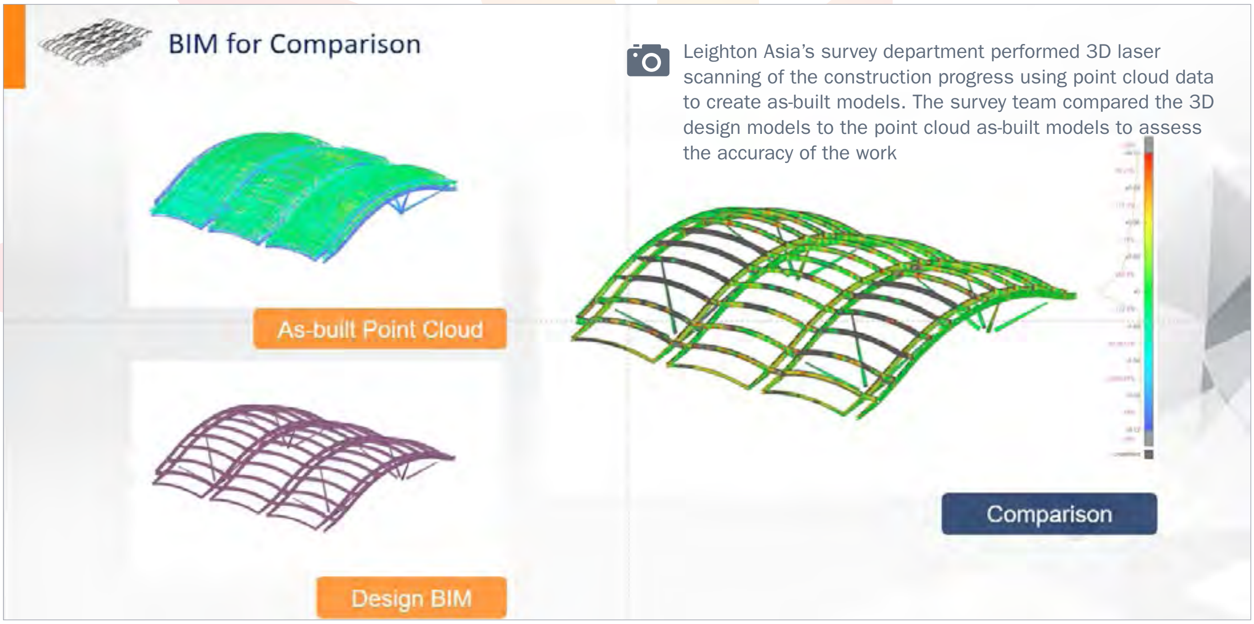
The Leighton-Chun Wo joint venture won the $4.6bn contract to construct the passenger clearance building and associated works. As the lead on BIM utilisation for contractor works, Leighton Asia used Bentley's BIM technology as the common platform for anticipating and rectifying construction problems, as well as building the as-built digital model for delivery to the Highways Department. Leighton Asia's innovative BIM strategy saved about 12 per cent of the construction budget.

"Bentley's civil BIM advancements bring BIM to the next stage by multiplying its benefits, especially in challenging and large-scale infrastructure projects. This platform has enhanced our collaboration with various stakeholders to import, acquire and exchange valuable information."

Michael Kin Wong, Survey Manager, Leighton Asia

A rendering of the pre-fabricated, pre-assembled roof structure, which was moved into place horizontally, eliminating the need for vertical movement above the airport height restrictions

Construction of the project commenced in 2014 and the passenger clearance building's wavy steel roof was a signature design feature and one of the major construction challenges of the project. Each steel roof segment was 60 metres long, 25m wide, and weighed more than 670 tonnes. Given the height restrictions imposed by the nearby airport, the constructors elected to use a horizontal installation method. The fabrication stages were performed at multiple locations, including Yinchuan, Hangzhou and Dongguan, and pre-assembly also took place offsite at ZhongShan. These steps progressed the roof's construction at twice the usual rate.



Leighton Asia's survey department performed 3D laser scanning of the construction progress using point cloud data to create as-built models. The survey team compared the 3D design models to the point cloud as-built models to assess the accuracy of the work

Adopting a BIM-enabled approach offered the team several advantages. The platform facilitated communication and collaboration among all participants. Bentley's civil software enabled Leighton Asia's survey team to organise and analyse the 2D drawings submitted by contractors and convert their designs into up-to-date 3D models.

