

CONNAECT

THE MAGAZINE OF THE GLOBAL BBR NETWORK OF EXPERTS



ANNIVERSARY
SINCE 1944

HERITAGE & INNOVATION

Special feature celebrating BBR's 75th Anniversary

TALE OF TWO BRIDGES

Moračica & UVAC 4 bridges in Montenegro

NEW TECHNIQUE FOR STAY CABLE REPLACEMENT

Fernando Reig Bridge, Spain

WIDENING THE MOTORWAY

French motorway viaducts strengthened with BBR VT CONA CMB system

NEW ADVANCED GENERATION OF FLAT POST-TENSIONING

Optimized BBR VT CONA CMF is unique in current market place



BBR A Global Network of Experts www.bbrnetwork.com

The BBR Network is recognized as the leading group of specialized engineering contractors in the field of post-tensioning, stay cable and related construction engineering. The innovation and technical excellence, brought together in 1944 by its three Swiss founders – Antonio Brandestini, Max Birkenmaier and Mirko Robin Ros – continues, more than 75 years later, in that same ethos and enterprising style. From its Technical Headquarters and Business Development Centre in Switzerland, the BBR Network reaches out around the globe and has at its disposal some of the most talented engineers and technicians, as well as the very latest internationally approved technology.

THE GLOBAL BBR NETWORK

Within the Global BBR Network, established traditions and strong local roots are combined with the latest thinking and leading edge technology. BBR grants each local BBR Network Member access to the latest technical knowledge and resources – and facilitates the exchange of information on a broad scale and within international partnering alliances. Such global alliances and co-operations create local competitive advantages in dealing with, for example, efficient tendering, availability of specialists and specialized equipment or transfer of technical know-how.

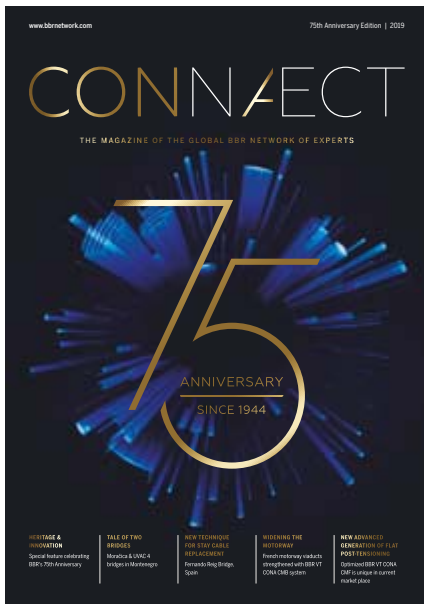
ACTIVITIES OF THE NETWORK

All BBR Network Members are well-respected within their local business communities and have built strong connections in their respective regions. They are all structured differently to suit the local market and offer a variety of construction services, in addition to the traditional core business of post-tensioning.

BBR TECHNOLOGIES & BRANDS

BBR technologies have been applied to a vast array of different structures – such as bridges, buildings, cryogenic LNG tanks, dams, marine structures, nuclear power stations, retaining walls, tanks, silos, towers, tunnels, wastewater treatment plants, water reservoirs and wind farms. The BBR™ brands and trademarks – CONA®, BBRV®, HiAm®, HiEx, DINA®, SWIF®, BBR E-Trace and CONNÆCT® – are recognized worldwide. The BBR Network has a track record of excellence and innovative approaches – with thousands of structures built using BBR technologies. While BBR's history goes back over 75 years, the BBR Network is focused on constructing the future – with professionalism, innovation and the very latest technology.

BBR VT International Ltd is the Technical Headquarters and Business Development Centre of the BBR Network located in Switzerland. The shareholders of BBR VT International Ltd are BBR Holding Ltd (Switzerland), a subsidiary of the Tectus Group (Switzerland) and KB Spennetknikk AS (Norway), a subsidiary of the KB Group (Norway).



Celebrating 75 years of BBR innovation

Welcome to the 75th Anniversary edition of CONNAECT! To mark this special occasion, you'll notice that we've made some small changes in the design of this issue – it's a BBR habit, always refreshing our approach to fit the times!

You'll also see that we've adopted innovation as the theme for this edition. In the special Heritage & Innovation feature, you will learn about structures that, in some cases, were ahead of their time – but all were made possible with BBR technology. Then in the Portfolio section, you'll find details of more recent projects – you can marvel at the elegance of the Moračica Bridge in Montenegro or at the skill of the BBR team in Malaysia as they provide specialist services for a further metro rail project. There are also many prestigious and practical building projects from all around the globe which demonstrate the expertise and teamwork capability of our PT Specialists.

The drama, as always, belongs to the stay cable bridges achieved with BBR HiAm CONA technology – the Saint Jacques Bridge in Montréal, Pulau Poh Bridge in Malaysia and the 30-year old Fernando Reig Bridge in Spain which, thanks to the talented local BBR team, now has BBR stay cable technology and a new lease of life. The BBR Network also exhibits great stewardship of the natural and the built environment through its many projects to strengthen, repair or improve structures and the landscape. Our sustainable approach ensures that aging infrastructure, precious buildings and green spaces continue to serve both people and the planet.

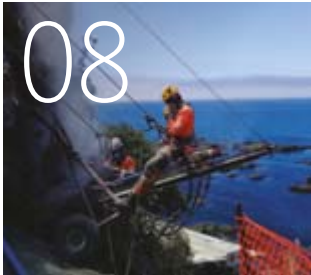
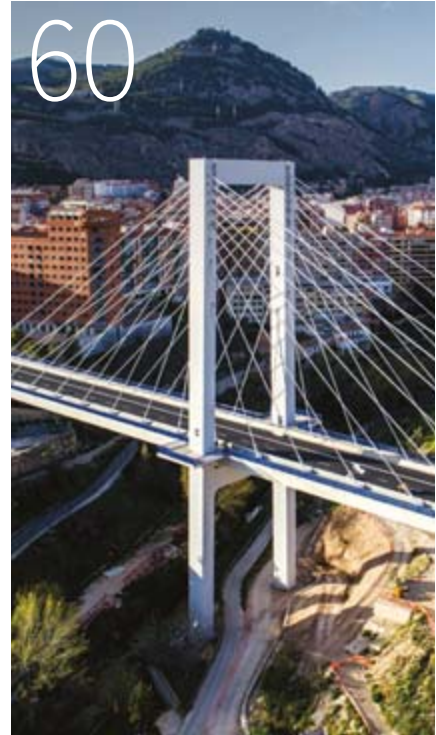
In the Technology section, we focus on the BBR VT CONA CMF S2 post-tensioning system – a new advanced generation of unbonded and bonded flat post-tensioning. You can also read about two further geotechnical bar systems – the BBR SDX Bar and the BBR WT Bar systems.

The enduring success of BBR technology and techniques is the result of the commitment and dedication of many people. Our thanks go out to all Members of the BBR Network around the globe, as well as to the team at BBR Headquarters too. At the heart of what we do are our customers, these are the people who share our vision for the finest, most flexible and durable construction technology. We thank them too – and look forward to many more opportunities to work together during the next 75 years!



Marcel Poser
Chairman, BBR VT International Ltd

José Manuel Illescas
Vice Chairman, BBR VT International Ltd



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EDITORIAL OFFICE

BBR VT International Ltd

Technical Headquarters and Business Development Centre, Switzerland

www.bbrnetwork.com

info@bbrnetwork.com

EDITOR

Jane Sandy

CONTRIBUTING EDITOR

Juan Maier

DESIGNER

Jenny Chillingworth

CONTRIBUTORS

Miguel Barbara, Jérémie Baumgartner, Derek Bilby, Paul Blundell, Cédric Brunner, Wai Hoe Chang, Haifeng Fan, Hiang Miang Goh, Peter Higgins, Tomasz Jendernal, Mathias Kaminski, Sean Kelly, Dean Latham, Dickson Liew, Juan Manuel Linero, Tomislav Lozančić, Behzad Manshadi, Adrien Marteddu, Dominic Meyer, Valentina Mihajlovic, Claude Néant, Marcel Poser, Zuhair Rawi, Thomas Richli, Cezary Sternicki, John Taraldsen, Bruno Valsangiaco, Chet Chie Voon, Xiaomeng Wang, Paul Wymer, Janelle Yeo, Rainer Zunde

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SOURCES AND REFERENCES

Front cover image: Traditionally, a 75th Anniversary is commemorated with gold or diamonds - both of which, like the BBR Network and BBR technology, are associated with quality and value. The front cover design incorporates an abstract image representing fireworks to celebrate BBR's 75th Anniversary around the globe. This lively backdrop is overlaid with gold lettering to represent both BBR's anniversary, and also the additional quality and value the BBR Network adds to the global construction industry.

Portfolio section

Creating new shapes & structures: www.e-periodica.ch, en.wikiarquitectura.com, Die Ausstellungshalle des C.N.I.T. bei Paris by H Jobst, in Schweizerische Bauzeitung No 76 (1958) Volume 44, www.vincent.callebaut.org, <http://english.dorts.gov.taipei>, www.theflorentine.net

A tale of two bridges: www.youtube.com, www.cdm.me, www.highestbridges.com, seenews.com, tunnelbuilder.com, www.crbcmne.me, Conceptual and preliminary bridges design on highway Podgorica-Mateševo – presentation by Professor Dr. Mladen Ulićević

Interchange of international relations: www.ageroute.ci, www.linodrome.com, <http://batirici.ci>, www.razel-bec.com, <https://fayat.com>

Swissness, surprise & connections: www.thecircle.ch, www.riken-yamamoto.co.jp

Speedy services to support growth: www.landolt-bau.ch, www.ittenbrechbuehl.ch, www.presseportal.ch

Making space for music: www.hslu.ch, www.srf.ch

Signature stay cables: www.turcot.transports.gouv.qc.ca, <http://montrealgazette.com>

Widening the motorway: <https://vinci-autoroutes.com>,

<https://fr.wikipedia.org>, <http://autorout.free.fr>

This paper is manufactured with 15% recycled fiber, FSC certified. All pulps used are Elemental Chlorine Free (EFC) and the manufacturing mill is accredited with the ISO14001 standard for environmental management. Vegetable based inks have been used and 85% of all waste associated with this product has been recycled.

Innovative family roots

For this 75th Anniversary edition of CONNÆCT, Bruno Valsangiacomo, Executive Chairman of the family-owned Tectus Group shares his thoughts on the successes of BBR – past, present and future.

How do present market conditions differ from when BBR was founded 75 years ago?

At the time my father-in-law, Antonio Brandestini, was setting up the business which became BBR with his partners Max Birkenmaier and Mirko Robin Roš, the Second World War was drawing to a close. It was clear that the post-war priority for the construction industry would be the rebuilding of infrastructure and industry. The application of BBR post-tensioning technology promoted the use of less concrete and reinforcing steel in structures and also allowed a new freedom in design and engineering of structures. Nowadays, we still seek optimized materials usage especially with the global need to reduce environmental impact for a more sustainable world – and BBR continues to maintain a special focus on relevant construction technologies.

Today we are confronted with a megatrend of aging infrastructure and buildings. Stakeholders have become aware of how important the monitoring and maintenance of structures has become in respect to safety, proper use and operation of infrastructure and buildings. The way of thinking is slowly and carefully adapting to a Net Present

Value (NPV) approach. It is important to calculate the NPV of each structure taking into account construction cost, maintenance and repair, continuous income and lifetime. Proper monitoring and maintenance are key for an optimal NPV of a structure. In addition, I also apply the term 'Economic Impact NPV' – especially to critical infrastructure. For example, a tunnel may cost US\$100 million to construct, then an unplanned maintenance exercise due to inadequate monitoring and inspection may last 48 hours and cost US\$0.2 million, but the fact that a critical tunnel had to be closed (in this example which did happen in the real world) costs the economy US\$1 million per hour, hence a cost of US\$48 million in Economic Impact NPV. With all the aging infrastructure and all the new global megaprojects, our industry will change radically. The BBR Network must grasp this opportunity as much economic value is at stake. A crucial issue which has been hanging over the construction sector for decades is the lack of productivity growth, which has been less than 1% annually – much lower than that achieved in other industries. When one thinks that currently construction-related spending accounts for roughly 13% of the world's GDP, it is clear that by improving efficiency and increasing productivity at the various levels will bring tremendous benefits to everyone, whether this is in the form of savings or in the form of being able to execute more projects with the same resources. Therefore, productivity growth in construction is another main driver in our industry. Also here a holistic view is vital and productivity will also include the Economic Impact NPV. It will make an enormous difference if the building of a structure can be carried out, for example, in six instead of 18 months. The construction cost may even become a negligible factor, as the disruption of a megacity may be the more relevant cost to consider.

We have a rich history of innovation and will continue to draw on this to support the global community in meeting future challenges.

BBR, in cooperation with the Tectus Group, will leverage these developments to create competitive advantage with sustainable value creation for all parties involved.

What advantages are there today?

It is not easy to develop new construction technologies and materials. Optimization of materials, equipment and human resources will be key, in addition to the optimization of an entire planning and execution exercise. Last but not least, only the integration of cost, revenues and economic impact of the lifecycle of a structure will give a completely different perspective to the stakeholders. We are now in a phase of rapid development and use of IoT, planning, monitoring and inspection technologies, visualization and predictive simulation by efficient use of Artificial Intelligence. BBR, in cooperation with the Tectus Group, will leverage these developments to create competitive advantage with sustainable value creation for all parties involved.

This is a path BBR embarked upon some years ago when it introduced BBR E-Trace – a unique-to-the-market cutting edge tool for trading, quality control and traceability management. One platform able to do all that for the entire BBR Network, this is definitely an example of how we have been front-runners in innovation and technology.

We are continuing to innovate at BBR and the Tectus Group. We have been early in starting to work on new ways on how to use the newest technology for inspection and monitoring structures which we have begun to roll out with Screening Eagle, Proceq and Tectus Dreamlab. We will also make these new technologies available to our BBR Network Members.

What do you believe makes a business successful?

You need to be curious, to have passion, to do your homework thoroughly, to ask others who may know better, to make a plan and, crucially, to take decisions and to execute with a target of optimum operational excellence. The key factor is to have the right people and to give them authority and responsibility, but also to make them accountable. Everything else is a consequence of the above – motivation, career, remuneration, satisfaction and all those things that are required to be part of a success story. Since I started to take the lead at the Tectus Group in 1993, we have tried our best to live up to the above values and I firmly believe that this has been one of the main reasons for our consistent and continued success.



What do you expect to see from BBR in the next 75 years?

There are dramatic changes coming up. In today's world, it is not a question anymore of how accurately we were able to stick to the original plan, but rather a question of how fast, how agile and how close we are able to sail to the ever-changing storms of the markets and how smart we are in leveraging the exponential disruptions that are happening all around us. Globally, we face many challenges – in how we will live, work, manage the infrastructure which has become the neural networks of our society, cope with climate change which affects everything including structures, manage environmental issues... to name just a few items. As a specialist construction technology business, we are focused on carving our own niche where we can create value and justify our price through such value creation. We have a rich history of innovation and will continue to draw on this to support the global community in meeting future challenges. There are exciting times ahead and I am looking forward to them.

Winner
ICE People's Choice
Award 2018



People, places & publications

There have been many events and activities around the BBR Network during the past year, a selection of highlights is presented here.

ICE People's Choice Award 2018

The Kaikoura Earthquake Recovery Project in New Zealand was declared the winner of the ICE People's Choice Award 2018. In November 2016, an earthquake measuring 7.8 on the Richter Scale struck New Zealand's South Island, leaving the town of Kaikoura and its neighboring communities completely cut off. The North Canterbury Transport Infrastructure Recovery (NCTIR) Alliance, representing the NZ Transport Agency and KiwiRail on behalf of government, worked speedily to reconnect railways, roads and harbor. Two BBR Network Members, SRG Global (Australia) and BBR Contech (New Zealand), were part of the large specialist construction team which was mobilized to ensure that the vital infrastructure could be reopened in only around 12 months after the disaster. BBR Contech undertook bridge repairs and, together with SRG, helped to stabilize a slip-affected site to the south of the Kaikoura township. The work involved installing self-drilling anchors, undertaking grouting and load

testing, and positioning foundation pads and a rock-fall netting system. The People's Choice Award, instigated by the Institution of Civil Engineers (ICE), celebrates the civil engineering projects that have made the most positive impact on their local communities. Read more about the project in [CONNÆCT 2018](#).

New BBR Network Members in Egypt & Turkey

In 2018, we were delighted to welcome Cairo-based ESPT to the BBR Network. The company has 150+ engineering and technical staff and specializes in post-tensioned concrete, precast concrete, tilt-up concrete, insulated concrete forms and PT design consultancy services. Meanwhile, Kappa joined the BBR Network in early 2019. It has built a reputation, from its Ankara headquarters, for bridge/viaduct construction using PT and construction methods including MSS technologies, for which it has a record-breaking 90m span MSS launching girder at its disposal. >



Award-winning achievements

Congratulations to the BBR Network teams whose work has attracted industry awards over past months!

- **Award-winning stadium in Spain:** The Wanda Metropolitano Stadium, built by FCC Construcción and featuring technology from BBR Network Member BBR PTE (part of FCC Construcción), won the award for Best Public Municipal Work 2017 in the prestigious Demarcation Awards of Madrid, presented by the College of Civil Engineers. The BBR VT CONA CMF flat system was used – for the first time in Spain – to post-tension the grandstands. (See CONNÆCT 2018 for full story.)
- **Hat-trick of awards for repair:** Congratulations to the Asset Services team at SRG Global – the BBR Network Member for Australia – who bagged three Australasian Concrete Repair Association Awards. They won Best Overall Project and Best Heritage Project for the Palais Theatre (see CONNÆCT 2018), plus Best Infrastructure Project for bridge strengthening works on the Monash Freeway (see CONNÆCT 2017).
- **Innovative project attracts prize:** SRG Global's Newcastle Road Bridge Refurbishment project in Northam, Western Australia has won the Civil Contractors Federation WA Earth Award for Category 2 (projects valued at A\$2m to A\$5m). A key innovation on this project was the design and commissioning of two bespoke temporary works jacking frames to lift complete sections of the bridge deck, removing the need to construct a conventional causeway beneath.
- **Two awards for Mersey Gateway Bridge:** This is the UK's only long-span cable-supported bridge constructed primarily using in-situ concrete, post-tensioned with the BBR VT CONA CMI internal system. The structure was declared Outright Winner of the 2018 Concrete Society Awards and also scooped the Infrastructure Award at the RICS Awards 2018.



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PT Design & Construction Seminar – New Zealand

The PT Design & Construction Seminar in Auckland was a massive success. Some 50+ delegates from right across the NZ construction industry participated in the event which was focused on exploiting the benefits of post-tensioned concrete to offer resistance against seismic effects. The two day seminar – which offered an additional day for a hands-on computer workshop session – was jointly delivered by BBR and Adapt Corporation. Hosts for the event were Concrete NZ, supported by the NZ Society for Earthquake Engineering (NZSEE) & Structural Engineering Society NZ (SESOC). This was a great opportunity to get both BBR technology and techniques in front of people who can influence BBR Network business.

BBR European Project Managers' Workshop

This three-day event, held in Podgorica, Montenegro, offered basic and advanced training on the BBR VT CONA CMX post-tensioning and BBR CONA HiAm stay cable technologies for delegates from within the BBR Network. The session also covered updates on latest developments including BBR VT CONA CMM, CONA CMF and the new CONA CME with monostrand, alongside the BBR geotechnical bar and ground anchor ranges and details of latest features within BBR's own Factory Production Control system, BBR E-Trace. Highlights included presentations from three guest speakers, plus a visit to the Moračica Bridge site where delegates were able not only to see how such a major project is managed, but also had the opportunity to go to the top of one of the bridge piers.

Multi-media marketing

The past 12 months have seen the creation and launch of a whole raft of marketing communications and educational tools. Among the items is a new BBR Network Technical Series video about the BBR VT CONA CMM post-tensioning system and applications which has been uploaded to the BBR Network YouTube channel. A major highlight of the video is that this versatile range of monostrand systems – CONA CMM Single, Two and Four – includes enhanced features designed to accelerate installation, offering potential materials, time and cost savings. In addition, two new brochures have been produced – to support the introduction of the BBR Bar Family – about the BBR SDX Bar System and the BBR WT Bar System. See also page 85, in the Technology section, for more information about both systems. Last but not least, extra special efforts have been made to increase awareness of both the BBR Network and BBR technology via posts on the BBR Network LinkedIn page. Overall, this has resulted in an almost 300% increase in the number of ‘followers’ and is proving to be a successful way of creating interest in BBR Network activities and achievements.

BBR Network logistics centers go live

The BBR Network global supply chain service has been significantly extended with the opening of BBR Network logistic centers in Europe and Asia. Operated by BBR VT International, the logistic centers offer a wide range of benefits including:

- Reduced freight & customs clearance effort/costs with one-stop-shop approach.
- Ready-to-use components without additional incoming inspections.
- Lower inventory requirements leading to lower working capital needs.
- Reduced production & delivery lead-time.

All of the above will certainly offer greater competitive advantages to BBR Network Members.

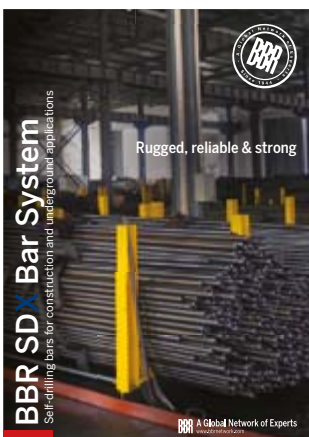
Conferences & exhibitions

Every year, the BBR Network attends many conferences and exhibitions around the globe. The major events attended in 2018 included the 5th International *fib* Congress, Australia and IABSE Conferences in France, Malaysia and Denmark. Each of the occasions provided many opportunities to renew old acquaintances, as well as to forge new relationships.

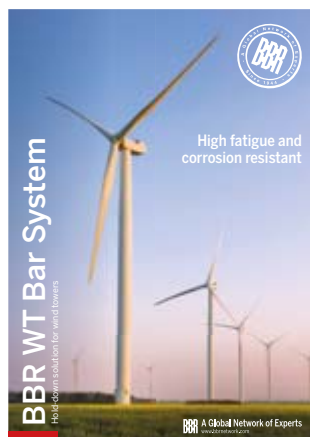
- 1 BBR Network Members SRG Global (Australia) and BBR Contech (New Zealand) were part of the team which worked on the award-winning Kaikoura Earthquake Recovery Project in New Zealand.
- 2 Cairo, Egypt – the home base of ESPT, one of two new BBR Network Members and leading providers of specialist contracting and construction engineering.
- 3 Wanda Metropolitan Stadium, built by FCC Construcción and featuring technology from the BBR Network.
- 4 The SRG Global team display the award for their work on the Newcastle Road Bridge Refurbishment project.
- 5 Representatives from the Asset Services team at SRG Global, the BBR Network Member for Australia, who won three Australasian Concrete Repair Association Awards for their projects.
- 6 The many marketing communications and educational tools recently produced include a new BBR Network Technical Series video on the BBR VT CONA CMM post-tensioning system and brochures on the BBR WT Bar System and the BBR SDX Bar System.
- 7 Delegates attending the BBR European Project Manager’s Workshop in Montenegro had the opportunity to visit the Moračica Bridge site.
- 8 Among the many industry events attended by the BBR Network was the IABSE Conference 2018 in Kuala Lumpur, Malaysia. Here, BBR Construction Systems (Malaysia) – who also gave a conference presentation on the Pulau Poh Bridge – were supported by BBR Headquarters in hosting an exhibition booth.



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Global BBR Conference 2018 goes to

Hong Kong

In March 2018, delegates from around the BBR Network arrived in Hong Kong for the Annual Global BBR Conference.



BBR VT International's former CEO, now CTO of Tectus Group, Antonio Caballero presents Mrs Nancy Tsang, CEO of the Hong Heep Society with a check for HK\$180,000. The Hong Heep Society is a locally based, registered charity which, for over 50 years has been providing professional training and education to young people of different abilities and their families, with the mission of helping them develop their potential and lead fulfilling lives. The Society's work includes helping children with special educational needs and, through support services in schools of all types, they help students to integrate better into mainstream education.



The **CONNÆCT 2018 Best Article Award** was accepted by Dickson Liew on behalf of BBR Construction Systems (Singapore) Limited for their article about the Eunoia Junior School. The article describes how – through involvement right from the design stage – This BBR Network Member is contributing to the realization of a unique and sustainable community-focused complex.

The **CONNÆCT 2018 Best Photography Award** was accepted by Claude Néant on behalf of French BBR Network Member ETIC for the illustration of their article about the precast segmental construction of the viaduct section of the Rennes Metro Line b. The images chosen successfully captured the grand scale of this project, as well as key stages of the work.



Paul Wymer of BBR Contech accepts the **BBR Project of the Year Award** for construction of the post-tensioned ground slab for the James Pascoe Distribution Center in Auckland New Zealand. During this project, the team demonstrated their extensive technical knowledge and experience of slab-on-ground techniques, as well as their passion for customer service.



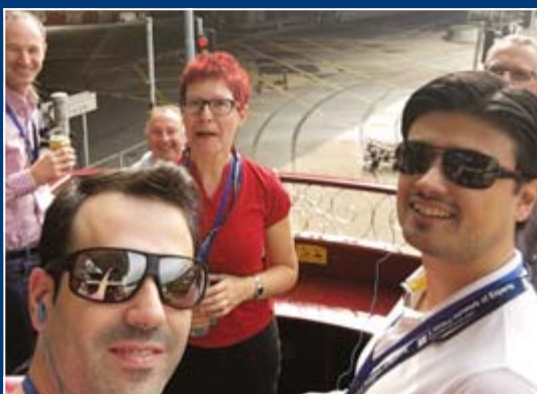
After the welcoming messages from BBR VT International CEO Antonio Caballero, Juan Maier, Cezary Sternicki, Xiaomeng Wang, Josef Lamprecht, Behzad Manshadi from BBR HQ presented latest news from BBR HQ, including details of BBR's extended product portfolio which now includes PT bars. Delegates enjoyed special presentations by Hotman Sianipar, CEO of BBR Network Member PCI and also a joint presentation about the Rennes Metro Viaduct project by Jérémie Baumgartner of French BBR Network Member ETIC and Mathias Kaminski of ETIC/Eiffage. There were discussions about construction trends and, of course, many opportunities for networking among Members.



As part of the 2018 Global BBR Conference's cultural activities, BBR Network delegates took in stunning views of Lantau Island while traveling by cable car to Ngong Ping village.

While at the village, they visited the imposing Buddhist Po Lin Monastery which founded in 1906 and now serves as an important center of worship and devotion.

Above the Po Lin Monastery with its gleaming gateway sits the famous 34m tall Tian Tian Buddha – also known as 'Big Buddha' – completed in 1993. BBR Network Members who embraced the challenge of ascending the 268 steps to the top enjoyed not only close-up views of the Buddha, but also sweeping panoramas across both land and sea.



