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HISTORIC BRIDGES

Iron works: A major refurbishment of one of England's most significant historic bridges has also given the public the once-in-a-lifetime opportunity to get up close and personal with a famous monument

READY FOR TAKE OFF

Rapid developments in drone technology are expected to enable a wider range of applications in the bridge inspection field. This article reveals the trials being conducted by a bridge owner in the USA

STAYING DRY

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ALL-IN-ONE PLATFORM FOR MACHINE CONTROL and **REINFORCING REWARDS OF EARLY ADOPTION OF BIM**

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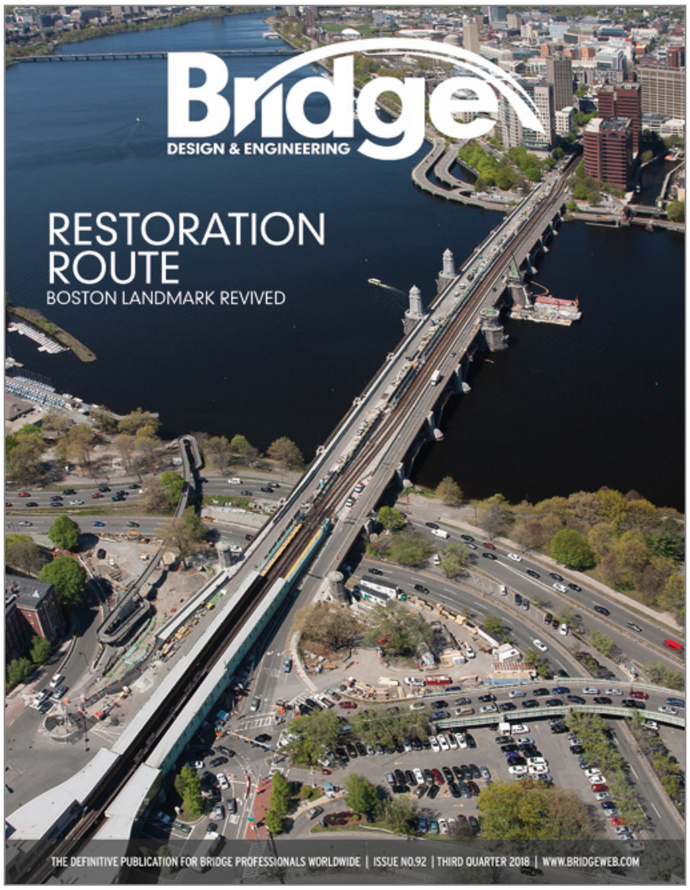
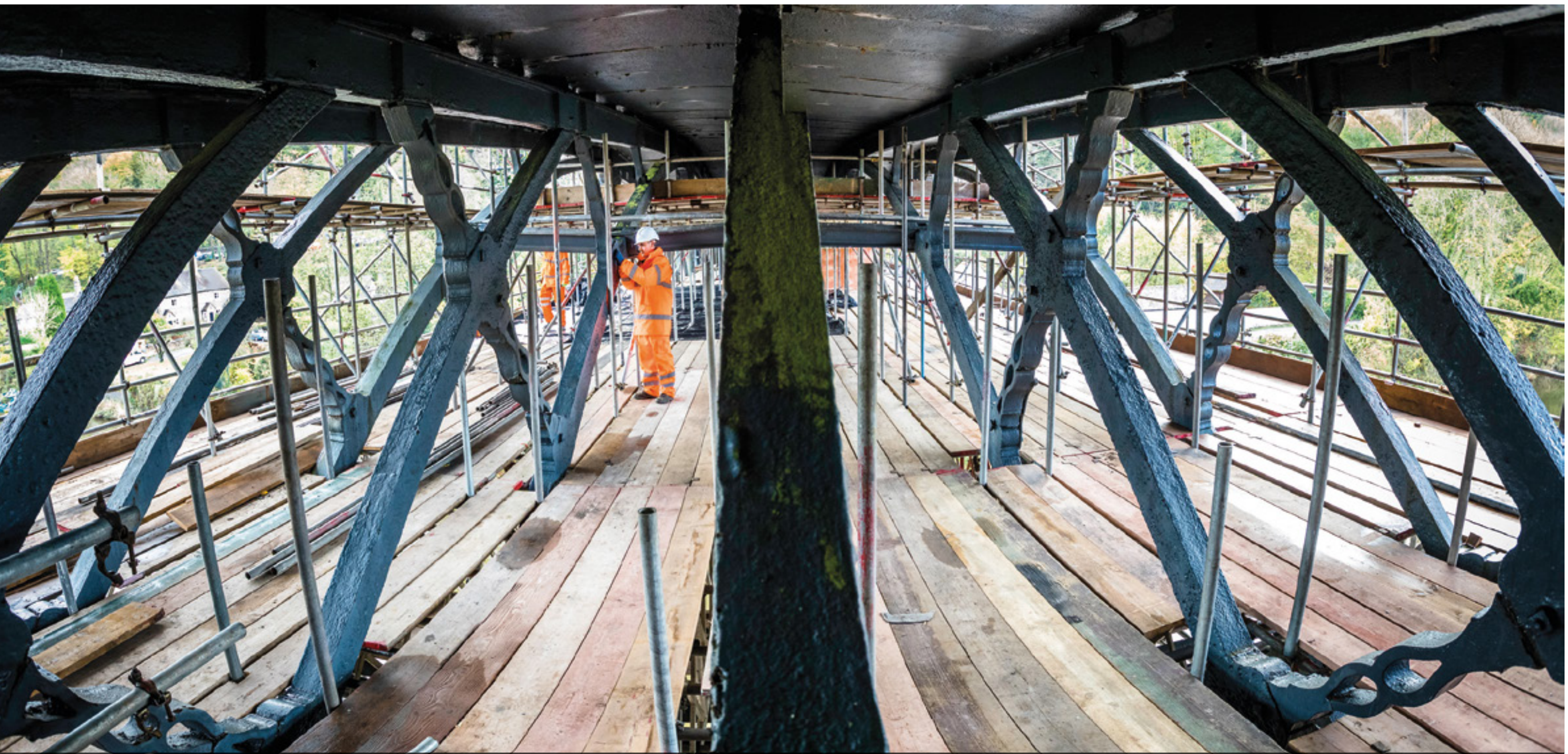