Visualisation

Using MicroStation, Bentley's modelling, documentation and visualisation software, the BIM platform enabled models from the eight contracts to be combined into one geo-referenced 3D model.

Leighton Asia partnered with The Earth Solutions to construct and maintain a geo-referenced as-built 3D model and Leighton Asia's survey department performed 3D laser scanning of the construction progress. The point cloud data was processed with applications called Pointools and Descartes to create as-built models. The survey team compared the 3D design models to the point cloud as-built models to assess the accuracy of the work and this process was integral to the project's quality assurance programme.

By continuously updating the as-built models, the survey team created accurate as-built BIM models suitable for facility lifecycle management by the Highways Department. The cost-effective method pioneered by the Leighton Asia Survey Department streamlined the workflow, saving 15 per cent of the survey budget.

Image of the roof structure with road beneath it taken from LumenRT design software

HEILONGJIANG RIVER ROAD BRIDGE CONNECTING CHINA AND RUSSIA

A comprehensive BIM strategy supported delivery of a new road bridge between China and Russia built by Long Jian Road & Bridge Company

The $383m Heilongjiang River road bridge connects Heihe, China, to Blagoveshchensk, Russia, making it the first highway connection in the trade route between North East China and Far East Russia. The 19.9-kilometre route incorporates a 1,284-metre cable-stayed bridge spanning the sensitive Black River Basin. The location has extreme seasonal temperature variations and strict environmental protection.

An ambitious, three-year construction schedule was planned to lessen the impact of these challenging conditions. As the contractor responsible for all civil construction, Long Jian Road & Bridge Company, part of the Heilongjiang Province Construction Group, implemented Bentley's collaboration and coordination platform ProjectWise for construction management and information sharing. This improved the contractor's project management efficiency by 25 per cent.

"Bentley's comprehensive software solution provided the management and collaboration capabilities that allowed us to increase efficiency on the project by 25 per cent, while coping with the engineering challenges faced in a complex construction environment"

Xuyuan Liang, Director, Technology R&D Centre, Long Jian Road & Bridge Company

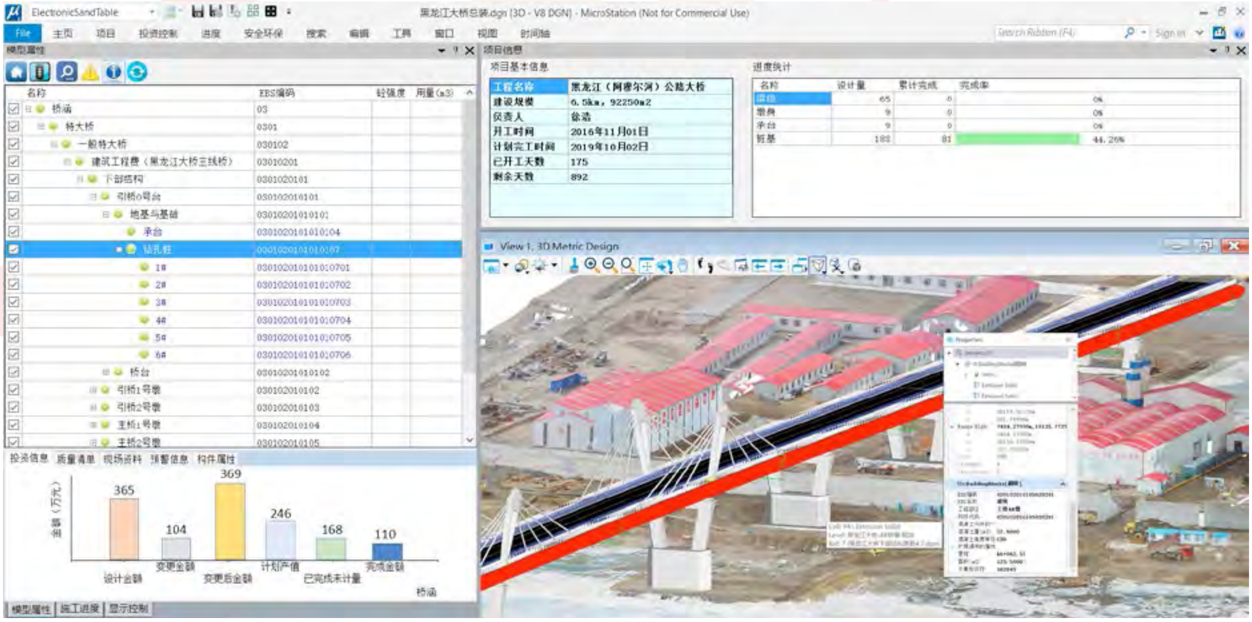
Construction began in November 2016, with the bridge scheduled to open in October 2019. The agreement called for China to build approximately 6.5km of the structure, starting in Changfatun Village, a suburb of Heihe City. Russia will build 13.4km, starting in Canikulgan Village. The Russian team is also tasked with connecting the two bridge sections.