Daniel Cuervo, Business Development Manager at BBR VT International Ltd, tries his hand at taking a selfie while on a vintage trolley bus tour of Hong Kong. Also in the picture are (left to right) Derek Bilby, Paul Wymer (both from New Zealand-based BBR Contech), Cecile Kopp, BBR VT International Ltd's Administrative & Senior Accounting Assistant (who organized the Conference), Juan Maier, formerly BBR VT International's Head of Business Development and now CEO, and Michael Lawson, also of BBR Contech.

2018 BBR Award Winners



BBR PROJECT OF THE YEAR 2018

James Pascoe Distribution Center, New Zealand – world leading super-flat PT warehouse floor by BBR Contech



BBR CONNÆCT BEST ARTICLE AWARD

Winner: BBR Construction Systems (Singapore)
Title: Innovation for new technology (Eunoia Junior College)

Runner up: BBR Construction Systems Malaysia
Title: Versatile options for bridge construction (Pulau Sekati Bridge)

Highly commended: ETIC (France)
Title: Fine art meets construction (Aquatic Center, Sainte-Nazaire)



BBR CONNÆCT BEST PHOTOGRAPHY AWARD

Joint Winner: BBR Polska (Poland)
Title: Bridge for patriotic pondering (Ostroda Bridge)

Joint Winner: ETIC (France)
Title: Momentum and rhythm (Rennes Metro Viaduct)

Highly commended: BBR Contech (New Zealand)
Title: World leading PT floor (James Pascoe Distribution Center, Auckland)

More about BBR Project of the Year







YEARS OF

HERITAGE & INNOVATION

This year, BBR celebrates the 75th Anniversary of its founding and can reflect on a rich history based on innovation and a practical yet pioneering approach to the creation of effective construction technology. Over the next few pages, we take a step back in time and look again at some of the developments, projects and stories that have set the stage for the future of the BBR Network.

The story of how three exceptional engineers – Max Birkenmaier, Antonio Brandestini and Mirko Robin Roš – worked together to develop more efficient construction technology and methods is now well-known. Together they built a construction engineering practice that has proved to be as successful and as durable as the technology it provides.

The arrival of BBR technology heralded a new era for construction where structural forms that could previously only be imagined were now achievable. In fact, many structures owe their very existence to BBR post-tensioning technology which made their creation possible. Other BBR publications show details of many of our projects, so for this special 75th Anniversary edition of CONNÆCT we offer some reminders of a few BBR 'world firsts' – including some that readers might have previously missed!

1999

WORLD'S LONGEST CABLE-STAYED BRIDGE MAIN SPAN

Tatara Bridge in Japan was celebrated for having the longest cable-stayed main span in the world when it opened and set a global technological benchmark for long stay cable bridges. It features 84 BBR stay cables installed in a two-lane multi-fan configuration which support the 890m main span of the bridge.

Creating new shapes & structures

Today, the BBR Network portfolio features over 400 cable-stayed projects spanning not only many landscapes, but also more than 60 years of experience in the development and application of stay cable technology.

While BBR pioneered wire stay cables (1958), strand stay cables (1968) and carbon stay cables (1994), as the years have passed, many of our stay cable structures have now become national treasures and some are even tourist destinations in their own right.

In recent years, for example, the very first BBR stay cable project has become a heritage-listed structure. The Schillersteg – now known as the Ferdinand-Leitner-Steg – in Stuttgart, Germany has been officially listed as a national monument. This footbridge, built between 1958 and 1961, as a link between two major sections of the 1961 German Federal Garden Show, has more recently received some maintenance and upgrading. Over five decades after their installation, the BBR stay cables were found to be continuing to perform well – only the pavements and handrails required remedial work.



2

2005

WORLD'S LONGEST FREE SPAN & CURVED STAY CABLE BRIDGE

The Langkawi Skybridge was created high in the mountains as part of a nature trail walk. The bridge features a curved deck of triangular truss section spanning between two triangular platforms which are secured to the landscape by ground anchors. The 81.5m high pylon supports the whole structural system of the deck by means of eight BBR CONA stay cables anchored to the deck structure. The pylon is balanced by two back stay cables connected to concrete back stay boxes. Construction work was logistically challenging as the only way to transport the major construction components to the site was by helicopter. The seven pylon segments each had to be fixed into position within a tight timeframe because the helicopter could only hover for 30 minutes without risk of overheating.



3

1986-88

^ WORLD'S LONGEST CABLE-STAYED PEDESTRIAN SWING BRIDGE

Around 30 years after the first application of wire stay cables in Stuttgart, Germany, BBR technology was being applied to yet another project connected with a horticultural exhibition. The construction of Bell's Bridge was underway, across Scotland's River Clyde for the Glasgow Garden Festival. The bridge allowed pedestrians to cross from the main exhibition site to the Scottish Exhibition & Conference Centre on the other bank of the river. Built in three spans, the northern span rests on the quay and a pier in the river, while the other two cable-stayed spans can pivot to allow tall river traffic to pass. Anchored at the tapered pylon, the 12 BBR HiAm stay cables radiate outwards towards the bridge deck.

2002

^ WORLD'S LARGEST ASYMMETRICAL CABLE-STAYED BRIDGE

The Rama VIII Bridge in Thailand was one of the world's largest asymmetrical cable-stayed bridges at the time of its completion. It features 56 wedge-anchored BBR HiAm strand stay cables arranged in two planes in a semi-fan configuration, to support the 300m long main span, while another 28 stay cables arranged in a single plane with a near-harp configuration connect the tower to the median of the anchor span. In the foreground, to the right, is the Bangkok Industrial Ring Road which was completed in 2006 – this also features BBR technology and techniques. The BBR Network installed post-tensioning and carried out design, fabrication and operated the movable scaffolding formwork for the approach structure leading to the main river crossing and also the interchange area.



4

1972-78

> WORLD'S FIRST EARTH-ANCHORED CABLE-STAYED BRIDGE

Stay cables for the award-winning Indiano Bridge over the Arno River in Florence, Italy were installed over 40 years ago. It is a distinctive bridge – with an underslung pedestrian walkway – which features a 206m long main span supported by 28 BBR stay cables. The stays are arranged in a fan configuration and anchored at the top of two 45m high backwards inclined pylons. The lower anchorages of the back stays transmit both vertical and horizontal forces from the stay cables into the ground – hence the expression 'earth-anchored'. The Italian engineering innovation behind the bridge's structural design came from Professor Fabrizio de Miranda. The bridge was named to honor the 21-year old Maharajah of Kohlhapur who, in 1870, went to Florence for a cultural visit, but sadly died soon after his arrival. According to Hindu tradition, his ashes were scattered where two rivers meet – and this is where the Indiano Bridge now stands.



5



6

1969-72

< WORLD'S FIRST PARALLEL WIRE STAY CABLE BRIDGE

Having created Stuttgart's Ferdinand-Leitner-Steg in collaboration with leading engineers Fritz Leonhardt and Wolfhart Andrä, the relationship with BBR continued and resulted in an imposing stay cable bridge across the River Rhine between Mannheim and Ludwigshafen. This time, the enterprising team pioneered the use of stay cables consisting of parallel wire bundles – the first use of the BBR HiAm stay cable system. The bridge has 36 stay cables with their upper anchorages on the single 71.5m high A-shaped pylon. The lower anchorages are placed on the bridge deck, either side of the double tram tracks in the middle of the highway.

The further evolution of BBR technology has seen the creation of many further ground-breaking structures, such as the cable-net supported roof of the 1972 Olympic Stadium in Munich, Germany and the cable-stayed Sydney Tower in 1981, both of which have become cultural icons while still serving their original purpose. The constant focus on R&D and technology development at BBR Headquarters in Switzerland means that the BBR Network continues to lead the way in both stay cable technology and techniques for its application.

Flashback to the Fifties

The 1950s were a formative time for BBR and indeed the whole construction industry. As the Jet Age gave way to the Space Age, people's aspirations for greater mobility and opportunities resulted in the creation of exciting new infrastructure. The benefits of using BBR post-tensioning technology for the speed of construction and lower volumes of materials required, made it a popular choice.

BBR's three founders recognized that the widespread use of post-tensioned concrete would be limited unless a reliable form of anchorage could be developed. A collaboration with wire producer Karl Vogt resulted in the BBRV cold-formed button-headed anchorage which made BBR post-tensioning the highest load bearing capacity system on the market at that time. This new anchorage, patented in 1950, had a huge impact on the direction of the business and by September 1954, the list of projects carried out using BBR technology included 36 road or pedestrian bridges and three railway bridges, while a further eight bridges were under construction.

1955-58

✓ FIRST STREAMLINED STRUCTURE

The opening to traffic of the Andelfingen Viaduct – officially known as the Weinland Bridge – was a major milestone for both BBR and, indeed, the bridge and structural engineering community. This was the first time that the BBR system had been applied to a long span bridge project and the first time that 1,250kN capacity post-tensioning tendons had been used. Construction of the bridge began in 1955 and three years later, when it was completed, the knowledge gained was used to drive both the wider use of post-tensioning and also to support the growing demand for highways infrastructure. The realization of this project brought together some of the finest engineering minds of the time who not only completed much technical analysis, testing and planning, but also delivered a streamlined structure, the like of which had never been seen before.



1954

✓ PROTOTYPE PLATFORM ROOF

Many early projects using BBR technology were completed for the SBB (Swiss Federal Railways) – including Zurich's Hardturm Viaduct and the Galgentobel Viaduct in St Gallen. However, the iconic 'flying roof' structures for the platforms at Winterthur-Grüze station, created as a prototype project for SBB, are less well known. They were the brainchild of engineer Hans Hilfiker, who was then working for SBB and who is best known for his design of the now internationally famous Swiss railway clock with its red baton-shaped second hand.

The 90m long cantilevering platform roofs were designed with a single central longitudinal steel beam, with 30 pairs of prefabricated prestressed concrete roof panels and resting as a gravity structure on three pillars. As the prestressed reinforcement was concentrated in a wide-meshed ribbed grid, large areas within the roof panels remained free of reinforcement, thus allowing the panels to be produced with only a 30mm thickness. The roof panels were produced using BBRV post-tensioning in the Stahlton factory, delivered to site by a special train and erected with the help of a rail-mounted crane, during night-time closures of the tracks. Today, the platform roofs have been listed for protection as historic monuments.

1958

> WORLD'S LARGEST SELF-SUPPORTING REINFORCED CONCRETE VAULTED ROOF

When it opened in 1958, the CNIT (Centre National des Industries et Techniques) in Paris was celebrated for having the world's largest and highest self-supporting reinforced concrete vaulted roof. The roof, designed by Nicolas Esquillan and created using BBR post-tensioning, stands 43.6m above the ground at its highest point and has a surface area of 22,500m². Inside the structure, there is over 101,460m² of completely column-free space.

The 60mm thick concrete shell roof structure arches between three points on the ground which form an equilateral triangle with 218m sides. The roof consists of a double reinforced concrete shell with a gap of 1.8m between the layers. The shell elements are double-curved and connected by full webs. The loads from the roof shell are taken up by BBRV band tendons, formed using around 300t of prestressing steel, which are anchored at the three massive 12m deep foundations. Now classified as an historic monument, CNIT has been the subject of several interior refurbishment programs – meanwhile, its unique shell roof has remained unchanged for over 60 years.





9

Many early structures featuring BBR technology are still performing their original function, others have been adapted to reflect changed usage – and some have even been singled out for conservation under local heritage regulations. With each passing year, the BBR Network is creating new landmark projects – using the latest, most up-to-date, BBR technology – and these too may one day be valued as precious monuments in their local landscapes.



10

- 1 Tataru Bridge, Japan – the bridge had the world's longest cable-stayed main span at the time of its completion.
- 2 Langkawi Skybridge, Malaysia – the world's longest free span & curved stay cable bridge.
- 3 Bell's Bridge, Glasgow, Scotland – the world's longest cable-stayed pedestrian swing bridge.
- 4 The Rama VIII Bridge (left) and Industrial Ring Road (IRR) in Bangkok, Thailand. Rama VIII Bridge was one of the world's largest asymmetrical cable-stayed bridges when completed.
- 5 Indiano Bridge, Florence, Italy – the world's first earth-anchored cable-stayed bridge.
- 6 Kurt-Schumacher Bridge, Mannheim, Germany – the world's first parallel wire stay cable bridge.
- 7 The Weinland Bridge, or Andelfingen Viaduct, featuring BBR's then new high capacity PT tendons, was a major milestone for both BBR and the bridge and structural engineering community. Image courtesy of ETH-Bibliothek Zürich, Bildarchiv. Photograph by Comet Photo AG (Zürich), Com_F64-04106, licensed under CC BY-SA 4.0.
- 8 The station platforms at Winterthur-Grüze railway station today with their 'flying roofs'. Photograph by Friedrich Engesser, reproduced by kind permission.
- 9 The CNIT in Paris, France for which the world's largest and highest self-supporting reinforced concrete vaulted roof was created using BBR post-tensioning.
- 10 Hall 7, Basel Mustermesse Exhibition Complex, Switzerland (1957-58): The new exhibition hall, now repurposed as the Musical Theatre Basel, was constructed to a very tight program and featured BBRV post-tensioning in the construction of its distinctive saw-tooth roof structure and also in a spiral staircase and pedestrian overbridge connecting Hall 7 to Hall 6. Photographs, reproduced by kind permission, are copyright of Musical Theatre Basel (www.musical.ch).

Moračica & UVAC 4 Bridges, Republic of Montenegro

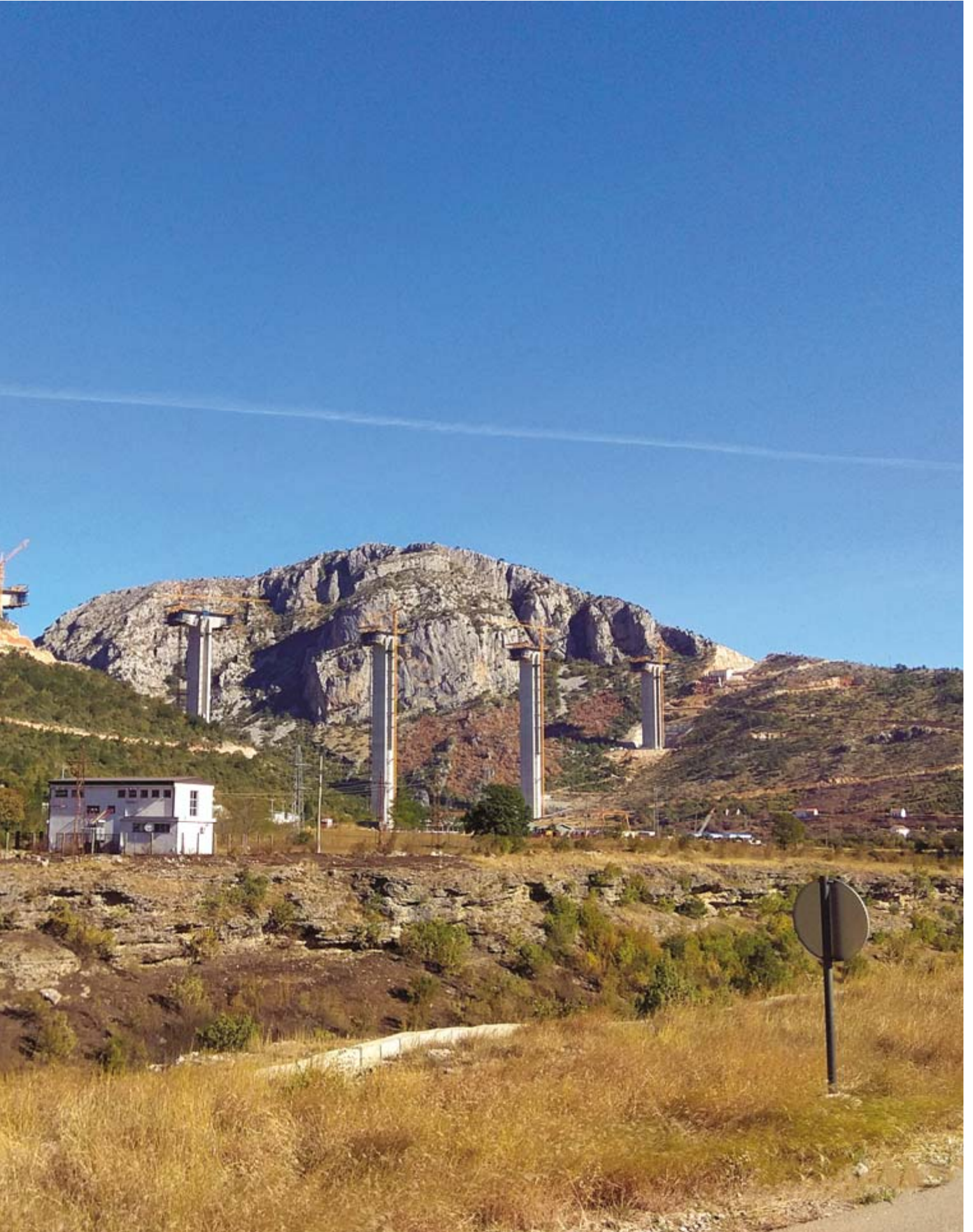
Cantilever bridge construction across valleys

Tale of two bridges

Construction of two bridges, including the tallest bridge in the former Yugoslavia region, is underway as part of a €809.6m new highway route in the Republic of Montenegro and BBR Adria is contributing both technology and expertise to the projects. Tomislav Lozančić takes us on a journey to explore the projects which are progressing well despite the challenging local landscape. >

Moračica Bridge – five piers have been constructed to carry the 960m long bridge deck.







1

The Moračica and UVAC 4 Bridges are part of the huge almost 170km-long Bar-Boljare infrastructure scheme known as pan-European Corridor XI which will provide a ferry and motorway corridor linking the port of Bari in Italy to Bucharest in Romania, via the port of Bar in Montenegro and Belgrade, in Serbia. The terrain is particularly mountainous and structures on the route will include 42 tunnels, plus 92 bridges and viaducts. A priority for the scheme is minimizing environmental impact, hence much of the route is carried on bridges or through tunnels.

Priority section

The highlight of the 42.4km long Smokovac to Mateševo section of the Bar-Boljare highway will be the elegant and impressive Moračica Bridge. This part of the scheme will run between Podgorica and Kolasin and is expected to reduce driving time by two-thirds between the two cities. On this section alone there will be around 14km of tunnels, 4km of viaducts and 14 bridges. The Smokovac to Mateševo section is being constructed ahead of the remainder of the scheme.

The Government of Montenegro, in the form of the Ministry of Transportation and Maritime Affairs, is leading the project and China Road & Bridge Corporation are the scheme's main design and build contractors.

FACTS & FIGURES MORAČICA BRIDGE

LENGTH

960m

NO. OF PIERS

5

TALLEST PIER

180m

WHOLE SCHEME

TOTAL COST

€809.6m

TOTAL LENGTH

170km

NO. OF TUNNELS

42

NO. OF BRIDGES & VIADUCT

92



2

Design considerations

Conceptual and preliminary design for the bridges on the Smokovac to Mateševo highway section was carried out by the Faculty of Civil Engineering at the University of Montenegro, led by Professor Dr. Mladen Ulićević. The main design aims were to:

- Emphasize rationality to obtain the best relationship between price and quality.
- Reduce construction costs through a greater degree of standardization.
- Minimize disruption of the natural environment by the construction of new bridges.
- Consider feasibility of using potential domestic contractors and the application of available technology.
- Deliver increased durability criteria in severe climate conditions at high altitudes.

This resulted in the evolution of a concept for an integral bridge structure with no bearings on the piers, greater values of concrete cover with no cracks – offering higher structural durability and low maintenance costs. The shallow span structure promotes reduced friction losses for post-tensioning tendons, simple formwork and reinforcement, easy installation and lessened visual impact on the landscape. Meanwhile, the ultra-slender rounded rectangular columns soften the view and offer a certain transparent quality when looked upon from the side.



3



4



5

The realization of the whole route is expected to create a new gateway for the future prosperity not only of Montenegro, but also for the whole of the Balkan region.

1 Moračica Bridge overview

The Moračica Bridge spans the main Podgorica–Kolasin road, the Moraca River and the Moračica Plateau, after which the bridge is named. It has been described as the most challenging structure of the project.

The 960m long bridge has six spans – 95m + 170m + 3 x 190m + 125m. The bridge deck is supported on five piers, the tallest of which is 180m and the central pier has foundations measuring 33m x 26m.

The shallow spread foundations are founded in limestone and riverbank pebble, while a prestressed concrete rigid frame has been adopted for construction of the superstructure. The pier cross-sections are combinations of double thin-wall at the upper levels and box-shape for the lower sections. The piers have been constructed by climbing formwork and the superstructure is being constructed by the balanced cantilever method. The BBR VT CONA CMI internal post-tensioning system is being installed for the balanced cantilever sections. Meanwhile, CONA CME external post-tensioning will also be used following completion of the deck segments.

2 UVAC 4 Bridge overview

The 890m long UVAC 4 Bridge, which is located on the Smokovac to Uvač section of the Podgorica to Mateševu motorway, stretches along a hillside and runs through a valley. Pier cross-sections are H-shaped and have piled foundations into the flysch geology beneath. The cast in situ prestressed concrete box girder superstructure is being constructed using a combination of scaffolding and form traveler technology. Again here, the bridge deck is being post-tensioned using the BBR VT CONA CMI internal system.

The Smokovac to Mateševu section of this ambitious scheme is due to open later this year. The realization of the whole route is expected to create a new gateway for the future prosperity not only of Montenegro, but also for the whole of the Balkan region.



Chrutacher Bridge, Flühli, Switzerland

Two span, post-tensioned concrete bridge

Alpine bridge replacement

A new bridge over the Waldemme was urgently required after the existing Chrutacher Bridge, built in 1912, had been declared no longer fit for service. BBR Network Member Stahlton was contracted to provide post-tensioning services for the new bridge.

The Chrutacher Bridge forms part of the K36 cantonal road serving the towns of Schüpfheim, Flühli and Sörenberg – in fact, it is the main access road to Sörenberg, so of vital importance to the town. The old bridge no longer met modern demands in terms of load capacity or width.

In replacing the bridge with a new two span 53m reinforced concrete structure, the team from Stahlton installed eight BBR VT CONA CMI 1906 tendons. They also renewed around 250m of road and adapted the road management to the applicable standards.



1



2

- 1 Moračica Bridge – stressing of tendons at the top of a bridge pier.
- 2 Moračica Bridge – view of the construction site compound, beside the Moraca River, taken from the top of a bridge pier.
- 3 UVAC 4 Bridge – looking down between the form travelers at a pier base.
- 4 UVAC 4 Bridge – view from inside the deck, showing ducting for the post-tensioning tendons – and the dramatic landscape in the background.
- 5 Moračica Bridge – work is underway high above the Moračica Plateau to prepare the piers.

TEAM & TECHNOLOGY

1 MORAČICA BRIDGE

Owner/developer – Government of Montenegro, Ministry of Transport and Maritime Affairs

Architect – Mladen Uličević, Željko Ličina

Main contractor – China Road & Bridge Corporation d.o.o.

Technology – BBR VT CONA CMI internal, BBR VT CONA CME external

BBR Network Member – BBR Adria d.o.o. (Croatia)

2 UVAC 4 BRIDGE

Owner/developer – Government of Montenegro, Ministry of Transport and Maritime Affairs

Architect – Aleksandar Čeranić

Main contractor – China Road & Bridge Corporation d.o.o.

Technology – BBR VT CONA CMI internal

BBR Network Member – BBR Adria d.o.o. (Croatia)

TEAM & TECHNOLOGY

Owner/client – Amt für Verkehr und Infrastruktur, Kanton Luzern

Engineer – ewp bucher dillier AG

Main contractor – Porr Suisse AG

Technology – BBR VT CONA CMI internal

BBR Network Member – Stahlton AG (Switzerland)

- 1 The new Chrutacher Bridge over the Waldemme River.
- 2 BBR VT CONA CMI internal post-tensioning was used for the 52m bridge span.



Emigrant & Duck Creek Bridges & Bolivia Hill Upgrade, New South Wales, Australia Construction of balanced cantilever bridges

New bridges for major highway schemes

After recently completing the new Mandurah Traffic Bridge project together in Western Australia, BBR Network Member, SRG Global and main contractor, Georgiou Group have moved to the east coast to joint venture for a further two infrastructure schemes. SRG's Civil Manager East Sean Kelly outlines the two projects which are now underway in New South Wales.

1 Pimlico to Teven Stage 3

SRG were selected to deliver part of Australia's largest regional infrastructure project, the Pimlico to Teven Stage 3 project, as part of the Pacific Highway upgrade for Roads and Maritime Services (RMS). In joint venture with Georgiou Group, SRG were awarded the Pimlico to Teven Stage 3 project involving the construction of two bridge structures in Ballina, New South Wales, Australia.

This critical infrastructure project for the Australian east coast is focused on improving safety and streamlining travel times along the Pacific Highway through some of New South Wales' highest volume tourist areas.

The project is part of the \$4.3 billion Woolgoolga to Ballina Pacific Highway upgrade between Pimlico and Teven. It involves construction of the final southbound carriageway, demolition and reconstruction of two currently decommissioned bridges, earthwork and

realignment of a new permanent junction with the Pacific Highway just south of Ballina.

The bridges span across Emigrant Creek and Duck Creek. Emigrant Creek bridge is an in situ balanced cantilever bridge constructed using a form traveler. The main span is 70m with 39.5m abutment spans. Each segment is 5m in length and the overall bridge width is 12.78m. The Duck Creek bridge is a precast girder bridge comprising three spans. Each span has six precast girders and a length of 39.3m. The precast girders are erected by crane.

SRG's involvement includes design, fabrication, supply, assembly and operation of the form traveler, management of temporary works design and procurement and construction of Emigrant Creek bridge. We are also overseeing management of Duck Creek bridge construction, as well as coordinating all bridge construction resources across the project.

2 Bolivia Hill Upgrade Project

Our construction work on the Bolivia Hill Upgrade Project, again with joint venture partner Georgiou Group, began in late 2018. This is another project for RMS and will see the construction of a 320m long balanced cantilever bridge along with 2.1km of new road, for the New England Highway located south of Tenterfield in New South Wales. Once complete, the project is expected to improve road safety, improve road transport productivity, efficiency and reliability of travel and minimize the impact on the natural, culture and built environment. A significant amount of temporary works have been required to gain access into the rocky terrain and this has seen the application of the BBR SDX Bar system to provide temporary slope stability around the piers. We have also installed temporary post-tensioned rock anchors to the first pad footing, which manages the cantilever loading during bridge construction. The bridge will be constructed on an 8.2% gradient and comprises a 150m main span with 86m and 80m back spans, featuring BBR VT CONA CMI internal post-tensioning. The first major concrete pour was completed in December 2018 and the whole project is scheduled for completion by late 2020. We look forward to presenting a full report of construction activities for this project in the 2020 edition of CONNÆCT.