The general public was offered the opportunity to get inside the structure on hard-hat tours that sold out within days *(English Heritage)*

IRON WORKS

A major refurbishment of one of England's most significant historic bridges has also given the public the once-in-a-lifetime opportunity to get up close and personal with a famous monument. Helena Russell reports

Making a special journey to visit a tourist attraction, only to find it encased in scaffolding and protective sheeting can be a disappointing and frustrating experience. But English Heritage has turned this on its head at Iron Bridge, by taking the opportunity to give visitors a different view of the bridge, along with a special insight into the structure of the historic monument, and the restoration process that is under way.

The Iron Bridge is notable as the first major bridge in the world to be built wholly of cast iron; its construction started in November 1777 and it was completed in December 1780, being officially opened on 1 January 1781. It spans the River Severn near Coalbrookdale and gives its name to the town that sprang up around it. It is Britain's best-known industrial monument and remains in use by pedestrians.

The main bridge span is a semi-circular arch which is 30.6m long and made up of 10 half ribs, each cast in one piece. It consists of 385t of ironwork and almost 1,700 components, the heaviest of which weighs 5.5t.

Although being an arch bridge, the structural members have connection details that owe more to woodworking techniques than anything else. Drawings for the detailed design of bridge members were made by Thomas Gregory, a pattern maker who usually worked with wood, and this is thought to be why the bridge uses carpentry jointing details such as mortises and tenons, and dovetails and wedges, despite the fact that it is built of iron.

The structure has been in a state of flux almost from the day it opened; ground movements in the gorge, which have caused movements of the abutment, resulted in the first repairs to the structure being recorded just three years after the bridge was opened. Repairs and adaptations have continued since that time, with a range of interventions intended to stabilise and strengthen the structure *(see box, page 36)*.

Despite having been subjected to a great deal of attention over its lifetime, the detailed condition of the bridge still had to be estalished in full at the start of the contract.

One of the difficulties that structural engineer Ed Morton Partnership faced at the outset of the project was knowing the condition of the structure in any great detail. Although a full laser survey had been carried out just a few years ago to map the physical dimensions of the structure, this did not provide them with any indication of the condition of the iron members or the presence of any new cracks or fractures. As Ed Morton explains, it was very much a case of drawing up a schedule of works on which to base the initial estimate, with the understanding that this might all change in the course of the contract.

The scope of works was to provide full access to all the spans of the bridge — the main one and the two more recent side-spans; to carry out whatever repairs to the iron structure were deemed necessary; to grit-blast the existing coating back to bare metal, and replace it with a new coating; to carry out repairs to the masonry on the abutments; and to remove the existing deck and provide a new one, including a new waterproofing system. Part of this, says Morton, included the opportunity to review the services currently incorporated into the deck, to see if any needed renewal or could usefully be eliminated.