The contractor estimates that it was able to use machinery and labour 15 times more efficiently thanks to the use of BIM

Design information

The site posed numerous obstacles to construction progress, including seasonal weather extremes, ice flows, limited channel width and a protected river basin. To overcome the hurdles and meet the project delivery deadline, the team had to rapidly build a bridge model within tight time constraints; create a digital environment to manage and exchange all civil design information; and define a BIM strategy that enabled the 3D monitoring of incremental bridge launching. The clear solution was adopting BIM methodologies to effectively manage the bridge construction.

The project team researched and developed standardised 3D design modelling methods that enabled members to collaborate effectively, including the use of software programme OpenBridge Modeler's 3D parametric modelling capabilities to achieve the required degree of accuracy for the bridge's superstructure. Parametric modelling sees a series of algorithms or 'parameters' used to generate the digital model and these rules create relationships between different design elements based on project and site-specific information.



The bridge design and reality model of the shoreline facilities in the Chinese version of MicroStation software

Integration between OpenBridge Modeler and the OpenRoads software used for road design enabled precise positioning of the substructure and customisation of more than 60 structures. As a result, the team improved efficiency by 50 per cent, compared to traditional methods.

ProjectWise enhanced collaboration and coordination among the different disciplines involved in construction of the bridge, roads, culverts, civil works and related infrastructure. Together with MicroStation, ProjectWise became the platform for 5D construction information management, creating a common data environment that allowed all participants to share, review and update information in real time. This collaboration improved modelling efficiency by 35 per cent and accelerated decision-making among management teams.

To date, Long Jian Road & Bridge Company has achieved a number of critical objectives, including reducing material waste by 1 per cent, using machinery and labour 15 times more efficiently, and limiting the cost of schedule deviations to under $80,000.

Upon completion, the project team will turn over the reality model-based asset management database to the owner for use in the operation and maintenance management phase.

Heilongjiang River Bridge with the reality model in the foreground

INNOVATION CUTS COST ON THAMES TIDEWAY EAST

Using model-based design delivery has resulted in a 32 per cent saving in required design resources and shaved six months from the project schedule

The Thames Tideway Tunnel in London is one of the most complex construction projects of its type in Europe. At $6.2bn, the 25 kilometre-long, 66 metre-deep tunnel is the UK's largest-ever water project and is designed to protect London's River Thames from sewage pollution for the next 100 years.

The tunnel dives 66m below London and will protect water quality for the next 100 years

It is being built under three major contract packages and the eastern section of the new 7.2m-diameter sewer is under construction by a joint venture of the UK's Costain, France's Vinci Construction Grands Projets and Bachy Soletanche. Working with lead designer Mott MacDonald, the team has embraced model-based delivery for design, replacing paper-based documentation required for traditional design milestones through stage gate reviews with digital information. The result has been a reduction of the design schedule by six months and design resources by 32 per cent.

In a traditional project, even those using Building Information Modelling (BIM), 2D information via a series of drawings is prepared and handed over to the client for review and

"We want to make better use of data by digitising our engagement and measuring what that is giving us. What is the return on investment? Collaborative understanding is the key. You engage around the topics in a very collaborative way rather than a transactional way. The client can visualise what the outcome is."

Mert Yesugey, Project Manager, Mott MacDonald, Thames Tideway East approval at each of the design stage gates. On the Thames Tideway East contract, these stage gates are: brief, concept, developed, detailed, construction and operation.