2



3

- 1 Pimlico to Teven – Emigrant Creek balanced cantilever bridge construction nearing completion in November 2018.
- 2 Bolivia Hill Upgrade – Pier 1 construction underway, slope stability work was first undertaken using the BBR SDX Bar system.
- 3 Bolivia Hill Upgrade – aerial view of the Pier 1 site.

TEAM & TECHNOLOGY

1 PIMLICO TO TEVEN

Owner/client – Roads and Maritime Services (RMS)/Pacific Complete

Main contractor – SRG/Georgiou Group JV

Technology – BBR VT CONA CMI internal, Balanced cantilever

BBR Network Member – SRG Global (Australia)

2 BOLIVIA HILL

Owner/client – Roads and Maritime Services (RMS)

Main contractor – SRG/Georgiou Group JV

Technology – BBR VT CONA CMI internal, BBR SDX bar, Balanced cantilever

BBR Network Member – SRG Global (Australia)



KVMRT2, Package V202, Kuala Lumpur, Malaysia
Specialist PT, launching & temporary works expertise

Building a bridge to a new future

As ambitious as it sounds, Malaysia is taking the next step on its journey to enhance the lifestyle of the people by adding the second MRT line (MRT Line 2) which is expected to be ready for service in 2022. The new MRT line 2 extends from Sg. Buloh towards Putrajaya and comprises a total of 36 stations along its route. Zuhair Rawi, Senior Design Engineer from BBR Construction Systems (M) Sdn Bhd describes the project.

The MRT Line 2 project has been divided into 10 packages and each one is being managed by different contractors. Ahmad Zaki Sdn Bhd (AZSB) was appointed as Work Package Contractor (WPC) for package V202 and has selected BBR Construction Systems to be their PT and launching specialist. Involving three different structures; standard span, T-shaped piers and long span crossings, BBR Construction Systems (M) Sdn Bhd is ready to be on board with the team as the PT Specialist for all three structures and as launching specialist for the T-shaped piers and long span crossings.

Teamwork is always the key in realizing such challenging tasks. These works require detailed coordination and planning between WPC and BBR and also within BBR itself, as we know that working on a large-scale project like this – in the busiest part of town – will not be easy. >

BBR Construction Systems Malaysia is providing operational and technical support for launching T-shaped piers and also long span crossings for Package V202 of the KVMRT2 project in Kuala Lumpur.



Appropriate systems

We are using state-of-the-art post-tensioning systems from the BBR VT CONA CMX range for this project. With its compact design, the system fits very well with the arrangement of the structure which has a quite slender profile and is congested with reinforcement, especially in the case of the segmental box girder. We have no worries on the installation front, as we have found the system, most conveniently, enables a reduction in space required for anchorage placement. We are providing BBR VT CONA CME as the external prestressing system for the standard span and BBR CONA VT CMI as the internal prestressing system for T-shaped piers and long span crossings.

Temporary works setup

As a launching specialist, we are in control of the design and supply of the temporary works which are involved in the segment launching process. For this project, we are providing our operational and technical support for launching T-shaped piers and also long span crossings. We are adopting a direct launching method, where the segments will be launched directly by crane.

Lifting frame

To stabilize and properly distribute the weight of the segment during the launching process, we have introduced a lifting frame/spreader beam. A steel frame with combination of I-beams and channels, weighing approximately 1.5t, was designed to suit the construction method.

We are using three types of lifting frame (Type A, B & C) for this project:

- **Lifting Frame Type A** is to be used in launching of the pier segments of the T-shaped piers. The pier segments of the T-shaped piers have a large void in the middle – a so-called inner core – which dictated that we should locate the four lifting points (embedded strands) quite far apart. Therefore, a long lifting frame was specially designed for the pier segments of the T-shaped piers where we decided to use a main beam with dimensions 533mm x 210mm and weighing 82kg/m and a secondary beam measuring 305mm x 165mm and weighing 52kg/m. Due to the clearance needed for the lifting lug for the segment, we are using bolts – which are designed to be subjected to tension – as the connection.

- **Lifting Frame Type B** was designed as a compact frame and at the same time also designed for lifting points using embedded strands. This frame is able to lift up to 80t segment weight which allows us to use it for launching of T-shaped pier segments and also the pier segments of the long span crossings. The detachable lifting lug allows the frame to be usable where lifting points are spaced differently.
- **Lifting Frame Type C** was specifically designed for span segments of the long span crossings, the segments are to be lifted by using prestress bars punched through to the top slab of the segment. Lifting Frame Type C can be adjusted to suit the different spacing of the lifting points. It was also designed with a very low lifting point which is limited to be approximately under 500mm clearance gap between the segment surface to the hook block of the crane. This was devised to allow lifting works to be carried out under the existing bridge which has a clearance of only 5.2m from the existing bridge soffit.





2



3

Temporary prestressing

After each of the segments has been launched – and prior to stressing of the permanent prestressing tendon – the segment must be temporarily supported by the adjacent segment. For this purpose, we designed a blister for a temporary prestress bar – steel blisters for construction of T-shaped piers and concrete blisters for long span crossings. This blister needs to be aligned to each adjacent segment to allow the prestress bar to be installed through the segment joint. The blisters were designed to be able to withstand the forces from the temporary prestressing and at the same time not damaging the structure. The purpose of temporary prestressing is also to allow a proper control of the stresses along the structure during the construction stages. These prestress bars will be removed after the construction is complete.

Temporary fixity

The long span crossings in this package are to be constructed by using the balanced cantilever method. As the segments are launched one-by-one for each pair, the structure is subjected by a temporary out of balance moment throughout the construction process. Due to the structure being designed to be supported by mechanical bearings, the see-saw action

from the construction method must be isolated as it could potentially damage the bearings. For this purpose, we proposed a temporary fixity system which comprises a temporary strut and tie support to the structure during the construction stages. For tie support, a number of prestressing bars are stressed to a certain jacking force and anchored from the soffit of the segment to the pile cap. These tie supports are designed to take the load of the overturning moment. While for strut support, a temporary steel tower comprising of I-beams with hydraulic jacks at the top are placed at each side of the bridge and bolted to the pile cap. These temporary steel towers are designed to take the compression from the overturning moment. The systems were installed at the start of construction and will only be removed after completion of the whole span of the bridge.

Expanding specialties

This project allows us to demonstrate our specialist capability in temporary works and permanent structural works and that, by adopting our state-of-the-art systems such as BBR post-tensioning technology, along with other highly specialized equipment and purpose-designed systems, we can bring many benefits to the planning and construction of major infrastructure schemes.

- 1 A completed T-shaped pier showing the temporary external prestress bars which are being used to allow proper control of the stresses along the structure during construction and will be removed when construction is complete. Permanent post-tensioning is provided by the BBR VT CONA CME system for the standard spans and BBR VT CONA CMI system for T-shaped piers and long span crossings.
- 2 Applying epoxy joint sealant to the surface of a T-shaped pier segment before it is lifted into place.
- 3 Lifting of segment for T-shaped pier.

TEAM & TECHNOLOGY

Owner/developer – MRT Corporation Sdn Bhd
Main contractor – Ahmad Zaki Sdn Bhd (AZSB)

Technology – BBR VT CONA CMI internal, BBR VT CONA CME external, Balanced cantilever

BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

Friendship Interchange, Abidjan, Ivory Coast, Africa Internal post-tensioning for viaducts

Interchange of international relations

In Abidjan, the capital city of the Ivory Coast, French BBR Network Member ETIC is installing post-tensioning for a major highway scheme aimed at improving traffic circulation between the north and south of the city.



1

Work is underway to construct a new interchange at the Solibra crossroads in the Treichville district, at the intersection of two major roads – the Boulevard Valéry Giscard d'Estaing and Boulevard du Canal/Pont General de Gaulle. This is a busy location with over 130,000 vehicles using the junction on a daily basis.

The project includes the construction of two elevated post-tensioned concrete decks, each designed to carry two lanes of traffic in each direction, which are 312m and 210m long and converge to form a Y-shape. The viaducts are supported on three abutments and 17 supports, the latter will rest on 123 piles each of which are 1,000mm in diameter and around 35m deep.

An unusual aspect of the work is that the Japanese engineering design requires the use of 400 BBR K couplers and a significant quantity of small PT tendons made of eight strands.



2



3

Working alongside civil works subcontractor Razel-Bec, the team from ETIC is installing BBR VT CONA CMI internal post-tensioning, involving a total of 120t of prestressing steel. An unusual aspect of the work is that the Japanese engineering design requires the use of 400 BBR K couplers and a significant quantity of small PT tendons made of eight strands.

The new infrastructure will be known as the Japan-Ivorian Friendship Intersection in recognition of the joint Ivorian and Japanese investment and collaboration for its realization. Completion of the whole project is scheduled for August 2019.

- 1 The Friendship Exchange in Abidjan, Ivory Coast – construction is underway of two elevated post-tensioned concrete highway viaducts which will converge to form a Y-shape.
- 2 Working alongside civil works subcontractor Razel-Bec, the team from ETIC is installing BBR VT CONA CMI internal post-tensioning, involving a total of 120t of prestressing steel.
- 3 An unusual aspect of the work is that the Japanese engineering design requires use of 400 BBR K couplers and large quantity of small PT tendons made of eight strands.

TEAM & TECHNOLOGY

Client – Ageroute
Main contractor – DAIHO
Civil works subcontractor – Razel-Bec
Technology – BBR VT CONA CMI internal
BBR Network Member – ETIC SA (France)



Motorway Bridge EP26, A2 Svincolo Di Mendrisio, Ticino, Switzerland

Post-tensioning for truss bridge

Easing traffic congestion

BBR Network Member Stahlton installed 12 x 60m long BBR VT CONA CMI 1906 tendons for the construction of a new bridge which forms part of the A2 Motorway junction at Mendrisio in the Swiss Canton of Ticino.

Designed as a truss bridge, the central span is 37m long and the two side spans are 11.3m each in length. The new junction was created to optimize the traffic flows and relieve the chronic congestion between Mendrisio and Lugano.

TEAM & TECHNOLOGY

Owner/client – Bundesamt für Strassen ASTRA
Engineer – Lurati Muttoni Partner SA
Main contractor – LGV Impresa Costruzioni SA
Technology – BBR VT CONA CMI internal
BBR Network Member – Stahlton AG (Switzerland)



The Wisteria Condominium & Mall, Singapore

BBR post-tensioning supports prefabricated construction

Innovative construction combination

Jointly developed and built by subsidiaries of BBR Holdings (S) Limited, Wisteria Condominium & Mall covers almost one hectare of land and is sited in the northern part of Singapore. Dickson Liew of BBR Construction Systems (Singapore) Ltd examines how, in this new development, two innovative construction techniques – post-tensioning and prefabrication – are being used together, to produce a high quality building, as well as to increase productivity.

With two floors of commercial space on basement and first floor levels and car parking facilities for visitors and residents on the second and third levels, Wisteria Mall offers retail, supermarket and multiple dining options to the neighborhood.

Being zoned as a plot of land suited for both commercial and residential usage by the Singapore Land Authority, Wisteria Condominium is a private development built directly above Wisteria Mall with condominium facilities, such as a swimming pool, gymnasium, barbecue pits and children's play areas integrated on the environmental deck situated on the fourth level of the development. Hence this can truly be heralded as a mixed development which is not commonly found in Singapore where land is scarce. >

Visualization of the completed Wisteria Condominium & Mall development.



1

The most significant contribution of post-tensioning was that it allowed for a reduction in construction cycle time, compared to conventional concrete construction.

Promoting productivity

Singapore is a strong advocate of productivity in the construction sector in its bid to reduce the reliance of on-site labor and to promote the adaptation of technology and new construction techniques. This is done through its various initiatives and by imposing requirements to adopt Design for Manufacturing and Assembly (DfMA) techniques in new projects, such as The Wisteria, built on land purchased through the government land sales (GLS) program.

DfMA in construction is the technique of designing the structure modularly and

manufacturing these modules in a factory for later assembly on the construction site. This greatly reduces the manpower required on the site, as well as reducing the commonly associated environmental issues such as noise and dust pollution. Moderna Homes (MH), a wholly owned subsidiary of BBR Holdings, is one of the leading pioneers of DfMA using Prefabricated Prefinished Volumetric Construction (PPVC) technology and was the first PPVC specialist to complete two student housing projects for a local university prior to the Wisteria scheme. With the Wisteria project, BBR Holdings and Moderna Homes are the first in Singapore to complete a residential project under the GLS scheme using PPVC technology – thus further enhancing our status as leaders in the field.

So what is PPVC?

As implied by its term, Prefabricated Prefinished Volumetric Construction involves the process of prefabricating steel or concrete modules in a factory, after which mechanical and electrical fittings are installed and finally architectural finishes are applied. At this stage, to complete the concept of “Prefinish”, sanitary ware and furniture are also installed in the factory. The modules are formed 3-dimensionally and include façade finishes for end modules which are implied by the term “Volumetric”. These modules are individually transported to the construction site and lifted into their final positions and mechanically fixed to the adjoining modules.



2

Design, co-ordination & installation

Adopting PPVC as opposed to conventional construction methods is an arduous journey. The design team at MH worked tirelessly with the main contractor Singapore Engineering & Construction (SEC), also a wholly owned subsidiary of BBR Holdings, as well as the various consultants. Right from the planning stage, MH had to liaise closely with the architect and developer on the overall tower layout and schemes for PPVC modules. This was to ensure the intended condominium unit layout was suitably sub-divided into modules, with considerations that the weight of individual modules did not exceed the capacity of lifting facilities, that the locations of inter-module joints would facilitate on-site stitching works and also that the limitations imposed during transportation on Singapore roads were not exceeded.

The next step of the PPVC co-ordination process involved MH and the other trade specialists such as plumbing, sanitary, electrical, façade and carpentry for the furniture. By using Building Information Modelling (BIM), the various penetrations and fixings are captured and coordinated.

Finally, after the co-ordination process, the information on drawings is brought to life in the factory where the steel members are welded together on the 2D plane before being combined to form the 3D modules. The concrete floors are then cast and dry walls installed. It is during this time that the various pipe sleeves are also installed for subsequent connections between modules after their installation on-site. Architectural finishes are also applied during this stage in the factory where floor tiles, wall painting, kitchen furniture and façades are completed.

The on-site installation process has often been described as a 'Lego-like' procedure because of the sheer ease of installation, very much like the stacking building blocks of the popular toy. While the actual modules do require mechanical connections between them which differs from the ease of the toy, high speeds can be achieved with PPVC installation. For The Wisteria project, MH were able to achieve a typical daily installation cycle of six to eight modules and achieved an outstanding one week per floor installation cycle time.

Post-tensioning

As well as using PPVC for the towers of The Wisteria project, post-tensioning was also adopted for the retail and car parking floors from the first to third floors as well as the environmental deck and transfer structure supporting PPVC modules from the tower at the fourth level. BBR Construction Systems (BBRCS) was the PT specialist for the design, supply and installation for this project.

Designed as a post-tensioned flat slab with drop panels, it allowed for easier accommodation to the required M&E services without compromising on the clear headroom. By using post-tensioning, it also increased the allowable span length between the lower floor columns to maximize the layout for car parking. The most significant contribution of post-tensioning was that it allowed for a reduction in construction cycle time, compared to conventional concrete construction.

Under the leadership of SEC and with active contributions from various subsidiaries of BBR Holdings, such as MH and BBRCS, and by the adaptation of technologies like PPVC, BIM and post-tensioning, we are proud to announce the completion of The Wisteria Condominium & Mall – three months ahead of schedule.

- 1 Lifting of PPVC module from planned access into final position.
- 2 Visualization of the 50m freeform lap pool at the center of The Wisteria scheme.
- 3 Wisteria Condominium.

TEAM & TECHNOLOGY

Developer – Northern Resi Pte Ltd/Northern Retail Pte Ltd
Architect/C&S consultant – Surbana Jurong Consultants
Main contractor – Singapore Engineering & Construction Pte Ltd
PPVC specialist – Moderna Homes Pte Ltd
Technology – BBR CONA flat
BBR Network Member – BBR Construction Systems Pte Ltd



The Circle, Kloten, Zürich, Switzerland PT for high quality mixed-use development

Swissness, surprise & connections

An exciting new development – The Circle – is taking shape directly opposite Zürich Airport. BBR Network Member Stahlton is providing specialist post-tensioning services to this massive scheme which has been described as one of the largest construction projects currently underway in Switzerland. Rainer Zünd, CEO of Stahlton, provides some background on the scheme and the scope of work involved.

The Circle is probably one of the highest profile projects, as well as being one of the largest developments under construction in Switzerland. Situated directly opposite Zürich Airport, each day over 150,000 commuters, staff and visitors have the opportunity to see this futuristic new complex as it grows. The finished scheme will offer 180,000m² of high

quality space for retail and business activities, facilities for art, culture and education, as well as a variety of restaurants, a medical clinic, two Hyatt hotels and a convention center. As well as indoor space, visitors and staff will be able to access some 80,000m² of parkland – The Park – which is immediately adjacent to the site and completes ‘The Circle’.

FACTS & FIGURES
NUMBER OF BBR PT TENDONS
INSTALLED

10
 BBR VT CONA CMI 0406
 LENGTH = 200M

65
 BBR VT CONA CMI 1206
 LENGTH = 920M

165
 BBR VT CONA CMI 1906
 LENGTH = 2,280M

2
 BBR VT CONA CMI 2206
 LENGTH = 24M



Visualization of The Circle development – directly opposite Zürich Airport, it is one of the largest and highest profile projects currently underway in Switzerland. Image courtesy of Flughafen Zürich AG.

Architectural design

Following a design competition involving the production and evaluation of 90 different approaches from architectural practices worldwide, leading Japanese architectural practice Riken Yamamoto & Fieldshop was chosen to design The Circle. All entrants to the competition were required, alongside other criteria, to contemplate three concepts – Swissness, Surprise and Connections to the World.

Given the Swiss roots of the BBR Network and BBR technology, it may be of particular interest to learn that the winning architects identified precision as an outstanding characteristic of 'Swissness'. They concluded that, as well as producing some of the finest engineering and services, precision was also "a way of thinking developed over time by the people of Switzerland." The architectural symbols of that Swissness carried into the design are the extremely slender columns which are a feature of the development.

Technical overview

Construction began in January 2015, after some six years of project development work. Stahlton's challenge has been to provide post-tensioning services for the massive post-tensioned beams which were required to transfer the main loads from the upper floors to the cast in situ bored piles. In addition, post-tensioned ceilings and beams were installed at various locations. Using both fixed and movable anchorages, we installed a total of 242 BBR VT CONA CMI internal tendons. To save time and space on this busy site, all tendons were prefabricated in our workshops and delivered to site on reels on a just-in-time basis.

Unique & innovative spaces

Due to open for business in 2020, The Circle has already attracted many high profile tenants who will benefit from high quality innovative spaces for work and leisure offered within this unique location – and the peace of mind offered by the expert application of the latest Swiss construction technology from the BBR Network.

TEAM & TECHNOLOGY

Owners – Flughafen Zürich AG & Swiss Life AG

Architect – Riken Yamamoto & Fieldshop

Management contractor – HRS Real Estate AG

Main contractors – Anliker AG, Frutiger AG & Barizzi AG

Structural engineer – Ribl + Blum AG

Technology – BBR VT CONA CMI internal

BBR Network Member – Stahlton AG (Switzerland)



Extension work at the Grand Hotel Neum featured three floors of post-tensioned concrete slabs which have created basement level hotel delivery space, a ground floor conference suite and a 1.6m deep swimming pool & terrace on the rooftop.

Conference Hall & Swimming Pool, Grand Hotel Neum, Neum, Bosnia & Herzegovina

Post-tensioning technology & techniques for new development

Complex calculations for conference space

Originally built in 1977, the Grand Hotel Neum on Bosnia & Herzegovina's Neum Riviera now has a new conference facility and rooftop swimming pool. The upgrade program, which lasted less than six months, featured post-tensioning services from BBR Adria.

The new structure measures 40m x 30m on plan and has three floors of post-tensioned concrete slabs. It consists of hotel delivery space at the basement level, a congress hall on the ground floor and a 1.6m deep swimming pool, with sunbathing terraces around it, on the top floor. The 750-seat congress hall area on the ground floor features a large 40 x 20m column-free space which can be subdivided into smaller conference or meeting rooms.

The load bearing structure was designed with shallow beams – with a cross-section of 3,000 x 750mm and depth of 280mm in the 20m span direction. Calculations for the beams and post-tensioned slabs were designed to reflect the loads from the swimming pool structure which are transferred directly onto the post-tensioned slab. The BBR VT CONA CMM Four (0406) system was

installed in the shallow beams, while the BBR VT CONA CMM Single (0106) system was installed in the slabs.

A particularly complex task facing the designers was the specification of maximum deflection requirements for the structure, especially in view of the cyclic change of loading conditions created by the fact that the loads generated by water in the swimming pool would only be present during the summer months.

TEAM & TECHNOLOGY

Owner – Grand Hotel Neum

Architect – ARS STUDIO R d.o.o.

Main contractor – Novogradnja d.o.o.

Structural designers – Ivan Primorac & Predrag Presečki

Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o. (Croatia)

Tropicana Gardens, Kota Damansara, Selangor, Malaysia

Post-tensioned flat plate transfer floor with inverted drop panels & remedial post-fire damage strengthening works

Time & place

In Kota Damansara, to the west of Kuala Lumpur, Tropicana Corporation Berhad has been developing a new urban hub which combines shopping mall, residences, offices and urban gardens in a single location – Tropicana Gardens. Arranged on a prime 17 acre site, the fourth and final residential phase of Tropicana Gardens – known as ‘Dianthus’ – is currently underway. The team from **BBR Construction Systems Malaysia** was appointed for specialist post-tensioning works on the project, however, part way through the contract their expertise in the field of remedial work was also needed by the client. Wai Hoe Chang, Design Engineer, takes up the story.

... to support the 27-floor residential apartment above, the transfer floor structure was designed as a 1.8m thick post-tensioned flat plate with inverted drop panels.

Encompassing a flamboyant mix of residential and commercial elements, Tropicana Gardens abounds with glitz, inspiration and rejuvenation for the modern urbanite. The landscape comprises serviced residences, a five level shopping mall, offices and direct MRT access, all within the vibrant township of Kota Damansara.

Dianthus, the lowest density phase of the development yet, promises renewed exclusivity with only 271 units distributed across 27 floors. BBR Construction Systems Malaysia was given the task of designing and installing BBR CONA bonded post-tensioning systems for the transfer floor of this tower development.

Transfer floor structure

In order to support the 27-floor residential apartment above, the transfer floor structure was designed as a 1.8m thick post-tensioned flat plate with drop panels. The design was completed by using ADAPT Floor Pro, a 3D Finite Element Analysis program which enables modeling of the tendons accurately and precisely at the location where required. However, there is a limitation of headroom in between the transfer floor and the floor below, so normal drop panels could not be adopted for this project. Therefore 1.2m thick inverted drop panels were designed to increase punching shear capacity at columns. The inverted drop panels were then covered by architectural features and thus hidden within the structure, maximizing the building’s aesthetics.

Casting & stressing

A three-stage casting with two stage stressing was adopted for this project. In the first stage, a 0.7m thick Grade 40 green concrete was cast on the temporary props. Upon achieving the concrete transfer strength of 30MPa, the first group of tendons consisting of 1205 BBR CONA internal tendons were stressed to support the weight of the second concrete casting (1.1m thick) and third concrete casting containing all the 1.2m thick inverted drop panels. The second group of tendons which were also 1205 BBR CONA internal tendons were finally stressed when the third casting concrete strength reached 30MPa.

This was the first project featuring post-tensioned flat plates with inverted drop panels that BBR Malaysia has designed. It was an interesting challenge for our team, particularly as there are only few references available about the construction of inverted drop panels.

Fire halts work in retail area

Construction work was in progress on this fourth and final residential phase and was expected to be completed by 2019. However at 2.10pm on November 13, 2017, a fire broke out at the Tropicana Gardens construction site. Thankfully, the situation was contained in an hour and no casualties were reported. Even though only a minimal part of the project, the retail area, was affected by the fire, it caused a huge impact to the contractor and developer in terms of time and cost.

TEAM & TECHNOLOGY

Owner – Tropicana Corporation Berhad

Main contractor – GD Capital Sdn. Bhd.

Technology – BBR CONA internal

BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

Testing & solutions

After several days of investigation, construction work at Tropicana Gardens was resumed with approval of the authorities. Several tests – such as core compressive test, petrography test, ultrasonic velocity test and more – were conducted to the damaged one-way post-tensioned slab. Strengthening works were then carried out by retrofitting specialist firm CASES, with advice from BBR CS Malaysia. The remaining slab capacity of the damaged post-tensioning slab was checked by BBR CS

Malaysia based on the estimated concrete grade judged by CASES. Several methods were proposed to counter the insufficient capacity. Before undertaking any concrete repair, the affected area – especially in the vicinity of damaged columns and beams – was back-propped for safety purposes.

Timely completion

When the repair mortar had reached its final setting, either after completion of the whole repair or between two layers, the repaired

areas were cured by traditional methods and protected by polyethylene sheeting to prevent it drying too quickly due to wind or fast evaporation. It was a huge challenge for all parties involved to complete the rectification works in such a tight construction time frame. Thanks to some really great teamwork, the project was successfully brought in on track.



Tropicana Gardens development in Kota Damansara, Malaysia.



Visualization of Woodleigh Village where the use of post-tensioning will be creating large clear spaces while also saving on time and materials usage.

Bidadari Contract 5, Woodleigh Village, Singapore

PT installation for project & specialist areas

Fulfilling need for large clear spaces

When listening to conversations about public housing in Singapore, one would normally hear schemes being described as “simplistic”, or having “minimal communal facilities” and being “located away from main transportation options”. This is definitely not the case for Woodleigh Village. Dickson Liew of BBR Construction Systems Pte Ltd in Singapore describes the project and the scope of his company’s work for this new development.

Woodleigh Village, owned and developed by the Housing and Development Board (HDB) of Singapore, is one of the many development plots designated for public or private housing in the recently redeveloped Woodleigh vicinity. Prior to its redevelopment, the land in Woodleigh was used as a cemetery. Now, with the completion of the north eastern line of Singapore’s Mass Rapid Transport (MRT), Woodleigh has become accessible and thus its development potential has increased as a residential district which offers close proximity to the central business district (CBD).

As one of several development plots, the aspect that sets Woodleigh Village apart is its accessibility. Sited just a two minute walk away from the entrance to Woodleigh MRT station, it gives residents the unparalleled convenience of a easy access to the well-connected

MRT network. Moreover, Woodleigh Village will be the first development to be sited above an underground and fully air conditioned bus interchange, which is also a first for Singapore. This transforms Woodleigh Village into a truly integrated transportation hub.