The first stage in the process, once the contract had been let, was to get the access scaffolding up and carry out a full inspection of the structure. This was no mean feat, as Morton recalls; erection of the scaffolding took several months to complete — in fact the system was fully designed before it went out to tender, as the team considered it too great a risk to leave this until after the contract was let. The access system envelops the structure entirely, and is supported not by the bridge itself, but rather by the concrete apron which was cast on the river bed between the two abutments in the 1970s. This was added in an attempt to halt the slow shifting of the abutments, one of the main problems for the structure over its long life.

The access system incorporates not only a full enclosure system for catching blast media from the paint removal process, but also a separate walkway along the side of the structure, which is accessible to the public on a daily basis and gives them the opportunity to see into the work area and observe what is happening on the bridge.

English Heritage corporate affairs manager Tom Jones explains that during the early development of the scheme, they spent quite a lot of time talking to the local community to try and establish the impact the work would have on the visitor economy in the gorge, which many businesses rely heavily on.

Visitors do not have to buy tickets to visit the bridge even under normal circumstances; it is open all hours and is free to access. There was concern that visitor numbers would drop during the works, when the bridge would be fully enclosed in scaffolding and not visible.

As Jones explains, the idea of a publicly-accessible scaffolding walkway was considered, and questions were asked about the impact this would have on cost and the construction programme. Although the work could have been done quicker without the public access, and at a lower cost, the newly-established charity recognised that it had greater benefits in terms of public outreach and education, and also keeping the local businesses on side.

This unprecedented and free opportunity to get 'up close and personal' with the bridge was supplemented by a series of ticketed hard-hat tours, which sold out within days of the announcement. It had been billed as a once-in-a-lifetime opportunity, says Jones, and although it was not possible to measure any change in visitor numbers, since the bridge is open to the public and unstaffed under normal circumstances, the anecdotal evidence suggests that the public has a healthy appetite for this kind of outreach. Jones adds that recruiting and training volunteers to assist on the walkway has also enabled EH to develop its relationship with the local community.

While the public walkway has specified opening hours, the contractor is also required to keep the bridleway over the bridge deck open throughout the project, as well as providing access to the tollhouse on the south side of the bridge.

The need to keep the bridleway open has meant that the deck has had to be refurbished in two phases, with the downstream side just being finished off when *Bd&e* visited, and the focus due to move to the upstream side in the next phase. A temporary protective cover was erected over the deck within which the existing pavement could be lifted, repairs made to the iron deck plates as required, the waterproofing membrane installed and the new pavement put into place without the weather causing delays.

The last time that the bridge was scaffolded was in 1999, says Morton, and things have changed a great deal since then, especially the legislation relating to temporary works and access requirements. The fact that the old lead paint had been removed in the 1980s, when the coating was last fully renewed, was something of a blessing as it at least removed one of the potential hazards for the workers and the environment. But even so, the limited capacity of the temporary works meant that the grit blasting media had to be swept up and removed from the scaffolding on a carefully managed basis, so as not to overload the structure.

Another recommendation in the early phases of the work was to carry out a diver survey of the concrete apron which acts as a strut between the two abutments, to check its condition. Morton says it was important to ensure that all elements of the structure had been assessed as much as possible before the work started, so that any necessary repairs could be incorporated into the programme.

However, the inspection revealed that no work was required to this part of the structure, and as Morton explains, the predominant action working on the structure today is corrosion. The brittle nature of the material makes it prone to fracture, and jacking forces created by corrosion between structural elements and the faces of fractures are the main actions that need to be addressed.

One of the particular difficulties on the Iron Bridge is the fact that it can't be dismantled. On other cast iron structures, Morton would recommend that they be fully dismantled to enable all the joints and faces of fractured elements to be treated for corrosion.

While the fractures and cracks are not ideal, the refurbishment work does not seek to repair them, only to fix in place any that might otherwise be at risk of falling off. Likewise the past repairs — of which there are many — are not being replaced unless absolutely necessary. The repairs are part of the history of the structure, says Morton - after all, the first repairs are almost as old as the bridge itself. Almost all of the original fabric of the bridge survives, and when considering what materials should be used for any repairs on this contract, heritage considerations supported the proposal to make repairs 'readable' for future understanding of the bridge. Rather than trying to replicate the original material, it is considered appropriate to use something different to allow additions to be identified.