Providing the physical information for these stages takes a lot of time as clients review and question the drawings, which then require updating and reissuing before final approval will be given. However, as the design evolves, these drawings quickly become outdated, leading to wasted time and effort. It can also mean that some designers continue working on the latest version of the model, when others are using earlier versions to cut the drawings – meaning there is more than one version of the design in circulation.

Design model

Instead the Thames Tideway East team moved away from this 2D paper-based approach and introduced model-based delivery into the concept and developed design gates. Information was shared through the design model, which was accessible to all parties involved in the project. Data was delivered to the client within the project model within hours (an average of 0.9 days), rather than days or weeks.

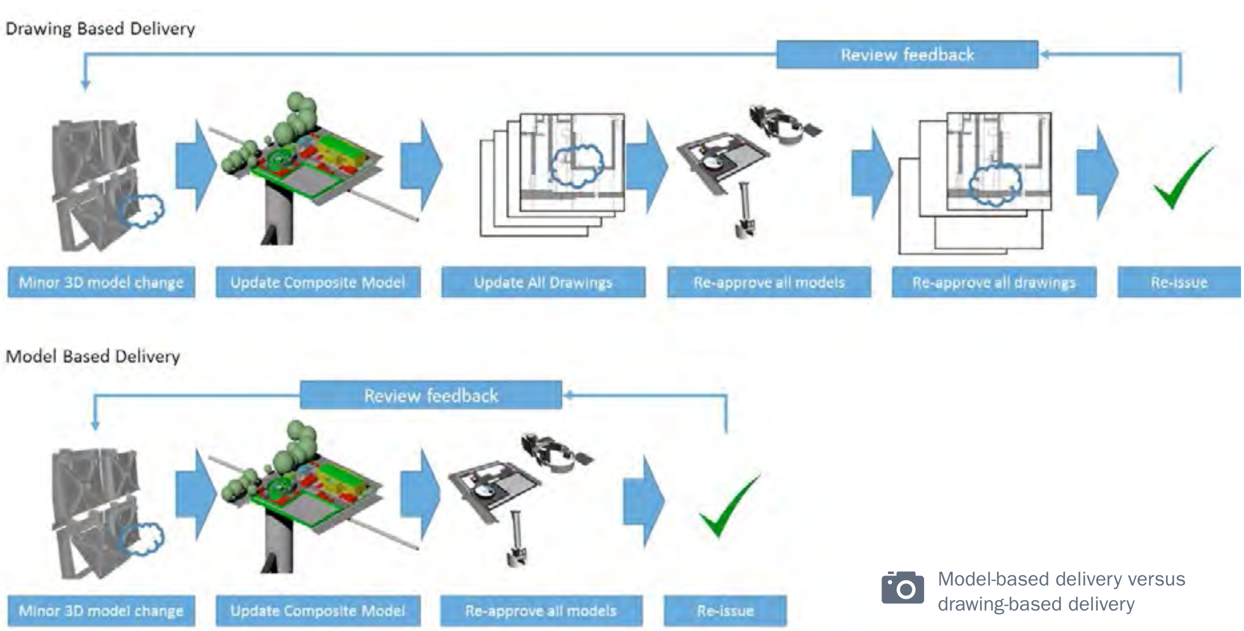
As a design-and-build contract, collaboration between the contractor and the designer was crucial and required very early appreciation from the designer of the construction methodologies to be employed by the contractor, who in turn had to make early decisions about their requirements to inform design.

Since the contract was awarded in September 2015, all parties have met weekly to discuss design development on what is described as BIM Wednesday. This clarity and collaboration enables the client and contractor to monitor design evolution and gain confidence as it progresses.

Required stage gate review information is shared in the model and approval for this information on first review cycle is now at 82 per cent, up from 76 per cent six months ago. Although this is considered to be high, comparing it to traditional approaches is not easy, because historically this data has not been digital, and not been measured. Having hard data on revisions and updates is another benefit of the model-led delivery approach.

Using Bentley's cloud-based ProjectWISE common data environment, the team used software applications such as AECOSim Building Designer to view the model in both 3D and 2D. Although these tools were critical, the project team says that the initial collaborative approach and the move away from transactional assurance into a digital delivery is what has really accelerated design.

The eastern section runs from Chambers Wharf to Abbey Mills Pumping Station



Model-based delivery versus drawing-based delivery

Source: Mott MacDonald written for ICE Proceedings

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