Meanwhile, the communal needs of the residents have not been forgotten. Woodleigh Village also boasts landscaped areas, links to parks, a childcare center, a food center and various family and social services centers, as well as several communal spaces where residents can get together or hold social events. Thus, Woodleigh Village can be heralded as a vibrant and well-connected development.

BBR Construction Systems Pte Ltd (BBRCS) is proud to be part of the team that is undertaking the construction work for Woodleigh Village. Bringing our expertise to the table, we are able to offer design capabilities to the project team for the environmental deck and communal facilities on level three, on top of our usual supply and installation work scope. As there is a bus interchange in the basement of this development, the first level of Woodleigh village requires large column-free zones to accommodate the wide turning circles needed by the buses, broad access roads, plus sufficient space for passengers to board and alight. Coupled with the need for large clear spaces beneath the structure soffit, we proposed a 900mm deep post-tensioned flat plate to cater for the large spans of up to 23m long. Compared to traditional reinforced concrete, the use of post-tensioning here reduces the expected slab thickness and also reduces the amount of reinforcement required. Another benefit of using post-tensioning is early stage stressing which allows for earlier removal of formwork than with conventional reinforced concrete construction.

The challenges we face in the design of the level one flat plate include the operational needs of various parties. From the drainage and plumbing requirements of the food center located on this floor, to the pneumatic waste disposal system and future vehicular or human ingress and egress to the development after completion. While ensuring structural design accommodates the demands, due consideration has to be given to the operational requirements of the basement level bus interchange, which severely limits the extent of encroachment that the structure can make into the basement space.

Although the challenges are many, the pride of being the appointed specialist for this unique development will ensure that we meet each challenge with the very best engineering skills. We look forward to celebrating the successful completion of this excellent project in 2021.

TEAM & TECHNOLOGY

Owner – Housing & Development Board

Architect – MKPL Architects Pte Ltd

Main contractor – China Construction (South Pacific) Development Co Pte Ltd

C&S consultant – KTP Consultants Pte Ltd

Technology – BBR CONA internal

BBR Network Member – BBR Construction Systems Pte Ltd (Singapore)

Slabs-On-Ground, New Zealand Celebrating a post-tensioning milestone

Chilling out down under

They may work in a small country, but the team at New Zealand's BBR Contech continue to rack up their record for post-tensioned concrete ground slabs. In the past ten years, they have installed a total of 1.5 million square meters of slabs on ground – and 2.5 million in the past 35 years!

In 2018, two projects in Canterbury – covering a combined area of 28,000m² – helped to boost the numbers. Both schemes were for long-term BBR Contech clients in the food industry – Fonterra, a global, co-operatively-owned company which is the world's largest dairy exporter and Foodstuffs, New Zealand's biggest grocery products distributor and one of the country's largest organizations. Together, these two companies have accounted for 364,000m² of BBR Contech's post-tensioned slabs in the past 18 years. >



While floor slabs may not be the most glamorous of structural elements, when constructed well they deliver decades of reliable and low-maintenance service – along with happy, loyal clients.

1 Fonterra – meeting the cream cheese needs of Asian customers

In October 2017, Fonterra broke ground on their new, NZ\$150m cream cheese cool store at their Darfield site in Canterbury – an investment made largely in response to the increasing popularity of cream cheese and other dairy products in Asian markets. In China for example, consumers have invented the ‘tea macchiato’, in which tea and cream are combined then topped with cream cheese.

Just a month later, BBR Contech was on site to install the post-tensioned floor for the cool store. It was the team’s seventh project on the Darfield campus – the first was in 2012-13, when they installed a 47,000m² post-tensioned floor for a dry-milk-powder warehouse, and a 31,800m² post-tensioned, heavy-duty outdoor apron slab that connected the warehouse to a rail line for transport.

The cream cheese store, which is located adjacent and is connected to the dry store, had similar requirements, this time a 2,777m² post-tensioned slab indoors and a 3,100m² outdoor apron slab.

Specialist design

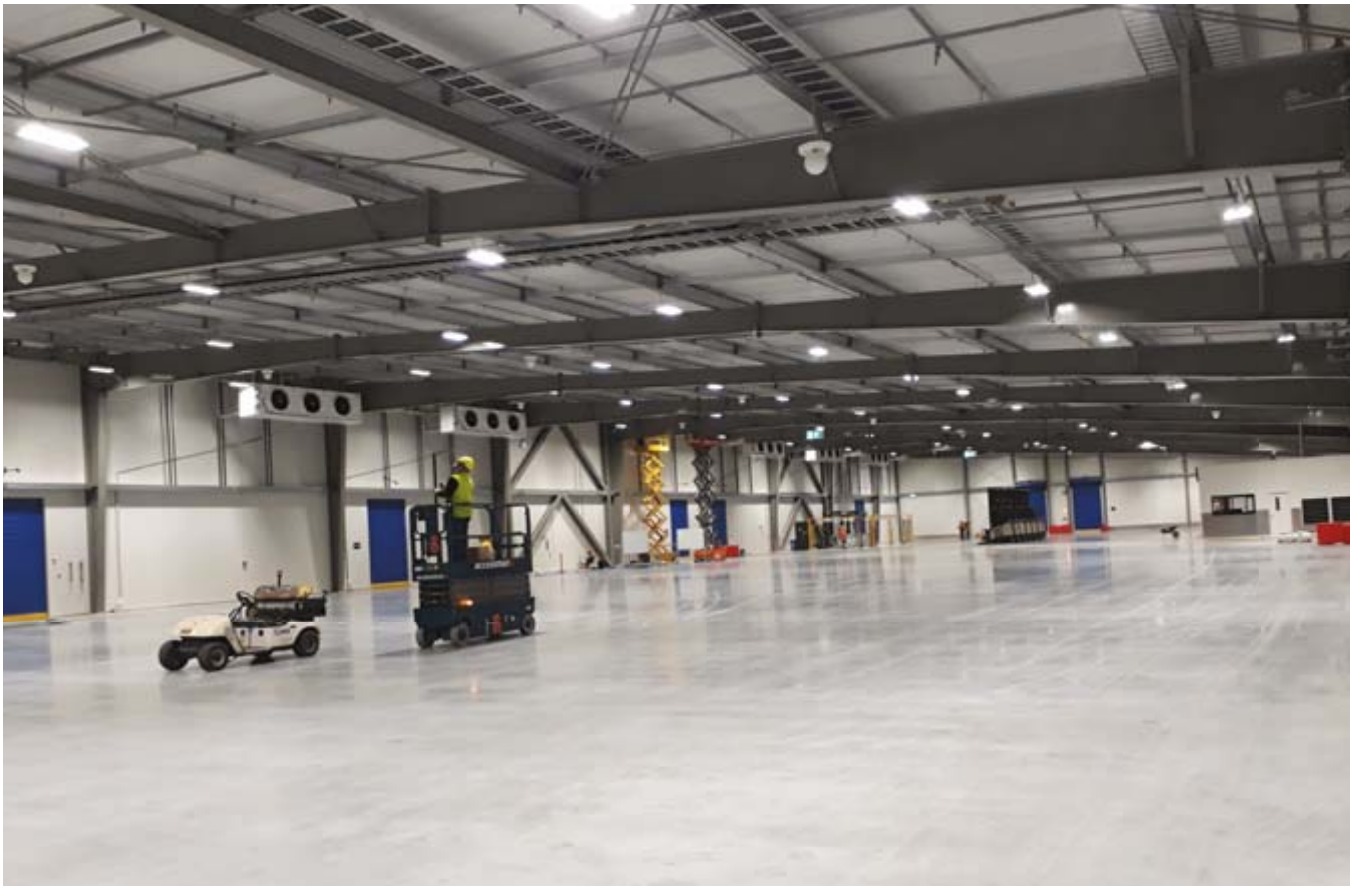
As well as designing and installing the slabs, BBR Contech’s role was to work with structural engineering firm RD Sullivan to design both the cool store slab – which includes a steel frame, cooling fans and insulated wall, ceiling and floor panels – and its interface with the external apron slab. The latter was a particular challenge, as the slab had to handle extremely heavy forklift loads, while the cream cheese must be maintained at a constant temperature at every stage of transport, from the cool store to the rail line and beyond.



2



3



4

2 Foodstuffs – expanding space to store fresh foods

Established in Auckland in 1922, Foodstuffs now employs more than 30,000 people at retail and wholesale grocery businesses throughout New Zealand – including full-service supermarkets, retail food warehouses, grocery and small convenience stores, and large- and small-format liquor stores. The stores are supported and serviced by a nationwide network of distribution centers, purpose-built to meet the specific storage requirements of dry, fresh and frozen goods.

BBR Contech's long association with Foodstuffs has included the installation of three post-tensioned floors at its distribution center in Christchurch, which services the entire South Island.

Project Chilly Bin

In 2017 the team were in there once again, this time as part of 'Project Chilly Bin' – a program developed by Foodstuffs to address customers' increasing demand for temperature-controlled goods and enable it to offer an expanded range of fruit, vegetable, seafood and meat products, seven-days-a-week.

This is part of Foodstuffs South Island's overall strategy to reduce product handling and enhance service delivery which is also accompanied by major investment in new streamlined systems and facilities.

Due for completion in 2019, Project Chilly Bin will see the construction of a new 28,500m² warehouse that will double the site's chiller capacity and increase its freezer capacity by 50%.

In collaboration with main contractor Calder Stewart and floor designer Powell Fenwick Consultants, BBR Contech is installing 180mm thick floors for the 18,504m² chiller – designed as ten slabs – and the single slab 1,885m² freezer which will feature insulated wall, floor and roof panels and, for the freezer, coolant pipes.

Building knowledge from experience

BBR Contech credits its 35-year record of success in designing and installing post-tensioned ground slabs to the company's commitment to excellence in product quality and service. While floor slabs may not be the most glamorous of structural elements, when constructed well they deliver decades of reliable and low-maintenance service – along with happy, loyal clients.

- 1 Fonterra, Darfield – the PT floor in progress for the outdoor apron slab of the new cool store. This was BBR Contech team's seventh project on the Darfield campus.
- 2 Fonterra, Darfield – the almost complete new cool store with its post-tensioned external apron slab.
- 3 Foodstuffs – the new chiller and freezer building which will double the site's chiller capacity and increase its freezer capacity by 50%.
- 4 Foodstuffs – BBR Contech has installed 180mm thick post-tensioned floors for the 18,504m² chiller, designed as ten slabs, and for the single slab 1,885m² freezer.

TEAM & TECHNOLOGY

1 FONTERRA

Owner – Fonterra Co-operative Group
Main contractor – Apollo Projects
Structural engineer – RD Sullivan
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

2 FOODSTUFFS

Owner – Foodstuffs South Island Properties
Main contractor – Calder Stewart Construction
Structural engineer – Powell Fenwick Consultants
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

National Art Museum & Deichman Main Library, Oslo, Norway BBR post-tensioning for public cultural spaces

Art & culture in Oslo

Norwegian BBR Network Member, KB Spennteknikk reports that two new cultural buildings currently under construction in Oslo will feature BBR technology – the new National Museum and the new Deichman Main Library.

1 National Museum

The Norwegian government has commissioned the building of a new 54,600m² museum in Oslo dedicated to the visual arts. It is located on the site of the former Vestbanen railway station, which was withdrawn from service in 1989, adjacent to the Nobel Peace Prize Center. The new National Art, Architecture & Design Museum will become one of the Norwegian capital city's most important buildings, as well as one of the largest museums in Europe. Architects for the project, Kleihues + Schuwerk Gesellschaft von Architekten, have prioritized dignity and longevity rather than sensational architecture and ensured that the design of the new building respects its surroundings and existing monuments in the area – such as Oslo's City Hall and the Akershus fortress. Main contractor for concrete work, AF Anlegg AS has appointed BBR Network Member KB Spennteknikk to carry out the delivery and stressing of post-tensioning for the slabs. The system used was the BBR VT CONA CMM, monostrand unbonded system for single and four strands. In addition, CONA CMI internal bonded tendons were used in some of the beams. The National Arts Museum will house collections that are currently spread between three separate sites in Oslo city center and, in its

13,000m² of public exhibition space, will display design, crafts and visual art from many centuries. Planned for completion in 2020, the museum is expected to engage a broader cross-section of the general public – on both a national and international scale.

2 Deichman Main Library

Meanwhile, work is well-advanced for the new Deichman Main Library which will relocate to Bjørvika. The area, formerly a container port, has been the subject of a major urban redevelopment program for some 10 years now. When completed the 'New Deichman' will join the National Opera House and the relocated Munch Museum where work is also in progress within this new cultural hub for Norway's capital city. This building is not only pioneering green architectural approaches with a specially designed façade to ensure optimal use of daylight and minimal heat loss, but also employing the very latest building techniques to ensure the project's place as a showcase for energy and environmental developments. The Spennteknikk team has delivered and installed post-tensioning for the beams for the special roof structure. The BBR VT CONA CMI internal bonded system was used for the post-tensioning tendons here.

- 1 The National Arts Museum – under construction on the site of the former Vestbanen railway station in Oslo, showing the preserved station buildings in the left foreground. Photograph by Ken Opprann, courtesy of Statsbygg.
- 2 New Deichman Main Library – the BBR VT CONA CMI internal bonded system was used for post-tensioning of beams for the special roof structure. Photograph courtesy of Doka.

TEAM & TECHNOLOGY

1 NATIONAL ART MUSEUM

Owner/developer – Statsbygg
Architect – Kleihues + Schuwerk Gesellschaft von Architekten mbH
Concrete contractor – AF Anlegg AS
Technology – BBR VT CONA CMM monostrand, BBR VT CONA CMI internal
BBR Network Member – KB Spennteknikk AS (Norway)

2 DEICHMAN MAIN LIBRARY

Owner/developer – Oslo City Council
Architect – Lund Hagem Architect + Atelier Oslo
Main contractor – Skanska Norge AS
Technology – BBR VT CONA CMI internal
BBR Network Member – KB Spennteknikk AS (Norway)



1



2

Multi-storey Buildings, Auckland, New Zealand Elevated PT slabs gain traction

Elevated floors on the rise



An Australasian joint venture is making good progress in raising the profile – and application – of elevated post-tensioned flooring in multi-storey buildings in New Zealand. Projects currently underway add up to a massive 60,000m² – including around 36,000m² of floors for one of the country's tallest new residential developments.

As reported in CONNÆCT 2018, the joint venture between New Zealand's BBR Contech and Australia's SRG Global – both BBR Network Members – was established in 2017 largely in response to the growing awareness in New Zealand of the commercial advantages of post-tensioned concrete compared with its precast equivalent.

It brings together the Kiwis' local knowledge of and experience in the New Zealand market with SRG's decades of experience in designing, installing and maintaining post-tensioned floors in Australia. Working together, the companies are sharing invaluable knowledge and expertise, as well as proving their capacity to take on large and complex projects. >

FACTS & FIGURES PACIFICA TOWER

HEIGHT

178m

FLOOR LEVELS

57

POST-TENSIONED FLOOR AREA

36,000m²



2

1 Pacifica Tower
– transforming the Auckland skyline

In a landmark achievement for the partnership, BBR Contech and SRG Global have been contracted to design and install post-tensioned flooring in one of Auckland's most high-profile building projects. Once complete, the Pacifica Tower – a 178m high, 57-level inner-city hotel and residential complex – will dwarf all the buildings surrounding it.

Costing around NZ\$200m and described as “redefining the quality of city living, bringing elegance and opportunity to a life lived at the center of everything”, the tower will comprise 282 apartments, a 41-suite boutique hotel, a high-end restaurant, shops at street level and facilities including residents’ lounges and a lap pool, sauna, steam room, spa, gym, media room, library and barbecue terrace. Apartment sales are progressing well, with completion expected in the fourth quarter of 2020 – just in time for the 2021 America’s Cup yacht regatta on Auckland’s Waitemata Harbour (see also page 80).

The BBR Contech/SRG team is working closely with main contractor Icon Co to design, procure and install all 56 floors of the complex, with the first to seventh floors spanning 1,000m² each and the eighth to 56th floors each covering 600m².

The challenges are many for this massive project, not least the central CBD location, the crowded working environment, the minimal space available for storage and loading – plus the tight delivery time frame. However, there’s a plus to lighten the load – for the first time in New Zealand, the team is

utilizing a full perimeter jumpform, encompassing all vertical tower elements. The jumpform climbs using electric jacks. A single floor ‘jump’ takes one hour. Floors and post-tensioning installation works are constructed within perimeter screens hung from the jumpform. The jumpform system being utilized is new technology for the NZ construction industry and offers higher levels of safety and productivity, along with material and cost efficiencies.

The building must also, of course, meet New Zealand’s seismic standards. With this in mind, post-tensioning is also used as part of the lateral load resisting system, with multi-strand tendons tensioned to 80% of their capacity to enable building flexibility in an earthquake.

2 Bunnings Westgate
– a floor fit for purpose

BBR Contech and SRG are also working on a 15,000m² elevated post-tensioned floor for a Bunnings Warehouse store at Auckland’s Westgate Shopping Centre. The store is part of the purpose-built, 56-hectare Westgate town, which includes street-based retail and community services, parks, office blocks, specialty shops and large-format and yard-based retail stores.

SRG has made a significant contribution to this project through its experience with about 35 Bunnings stores in Australia. It also has a long-standing relationship with the main contractor, H Troon Pty Ltd, which heads the Bunnings contract from Australia.



3

3 Highbrook Business Park

– enabling easy parking

In a third project underway, BBR Contech and SRG are working on a multi-level car park development at Highbrook Business Park in Auckland's East Tamaki. This NZ\$1.3bn, 108-hectare estate is owned by Goodman Property Trust. The Trust has a NZ\$2.3bn portfolio of industrial real estate located throughout Auckland. Its assets include logistics facilities, warehouses and business parks. Highbrook is a master-planned development that differs from Goodman's other investments in its sheer scale. Currently home to more than 80 businesses employing over 5,000 people, it adjoins over 40 hectares of parkland and public spaces along the Tamaki River.

The BBR Contech/SRG partnership has been charged with designing and installing elevated post-tensioned floors and a ramp for the three-level public car park, with each floor spanning 1,320m². The car park will provide space for 324 vehicles and largely service 'The Crossing' – a town center style development which is the focal point of the Highbrook community, providing accommodation, business support services and amenities such as cafés, bars, banks, childcare, a gym, a superette convenience store and a conference center.

- 1 Visualization of the completed 56-storey Pacifica Tower in Auckland. Image courtesy of Hengyi Pacific.
- 2 Highbrook Business Park – visualization of the completed car park
- 3 Highbrook Business Park – the BBR Contech/SRG partnership is designing and installing elevated post-tensioned floors and a ramp for the three-level public car park.

TEAM & TECHNOLOGY

1 PACIFICA TOWER

Developer – Hengyi Pacific

Architect – Plus Architecture

Main contractor – Icon Co Pty (NZ) Ltd

Technology – BBR CONA flat

BBR Network Members – BBR Contech (New Zealand) & SRG Global (Australia)

2 BUNNINGS WESTGATE

Developer – Bunnings

Structural engineer – Stiffe Hooker Ltd

Main contractor – H Troon Pty Ltd

Technology – BBR CONA flat

BBR Network Members – BBR Contech (New Zealand) & SRG Global (Australia)

3 HIGHBROOK BUSINESS PARK

Developer – Goodman Property Trust

Architect – JWA Architects Ltd

Main contractor – SMC Construction

Technology – BBR CONA flat

BBR Network Members – BBR Contech (New Zealand) & SRG Global (Australia)



Artist's impression of the new Hochschule Luzern – Musik building in Kriens, Switzerland. Image courtesy of Hochschule Luzern.

Hochschule Luzern – Musik, Kriens, Switzerland

Creating space & flexibility with BBR PT systems

Making space for music

In the new Hochschule Luzern – Musik building, there will be space for around 500 students who will be taught in all styles of music, as well as having access to library, research and event rooms. Rainer Zünd, CEO of Swiss-based BBR Network Member, Stahlton provides a brief insight into the project.

The new building is located next to the 'Südpole' (South Pole) music and dance theatre in Kriens, a district to the south of Lucerne.

As well as music teaching space, the building will have a chamber music theatre and a jazz club. A major feature of the structure will be a central foyer with four sound and light towers. In anticipation of their move and with their sights firmly set on high quality teaching, the Hochschule Luzern – Musik has already agreed the purchase of a further 49 grand pianos!

The building has been designed to meet high demands for good acoustics and sound insulation, as well as flexibility of space and sustainability. As floors were planned with relatively thin slabs and large spans, BBR post-tensioning systems were installed in floors from the

second underground level to the fifth above-ground level. This will ensure both safe load bearing and ultimately, the usability of the spaces. Both BBRV wire and BBR VT CONA CMI internal strand post-tensioning systems were applied in both longitudinal and transversal directions. The total length of PT tendons placed by the team from Stahlton was 9,500m.

TEAM & TECHNOLOGY

Client – Luzerner Pensionskasse

Architect – Enzmann Fischer & Büro Konstrukt AG

Main contractor – Anliker AG

Structural engineer – Felder Ingenieure Planer AG

Technology – BBR VT CONA CMI internal, BBRV wire

BBR Network Member – Stahlton AG (Switzerland)

Max Stoja Shopping Mall, Pula, Croatia BBR post-tensioning technology & techniques for new development

Time, materials & cost savings

The new Max Stoja Shopping Mall in Pula was conceived as a sustainable development on disused land and, as Tomislav Lozančić reports, the specialist expertise of BBR Adria brought significant savings on time, materials and costs to the project.

Officially opened in November 2018, construction work on the new shopping mall began in July 2017. The site chosen for the mall was the former “Max” quarry between Stoja Bay and the famous Uljanik Shipyard in the historic north Croatian city of Pula.

The building has six floor levels of which the lower three are parking areas, while the upper floors contain retail and leisure facilities. The new structure extends over a gross floor area of 74,000m² and offers over 30,000m² of lettable space. On plan its dimensions are 200m long by 50m to 90m wide. A central expansion joint divides the structure into two parts, each of which has four construction joints. The largest single concrete pour covered an area of 2,500m².



1



2

FACTS & FIGURES MAX STOJA SHOPPING MALL

120

DAYS SAVED ON CONSTRUCTION PROGRAM

26%

MATERIALS VOLUME SAVING

€1m

PROJECT COST SAVED

- 1 View of the site in the early stages of construction.
- 2 The new Max Stoja Shopping Mall in Pula, Croatia nears completion.

Overall, this alternative design delivered a reduction of around €1m to the construction budget ... and the construction program was reduced by 120 days.

The original design for the structure, produced by the ATP Zagreb architectural and engineering practice, featured traditional reinforced concrete slabs and beams – with 300mm deep slabs for the 8.7m spans and 450mm deep slabs for the 12.7m spans.

BBR Adria presented an alternative proposal, involving the use of post-tensioned slabs, to the developer and the main contractor. By rationalizing the structure through the use of post-tensioning, slab thicknesses were reduced to 240mm and 300mm. This solution resulted in savings of around 26% on concrete and reinforcement alone. Overall, this alternative design delivered a reduction of around €1m to the construction budget, even after adding in the cost of the BBR VT CONA CMM monostrand internal post-tensioning system, and the construction program was reduced by 120 days.

TEAM & TECHNOLOGY

Owner – Tragovacki centar Max Stoja d.o.o.
Architect – ATP Projektiranje d.o.o. Zagreb
Main contractor – Kamgrad d.o.o.
Structural designers – Berislav Bošnjak, Krešimir Tarnik & Predrag Presečki
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o. (Croatia)



1

Lidl Headquarters Building, Weinfelden, Switzerland

Specialist post-tensioning for new build

Speedy services to support growth

Discount supermarket chain Lidl already has over 100 outlets in Switzerland and is continuing to expand. To support future growth, the company needed a larger Swiss Headquarters building to accommodate 300 staff. BBR Network Member Stahlton joined the professional team to provide post-tensioning expertise.

The new four level building in Weinfelden, Thurgau has a basement intended for parking and stores, while the ground floor will be for mixed use and the two upper levels which have an inner courtyard will serve as offices.

The team from Stahlton placed a total of 234 BBRV wire and eight BBR VT CONA CMI internal post-tensioning tendons. Special anchorages were provided for transferring the load to the special horizontal stiffeners.

The project represents an investment of around CHF50m and was completed in record-breaking time, reflecting not only the professionalism of the whole team, but also the excellent relationships which developed on site.



2

- 1 Artist's impression of the new Lidl Headquarters building in Weinfelden, Switzerland.
- 2 Special anchorages were provided to connect the post-tensioning tendons with the horizontal stiffeners.

TEAM & TECHNOLOGY

Owner – Lidl Schweiz
Architect/general planner – Itten+Brechbühl AG
Structural engineer – Borgogno Eggenberger Partner AG
Technology – BBR VT CONA CMI internal, BBRV wire
BBR Network Member – Stahlton AG (Switzerland)



Saint Jacques Bridge, Montréal, Québec, Canada

BBR HiAm CONA stay cables for landmark bridge

Signature stay cables

After just five weeks' work, BBR Network Member ETIC has completed the installation of BBR HiAm CONA stay cables for the new Saint Jacques Bridge in Montréal, Canada for main contractor Demathieu et Bard Construction. Cédric Brunner, Site Engineer for ETIC, takes up the story.

Inaugurated in 1967, the Turcot Interchange – an important traffic intersection, carrying around 300,000 vehicles daily – was showing signs of aging and thus Transports Québec embarked upon a major rebuilding program. When completed, the massive \$3.7bn Turcot Reconstruction scheme will have seen the replacement of some 128 lane kilometers of elevated highways that are, in some places, stacked three high. Reconstruction of the Saint Jacques Bridge is part of this scheme. >



General view of the Saint Jacques Bridge – a new gateway to Montréal, Canada.



1

Bridge design & structure

The new bridge was designed as a signature overpass, one of three such structures marking entrances to the city. Its form is reminiscent of an aircraft – with the aerodynamically-shaped pylon as the fuselage and the two arrays of stay cables as the wings. Replacing a now dismantled bridge, it allows the continuation of Saint Jacques Street, above the Decarie Expressway, part of the A15 highway which runs through the Turcot Interchange.

The new Saint Jacques Bridge has two spans, 63m and 52m long, plus an elegantly designed central pylon. The new bridge was launched in May 2018 and, subsequently, 30 prefabricated steel plates were installed to form the deck.

Then, during a weekend in August 2018, the three prefabricated steel segments for the pylon – weighing 14, 40 and 50t – were installed with the help of a two cranes, the largest of which weighed 650t.



2

Stay cable installation

The first two weeks of our program were needed for the installation of threading systems, some of which were high on the pylon, the pre-cutting of all the strands and the installation of the 20 BBR HiAm CONA 3106 anchorages on the pylon and on the bridge deck. Access inside the pylon was achieved via a staircase for the first 17m and by a ladder for the following 40m.