A major survey and finite element analysis of the bridge was commissioned by English Heritage in 2012 — the first ever full-strength assessment of the structure — and this

Although the bridge was fully enclosed for the refurbishment work, a walkway built alongside let visitors observe work through special portholes. Inset: detail of one of the iron members

CHEQUERED PAST

Despite its rural setting, east Shropshire played a significant role in Britain's Industrial Revolution. At the start of the 18th century, a shortage of timber needed for making charcoal to fuel blast furnaces meant pig iron had to be imported from Europe. But in 1709, Abraham Darby developed a method for using coke instead of charcoal to fuel the furnaces at his Coalbrookdale foundry. The new technique meant high-quality iron could be produced in larger quantities than before, but better infrastructure was needed.

In 1775, a bridge was proposed between Broseley and Madeley Wood, using a single span to avoid putting piers in a river prone to flooding. Thomas Farnolls Pritchard was the bridge's architect, although the structure that was actually built was his third attempt – the two previous designs having been rejected.

The bridge has a history of structural problems and repairs, mostly due to gradual movement of the abutments. A few years after it opened, cracks were found in the south side of the arch, and the near abutment showed signs of movement. Repairs were carried out three times in the first decade of its life.

In 1800, the stone-faced embankment behind the south abutment was replaced with two small timber land arches to relieve pressure on the river span, and these were replaced with cast iron arches in 1821. Iron Bridge continued to carry vehicular traffic until 1931, when it was closed to all but pedestrians. The bridge was designated a Scheduled Ancient Monument in 1934.

By the time the Ironbridge Gorge Museum Trust was founded in 1967, the bridge needed major work as a result of ongoing movement of the gorge sides. In 1972-5, a reinforced concrete inverted arch was built on the river bed between the abutments, and the rubble fill in the north abutment replaced with concrete.

In 1980, the bridge was blast cleaned and painted with a five-coat system. It was Grade I listed in 1983. In 1999, the structure was inspected, the paint retouched and a new top coat applied to the ironwork. The same year, a watercolour sketch by Swedish artist Elias Martin of the bridge being built was discovered, sparking an in-depth investigation of its construction methods.

The bridge was surveyed in 1999-2000, using 3D EDM and CAD techniques, enabling accurate computer modelling of the structure *(Bd&e issue no 26)*. The data helped English Heritage to assemble a half-size physical model in 2002, reproducing the original construction methods and validating its design. They found that most of the components had been cast individually to ensure a good fit. In 2001-2, cracks in the original cast iron parapet railings were repaired with 3.8mm-thick carbon fibre reinforced epoxy plates, a repair procedure chosen to circumvent the difficulty of welding cast iron in situ.

▶ work was carried out by consultant Ramboll. It used the geometry produced by a comprehensive laser scan to produce a solid model which could be used for finite element analysis. All defects and cracks in the structure were also incorporated in the model – about one hundred in total. The analysis found that the main span has good capacity, able to take a pedestrian load of $3kN/m^2$ or a 7.5t double-axle inspection access vehicle. The cast iron deck plates, which are on all spans, are also able to take this level of loading, but the report recommended that outrigger loads should always be spread across the deck, as some of the plates are cracked. The deck plates also have 'lobes' on them which are necessary for transferring forces between the different elements of the superstructure, but they have proved challenging to repair and paint. They are integral to the deck plates but tend to suffer from a build-up of corrosion behind them, which not only threatens the longevity of the lobes themselves but can introduce additional forces into the structure.

The old paint has been removed back to bare metal, and a new coating from supplier Sherwin Williams has been applied. The atmosphere is not particularly corrosive, says Morton, but humidity can be a problem. More difficult is the fact that there are so many connections, junctions, fractures and repairs to consider. Whether mastic sealant should be applied, or the joint left open to 'breathe', has generally been decided on a case-by-case basis. Larger gaps are mostly left open to allow air to circulate through them, with smaller cracks and fractures filled.

The paint system is Sherwin Williams M24 which consists of three layers; a primer of Macropoxy M902 (100µm); an intermediate coat of Macropoxy M905 (100µm) and a top coat of Acrolon C237 Sheen (50µm). A stripe coat of Macropoxy M905 (75µm) is applied to edges, joints and junctions as necessary between the primer and intermediate paint coats.

Once contractor Taziker had put the access scaffolding in place, the team could inspect the bridge at close quarters to establish a more accurate schedule of repairs, and start the process of making templates for any pieces that needed to be replaced. Any new fractures or damage were noted, and trial repairs were carried out at certain locations. All procedures had to be approved before they could rolled out across the bridge; just one of the requirements of working on a structure that is protected as a listed building as well as a scheduled ancient monument.