The days which followed this preparation phase were taken up with on-site welding of HDPE sleeves. Their installation could begin once the first ducts were made. For a fortnight, two teams of 12 people worked continuously to ensure the welding of all ducts while at the same time carrying out the threading and tensioning of the strands.

The length of the stay cables varies – the shortest was 30m and the longest 70m.

It was with the support of BBR Polska, that the tensioning operation was carried out successfully using the BBR ISOSTRESS method to ensure the equal stress was applied to all of the strands. As soon as favorable feedback was received from the design office, ETIC teams were able to undertake the finishing works.

On Monday, 15th October, the whole of the stay cable work on the Saint Jacques Bridge had been completed. Our work ensured that the bridge opened in time for Christmas 2018!



3



4

- 1 Preparation and pre-cutting of the stay cable strands – steel bobbins were used to assist with preparing the strands.
- 2 Stay cable threading system inside the pylon.
- 3 The new Saint Jacques Bridge, showing off its BBR HiAm CONA stay cables, at sunset.
- 4 Installation of the HDPE sleeves for the stay cables.

TEAM & TECHNOLOGY

Owner – Transports Québec

Main contractor – Demathieu et Bard Construction

Technology – BBR HiAm CONA stay

BBR Network Member – ETIC SA (France)

Fast-tracking to eliminate risks

The construction of the Pulau Poh cable-stayed bridge has been challenging both technically and environmentally. The curved pylon shape in two planes, with changing cross-section and heavily congested reinforcement posed constructability concerns. Accurate geometry control and positioning of stay cable anchorages within the pylon are crucial to ensure the bridge meets its intended design life. Located in an area with high rainfall intensity, where working areas are constantly submerged, presents additional environmental challenges. Chet Chie Voon and Hiang Miang Goh of BBR Construction Systems (M) Sdn Bhd, the BBR Network Member for Malaysia, describe the innovative construction methodologies adopted in the construction of the cable-stayed Pulau Poh Bridge.

Structural features

The 133m long, single span Pulau Poh cable-stayed bridge is supported by a 61.5m tall A-shaped pylon, inclined at approximately 30 degrees from vertical and leaning towards the main span. Apart from the inclination, the pylon also adopts a curved profile in two planes, creating an aesthetically pleasant look. Supporting the bridge deck are 20 pairs of front stays spaced 6m apart and arranged in a semi-fan like manner. The length of the front stay cables varies from 22m to 118m and consisting of 24 to 37 individually galvanized, waxed and HDPE sheathed strands. The seven pairs of back stays anchored into the back-stay counterweight structure provide a counter-balance for the main span of the bridge. Each back stay cable is made up of 109 strands and varies between 64m to 88m in length.

The back stay counterweight structure is located approximately 42m away from Abutment A and provides a downwards anchoring force to resist the upward force induced by the back stay cables. Two tiers of ground beams connecting the back stay structure to the deck and pylon base counteract the horizontal force component from front stays, thus ensuring lateral loads induced on the foundation are kept to a minimum.

The beginning

The planning of the Pulau Poh cable-stayed bridge started in early 2014. The bridge was to be constructed in a staged cantilever manner, where the reinforced concrete (RC) pylon construction, bridge deck installation and stay cable installation sequence were inter-dependent.

The bridge is located in the State of Terengganu which historically experiences the yearly Northeast monsoon between November and March, thus the water level at Lake Kenyir is expected to rise during this period due to heavy rainfall. Theoretically, this leaves approximately seven months of 'good' weather for construction works to be done – in the months from April to October.

Decoupling work sequence

With the end date of the project remaining unchanged, adopting the staged cantilever work sequence would have put the project at risk of further delay. Hence, the idea of decoupling the RC pylon, bridge deck and stay cable installation sequence was explored. By adopting this strategy, the RC pylon, bridge deck and stay cable installation works could progress independently. Other advantages of adopting this construction method would be reduced idling time between each work trade and better resource utilization.

New technologies which were adopted, such as BIM, have helped to identify out-of-tolerance issues and enabled advance planning for pylon construction works, hence further minimizing risk of delays.



1

While work was still progressing, the North-east monsoon started and was unexpectedly prolonged beyond its anticipated duration. In April 2017, the water level at Lake Kenyir was still approximately 144m and inundating working areas.

Deck construction works however continued to progress despite the unfavorable weather conditions – proof that the changed construction sequence had some advantages.

More obstacles & enhancement via technology

By April 2017, the water level at Lake Kenyir was showing no sign of receding and the project deadline was approaching. Hence, the pylon design was revisited while considering the challenges and issues that would arise if the pylon were to be constructed by the conventional climbing formwork method. Therefore, the idea of a steel composite pylon was considered. The conversion of the upper pylon into a steel composite section had the following advantages:

- Off-site fabrication of the upper pylon without being affected by the weather conditions and progressing in parallel with the pylon base.
- Better construction tolerances by adopting steel fabrication, hence lesser geometry control uncertainties.

- Reduction in overall reinforcement as outer pylon plates are considered as part of the structural design.
- Integration of the working platform at predetermined positions over the full height of the pylon which also formed the vertical access.

The conversion of the upper pylon into a steel composite section necessitated the modeling of the steel structure in 3D. This allowed for the better visualization, planning, clash checking, optimization of materials and sequencing of the pylon construction activities – and thus further minimizing uncertainties.

Towards completion

Moving from design stage to construction stage, the Pulau Poh cable-stayed bridge project faced multiple challenges – starting with unfavorable weather and site conditions. With the unchanged completion date, the bridge design and construction sequence needed to be revisited to expedite the overall completion of the bridge structure and also to reduce down-time caused by the uncertain seasonal monsoon weather. New technologies which were adopted, such as BIM, have helped to identify out-of-tolerance issues and enabled advance planning for pylon construction works, hence further minimizing risk of delays. Currently, construction of the bridge is on track and completion is expected by mid-2019.

1 Aerial view of Abutment A, showing flooded working area with on-going deck installation works in the background (April 2017).

TEAM & TECHNOLOGY

Owner – Jabatan Kerja Raya Negeri Terengganu (Public Works Department of Terengganu State)

Main contractor – Casa Hartamas Sdn Bhd –

Designer – Roadnet Solutions Sdn Bhd

Technology – BBR HiAm CONA stay

BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

Stay Cable Replacement Fernando Reig Bridge, Alcoy, Spain

New technique for stay cable replacement

When the stay cables of southern Spain's Fernando Reig Bridge needed replacing, Spanish BBR Network Member BBR PTE, part of FCC Construcción S.A., delivered the technical skills and latest BBR stay cable technology for the project, as well as a new technique for stay cable replacement. Juan Linero describes the project and how the team overcame the challenges.

Damage to structure

During maintenance operations on the bridge in 2016, involving asphalt roadway and sidewalk renovation, a sudden rupture of one of the stay cables took place. The bridge was closed to traffic and a complete examination of the broken stay cable was carried out. Exhaustive examination of the stay cable determined that the steel strands were completely corroded, possibly due to a poor cement grouting procedure that left pockets of air inside the stay cable duct. This discovery prompted the need to determine the structural status of all of the bridge's stay cables.

The 38 stay cables were examined with capacitive gauges to try to find possible gaps or voids in the cement grout inside the stay cable ducts. The examination was not complete because there were zones in the stay cables that were

impossible to analyze – for example, the stay cable zone inside formwork pipes in the deck and on the pylon. So the results were not conclusive and, consequently, the structural stability of the bridge could not be guaranteed. Thus it was decided to replace the bridge's entire stay cable system. In addition to the stay cable replacement works, some other repair activities and further installation renewal and updates were included, for example concrete repair works at the pylons, new pavements, new lighting systems and new vehicle barrier, in order to meet current safety code requirements. The overall reconstruction project was awarded to FCC Construcción S. A. which is a leading international construction company, and also – through BBR PTE – operates the franchise for BBR technology in Spain and some other countries. >

Fernando Reig Bridge after the stay cable replacement and refurbishment.







1

FACTS & FIGURES FERNANDO REIG BRIDGE

STAY CABLES

38

MAX. STAY CABLE LENGTH

127.6m

BRIDGE LENGTH

273m

SPANS

108 + 132 + 33m

DECK

17.4m wide

CARRIAGEWAY

12m wide

SIDEWALKS

2 x 2.7m wide

Repair works strategy

Repair works began in August 2017 and the original project envisaged the temporary support of the complete bridge deck and removal of almost all the stays prior to installation of some of the new stay cables.

As the bridge consisted of two independent planes of cell box girders and stays, FCC Construcción proposed to work on one plane at a time, replacing firstly the stay cables on one side and then the stay cables on the other side. This modification to the initial plan provided a major time saving to the project, and thus it was finally approved allowing the works to be completed some weeks before the deadline. The Fernando Reig Bridge, inaugurated in 1987, carries the N-340 road over the Barxell river at Alcoy, near Alicante. Crossing the river at a height of about 40m and featuring 38 stay cables supporting two asymmetric deck spans, this was one of the first stay cable bridges to be constructed in Spain. Distinctive features at the time of its construction included the total prefabrication of the spans which represented an innovative solution for this type of bridge back then. Later stay cable bridges, constructed from the 1990s onwards, used the same techniques and designs realized in this bridge.

Bridge overview

The bridge consists of two post-tensioned cell box girders of 2.50m in height with a maximum width of 3.80m to which the main beams of the deck are connected. The two cell box girders are constructed of 5 and 7m segments placed in such a way that the short segments contain the lower stay cable anchorages which are thus positioned 12m apart along the length of the completed girder.

The upper anchorages of the stay cables are located on the pylon and they cross each other in different planes within the pylon itself. The three shortest stays of each plane are anchored in a chamber inside the pylon. The original 38 stay cables represented the state-of-the-art of stay technology at the time they were originally installed. Their main characteristics were:

- Stay cables consisted of between 23 and 55 steel strands, each with a diameter of 15.2mm and an area of 140mm².
- Black polyethylene duct covered the whole length of the stay cables.
- Anchorages with wedges and hardening filler material for clamping the steel strands.
- Cement grout filling to cover and protect the steel strands and wedges.

This latest technique will prove useful for the generation of stay cable bridges constructed before the 1990s which may also suffer similar problems caused by the passing of the years.

Unforeseen challenge

For replacing the stay cables on each side of the bridge, five temporary support towers with hydraulic jacks were installed under the box girders, in addition to a hydraulic jack installed in the intermediate crossbeam beneath the pylon to support the deck.

For the stay cable de-stressing operation, the team planned to use hydraulic jacks connected to the rear of the stay cables to be replaced. The process would involve transferring the load of the stay to the jack, unthreading the locking nut of the active anchorage of the stay and, finally, releasing the load of the jack until the stay cable force had been totally released. However, when the protective caps of the anchors were removed, it was realized that this approach would only be possible for six of the 38 anchorages. For the 32 remaining stays, there was insufficient length of strand or anchorage thread at the back of the anchorages to enable the hydraulic jack to be mechanically connected to them. This unforeseen challenge demanded the urgent development of an alternative system for de-stressing the stay cables. The solution was developed by the highly experienced Technical Services of FCC Construcción, in collaboration with its PT and stay cable department BBR PTE.

Innovative solution

As it was impossible to connect to the stay cable anchorages, the only option was to perform the de-stressing operation by working on the free length of the stay cables.

For this, a new system was devised consisting of removing HDPE duct and the cement grout filler in a portion of the free length of the stay cable and replacing it with a special filler compound which would improve the mechanical properties in the local zone of the stay.

After the operation to increase capacity to this part of the cable had been completed, two friction clamps could be used to hold and transfer the cable force to two PT bars. These were placed either side of the clamps, using two hydraulic jacks. Once the stay force was transferred to the PT bars, the stay cable was cut between the clamps. After this, the stressing jack released the force in the PT bars. This innovative system is currently subject to a Patent Application by FCC Construcción, S. A. Once totally de-stressed, the stay cable was fully dismantled from the structure. Special attention was paid to the unbalanced catenary forces in the heavy and long stays. When the bearing plates located at the pylon and on the deck became free and accessible, the operation to install the new stay cables began.



2



3



4



5

New stay cable system

The latest European-approved, Swiss-engineered BBR HiAm CONA stay cable technology – which fulfills all recognized international standards and recommendations such as *fib*, PTI and CIP (SETRA) – was chosen for the new stay cables.

The installation of the stay cables was performed on site using the typical strand-by-strand installation method, which is comprised of four basic steps:

- Installation of the upper (pylon) and lower (deck) anchorages.
- The pre-assembled stay cable pipe is suspended between the two anchorages using two master strands. The stay cable pipe is then used as a guide to insert the successive strands from anchorage-to-anchorage using a guide wire.

- The strand is positioned at deck level and pulled up through the stay pipe and the upper anchorage and inserted into the lower anchorage.
- Each strand is tensioned immediately after installation, using the BBR ISOSTRESS tensioning method, ensuring an equal stress distribution among the strands of an individual cable.

The stay cable system replacement was completed in a record time. The 38 stay cables were replaced at a rate of two stay cables per week. It took six months for the complete operation, including installation of the clamping system for de-stressing, lifting down operations and installation of the new stay cables.

- 1 Installation of the new stays (white color) in progress.
- 2 Stay cables were anchored in two planes on either side of the H-shaped pylon.
- 3 De-stressing device in operation.
- 4 New stay cables installed at rate of two per week.
- 5 Delegates attending the BBR Network European Project Managers' Workshop in Valencia visited the site.
- 6 Temporary support towers with hydraulic jacks were installed under the cell box girders and a hydraulic jack installed in the intermediate crossbeam beneath the pylon to support the deck.

TEAM & TECHNOLOGY

Owner – Ministerio de Fomento

Consulting engineer – Fhecor

Main contractor – FCC Construcción S.A.

Technology – BBR HiAm CONA stay

BBR Network Member – FCC Construcción S.A. (Spain)

Re-opening & final result

On 17th April 2018, 31 years after its first inauguration by the Spanish Minister of Public Works the Fernando Reig Bridge was officially re-opened.

With these rehabilitation works, the old Fernando Reig Bridge now has a completely new stay cable system, created by using the latest stay cable technology. The pylon has been renewed and the deck shines with a new concrete cover, new pavements, new LED lighting systems and new vehicle barriers which have been included to convert the old bridge built in the 1990s into a bridge fit for the 21st century.

The Fernando Reig Bridge re-opening was a proud moment for FCC Construcción S.A. and for its PT/stay cable department BBR PTE and has a deep relevance for stay cable technology history. Innovative techniques and designs were used in the original construction of this bridge back in the 1980s – and now the latest innovation and practice has again been applied to the recent stay cable replacement project. This latest technique will prove useful for the generation of stay cable bridges constructed before the 1990s which may also suffer similar problems caused by the passing of the years.



BBR HiAm CONA Stay Cable System

TECHNICAL FEATURES & BENEFITS

The new BBR HiAm CONA stay cable system installed for the Fernando Reig Bridge offers many superior features and benefits, including:

- Excellent fatigue resistance with BBR benchmark testing above-and-beyond international standards.
- Superior bending fatigue resistance – 2 million cycles with an angular deviation of $\pm 0.6^\circ$ plus a further 250,000 cycles at $\pm 1.4^\circ$.
- Outstanding long term fatigue resistance – 50 million cycles at the BBR benchmark loading criteria.
- The stay cables consist of between 23 and 55 steel strands (diameter 15.7mm, 1,860MPa and area of 150mm²). This represents an increase of 7.1% in capacity compared to the old stay cable system.
- Advanced water sealing system featuring independent and individual strand sealing, triple redundancy and no requirement of pre-compression to activate the water sealing mechanism.
- Parallel strand stay cable system that allows stay installation and replacement on a strand-by-strand basis.
- Steel strands are provided with three protection barriers against corrosion – steel galvanization, wax protection and individual HDPE sheathing.
- White polyethylene duct that reinforces strand protection and reduces the temperature caused by solar radiation.
- Flexibility in stay cable force regulation and fine-tuning via the threaded nut in the anchorage.
- Extra length of steel strand in active anchorage to allow re-stressing, or single strand inspection and replacement.
- Protective flexible filler injection in anchorages to encapsulate them and provide protection against corrosion.

Tanks, Kuwait & Western Australia BBR post-tensioning for 16 new LNG and wastewater storage tanks

Two times eight

In Chinese culture, eight is a lucky number and good fortune – this, as well as their own specialist skills, seems to be working in favor of BBR Network Member **SRG Global**. The company has recently been providing BBR technology and services for two major installations – each requiring the construction and post-tensioning of eight massive tanks.

Not only is SRG Global providing post-tensioning services for the eight new cryogenic LNG storage tanks at the Al-Zour Import Terminal project, but the company has also recently completed work on same number of new tanks for Woodman Point Wastewater Treatment Plant in Western Australia.

1 Al-Zour Import Terminal Project, Kuwait

The Al-Zour Import Terminal Project, now well underway, includes the construction of a large-scale liquefied natural gas plant, including eight LNG storage tanks, located 90 kilometers south of Kuwait City.

SRG is responsible for post-tensioning the eight LNG storage tanks which are a core part of the project. Once fully operational, the facility is expected to produce around 22 million metric tonnes (MMT) of natural gas per year

and will have a storage capacity of 1.8 million cubic meters of LNG.

Each tank has a capacity of 225,500m³ with a height of 47.65m, diameter of 97m and 750mm wall thickness.

BBR VT CONA CMI internal post-tensioning is being used and features 27 strands of 15.2mm diameter prestressing steel per tendon. The installation includes 96m long vertical loop tendons and 150m long horizontal loop tendons.

FACTS & FIGURES AL-ZOUR IMPORT TERMINAL PROJECT

NUMBER OF TANKS

8

TANK HEIGHT

47.65m

TANK DIAMETER

97m

TANK WALL THICKNESS

750mm

CAPACITY OF EACH TANK

225,500m³

STRANDS PER TENDON

**27 x 15.2mm
diameter**

VERTICAL LOOP TENDON LENGTH

96m

HORIZONTAL LOOP TENDON LENGTH

150m



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2 Largest wastewater plant in Western Australia

The SRG team has recently completed post-tensioning works on eight new tanks at the Woodman Point Wastewater Treatment Plant – the largest wastewater treatment plant in Western Australia. It treats wastewater for a population of about 680,000 people living south of the Swan River in the Perth metro area. As the population in the catchment area continues to grow, additional treatment capacity is required at the plant. This upgrade project will see the plant's capacity increase to 180 million liters per day, accommodating a population of more than 900,000, and is expected to be complete by late 2019.

Phase one of the project includes the construction of eight new secondary sedimentation tanks. SRG were contracted by WP180 – an alliance between Water Corporation, Black & Veatch and Civmec Construction & Engineering – to carry out all post-tensioning works to the eight new tanks on this project.

Each 6.4m high tank has a capacity of 11 million liters and measures 50m in diameter. SRG installed, stressed and grouted 60t of 12.7mm

diameter strand for the base slabs and also carried out post-tensioning works to the walls of the tanks.

The walls consisted of precast panels which were manufactured off site, transported to site then installed using a 500t crane. SRG were involved in inspecting all precast panels prior to the concrete pours. Once the wall panels were lifted into place, post-tensioning duct coupling works were completed and an infill pour was carried out before the post-tensioning strands were installed. The BBR CONA CMI internal post-tensioning system was used for this and SRG installed over 130t of post-tensioning strand for the 12 hoop tendons through four buttresses. The hoop configuration basically acts like a huge elastic band holding the walls tight.

A team of ten SRG personnel were on site performing the specialist post-tensioning operations which were completed ahead of schedule, much to the client's satisfaction! SRG's Services team were also involved in this project having been engaged to carry out waterproofing at the interface of the wall and the base slab which is critical to the performance of the tanks.

- 1 Al-Zour Import Terminal Project – visualization of the eight new cryogenic LNG storage tanks at the Al Zour LNG Import Project.
- 2 Woodman Point – eight new 6.4m high 11 million liter wastewater tanks are under construction at Woodman Point, near Perth, Australia.

TEAM & TECHNOLOGY

1 AL-ZOUR LNG IMPORT TERMINAL PROJECT

Owner – Kuwait National Petroleum Company (KNPC)

Main contractor – Hyundai Engineering and Construction Co., Ltd

Technology – BBR VT CONA CMI internal

BBR Network Member – SRG Global (Middle East)

2 WOODMAN POINT

Client – Water Corporation WA

Main contractor – WP180 (alliance of Water Corporation, Black & Veatch and Civmec Construction & Engineering)

Technology – BBR VT CONA CMI internal

BBR Network Member – SRG Global (Australia)

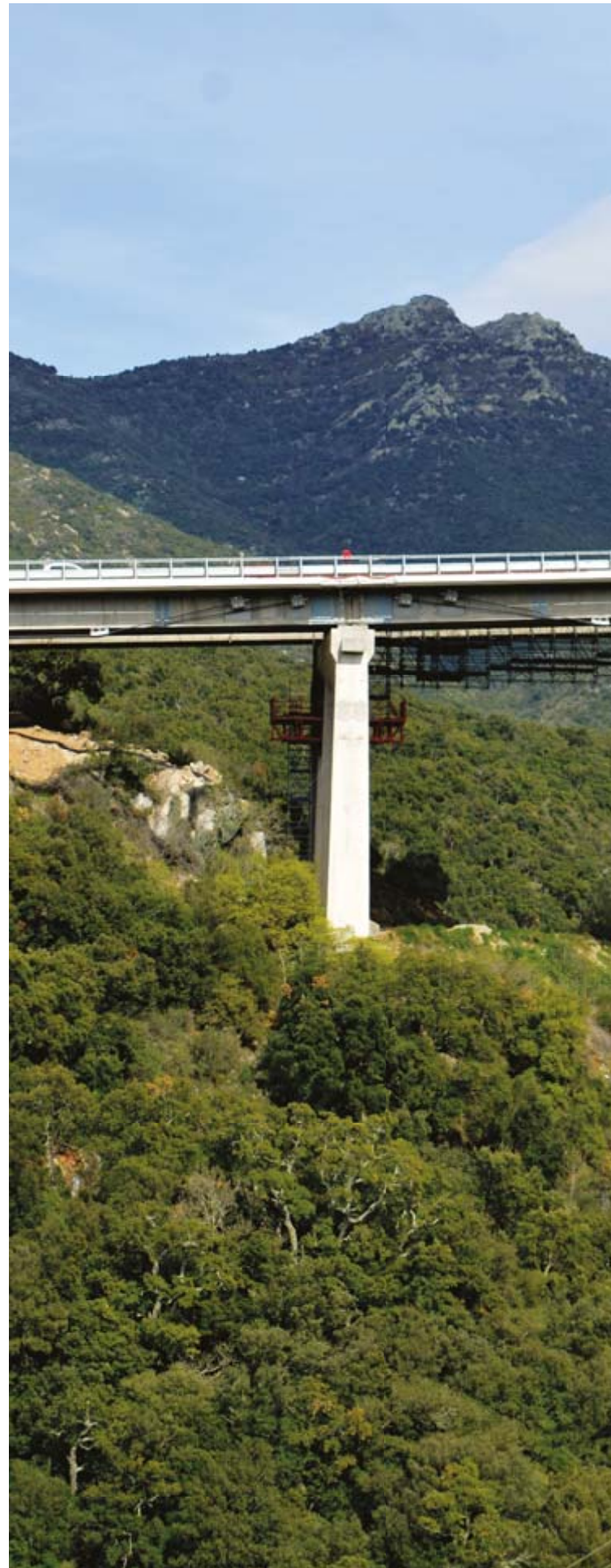
Calcine & Pox Viaducts, A9 Motorway, France

Reinforcement of two viaducts using BBR VT CONA CMB

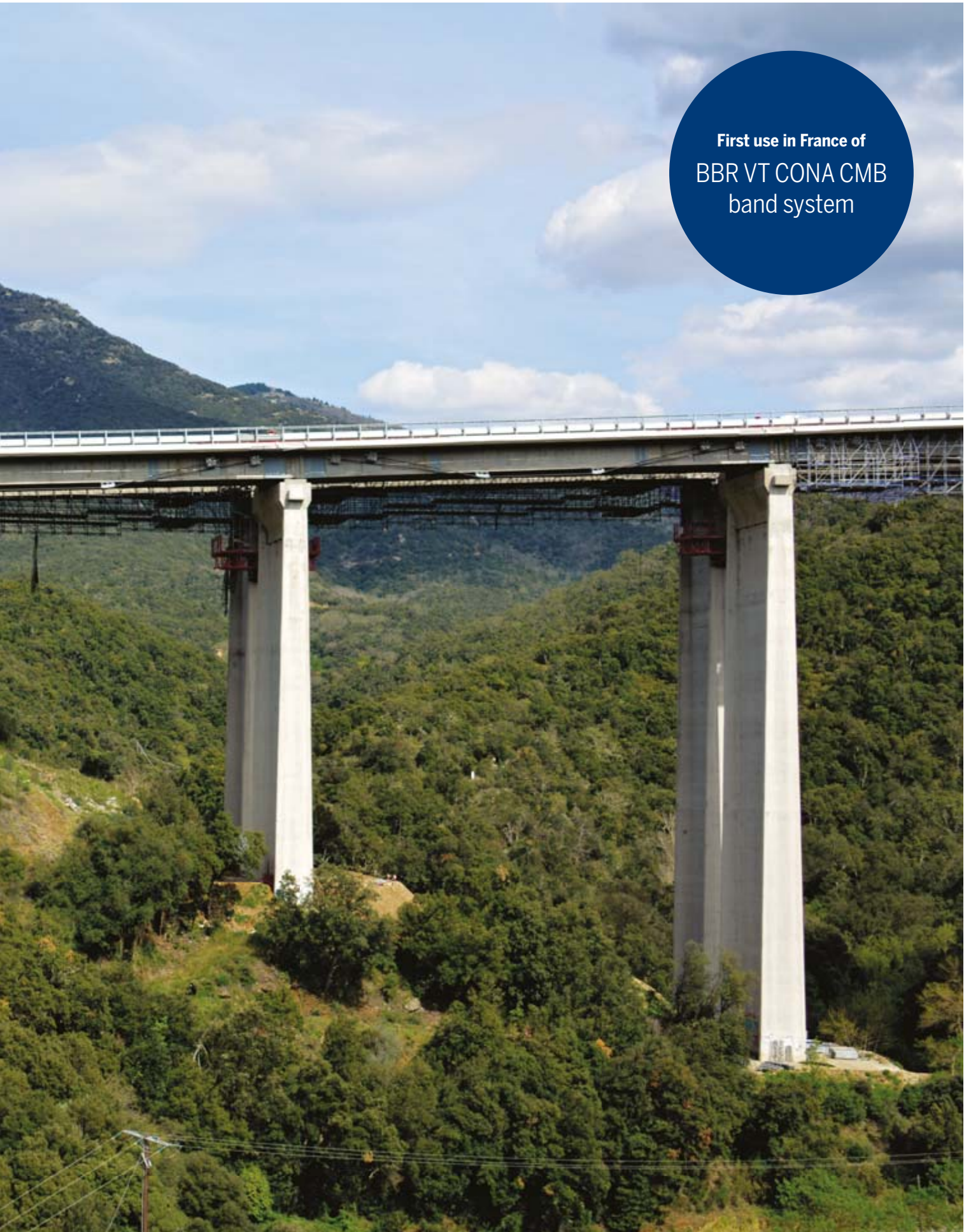
Widening the motorway

A 40km stretch of the A9 motorway is being widened between Perpignan in France and the Spanish border in response to a huge increase in traffic over the past decade. Jérémie Baumgartner, Operations Director for ETIC, the French BBR Network Member, gives an insight into both the scheme and his company's specialist role in the works. >

Structural strengthening was required so that two viaducts on the A9 motorway in south-western France, 50m above valley floors, could each accommodate an additional two lanes of traffic.