The scope of the work included the full removal and replacement of the deck pavement, which has been done in two phases to allow it to be kept open for public access throughout. The deck had been paved with bitumen in the past, but this was not successful in keeping the water out of the structure and a damp-proof membrane is now being applied.

The masonry of the bridge was not in bad condition, says Morton, except for damage caused by the ingress of water from the deck. Repairs here will be simply removing vegetation, repointing the mortar, and pinning any stones that need holding in place.

Having the public at such close quarters is also a challenge – the contractor's site induction video not only covers health and safety issues, but also reminds staff that they should adapt their behaviour and language appropriately.

The walkway provides access along the side of the bridge, just below deck level, and the plywood hoardings have windows cut at intervals along the bridge span, letting the public see into the work zone between the bridge superstructure. The walkway is accessible every day of the week, and visitors can also book guided tours into the work zone.

The project team has been on site since September last year, with completion currently scheduled for November 2018 ■

Bridge owner: English Heritage
Statutory body: Historic England
Quantity surveyor: Press & Starkey
Architect: Mann Architects
Structural engineer: The Morton Partnership
Main contractor: Taziker Industrial
Ironwork subcontractors: Barr & Grosvenor, Topp & Co
Scaffolding subcontractor: Network Scaffolding
Deck works subcontractor: P&N Plant Civil Engineers

READY FOR TAKE OFF

Rapid developments in drone technology are expected to enable a wider range of applications in the bridge inspection field. Shekhar Scindia, David Day and Matt Bacon reveal the trials being conducted by a bridge owner in the USA

The cost of annual inspections constitutes a significant recurring expense for bridge owners and operators everywhere. In the United States alone, some estimates have placed the annual cost of bridge inspections between US$2.7 and US$3 billion. As bridges age, thorough and rigorous inspections of the aging bridge inventory can only increase in importance. The logic of the Pareto principle applies as much to bridge inspections as it does to other areas of human endeavour; 20% of the connections and details on bridge members can, on most bridges, account for 80% or more of the risk posed to the bridge structure by structural defects and deficiency. Within the limited time and shrinking budgets available for bridge inspections, inspectors cannot manually and physically inspect all parts of bridges – especially larger bridges – and still expect to do justice to all of the requirements of a bridge inspection programme.

It is in this context that the use of unmanned aerial systems or drone technology has found application in the bridge inspection arena.

Flying a caged drone avoids the camera being damaged as a result of accidental collision with steel members

UAVs have been used on the Delaware Memorial Bridges since 2015

Over the last decade, unmanned aerial vehicles equipped with high-definition cameras have started to find wider application in the visual inspection of bridges. At the same time, the capabilities they offer have also improved significantly. In the near future, UAVs that are compact enough to navigate through the framework of a bridge superstructure and those that can hover stably in front of bridge connections/details to allow for high-definition video and photography, will be readily available in the market.

UAVs allow the inspection team to focus on and spend more time on those 20% high-risk details and connections, while delegating the visual scanning of the lower risk areas on bridges to drones. This is not to say the areas perceived as presenting lower risk do not need to be subjected to a rigorous visual inspection. The video feeds and imagery of such low-risk areas that are obtained by drones can be recorded and reviewed in the office by engineers and inspectors; if new distress is observed, those areas can be manually inspected.

UAVs have been used for bridge inspections of the Delaware Memorial Bridges since 2015. These twin suspension bridges over the Delaware River connect the states of Delaware and New Jersey, and are subjected to a rigorous annual inspection programme. The Delaware River & Bay Authority is responsible for the operation, maintenance and upkeep of these two major crossings and in 2015 they engaged the services of WSP as a general engineering consultant. WSP was also tasked with conducting annual inspections of the two bridges, and in 2015, the firm engaged the services of UAV specialist Keystone Aerial Surveys as subconsultant-subcontractor to assist with the application of UAVs in the annual bridge inspection programme. Keystone has more than 50 years of experience in manned and unmanned flight operations for mapping, inspection, GIS and remote sensing.

One of the principal objectives of the application of UAVs and UAS technology to the DRBA's bridge inspection programme has, from the very beginning, been that applying this technology in the inspection programme should not result in a dilution of the rigour, thoroughness, and diligence that is expected of an annual bridge inspection effort.

The preparatory effort required to initiate the drone inspection component of the programme involved obtaining the necessary clearances and permits from the FAA, informing local airports, and convincing stakeholders of the value of the proposition to deploy drones as part of the bridge inspection programme. This effort itself took about six to eight months, however the effort was well worth it since it meant that further trials and inspections could proceed with little or no regulatory hurdles.

To date, UAV-enabled inspections have been performed on the suspension bridge towers, main cables, suspender ropes, the steel superstructure as well as the anchorages and piers. Some of the flights performed by UAVs have helped the engineers see nooks and corners of the bridges – whether that be on the tall vertical faces of the steel towers, or on the framing of the superstructure – that had been at best difficult to access or at worst, inaccessible without a concerted effort to erect special and expensive scaffolds to view and inspect those details.

Following three successive years of using UAVs in the inspection programme, the team has attempted increasingly complex exercises, including flying caged UAVs between the tight spaces of the superstructure; viewing live feeds from drone mounted cameras on smart glasses worn by inspectors on the ground; 3D point cloud mapping of the massive bridge anchorages; and semi-autonomous and autonomous flights designed for routine safety checks on suspender ropes and bridge bearings.

The intention of these progressively more complex exercises is to gain a good understanding of the true capabilities of the UAVs being used, to closely review the quality of the deliverables – video recordings and still imagery – provided by the drones, and to develop the right tools and procedures to eventually bring this technology to a state where it is accepted as a routine, yet valuable, component of the annual bridge inspection effort.

The solutions trialled for the inspections were tailored to suit the requirements of specific inspection tasks. For instance, flying a caged drone between the steel elements of the superstructure prevents damage being caused to the camera by the drone accidentally bumping into steel members. Live feeds sent by drone-mounted video cameras straight into smart glasses worn by inspectors on the ground provide the potential of safely inspecting a damaged component of a structure without the need to put inspection personnel in harm's way. Three-dimensional point cloud mapping helps bridge owner agencies build accurate 3D models of entire bridge structures, while semi-autonomous and autonomous UAV flights offer the promise of routine, automated drone flights to check the safety and stability of critical components of bridge structures such as suspender ropes on suspension bridges.

Stepping through these numerous trials has not been without its challenges. Caged drones used for inspections within the framing of the steel superstructure were observed to lack adequate stability to provide high-quality deliverables. The live video feeds from drone-mounted cameras, while clear and rich in detail, could only be obtained for limited time intervals due to the battery life of the small drones being eight minutes or less. The 3D point cloud mapping of massive anchorages at the ends of suspended spans contained parts that were not as detail-rich as the rest of the structure, and the semi-autonomous and autonomous flights delivered images taken from locations that, due to wind and UAV instability, varied slightly from programmed flight-path locations.

Each trial inspection has fed into further development for the technology

Nevertheless, in the aftermath of every trial, the inspection team has learned something new that will help with further development of this technology. For instance, the inspection team now knows that the next caged-drone flights within the superstructure framing will need a compact, yet far more powerful UAV. The variation in accuracy of the deliverables from autonomous and semi-autonomous UAV flights points to the need for better GPS connectivity or even a special, localised GPS network requirement for autonomous inspections. Great wireless connectivity between the UAV and the ground operator, combined with strong GPS signal strength, can make a vast difference in the degree of success achieved from a UAV inspection. A compact yet powerful drone – one that can hover stably even in moderately windy conditions – can significantly improve outcomes for UAV-enabled inspections.

Although some of the features that could help deliver great outcomes from UAV-enabled inspections are beginning to emerge in the market, benefits such as autonomy and change detection in site conditions can be applied right now. The cost of UAVs, cameras, and the associated devices that will help deliver such outcomes, is expected to rapidly drop over the next few years. High-quality live video feeds sent from UAVs directly to an engineer or a bridge inspector's smart glasses, while simultaneously also being recorded for future viewing, present the one area of greatest promise in this field.

Various improvements to technology should assist in delivering better outcomes, if and when they come on stream. These include longer battery life; robust sense-and-avoid technology so that the drone can automatically avoid obstacles; advance flight planning to facilitate autonomous flight; and machine learning onboard the drone to autonomously spot possible issues.

The DRBA bridge engineering team plans to continue working with its consultants and specialists on further development of this technology, to ensure that UAVs make further inroads into bridge inspections

Shekhar Scindia is project engineer at the Delaware River & Bay Authority; David Day is executive vice president of Keystone Aerial Surveys; Matt Bacon is bridge inspection manager for WSP

STAYING DRY

The old Cayirhan Bridge with the building site for the new double bridge with tunnel connections on the right. *(Maurer)*

Inset: the sliding isolation bearing before delivery to Turkey. The rubber ring protects the bearing against intrusion of dirt particles in case of inundation *(Maurer).*

Design of a new bridge on a highway in Turkey has had to address the fact that the piers of the structure will periodically be submerged in water

The new Cayirhan Bridge will carry highway traffic across the upper end of the Sariyar Reservoir west of Ankara, and incorporates large sliding isolation pendulum bearings. These have been designed to fulfill three core tasks: ensuring full functionality at any time by preventing intrusion of dirt particles, accommodation of high loads exceeding 10,000t, and enabling service and seismic movements with a corresponding reduction of horizontal forces. Specialist manufacturer Maurer has been contracted to deliver these SIP bearings as well as all other bearings for the bridge.