First use in France of
BBR VT CONA CMB
band system





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The A9 motorway, today part of the European E15 and E80 highways and operated by ASF (Autoroutes du Sud de France), was first conceived in the 1960s. The motorway route was to run in a south-westerly direction from Orange where it intersects with the famous A7 'Autoroute du Soleil', then continues onwards through Narbonne to Perpignan and finally to Le Perthus. Construction of the final section, taking it to the border with Spain, was completed in 1978.

Widening project

So, some 40 years on, it is no surprise that the infrastructure requires upgrading and updating. The recent widening project, reported to be valued at around €500m, was divided into three phases:

- Phase 1 Perpignan Nord to Perpignan Sud (17km)
- Phase 2 Perpignan Sud to Le Boulou (15km)
- Phase 3 Le Boulou to Le Perthus (9km)

It was for Phase 3 – the shortest, but most technically complex section – that ETIC were contracted for their specialist knowledge of external post-tensioning. This section of motorway carries some 40,000 vehicles daily, around 25% of this traffic is heavy goods vehicles destined for the lorry-rail terminus at Le Boulou.

Two viaducts

Our work was on two of the viaducts – Calcine and Pox – which sit some 50m above valleys in this mountainous landscape. Structural strengthening was required so that the viaducts could accommodate an additional two lanes of traffic – one in each direction.

We worked in cradles and from scaffolding platforms beneath the deck of the viaducts – and mostly at night under live traffic conditions. We were also at the mercy of the Tramontane winds which can blow violently for several days in a row – for safety reasons, work would stop during this time.



3

We worked in cradles and from scaffolding platforms beneath the deck of the viaducts – and mostly at night under live traffic conditions.

In total, we placed around 11t of external post-tensioning, using the BBR VT CONA CMB band system. For each viaduct span, we installed four CONA CMB tendons each with four strands of 15.7mm cross-section – there were two PT tendons on each side of the bridge beams. First, we secured the anchorages which were installed in concrete blocks secured to the sides of the existing bridge beams using 40mm diameter bars.

For ease of handling and installation, the deviators – designed to be as lightweight as possible – were manufactured in two parts which could be bolted together on site. The BBR VT CONA CMB band tendons were produced by Austrian BBR Network Member KB VT in their workshops in conformance with ETA requirements. After installation, stressing of the post-tensioning tendons was carried out symmetrically, using the strand-by-strand method, starting from the inside and working towards the exterior of the deviation curvature. This was an extremely challenging project, largely because of the high and exposed working conditions, however we completed our specialist activities in around only three months.

- 1 There were two PT tendons on each side of the bridge beams, seen here passing beneath the deviator.
- 2 The deviators were designed to be as lightweight as possible and manufactured in two parts, for ease of handling and installation, then bolted together on site.
- 3 The BBR VT CONA CMB anchorages were installed in concrete blocks secured to the sides of the existing bridge beams using 40mm diameter bars.

TEAM & TECHNOLOGY

Client – Autoroutes du Sud de France (ASF)
Main contractor – Eiffage Génie Civil
Technology – BBR VT CONA CMB band
BBR Network Member – ETIC SA (France)

Mount Pleasant No. 1 Reservoir, Mackay, Queensland, Australia

External post-tensioning for water tank

Ensuring continued water supply

Australian BBR Network Member SRG Global has recently completed external post-tensioning works on the Mount Pleasant No. 1 Reservoir located in Mackay, Queensland.



SRG's installation of 43 layers of BBR VT CONA CMB bands around the tank at Mount Pleasant No. 1 Reservoir, means that the town of Mackay's water supply has been ensured for at least another 50 years.

Originally constructed in the 1960s, the tank was built using an early method of post-tensioning known as 'wire-wrapping'. After wrapping the wires around a concrete tank, they are given a protective cover of sprayed concrete, however over the years, water permeates through the wall to the wires and corrodes them, leaving the tank liable to potential failure. Mackay Regional Council undertook a remediation program to remove all the wire-wrapping and looked for a modern, durable, external post-tensioning system to replace it.

SRG recommended the BBR VT CONA CMB band system – a fully-sealed assembly of high-tensile grease-coated steel strands within a double layer of HDPE protective sheathing, giving a design life of 50 years. SRG's Sydney office undertook the full structural design of the tank, detailing 43 layers of

CONA CMB bands encircling the tank to provide the necessary strength to resist water, thermal and earthquake loads. A unique external anchor component was also developed, which allowed the lower CONA CMB bands to be placed at closer than normal spacing.

This was an important project for Mackay, so over 30t of CONA CMB band was air-freighted from Austria to Mackay to allow the earliest possible start – and resulted in completion ahead of schedule.

TEAM & TECHNOLOGY

Client – Mackay Regional Council
Consultants – GHD
Main contractor – McElligotts QLD Pty Ltd
Technology – BBR VT CONA CMB band
BBR Network Member – SRG Global (Australia)

Modern techniques preserve historic structure



Restoration and strengthening work underway at Flinders Street Station, Melbourne.

BBR Network Member for Australia, SRG Global has carried out heritage façade restoration works on one of Melbourne's most iconic buildings in the CBD, Flinders Street Station.

As part of the Government of the State of Victoria's A\$100m program to repair Melbourne's iconic Flinders Street Station, SRG worked with Built Pty to give the building a new lease on life, undertaking the refurbishment works on the Station's heritage-listed administration building.

More than 100 years old, the building required urgent restoration and maintenance to conserve its heritage elements for future generations. Situated in the heart of Melbourne's CBD, the building is listed under the Victorian Heritage Act and by the National Trust.

Work scope

SRG's scope on this project includes façade refurbishment with a combination of repair types. As the largest contractor on site, SRG had up to 54 remedial technicians and subcontractors performing a very complex and varied scope of works. Kilometers of brick repointing was carried out, in a number of aesthetic finishes to match the existing surrounding finishes. This included tuck-pointing to the main façade and other feature areas of the building, including the clock tower. Existing struck pointing and flush pointing finishes also had to be

matched, both in form and color. Patina formed on the outside of the bricks was to be left as a memory of a bygone era when steam trains rolled daily over Melbourne's railway tracks.

Brickwork strengthening

Structural strengthening of brickwork was completed with many kilometers of helibar, a stainless steel strengthening bar inserted into the mortar lines across cracks in the brickwork. Areas too dilapidated necessitated localized demolition and rebuilding of brickwork, this included protruding corners of the building, where temporary propping needed to be installed to support the building structure above.

Other areas demolished and rebuilt included where doors had been moved since the original construction. These doors were relocated back to their original locations to restore the heritage value of the building.

Seismic strengthening for clock tower

SRG's work also included the seismic strengthening of the clock tower. With their input, the design was changed from stress bars which would be heavy and costly due to the amount of couplers required, to sheathed 15.2mm diameter strand in the form of the BBR VT CONA CMB band system.

Two strand post-tensioning bands were utilized with a water-blocking filling compound to prevent the product dropping out as the strands were oriented vertically. Four 8-strand tendons were installed between Levels 2 to 6, four 4-strand tendons were installed between Levels 5 and 8, and eight 2-strand tendons were installed between Levels 8 and 10.

The structure did not have sufficient anchorages for the post-tensioning, so new structural steelwork was installed in Level 2 in the form of 460mm universal beams, shotcrete anchorages were sprayed into the corners of Level 6, cast in situ concrete beams 1500mm high were cast into Level 5, and the upper levels were also structural steel.

TEAM & TECHNOLOGY

Client – Department of Economic Development, Jobs, Transport and Resources
Major Projects Victoria

Architect – Lovell Chen

Main contractor – Built Pty

Technology – BBR VT CONA CMB band,
MRR range

BBR Network Member – SRG Global
(Australia)

Raising walls for post-quake library

Eight years since the devastating Canterbury earthquakes, New Zealand's Garden City is re-emerging like a butterfly from a chrysalis. Restored, rebuilt and brand new buildings are starting to dominate the Christchurch landscape, bringing with them not only seismic resilience but also innovation and excellence in design and construction. BBR Contech's Peter Higgins describes one such project.



Christchurch re-imagines the library concept and the building is now restored and strengthened with the help of BBR Contech.

The result is a refreshing 're-imagining' of the library concept that, over four levels and in almost 10,000m² of space, combines creative, entertainment, play, relaxation and meeting areas with modern technology, equipment and facilities. As well as housing digital, specialist and print collections, Tūranga offers a café, retail space, meeting rooms and a community auditorium, along with spaces for people to trial new technology and edit music, film and video productions.

Having never worked on a library project before, the BBR Contech team leapt at the opportunity to strengthen the building's 10 shear walls and help ensure that Tūranga withstands future earthquakes. However, while the specifications were relatively straightforward, the central-city location, tight site size and pre-built roof, together with a requirement to install 80 vertical tendons – weighing 400kg and measuring 28m long – from a seven-storey height, meant some very tricky maneuvering. The challenges were clear right from the start, when the crew were required to pre-cut and assemble the tendons on site, each comprising eight 15.2mm strands individually greased and sheathed to protect them from corrosion. The tendons then had to be taped together and craned to the top of the walls, from where they were guided into ducting and sent on their way to ground level.

The fun continued, as the receiving team had to crawl into a small, cramped reinforcing cage to move the tendons to a 'dead-end' anchorage cast into the foundations. The tendons were stressed at roof level, then galvanized caps were fitted to the tops and filled with grease. Now a popular destination for the people of Christchurch, Tūranga is a fine example of the use of PRESSS (PREcast Seismic Structural System) technology – where the unbonded post-tensioning tendons allow for a controlled rocking mechanism that, even in a major seismic event, will return the building to an upright position without significant structural damage.

One of the newest arrivals is Tūranga (the New Central Library), which opened its doors in October 2018 with the goal of "fostering lifelong learning and being the place for information, inspiration and entertainment". Occupying a prominent site in the heart of Christchurch city, Tūranga was designed by local firm Architectus in partnership with Schmidt Hammer Lassen Architects, a Danish firm with a long and award-winning record of excellence in library design. The design process included close consultation with local Ngāi Tahu and Ngāi Tūāhuriri rūnanga (tribal councils) to incorporate the Māori worldview and cultural traditions.

TEAM & TECHNOLOGY

Owner – Christchurch City Council
Main contractor – Southbase Construction
Consulting engineer – Lewis Bradford Consulting Engineers
Technology – BBR VT CONA CMI internal, MRR range
BBR Network Member – BBR Contech (New Zealand)



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Springbrook Road, Springbrook National Park, Queensland, Australia BBR SDX bar installation for ground support works

Stablization & reinstatement with BBR SDX Bar system

The BBR Network Member for Australia, SRG Global, is performing ground support works in Springbrook, Queensland, following the rainfall event associated with Severe Tropical Cyclone (STC) Debbie in March 2017.

STC Debbie caused extensive damage across Queensland including Springbrook National Park located in the Gold Coast Hinterland. The damage resulted in a 10km section of the Gold Coast to Springbrook Road being closed to traffic until reconstruction work has been completed. Work is being jointly funded by the Commonwealth and Queensland Governments under the Natural Disaster Relief and Recover Arrangements (NDRRA).

Work on site commenced in late January 2018 and includes minimizing the potential of erosion and loss of sediment to the local waterways and ultimately reinstating access to the road. The installation of anchors and soil nails, gabion walls, rockfall netting and shotcreting is also required at 53 critical sites – 18 major and 35 minor – to stabilize the slopes above and below the road.

SRG Global are supplying and installing over 12,500m of BBR SDX Bars with Galpex corrosion protection. The SDX range is a fully threaded hollow bar system comprising sacrificial drill bits, anchor nuts, bearing plates and couplers. The system is specifically designed to be used in challenging fragmented rock and soil conditions where boreholes can easily collapse. The BBR SDX system offers double corrosion protection as the bars are hot dip galvanized and epoxy coated. The system allows for simultaneous drilling, borehole flushing and grout injection and at the same time functions as load bearing anchors. The project team is satisfied with the SDX system performance which greatly assisted the team to achieve the project requirements.

- 1 Ground support works in Springbrook, Queensland, included the installation of anchors and soil nails, gabion walls, rockfall netting and shotcreting at 53 critical sites to stabilize the slopes above and below the road.
- 2 Water pours across the road during Severe Tropical Cyclone Debbie which caused extensive damage in many locations across Queensland, including Springbrook National Park.

TEAM & TECHNOLOGY

Client – Department of Transport and Main Roads QLD

Main contractor – Georgiou Group

Technology – BBR SDX Bar

BBR Network Member – SRG Global (Australia)

Repairs for reliable future performance

In a specialist engagement, Australian BBR Network Member SRG Global not only carried out investigations and trials, but also repairs to the whole anchor installation at Emigrant Creek Dam.

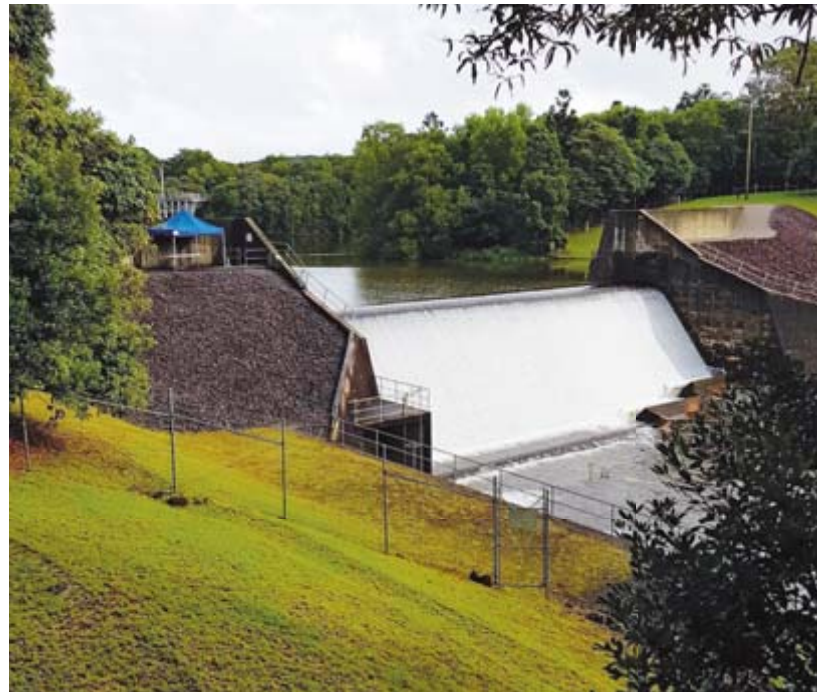
Emigrant Creek Dam is located in Tintenbar, 12km north-west of Ballina and has a water catchment area that is agricultural with rural residential and some tourist development. The structure is a gravity dam with a post-tensioned concrete spillway and earth-filled embankment abutments stretching for a length of 140m and to a height of 13m. Originally constructed between 1967 and 1968 to provide the major water supply to Lennox Head and Ballina, the dam has a capacity of 820 megaliters and a catchment area of 19km².

Earlier upgrading

In 2001, the dam was upgraded to new design standards with works undertaken to raise the embankments and reinforce the spillway by anchoring it to bedrock approximately 30m below the creek bed. However, these works were not undertaken to a high standard and consequently water had been seeping through the anchor head assemblies. This caused corrosion of the anchor head assemblies and strand resulting in some breakages. The condition of some of the anchors was so bad that it was concluded they were on the path to failure.

Specialist services

SRG Global was engaged as a specialist contractor to undertake intrusive investigation and trial repairs on two of the eighteen anchors which involved research and development to ensure the dam was remediated efficiently and effectively to meet the current design standards. After six months during the preliminary phase developing an agreed methodology with the client, SRG undertook the works to remediate the remaining damaged anchors. SRG commenced by lowering the level of the dam to reduce water ingress. Works then commenced on the existing anchors each of which had six or seven strands.



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The anchors were de-stressed in a planned sequence to ensure the performance of the structure was not compromised during works. Concrete anchor blocks surrounding the anchors were demolished, anchors were waterproofed and sealed with epoxy and grout before installing new bearing plates and BBR CONA SOL+ anchor heads to each anchor. The anchors were then stressed to approximately 60% Minimum Breaking Load (MBL). SRG have also supplied Rous County Council with a load cell and engineering support, so regular future monitoring can be undertaken in-house. This will allow the asset owner to identify when the existing corrosion damage to the strands reaches a state where a more permanent repair/replacement is needed.

1 Emigrant Creek Dam, near Tintenbar, New South Wales, where failure to adequately protect the ground anchors had jeopardized their reliable performance.

TEAM & TECHNOLOGY

Owner – Rous County Council
Design & build contractor – SRG Global
Technology – BBR CONA SOL+
BBR Network Member – SRG Global (Australia)

Protecting heritage structures for the future

Visitors taking guided tours of New Zealand's largest city often stop at a building that generated heated debate when it was constructed nearly 100 years ago.

Scathingly described as 'un-British', denounced as resembling a wedding cake and derided as likely to frighten old ladies passing by, the 54m high, octagonal-shaped Clocktower (also known as the Old Arts) Building at the University of Auckland is the centerpiece of what is otherwise a very modern campus.

It's also a protected heritage treasure, lauded as "an architectural milestone of great aesthetic appeal" – an opinion that would surely have horrified the critics of the past.

With the Clocktower itself having been renovated, restored, strengthened and cleaned in the mid-1980s, attention turned in 2018

to the seismic strengthening of a building at the rear (the East Wing) and a covered walkway connecting it to the Clocktower (the Cloister).

The East Wing and Cloister were both part of the original 1923-26 construction project and were designed to the same style – an Arts and Crafts interpretation of Perpendicular Gothic – by American-born architect Roy Lippincott and his partner Edward Billson. In an architectural move that was radical for the time, the structures feature native flora and fauna, while their reinforced-concrete walls are sheathed in New Zealand stone.

Complex challenge

BBR Contech's role was among the most complex of the 2018 project – to replace damaged, loose concrete and rusty reinforcing steel in the East Wing and Cloister walls, and to work closely with heritage advisers to strengthen the walls while meeting conservation requirements for materials and visual aesthetics. For example, in keeping with heritage principles, a steel bracket installed in the Cloister – and visible to passers-by – had to complement the character of the structure. For main contractor Argon Construction, details like these were critical to the project's success, so it was imperative to find the right specialists for the job. Fortunately General Manager Matt Gabriel was familiar with BBR Contech's work on similar projects and decided to get in touch.

"I was impressed with the team's experience, can-do attitude and partnership approach," he said. "They were involved right from the beginning in designing the solution, which included a helpful 'dry run' to test its feasibility and practicality."



I was impressed with the team's experience, can-do attitude and partnership approach. They were involved right from the beginning in designing the solution, which included a helpful 'dry run' to test its feasibility and practicality.

Matt Gabriel, General Manager,
Argon Construction

Project components

The year-long project had two components:

- in the Cloister, installation of horizontal and vertical stainless-steel rods to bind the open-air space
- in the East Wing, installation, tensioning and grouting of stainless-steel bars in 40 vertical concrete columns and tying the masonry horizontally to the concrete.

A seismic joint was also cut mid-Cloister, separating and decoupling the Clocktower and East Wing to give each 'room to move' in an earthquake. The goal was to have the structures meet 67% of New Zealand's Building Code standards and survive a one-in-500-year earthquake.

The East Wing project was particularly challenging as the columns had to be drilled into from the rooftop, sometimes as far as 11m. Steel bars were then inserted, secured in place with lime-based grout and finally mechanically tightened. Next, the capstones on the rooftop were drilled out, to conceal the protruding bar tips and nuts, and attached to the building. Internally, 3,600 ties were installed to tie the interior brickwork to the stone exterior walls. For the finishing touch, the BBR Contech team strengthened the floor with FRP, an extra defense against the risks of earthquakes.

At ground level the building's outer foundations were upgraded to increase their capacity, and new foundations were installed inside the existing walls. The walls were effectively sandwiched between the two new foundations, with the vertical bars anchored to the newer, larger, foundation unit.



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Wide range of skills

This unique project was notable for the wide range of skills required of BBR Contech, from concrete repair, crack injection and concrete spraying to drilling, post-tensioning, grouting and FRP strengthening.

"The project was a challenge for all of us," says Matt Gabriel, "especially given the potential for irreparable damage and the need to work in a busy university environment."

"Working with BBR Contech was a good example of effective collaboration and knowledge-sharing," he says. "The team understood what we needed, were well resourced and advised us promptly of issues and proposed solutions. Most importantly they were helpful and easy to work with, and did a great job in managing and delivering the project."

- 1 Tensioning of vertical steel bars for the columns in the East Wing.
- 2 Two further areas within the University of Auckland's historic Old Arts (or Clocktower) Building have recently been the subject of major seismic strengthening work. Image by Colin Rose, Montreal, Canada licensed under CC BY 2.0, via Wikimedia Commons.

TEAM & TECHNOLOGY

Owner – University of Auckland
Main contractor – Argon Construction
Structural engineer – Structure Design
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

Strengthening for new use

As part of the client's global expansion plans, an existing light industrial factory located on the eastern side of Singapore was purchased with the intention to convert the building into a data center. Dickson Liew from BBR Construction Systems Pte Ltd, the local BBR Network Member, outlines the scheme and his company's role in the project.

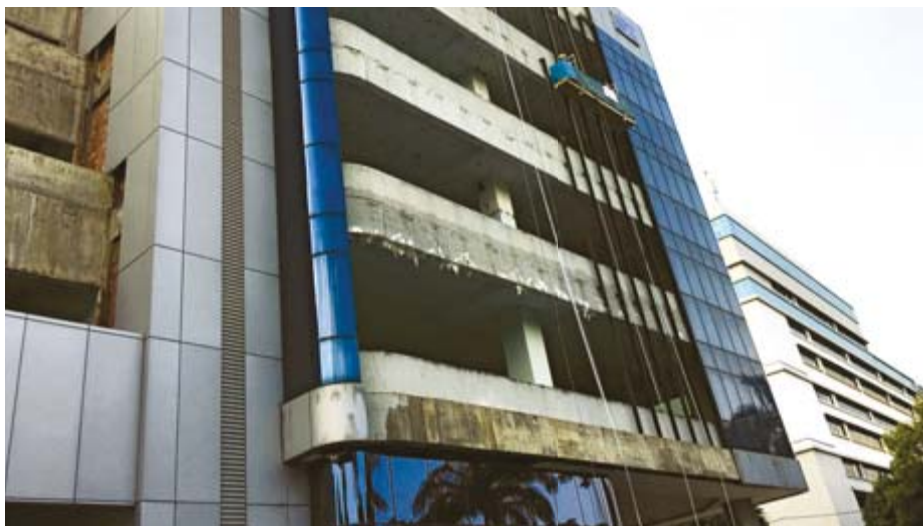
The client's plan is to retain much of the existing building, constructed some 25 years ago, and add further steel structures to create extra space. The existing structure is a six-storey reinforced concrete building with post-tensioned flat slabs, designed to support loads up to 10kPa, as the typical floor structural system. The roof structure is designed to be a reinforced concrete flat roof to allow the placing and housing of the mechanical and electrical equipment needed to service the building.

Unique structural feature

A unique feature of the existing structure is that the southern face of the building was designed as a tiered terrace whereby the building edge is gradually recessed floor-by-floor, resulting in an almost eight meter difference in width between the building footprint on the ground and at roof level.



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- 1 Visualization of the north elevation of China Mobile International's new Data Center in Singapore.
- 2 Removal of the tiered terrace façade in progress.
- 3 All tendons on an entire floor must be exposed and re-anchored before demolition work can take place.

TEAM & TECHNOLOGY

Client – China Mobile International
Lead consultant/M&E consultant – DSCO Group Pte Ltd
Architect – Scott Brownrigg
C&S consultant – Beca Carter Hollings & Ferner (SE Asia) Pte Ltd
Main contractor – China Construction (South Pacific) Development Co Pte Ltd
Technology – BBR CONA flat, MRR range
BBR Network Member – BBR Construction Systems Pte Ltd (Singapore)



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New structures

In view of the client's need for space and operational requirements, the new building design features new steel structures on the eastern side and also the demolition of the tiered terrace on the south face to make way for additional steel structures to increase the available floor area. Some demolition within the existing structure is also required to create shafts for the routing of mechanical or electrical services.

Need for strengthening

The intended demolitions on the post-tensioned slab coupled with the need for designing of strengthening systems for the existing structure led to the award of a subcontract to BBR Construction Systems Pte Ltd from the main contractor. We were selected for our ability to provide a wide range of services – such as the re-analysis of the existing structure with required demolition, re-anchoring of existing post-tensioning tendons, design of strengthening systems using a fiber reinforced polymer (FRP) system and also its supply and installation.

Progress on site

Site work has commenced with the removal of floor finishes and façade. The next item on the program is the exposing of existing tendons in the post-tensioned slab and this is currently in progress. This element of the work must be completed for the entire floor before demolition work can take place on the tiered terrace. Finally, the FRP part of the project will be carried out concurrently with the internal strengthening works which involve steel framing beams at the planned shaft openings.

Workshop Garage, Villingen, Switzerland

Strengthening of reinforced concrete ceiling

Making more space

The BBR Network Member for Switzerland, Stahlton, has completed the strengthening of a reinforced concrete ceiling which will allow former carpentry store rooms to be used as a garage.



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To create sufficient space, a load-bearing wall had to be demolished which necessitated strengthening of the concrete ceiling.

The team from Stahlton installed two composite steel beams and then applied and tensioned 14 lamellas made of so-called 'memory steel' over a span of 5.5m. In addition, 12 smaller CFRP lamellas were applied crosswise to make up for the lack of internal reinforcement following removal of the wall.

- 1 To strengthen the former carpentry store for use as a garage, Stahlton installed 14 memory steel and 12 CFRP lamellas.
- 2 Tensioning the memory steel lamellas.

TEAM & TECHNOLOGY

Client – Keller Zimmerei & Messebau

Engineer – HKP/Stahlton AG

Main contractor – Keller Bau

Technology – MRR range

BBR Network Member – Stahlton AG (Switzerland)



Auckland's Wynyard Wharf is being repaired and upgraded by BBR Contech ahead of the 2021 America's Cup.