The new bridge is part of the expansion of the D140 Ankara-Nallihan-Yolu highway and is being built adjacent to the existing bridge at the upper end of the Sariyar reservoir. Here the River Sakarya temporarily becomes a lake at times, due to water backing up in the reservoir.

The new crossing will consist of twin bridges, each 270m long and with a width of 13.5m. From each foundation, two concrete struts extend upwards on an incline to form a pedestal shaped like an inclined triangle. The central part of the bearing system is large sliding isolation pendulum bearings at the base, and these must be designed to cope with occasionally being under water. In addition, flat sliding pendulum bearings are installed in the struts, and spherical bearings at the two abutments.

The framework conditions for the sliding isolation pendulum bearings at the base points of the Cayirhan Bridge are defined by three aspects: flooding, earthquake risk and high structural load.

For the earthquake load case, a structural load of 45MN had to be considered and 101MN for the ultimate load case.

To protect these bearings against pollution in case of inundation, they have been equipped with a sophisticated circumferential protection ring made of 10mm-thick special chloroprene rubber. The rubber protection is a custom-built component produced by a company that manufactures similar movable and watertight sheaths for use in ports. The rubber ring features a curvature ensuring the mobility of the bearing.

Inundation also imposes special requirements on corrosion protection, since running water always carries small sand particles which can damage the corrosion protection. This is why all bearing components not protected by the rubber sheathing have been manufactured in stainless steel. The selected steel features the same solidity and load capacity but is corrosion-resistant.

The SIP bearings are designed to enable movements in all directions in case of an earthquake. Further specifications were free twisting capability of the bearings, 5.5% friction and a 3.5m radius.

This resulted in very large bearings with a diameter of 1.9m, capable of accommodating the ultimate load of 101MN.

The Maurer sliding isolation pendulum fulfills four tasks in the event of an earthquake: transferring vertical loads of up to 56MN, isolating the bridge deck from the foundation and allowing horizontal displacements of ±157mm; they dissipate seismic energy through friction and they return the bridge superstructure to the central position after an earthquake, thanks to the concave, curved sliding plate.

The single-sided movable sliding pendulum bearings contain a calotte as a tilting element with the upper surface slightly curved. This calotte is manufactured from Maurer Sliding Alloy - a particularly corrosion-resistant metal alloy developed by Maurer. In the event of bridge movements, this calotte slides horizontally in the concave sliding plate with a pendulum motion, and by this means, the bearing automatically returns to the centre in an earthquake by storing potential energy.

The sliding friction of 5.5% acts as a brake and ensures that the projected seismic movements of the superstructure are not exceeded. This horizontally-flexible bearing function enables the horizontal seismic loads to be reduced by a factor of approximately four, compared with a rigid retention.

Eight sliding isolation pendulum bearings have been installed, two at each base point. Due to the ultimate load, they have all been designed for a bearing load of 101.8kN.

In addition, the bearing system includes flat sliding bearings and spherical bearings. Neither of these will be subjected to inundation.

The eight flat sliding bearings allow for horizontal displacements on all sides and consist of a polyethylene disc of Maurer Sliding Material against a polished stainless steel sheet. They will be installed at the outer struts, halfway up; they are designed for a structural load of 36,690kN and are about 1m in diameter.

A special construction feature protects the bridge against uplift forces. The bridge deck is connected to the abutment via a concrete cantilever, and the abutment encircles the cantilever like a claw.

Both above and below the bridge cantilever, a spherical bearing is installed at each location. A total of 16 bearings accommodate the traction and pressure forces that are predicted – they are each designed with a capacity of 21,654kN. In addition, they compensate for displacements of the bridge deck by means of an inner calotte.

The large sliding isolation pendulums were installed earlier this year, and the installation of the other bearings will follow, depending on construction progress, over the remainder of the year. The Cayirhan Bridge and the associated tunnel construction is scheduled to be completed in spring 2019. Building contractor is the regional highway direction section 4 Ankara ■

ALL-IN-ONE PLATFORM FOR MACHINE CONTROL

An all-in-one machine control platform that combines intuitive hardware and software has been launched for the heavy construction industry to increase productivity and accuracy.