25+ years'
experience with
Auckland's wharves
& ferry terminals

Wynyard Wharf, Auckland, New Zealand Wharf repairs for yachting spectacular

New Zealand prepares for America's Cup

In March 2021 New Zealand will host the 36th America's Cup yacht regatta – a 170-year-old race for what's considered to be sport's most difficult trophy to win.

Having last hosted the regatta in 2003, the organizers are now preparing for the tens of thousands of local and international visitors who'll descend on Auckland's waterfront to watch Team New Zealand defend the Cup against some of the best sailors in the world. The team delivered an emphatic win of 7:1 against the United States in the 2017 regatta, so Kiwis everywhere will be cheering them on! BBR Contech has been heavily involved in readying key parts of the waterfront for the influx of challengers, supporters and spectators, as well as the yachts that will be berthing there. Fortunately the company already has more than 25 years' experience with Auckland's wharves and ferry terminals, including work in 2017 to repair and upgrade the Hobson

and Te Wero Wharfs (see CONNÆCT 2018). These two structures are part of the 'Viaduct Harbour' precinct, a waterfront hub for the America's Cup that includes marina facilities, more than 30 restaurants and bars, superior hotel and apartment accommodation and venues for events and art installations. In mid-2018, the BBR Contech team returned to the waterfront, this time as part of a design and construction alliance comprising Downer, McConnell Dowell, Beca and Tonkin & Taylor, which is tasked with developing facilities and other infrastructure for the event. The work is still underway, with BBR Contech responsible for repairing and upgrading Wynyard Wharf, where four of the challenger syndicates will be based. Incidentally, Team New Zealand will

be based at the Viaduct Events Centre – for which BBR Contech installed the joint-free, post-tensioned concrete floor in 2010. Having previously been used for a variety of heavy-duty purposes – including as a ship refueling station, cross-harbor-ferry base and hub for scenic flights of the Hauraki Gulf – Wynyard Wharf requires extensive repairs. BBR Contech's role is to ensure that it will be ready for the next stage, when the complex infrastructure required for the challenger syndicates – including decks and pontoons – will be built. As was the case for the Hobson Wharf project, the team must consider the needs of everyone in the area – residents, businesses, boat owners and visitors – and ensure minimal disruption to their everyday lives and livelihoods.



TEAM & TECHNOLOGY

Client – Wynyard Edge Alliance
Main contractor – BBR Contech
Structural engineer – Beca
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)



Work at Wynyard Wharf includes:

- breaking out damaged and deteriorated concrete using hydro-demolition
- removing corrosion on exposed reinforcing steel
- installing new reinforcing steel where required
- applying new, marine-grade concrete using either box-and-pour or dry-spray gunite techniques to create a structure with a long life expectancy.

Ngaio Gorge Road, Wellington, New Zealand

New retaining wall for key inner-city access route

Enabling comings and goings

An essential access route in New Zealand's capital city is now better prepared for major earthquakes and storms, thanks to the construction by BBR Contech of a new 45m-long retaining wall.

The wall is the latest in a series of strengthening projects undertaken along the Ngaio Gorge Road, a high-traffic commuter route to-and-from Wellington's central business district. The two-lane, often windy road is wedged between a steep hill and an equally steep gully that have long been prone to slips and landslides.

Having already worked on two retaining walls in the gorge, BBR Contech was well qualified to take on the NZ\$1.4m gully-side project – installing 26 reinforced-concrete piles up to six meters deep and tying the wall to rock with 17 ground anchors of depths up to 20m.

The team also undertook several other aspects of the project, including piling, concrete works, road and footpath reinstatement, handrail installation and landscaping. The terrain did impose its challenges – the gully work required extensive scaffolding to protect workers from falling into the stream below and the crew had to meet strict environmental protection standards.

With a design life of 100 years, the wall is a major asset for Wellington and the wider region – enabling safe access for road users and providing a viable alternative route out of the city in case of emergencies and natural disasters.



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- 1 The completed retaining wall on the Ngaio Gorge Road, Wellington, New Zealand.
- 2 The team installed 26 reinforced concrete piles up to six meters deep.

TEAM & TECHNOLOGY

Owner – Wellington City Council
Main contractor – BBR Contech
Consulting engineer – WSP Opus
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)



1

Research & development BBR VT CONA CMF S2

New advanced generation of flat post-tensioning

The spirit of the BBR VT International R&D team in Switzerland can be characterized as the endless pursuit for improvement across all our technologies. Dr. Haifeng Fan, R&D Engineer at BBR Headquarters, explains how this spirit of perfectionism has recently resulted in the development of a new advanced generation of unbonded and bonded flat post-tensioning – the BBR VT CONA CMF S2 system. This advanced technology offers significant benefits for owners, designers and contractors.

The existing BBR VT CONA CMF S1 system – for both 0.5" (12.9mm) and 0.62" (15.7mm) strands – is a multi-strand technology for bonded or unbonded post-tensioning applications in thin concrete cross-sections. Taking advantage of the optimized design in terms of small tendon center spacing and low concrete strength, the system has been widely used for post-tensioned thin slabs, such as suspended slabs in car parks, apartment buildings, commercial office space and retail centers, as well as slabs-on-grade in warehouses. For bonded applications, the ducts are filled with high-performance BBR grout, while for unbonded applications, the ducts are injected with grease, wax or circulating dry air.



New CONA CMF S2 system

The CONA CMF S2 system is an advanced version of the present CONA CMF S1, again for both 0.5" and 0.62" strands in bonded or unbonded applications. The improved features are as follows:

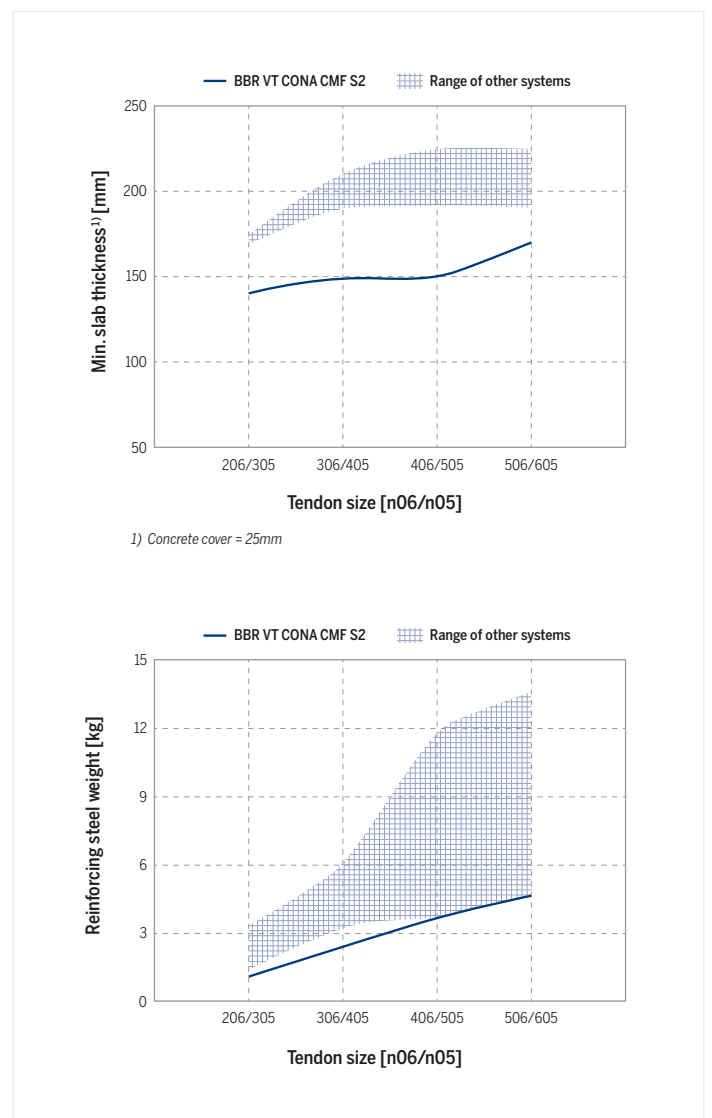
- thinnest slab thickness, as well as the widest anchorage and coupler size range on the market (from three to six 0.5" strands and from two to five 0.62" strands).
- saving material, labor cost & stock maintenance through the usage of universal anchor heads – two types of mono barrels for 0.5" and 0.62" strands – for all sizes; optimization of the key load-carrying components, i.e. bearing trumplate and anchor head; and elimination of a trumpet.

Slab thickness

The optimized design of the CONA CMF S2 system achieves the lowest minimum center spacing and slab thickness at low concrete strength for all sizes on the market. The minimum slab thickness, *h*, achieved by the CMF S2 system is up to 36% lower in all sizes than the range of achievable values of other systems on the market. These lower requirements result in a reduction in the amount of concrete used and consequently the material cost, as well as reducing CO₂ emissions and related impacts on the environment.



2



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Saving material, labor cost & stock management

For the CONA CMF S2 system, universal mono barrel anchorage heads – dependent only on the strand diameter (0.5" or 0.62") – are used for all sizes. The other key load-carrying component, the bearing trumplate, can be used for tendon sizes with similar capacity using either 0.5" or 0.62" strands. These two optimizations can significantly simplify stock management and reduce the complexity of selecting load-carrying components on site. Furthermore, by eliminating the trumpet and preassembling components, the new system offers a saving in both labor and material costs. It also offers the flexibility of using either helixes or stirrups as anti-bursting reinforcement, depending upon project requirements. The installation of this reinforcement can be simplified and accelerated with the help of new accessories – for example, steel reinforcing centralisers.

Anchorage and coupler configurations

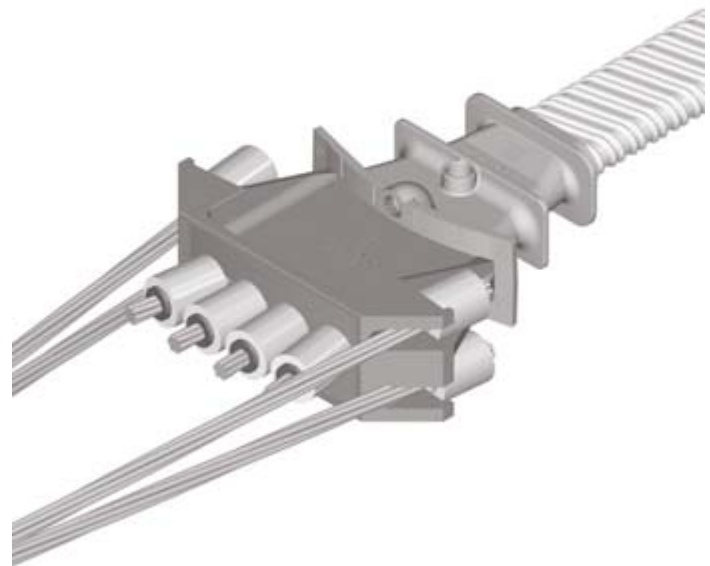
Fixed end anchorages can be identical to the stressing ones – or can also be from the BBR VT CONA CMO bonded anchorage which is a multi-strand dead end anchorage with an array of onion-bulb strand ends. The CONA CMO anchorage offers engineers the possibility of very small center spacing and concrete edge distances without the need for local anti-bursting reinforcement. It also eliminates the usage of anchorage components, thus significant savings on material volumes and costs, as well as a reduction in environmental impact, can be achieved – making the BBR VT CONA CMF S2 the most optimized system on the international marketplace.

The CONA CMF S2 system offers a new coupling anchorage system with the widest size range enabling the construction of post-tensioned slabs in multiple pours. The coupling is achieved by seating the mono barrels for two adjacent slab sections on the opposite sides of the coupler. Furthermore, a housing, enveloping the whole coupling anchorage zone, is used to achieve high corrosion protection for the coupling components.

The BBR VT CONA CMF S2 system is easy to install, simplifies stock management, is reliable in applications and also offers versatile solutions for different project requirements. Furthermore, the system saves materials and thus reduces the impact on budgets and the environment. Last but not least, the BBR VT CONA CMF S2 system been independently tested and approved in accordance with the test procedures specified in the European Assessment Document for Post-Tensioning Kits for Prestressing of Structures, EAD160004_00_0301.*



4



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- 1 The BBR VT CONA CMF S2 flat post-tensioning system is the only one of its type on the international market.
- 2 Visualization of the CONA CMF S2 tendon in bonded and unbonded applications.
- 3 Graphs showing comparison of minimum slab thickness and reinforcing steel quantities: common requirements on the market vs. the CONA CMF S2 system.
- 4 Visualization of the CONA CMF S2 applications with identical anchorage components at both ends (left) and also shown (right) with the CONA CMO onion bonded anchorage at the dead end.
- 5 Visualization of the CONA CMF S2 tendon with a coupler.

* EAD160004_00_0301 is successor of ETAG 013, Guideline for European Technical Approvals, edition June 2012.

Meet more members of the BBR Bar Family

Information about the BBR H Bar system was presented in CONNÆCT 2018, now Dr. Xiaomeng Wang, BBR VT International's Senior R&D Engineer, Geotechnical Systems reveals details of two further family members – the BBR SDX and BBR WT Bar systems.

1 BBR SDX BAR SYSTEM

– self-drilling bars for construction & underground applications

The BBR SDX Bar system is a fully threaded hollow bar system, which allows for simultaneous drilling, borehole flushing and grout injection – and at the same time functions as a load bearing tendon. Both R and T thread profiles are provided to meet the needs of different markets.



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System features & advantages

The BBR SDX Bar system covers an ultimate force range from 200kN to 3,460kN and can be used for underground, as well as other construction applications. The left- or right-hand thread is compatible with most common drilling machines and allows for rotary or rotary-percussive drilling.

The system also includes couplers, nuts, centralizers, bearing plates and adaptors – as well as a selection of drill bits designed to suit the widest variety of ground conditions. Shorter sections of BBR SDX bar can be joined with couplers which allow for their application in confined or restricted spaces.

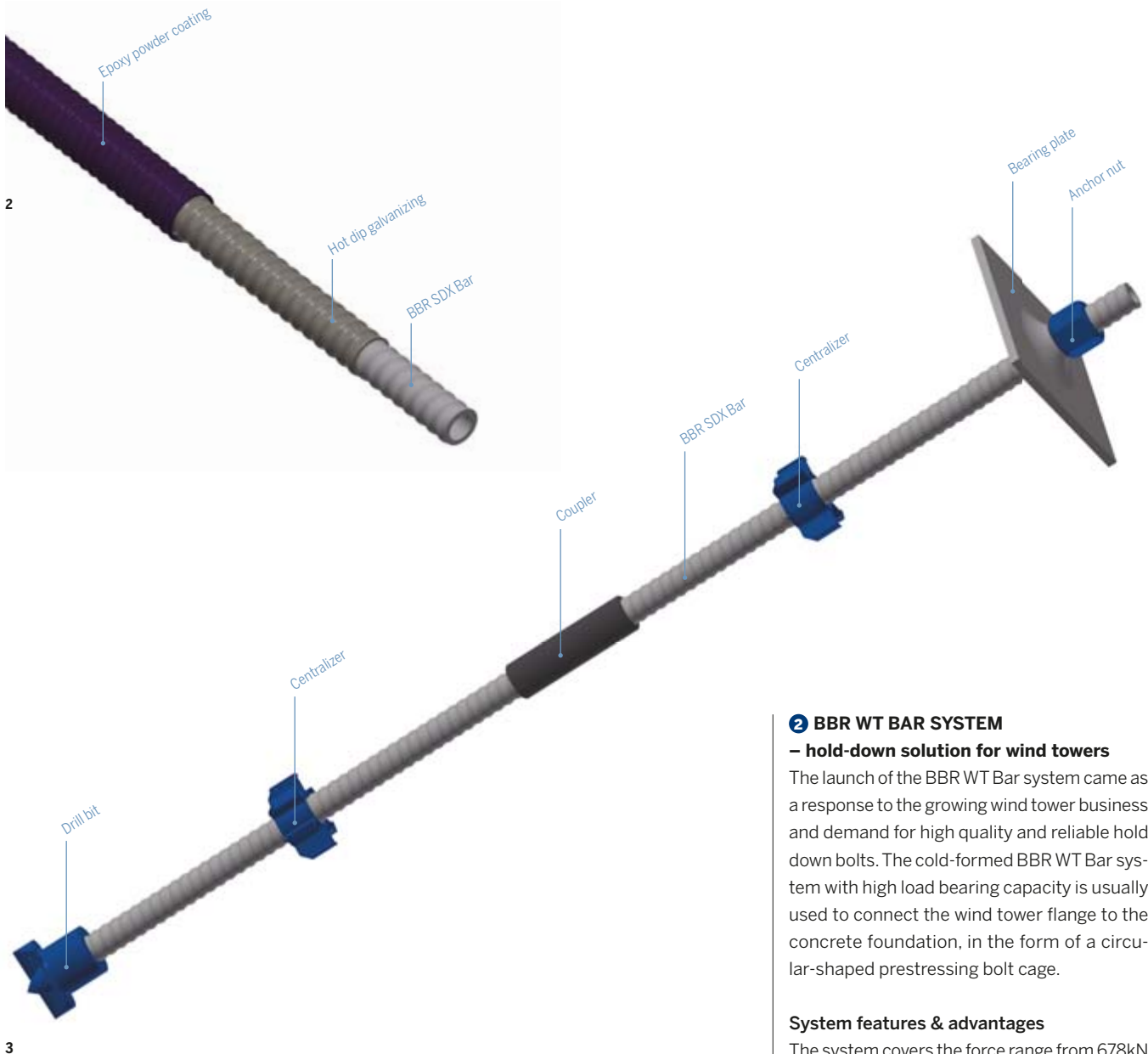
BBR SDX bars are produced as seamless hollow tubes which guarantee the highest quality and reliability – even in the most difficult and demanding ground conditions. In addition, cold rolling technology refines the grain structure of the BBR SDX bar and thereby increases the final yield strength.

Corrosion protection

The BBR SDX Bar system provides multi-level corrosion protection for applications with different lifespan expectations. The selection ranges from sacrificial corrosion allowance which balances environmental aggressivity with required loading capacity, through galvanization and epoxy coating, up to BBR Galpex double-layer protection in which the bar is both galvanized and epoxy-coated to meet the highest anti-corrosion protection requirements.

Proven performance beyond requirement

As a part of our testing program for technical approval, we have carried out demanding mechanical and material tests on the BBR SDX Bar system comprising bar and anchoring accessory components. All tests were executed in independent accredited laboratories in Europe. Through the tests, the excellent tensile and ductility behaviors of the system have been verified. The test results have proved that the BBR SDX Bar system not only complies with the relevant European norms, standards and guidelines, but also fulfills additional requirements specified by local authorities in other regions.



2 BBR WT BAR SYSTEM

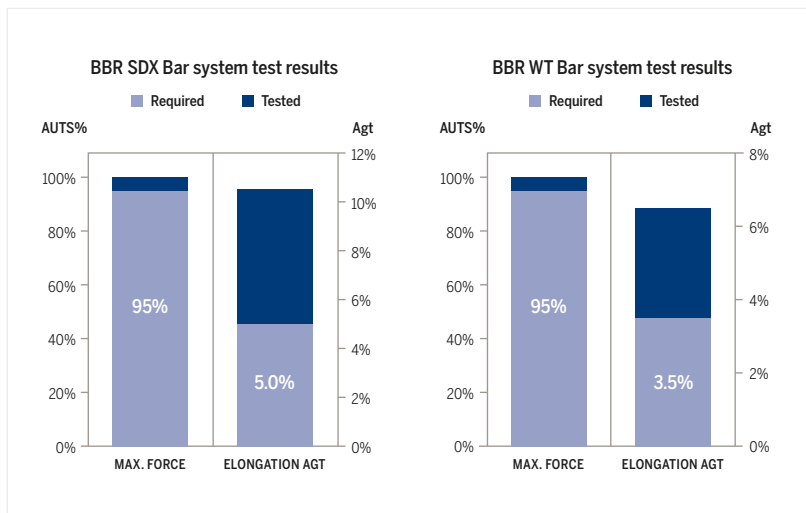
– hold-down solution for wind towers

The launch of the BBR WT Bar system came as a response to the growing wind tower business and demand for high quality and reliable hold down bolts. The cold-formed BBR WT Bar system with high load bearing capacity is usually used to connect the wind tower flange to the concrete foundation, in the form of a circular-shaped prestressing bolt cage.

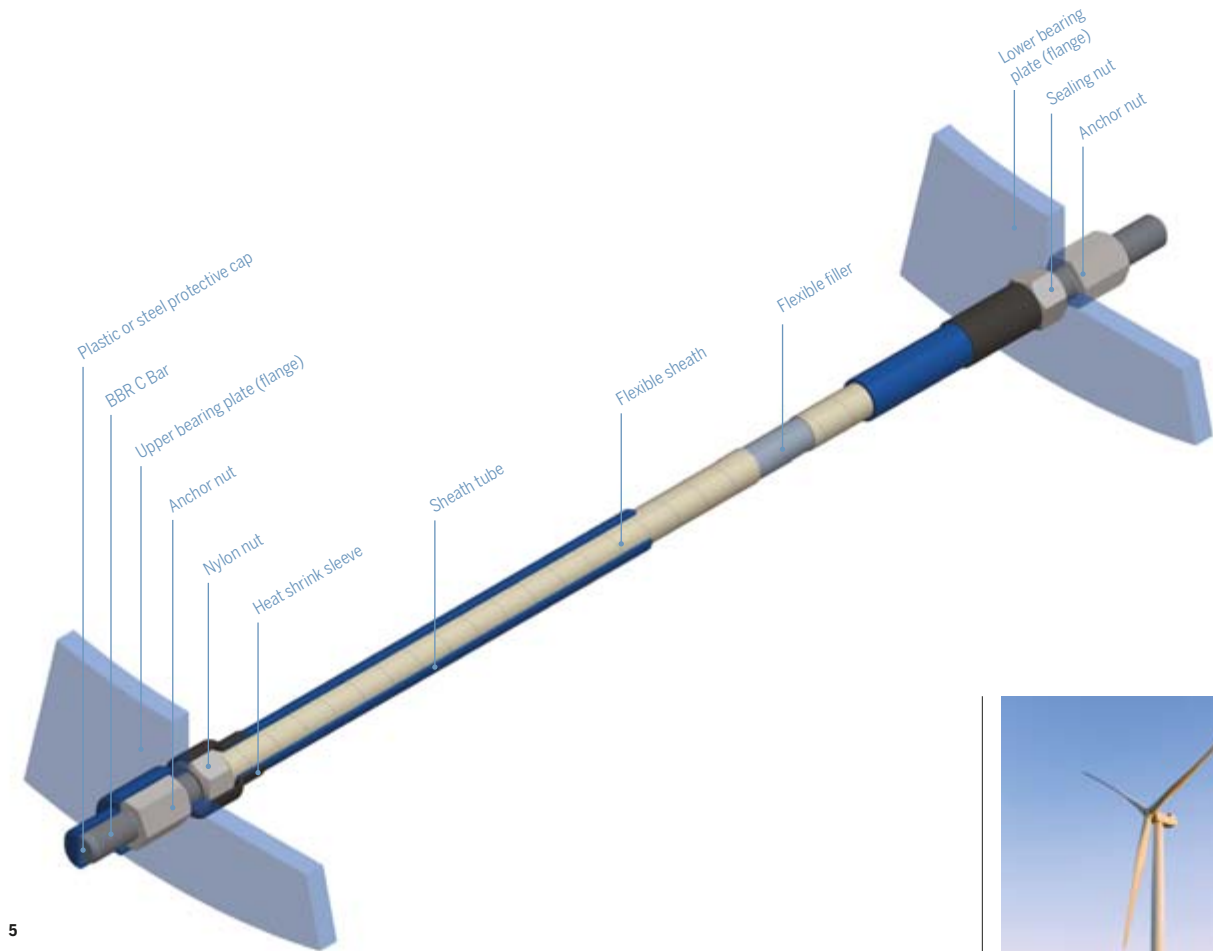
System features & advantages

The system covers the force range from 678kN to 2,111kN by four steel grades (8.8, 9.8, 10.9 and 12.9) of bars with standard thread from M36 to M56. The metric thread rolling at the two ends and the section length of the bar are customized according to project requirements. The system includes BBR C Bar (as post-tensioning tensile element), bearing plate (flange), anchor nut, sealing nut and nylon nut for positioning, as well as various components for corrosion protection, i.e. flexible sheath and filler, sheath tube, protection cap and heat shrinkable sleeve.

BBR C Bar is made of high alloy steel with enhanced resistance to corrosion. The heat treatment process is delicately controlled to optimize the microstructure by fine and homogeneous crystallization, which leads to an important improvement in mechanical properties especially the ductility of the steel against fatigue, which is of great importance for wind tower applications.



4



Corrosion protection

The BBR WT Bar system provides one of the highest levels of durability available in the market thanks to its multi-layer corrosion protection. The body of the bar is fully covered by a flexible sheath and filler. Then, as an additional layer of protection, the sheathed bar is fitted with a PVC tube, the annular space of which is filled with anti-corrosion filler. The bar anchorage is covered by grease and protected by a PE cap which is removable allowing for the restressing, as well as regular inspection during the service life of the bar. Risk of exposure is further eliminated by heat-shrinkable sleeves which cover the joints between each of the various components. The performance against corrosion of the BBR WT Bar system

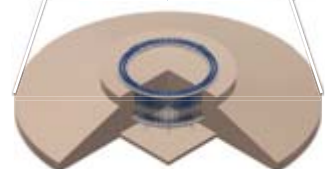
has been assured by a neutral salt spray test according to ISO standards. The system has withstood 1,000 hours of testing without any sign of corrosion on the surface of the bar.

Exceptional fatigue resistance

Major mechanical properties of the BBR WT Bar system have been verified by tests executed in independent European laboratories. Besides the success in all the static tests, the BBR WT Bar system achieved 10 million cycles without failure during system fatigue testing, although the normal requirement is only two million cycles. In addition, the anchor nut was easily removed after the severe fatigue test – evidence of the high quality of the thread on the BBR WT Bar systems and anchorage components.

Quality assurance of BBR Bar systems

Extended triple-stage quality assurance procedures have been applied to BBR Bar systems: Factory Production Control (FPC) including continuous surveillance and full traceability, Pre-Delivery Inspection (PDI) and Sample Testing (SaT). The high standard of quality control applied in the selection of raw materials, the production process and the mechanical and geometrical features of the end product guarantee that BBR Bar systems offer the highest quality and performance.



6

- 1 Application of bar systems in geotechnical engineering.
- 2 BBR Galpex double-layer corrosion protection.
- 3 BBR SDX Bar system components.
- 4 Test results of BBR SDX Bar and BBR WT Bar systems.
- 5 BBR WT Bar system components.
- 6 Application of BBR WT Bar system for wind tower.

Application of latest BBR damping technology

After a period of structural monitoring, BBR Network Member BBR Polska was commissioned to install BBR Viscous Dampers for the Tadeusz Mazowiecki Bridge in Rzeszów.

During construction of the bridge in 2015, BBR Polska installed 64 BBR HiAm CONA stay cables which were anchored on the bridge deck and at the 107m high pylon. As a primary countermeasure against cable vibration, the stay cable pipes feature a helical rib on the outer surface.

Meanwhile, a permanent structural monitoring system was installed on the bridge and, during normal operation of the bridge under live traffic and in all seasons, has been used to establish optimal damping parameters.

However, during construction, it was decided to make provision for internal supplemental damping devices to be installed on some of the stay cables at a later stage. Consequently, it took BBR Polska's team of two specialist installers just a few days to open the already present damper housings – located

between the bottom of the anchor zone and the anti-vandalism pipe – and mount the pre-assembled BBR Viscous Dampers on the selected stay cables.

BBR Viscous Damper installation is a simple process. The damper housing is secured, by flanges at the base, to the recess pipe which is connected to the bridge deck.

The anti-vandalism pipe is temporarily moved up and the damper is placed in the correct location inside the lateral cylindrical pipe for which it is designed. On the lower side, the damper is pinned to the base plate located at the end of the lateral pipe. On the upper side, the damper is connected to the free deviator which is clamped around the stay cable bundle. The connection is made by using the two sliding half-rings and two Teflon half-shells clamped around the free deviator.



The BBR Viscous Damper stay cable damping system offers a 'real-time' reaction to induced vibrations. It works based on resistance induced by the rapid passage of a viscous fluid through a narrow opening. This resistance can dissipate a large amount of energy, resulting in damping of the cable. The BBR Viscous Damper can be installed in either an internal, as in the case of this bridge, or external damper configuration and offers damping forces of 50kN and 70kN, although dampers with larger force resistance are available by special request.



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- 1 The Tadeusz Mazowiecki Bridge in Rzeszów has 64 BBR HiAm CONA stay cables anchored at a 107m high pylon.
- 2 As provision for supplemental damping, in the form of damper housings, had been made during construction, installation of the BBR Viscous Dampers was completed by BBR Polska's team of two specialists in only a few days.
- 3 A fully-installed BBR Viscous Damper, offering a 'real-time' damping reaction to induced stay cable vibrations.

TEAM & TECHNOLOGY

Owner – Gmina Miasto Rzeszów
Preliminary design – Promost Consulting
Designer – Mosty Gdańsk
Main contractor – Porr Polska Infrastructure (formerly Bilfinger Infrastructure)
Technology – BBR HiAm CONA stay, BBR Viscous Damper
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

Technical Update Recent European Technical Assessments

European approved technology

Over recent months, three European Technical Assessments have been issued or renewed – for the BBR VT CONA CMM, BBR VT CONA CMI BT and BBR VT CONA CMI SP post-tensioning systems.

CONA CMM ETA

The new CONA CMM ETA (ETA-06/0165) has been renewed and is available on the BBR Network website for download. This ETA covers both the CONA CMM S1 system and the advanced next generation CONA CMM S2 system which offers features to accelerate installation and thus reduce labor and material costs. In addition, this ETA covers the ETA-12/0282: single – internal bonded post-tensioning system with 01 strand.

CONA CMI BT/SP ETAs

The CONA CMI BT and CONA CMI SP ETAs (ETA-09/0286 & ETA-09/0287) have been renewed and are available on the BBR Network website for download. These ETAs cover the BBR VT CONA CMI – internal post-tensioning system with 02 to 61 strands using either Bearing Trumplate (BT) or Square Plate (SP) for transferring the post-tensioning load to the structure.



Creating value in a commoditized business

BBR has introduced BBR H, BBR C and BBR SDX Bars along with a full range of accessories – as part of the growing BBR Bar Family – and BBR Network Members are now using these for their projects. Cezary Sternicki, Deputy CEO at BBR VT International, talks us through the reasons for entering a commoditized business area and explains the benefits BBR VT creates across the value chain.



The idea of having a BBR proprietary bar system has long been on the BBR Network's mind, however it had to make sense from a number of perspectives. We also balanced our thinking against history which has seen established innovative companies missing the right moment to disrupt themselves and disappearing from the market. You only have to look at the DVD rental businesses Blockbuster and Netflix. Both of them had a comparable market capitalization in the early 2000s and today, Blockbuster is pretty much just a blurred memory in the archives of company history, while Netflix flourishes in the media business.

BBR VT International – BBR Headquarters – is not only a platform for innovative technology, but also an innovative business model. We have pioneered successful business innovation implementations in the past – including the creation of the first and biggest franchise, the BBR Network, within the worldwide construction sector. In the context of these initiatives,

the introduction of the BBR Bar Family into an already commoditized market place, yet in a way which creates value, represents a natural progression of our strategy.

Synergy & holistic approach

Bars find applications across various construction and underground businesses, from bridges and buildings, across geotechnical, tunneling and mining projects. Over the years, the bar market has become commoditized with offerings from many manufacturers. Meanwhile, the absence of a BBR proprietary bar solution has meant that the BBR Network could not fulfill customer requests or was entirely missing a business opportunity due to a weak position across the value chain – bar solutions were sourced from our competitors.

The introduction of the BBR Bar Family not only leverages our market position by satisfying our existing customers' needs within current businesses, but it also opens the door to new industries or increases the scope of our

participation by offering complementary solutions. Let's look at the wind power market, for example. Here, BBR is already a relevant player offering strand post-tensioning technology for vertical stressing of wind towers. However, BBR bars can be also used as wind tower bolts – to securely connect the lower tower section with the foundations. So, in this sense, there is a synergistic effect – existing post-tensioning solutions bring business for bars and both ultimately create an attractive package for the customer, with technology coming from one system provider – the BBR Network.

The right range

With such a wide variety of bar applications, it is important to offer the right range of bars and comprehensive selection of accessories – the 'one solution fits all' concept does not work well here. In specifying the BBR bar products, we have taken time to select proper production technology – for example, cold-rolled, hot-rolled or heat-treated – and taken care in



Triangular business concept.

the selection of the right thread type – metric, coarse or customized, with various pitches and geometries. We have also given careful consideration to making a proper selection of related accessories – nuts, couplers, washers, drill bits and other auxiliary solutions. Unlike some of the existing bar products on the market, BBR offers bar types that are application-specific, ensuring that the right technical solution is used in the right place – and that the costs to the project budget are thus proportionate.

Value creation

The value of the BBR bar proposition is created through a triangular business concept which harnesses and maximizes the specialist knowledge and experience at each of its three points. BBR VT, as a technology and business development center, has people experienced and qualified in the successful development of both technology and business. The expertise of the BBR Component Manufacturers (CMs) resides in their knowledge of materials and production techniques. Meanwhile, BBR Network Members specialize in providing construction solutions on site for their clients and have expert knowledge of their own local markets. By leveraging the experience and capability of all three groups, there is greater opportunity for innovation, efficiency and economy. BBR VT International has decades of expertise in load bearing technology systems and

is well-versed in specific design and quality control measures – thus, we are drawing on our existing capabilities to expand into new industries through the BBR Bar Family. This business expansion comes without significantly increased business running costs – we are extending our 'lean concept' by engaging our R&D staff in new tasks and expanding the network of BBR CMs. Therefore, the introduction of BBR Bar technology is being realized not by extending the value chain and incurring costs, but by sourcing differentiation and further utilizing BBR's capabilities.

Moreover, integration into BBR's unique E-Trace sales and quality assurance platform, to which BBR Network Members have access, eliminates human errors during project execution, thus limiting the workload and costs. BBR E-Trace ensures easy access to up-to-date prices, quality documents and project references – all in one place.

Consistent quality worldwide

One of BBR's long-held principles is not to compromise on the quality of the delivered product. Unlike some of the other market players, who pursue a business strategy of adjusting the solution to the local demand, BBR offers the same construction technology the world over. While the product is obviously different, think about a McDonald's burger – wherever you are in the world, it tastes the

same – that is reliability. BBR has not pioneered this as a concept, but has definitely implemented it successfully in the construction and underground business.

As the final link along the value chain, the role of our franchisees and licensees, the BBR Network Members, is key. They are in the front-line, customer-facing position and they do not compromise on quality to secure a project. Instead, they use their expertise and experience to win with a sound and compelling technical solution founded on using BBR technology.

Streamlined delivery

Further efforts and investment went into finding the right distribution mechanism. We recognized that customers for bar solutions come from industries with high turnover rates – based around smaller projects with fast execution times. Also, bars are very often used as a fast retrofitting solution – for example, if there is a strata collapse in the mines or need for rockfall protection. Products need to be delivered fast – without compromising on the delivered solution.

The BBR response has been to invest in setting up logistics hubs, both in Europe and Asia, to secure faster delivery lead times and shift the quality control (QC) procedures further upstream in the value chain. We have adopted this approach to make sure that the right solution is delivered when it is needed – not weeks later.

The solution which BBR has applied – not only for bars but also for each of our product ranges – is the production and holding of a predefined selection of product components. This stock has been QC-checked, undergone a PDI (pre-delivery inspection) to ensure that it conforms with order quantities and that packing is of good quality, and been delivered to our special warehousing facilities pending receipt of orders from the BBR Network. This releases BBR Network Members not only from organizational and time-consuming Quality Assurance (QA)/QC workload, but also from impacts on their reputation and profitability.

Leveraging technology without the high overheads

Centrally developed world class technology, processes and services are available to individual BBR Network Members without impacting on their bottom line. If every BBR Network Member were to have embarked on the same R&D journey individually, they would never be able to capitalize on their initial investment because sales would not reach the critical volume needed to compensate the investment costs.

Thinking Aloud Marcel Poser, Tectus CEO & Chairman of BBR VT International Limited

The construction industry reimagedined

Speaking at the 2018 G-20Y Summit in Evian, France, Marcel Poser, Tectus CEO and Chairman of BBR VT International Limited, talked about embracing change and of the need for businesses to reimagine themselves. For this 75th Anniversary edition of CONNÆCT, we invited Marcel to share further background and insight.



... our vision is to drive the transition from reactive to predictive maintenance – and, along the way, we've created a number of 'world firsts' for the industry.

Is it possible for the construction industry to 'reimagine' itself?

It's already happening. Yes, I know many people regard construction as a 'traditional' and slow-moving industry. The fact is that the industry has been progressively changing to meet demands of its customers.

The hottest topic is productivity and there's been – and continues to be – great pressure on the industry to produce faster and more economical ways of working. The response from construction companies has been to adopt more efficient methods – computer modeling, digital management and QA platforms, just-in-time delivery, prefabrication and modularized construction, such as the prefabricated pre-finished volumetric construction (PPVC) method implemented by BBR Singapore (see also page 36). These are all methods and tactics with which every BBR Network Member will be familiar. However, this is just the tip of the iceberg – believe me, there is yet much, much more to come. While we acknowledge breakthroughs in smart phone, AI, drone and AR/VR technology, construction remains one of the least digitized industries. This is about to change.

What do you see being added to the mix? And how will these elements be introduced?

Well, with IoT technologies – the so-called 4th Industrial Revolution – we have access to many new ways of working. There's work underway within the Tectus Group to harness and incorporate latest technologies – like Augmented Reality, Virtual Reality, Artificial Intelligence, sensing and Big Data – into our portfolio. Take the Screening Eagle platform which is being developed at Tectus Dreamlab and will revolutionize asset inspection and management.

There have been many reports about the failure of infrastructure inspection and maintenance strategies on a global scale. In a worst case scenario, lack of proper inspection and maintenance leads to devastating disasters and massive economical impacts.

As a result, our vision is to drive the transition from reactive to predictive maintenance – and, along the way, we've created a number of 'world firsts' for the industry.

Are any of these relevant to the BBR Network?

Perhaps the most relevant development for the BBR Network is the leveraging of Screening Eagle to manage Proceq's Pundit Live Array concrete testing tool. This has resulted in the creation of the world's first wireless, artificial intelligence-assisted cloud-enabled instrument of its kind. The instrument also offers 3D visualization of what is inside the structure to easily visualize such things like grouting defects inside post-tensioning tendons.

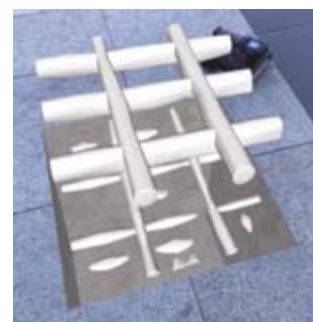
The very latest inspection tool – Proceq's GPR Live – lets you see through things, just like Superman does. It uses Augmented Reality to allow you literally to look inside concrete and, as you can imagine, this radically changes the way data is interpreted on site.

The pace is increasing and there will be many more developments too that will also benefit BBR technology and the BBR Network, either directly or indirectly.

Should we be worried about this era of huge change?

Rather than being concerned about the changing world, for me, change creates a sense of urgency to move faster and it is a source of inspiration to create better products and to build better businesses, stronger teams and indeed to make the world a better place for the generations to come. People make the mistake of thinking that they, as individuals, cannot change the world – they are wrong, very wrong. It doesn't matter whether you're working in technology, production, sales or wherever – it all starts with a small group of people who accept that business is not always fair, who take risks despite knowing that they might fail – and indeed are likely to fail often. It is those who step up and those who never ever give up despite having failed many times who learn how to succeed.

We not only need to have a 360-degree view around us, but we also need to change the position from where we look at things to anticipate what might be coming. The best way to anticipate what might be coming – in other words, to predict the future – is to be part of creating that very future.



2

- 1 Marcel Poser speaking about digital disruption at the G-20Y Summit in 2018. The G-20Y Association is an independent forum for a new generation of business leaders and brings together executives from 20 of the major global economies to engage in meaningful dialogue aimed at shaping a better future.
- 2 The very latest inspection tool – Proceq's GPR Live – uses Augmented Reality to allow you literally to look inside concrete. This radically changes the way data is interpreted on site.

Our global presence

Our clients are based in over 50 countries – so our global presence is a vital asset.

We can share our international experience locally, provide solutions adapted to specific conditions and be on hand to offer a personalized service.



HEADQUARTERS

BBR VT International Ltd
Ringstrasse 2
8603 Schwerzenbach-Zurich
Switzerland
Tel +41 44 806 80 60
Fax +41 44 806 80 50
www.bbrnetwork.com
info@bbrnetwork.com

EUROPE

AUSTRIA

KB Vorspann-Technik GmbH
Weitwörth 25
5151 Nussdorf a.H.
Tel +43 6272 407 90
Fax +43 6272 407 90 11
www.kb-vt.com
office@kb-vt.com

BOSNIA & HERZEGOVINA

see Croatia

BULGARIA

see Spain

CROATIA

BBR Adria d.o.o.
Kalinovica 3
10 000 Zagreb
Tel +385 1 3839 220
Fax +385 1 3839 243
www.bbr-adria.com
bbr-adria@bbr-adria.com

DENMARK

see Norway

FINLAND

see Norway

FRANCE

ETIC S.A.S.
80 Boulevard du Général Leclerc
F-78220 Viroflay
Tel +33 1 39 50 11 20
www.etic-sas.fr
contact@etic-sas.fr

GERMANY

see Austria

KOSOVO

see Croatia

LIECHTENSTEIN

see Switzerland

LUXEMBOURG

See France

MONTENEGRO

see Croatia

NETHERLANDS

**Spanstaal – Ballast Nedam Infra
Specialiteiten B.V.**
Nijverheidstraat 12
4143 HM Leerdam
Post Address: PO Box 236
4140 AE Leerdam
Tel +31 345 63 92 00
Fax +31 345 61 91 07
www.ballast-nedam.com
info@ballast-nedam.com

NORWAY

KB Spenneteknikk AS
Siva Industrial Estate
Norvald Strands veg 19-21
Postboks 1213
2206 Kongsvinger
Tel +47 62 81 00 30
Fax +47 62 81 00 55
www.spennteknikk.no
spennteknikk@spennteknikk.no

POLAND

BBR Polska Sp. z o.o. (Head Office)
ul. Annopol 14, 03-236 Warszawa
Tel +48 22 811 50 53
www.bbr.pl
bbrpolska@bbr.pl

BBR Polska Sp. z o.o.

ul. Tarnogórska 214a, 44-105 Gliwice
Tel +48 32 331 47 98
www.bbr.pl
bbrpolska.gliwice@bbr.pl

PORTUGAL

see Spain

ROMANIA

see Spain

SERBIA

see Croatia

SLOVENIA

see Croatia

SPAIN

FCC Construcción, S.A.
Antigua Carretera N-III Km. 31,150
28500 Arganda del Rey, Madrid
Tel +34 91 876 09 00
Fax +34 91 876 09 01
www.bbrpte.com
bbrpte@bbrpte.com

SWEDEN

Spännteknik AB
Sjöängsvägen 7, 192 72 Sollentuna
Tel +46 8 510 678 10
Fax +46 8 510 678 19
www.spannteknik.se
info@spannteknik.se

SWITZERLAND

Stahlton AG
Hauptstrasse 131, 5070 Frick
Tel +41 44 938 99 00
Fax +41 44 938 99 01
www.stahlton.ch
bautechnik@stahlton.ch

TURKEY

Kappa Kalip Insaat Ve Taahhut A.S.
ASO 1. Organize Sanayi Oguz Cad. No.47
06935 Sincan/Ankara
Tel +90 312 280 86 91
Fax +90 312 280 86 94
www.kappa.gen.tr
info@kappa.gen.tr

UNITED KINGDOM

Structural Systems (UK) Ltd
12 Collett Way, Great Western Industrial
Estate, Southall, Middlesex UB2 4SE
Tel +44 20 8843 6500
Fax +44 20 8843 6509
www.structuralsystemsuk.com
info@structuralsystemsuk.com

AMERICAS

EASTERN CANADA

Canadian bbr Inc.
3450 Midland Ave.
Scarborough, Ontario M1V 4V4
Tel +1 416 291 1618
Fax +1 416 291 9960
mducommun@bbrcanada.com

AFRICA

LESOTHO

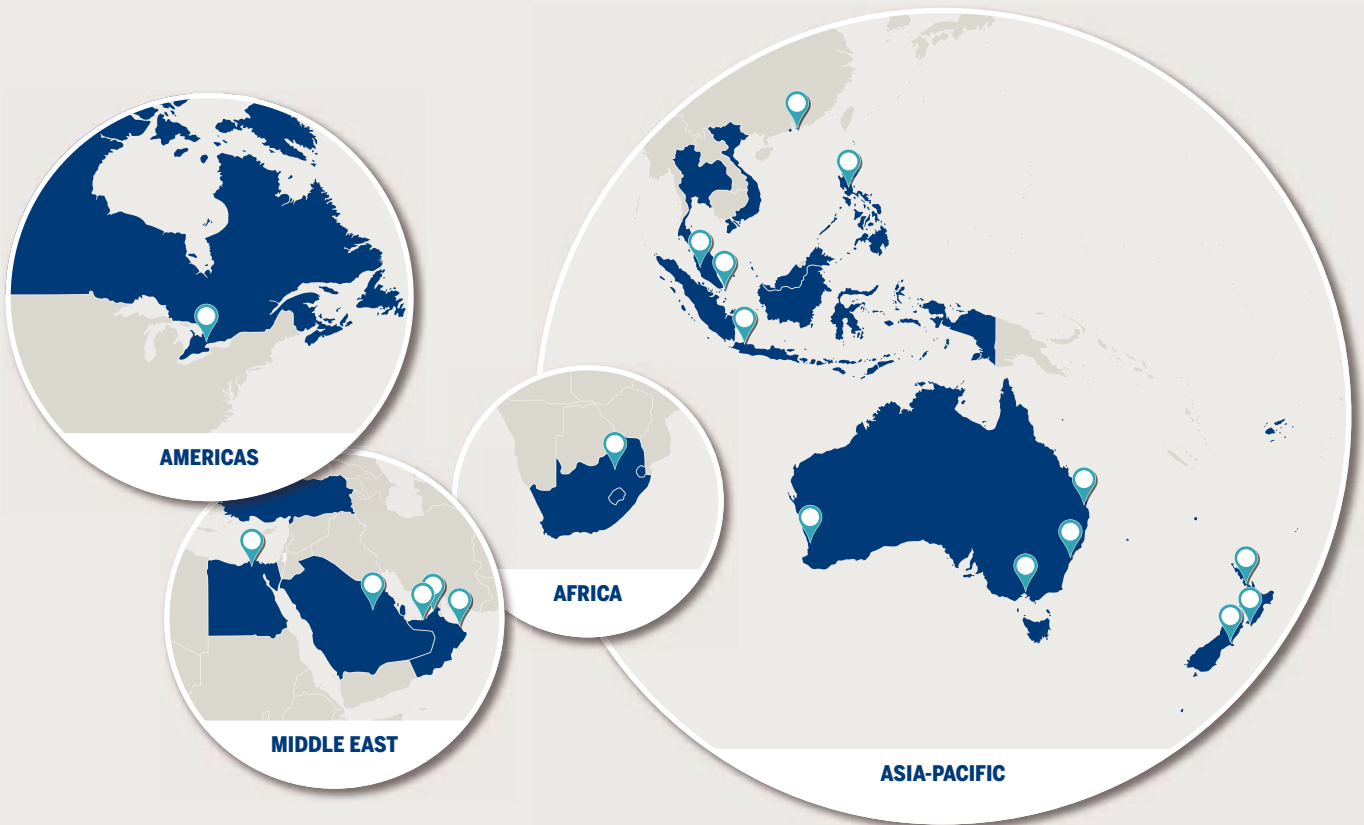
see South Africa

SOUTH AFRICA

Structural Systems (Africa)
Group Five House, 9 Country Estate Drive
Waterfall Business Estate, Jukskei View
Johannesburg 2090
Tel +27 10 060 1555
Fax +27 86 616 7482
www.structuralsystemsafrika.com
info@sslafrica.com

SWAZILAND

see South Africa



MIDDLE EAST

BAHRAIN

see United Arab Emirates

EGYPT

ESPT
43 Moez Al Dawla Street
Nasr city, Cairo
Tel +20 106 094 1272
Fax +20 2 267 102 51
www.bbr-espt.com
info@bbr-espt.com

OMAN

**Structural Systems Limited
(Oman Branch) Part of SRG Global**
Office A-11, Al Souruh Building
Al Ghala Industrial
PO Box 1946, PC-130
Muscat, Sultanate of Oman
Tel +968 2459 5279
Fax +968 2459 5252
www.srgglobal.com.au
info@srgglobal.com.au

QATAR

see United Arab Emirates

SAUDI ARABIA

Structural Technology Innovation
Riyadh King Saud Road
Al Mazaya Building Ground Floor
PO Box 5005, Riyadh 11371
Saudi Arabia
Tel +966 1 1461 1144
Fax +966 1 1293 4400
info@bbrsti.com

UNITED ARAB EMIRATES

**NASA Structural Systems LLC
(Head Office) Part of SRG Global**
Office M-03 Bu Shaqar Building
Garhoud, PO Box 28987, Dubai
Tel +971 4 2522 501
Fax +971 4 2522 502
www.srgglobal.com.au
info@srgglobal.com.au

Structural Systems Middle East LLC

Part of SRG Global
Office 38, Sheikh Abdullah Bin Zayed Al
Nahyan Industrial Area, Musaffah-2
PO Box 126740
Abu Dhabi
Tel +971 2 5554 347
Fax +971 2 5554 348
www.bbrstructuralssystem.com
bbr@bbrstructuralssystem.com

ASIA-PACIFIC

AUSTRALIA

SRG Global
Level 1, 338 Barker Road
Subiaco, WA 6008
Tel +61 8 9267 5400
Fax +61 8 9267 5499
www.srgglobal.com.au
info@srgglobal.com.au

SRG Global

Suite 3, Level 1, 75 Carnarvon Street
Silverwater, NSW 2128
Tel +61 2 8767 6200
Fax +61 2 8767 6299
www.srgglobal.com.au
info@srgglobal.com.au

SRG Global

18 Lions Park Road, Yatala
Queensland 4207
Tel +61 7 3442 3500
Fax +61 7 3442 3555
www.srgglobal.com.au
info@srgglobal.com.au

SRG Global

2/290 Salmon Street
Port Melbourne
Victoria 3207
Tel +61 3 9296 8100
Fax +61 3 9646 7133
www.srgglobal.com.au
info@srgglobal.com.au

FIJI

see New Zealand

HONG KONG

SRG (Hong Kong)
Unit 1110 11/F, Exchange Tower
33 Wang Chiu Road
Kowloon Bay
Tel +852 2711 1091
www.srgglobal.com.au

INDONESIA

PT Prestress Construction Indonesia
Komplek Ruko Sentra Niaga Kalimalang
Blok A1/12A
Jl. Jend. Achmad Yani
Bekasi Barat – 17144
Tel +62 21 8893183
Fax +62 21 8848694
www.pcindonesia.net
customer-service@pcindonesia.net

MACAU

see Hong Kong

MALAYSIA

**BBR Construction Systems (M)
Sdn Bhd**
No.17, Jalan Sg. Jeluh 32/191
Kawasan Perindustrian Kemuning
Seksyen 32
40460 Shah Alam
Selangor Darul Ehsan
Tel +60 3 5525 3270
Fax +60 3 5525 3285
www.bbr.com.my
enquiry@bbr.com.my

NEW ZEALAND

BBR Contech
15 Kerwyn Ave
East Tamaki
PO Box 51-391
Pakuranga, Auckland 2140
Tel +64 9 274 9259
Fax +64 9 274 5258
www.contech.co.nz
akl@contech.co.nz

BBR Contech

27 Port Road, Seaview
PO Box 30-854
Lower Hutt, Wellington 5040
Tel +64 4 569 1167
Fax +64 4 569 4269
www.contech.co.nz
wgn@contech.co.nz

BBR Contech

7A Birmingham Drive
Middleton, PO Box 8939
Riccarton, Christchurch 8440
Tel +64 3 339 0426
Fax +64 3 339 0526
www.contech.co.nz
chc@contech.co.nz

PHILIPPINES

BBR Philippines Corporation
Suite 502, 7 East Capitol Building
No.7 East Capitol Drive
Barangay Kapitolyo
Pasig City, Metro Manila 1603
Tel +632 638 7261
Fax +632 638 7260
info@bbr.com.ph

SINGAPORE

BBR Construction Systems Pte Ltd
BBR Building, 50 Changi South Street 1
Singapore 486126
Republic of Singapore
Tel +65 6546 2280
Fax +65 6546 2268
www.bbr.com.sg
enquiry@bbr.com.sg

THAILAND

Siam BBR Systems Co. Ltd
No.449, 2nd Floor, 559 Building
Bangpood Sub-District
Pakkred District
Nonthaburi 11120
Tel +66 80 280 8802

VIETNAM

see Singapore