The all-in-one machine control platform enables multiple machines to be controlled during construction operations via a single panel and docking station.

The MCP80 control platform automates the process of managing a fleet of machines and helps the operator during their operation. The control unit automatically positions tools such as bucket, blade or drill bit, to help dig, grade or drill guides, all to the required design and with high accuracy. Whilst the unit is in operation, all data regarding the work is displayed on a large screen on the panel.

The MCP80 control unit runs the common software platform Leica MC1, which acts as the interface across Leica Geosystems' 3D machine-control software portfolio, and which is interchangeable between several heavy-construction machines. With one panel and one software for all 3D applications, as well as common data formats, users can operate their machines on site in an intuitive way, with seamless data transfer from project start to finish.

Machine-specific data, such as calibration values and hydraulic parameters, are stored in the docking station, so users can switch from one machine to another while building complex designs with simpler workflows and less down time.

The interchangeable, cable-free control unit comprises robust housing and connectors as well as a 20cm touchscreen with 3D and 2D simultaneous views.

Leica Geosystems
www.leica-geosystems.com

REINFORCING REWARDS OF EARLY ADOPTION OF BIM

Highly accurate quotes and estimates; quick and easy clash checks; and the creation of detailed plans are some of the benefits that have been specified by one of the first engineering consultants to provide BIM Level 2 reinforcement models to clients.

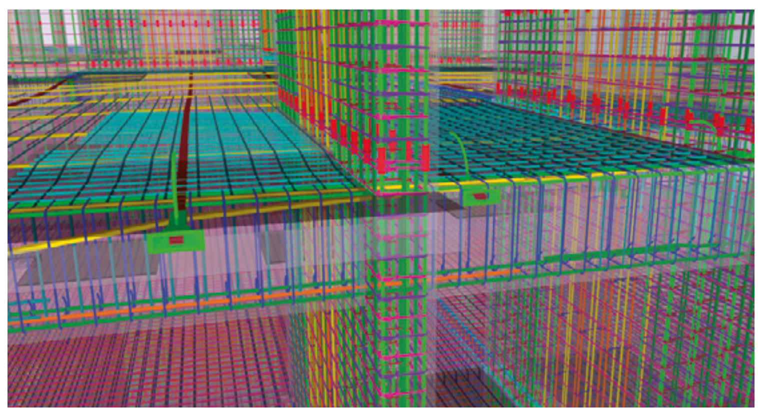
Structural and civil engineering consultancy Solve Structural Design incorporated Trimble's Tekla software into the business over 15 years ago. The company uses the 3D modelling software for the structural analysis, design and detailing of building structures, and their implementation within BIM projects.

The firm's founders saw the potential of 3D modelling over 2D software for design and detailing projects when the technology was first being introduced to the industry. A licence for Tekla Structures was purchased in 2005 and the software has since become the preferred method for everyday detailing, while the Tekla Structural Designer module is used on smaller projects. "Tekla Structures can be used throughout an entire construction project, from the tender, design and construction stage through to model sharing – which is why it is has been our software of choice for so long," said founding director Greg Johnson.

Models created with Tekla Structures contain the detailed information required for BIM and construction, including features that streamline collaboration between all parties. Tekla Structural Designer enables the efficient analysis and design of buildings.

According to Johnson, using the software has enabled the company to produce very accurate quotes at pre-construction tender stage, as it provides tonnage estimates for reinforcement. "In fact, once we have won a tender and the final detailing plans have been produced, the estimate has never been out by more than 3%," he said.

Other benefits found by the consultancy are the speed and ease with which clashes can be found at design stage, due to the software highlighting any potential problems. In addition, the visual nature of the 3D process enables typographical errors on the models to be quickly



identified and rectified immediately, which could not be done using a 2D process.

After the design stage, 3D Industry Foundation Classes models are submitted for incorporation within a project's federated BIM model, where the project information from all stakeholders is housed.

As all model sharing has been coordinated at design stage, a significant benefit follows that there are no on-site surprises. "And we are also able to spend less time cutting steel on site, as it is all done beforehand at the manufacturing plant," said Johnson.

The company also pointed out that it had not found the 3D process to be slower than the 2D, in fact just the opposite – the 3D process was much faster, and to a high quality. The consultancy is now looking forward to the introduction of new technology in the future, such as Trimble Connect and Hololens.

Trimble
www.tekla.com