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Edition 14 | 2020

CONNECT

THE MAGAZINE OF THE GLOBAL BBR NETWORK OF EXPERTS

60TH ANNIVERSARY OF BBR STAY CABLE TECHNOLOGY

Staying strong for six decades

SHAPING THE SINGAPORE SKYLINE

BBR technology & techniques for high-rise buildings

SPARKLING AWARDS FOR BRIDGE

UK's Mersey Gateway Bridge wins multiple awards

NEW INTERNATIONAL BENCHMARK IN GT TECHNOLOGY

BBR VT CONA CMG strand ground anchors

WORLD RECORD CAPACITY ANCHORS

Installation of largest anchors for dam project

A Global Network of Experts
www.bbrnetwork.com

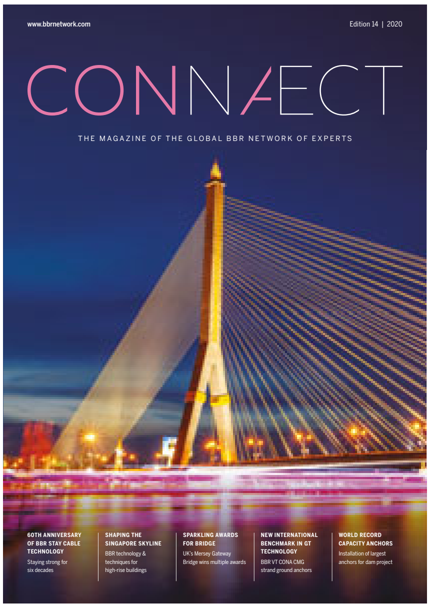
The BBR Network is recognized as the leading group of specialized engineering contractors in the field of post-tensioning, stay cable and related construction engineering. The innovation and technical excellence, brought together in 1944 by its three Swiss founders – Antonio Brandestini, Max Birkenmaier and Mirko Robin Roš – 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 Spennteknikk AS (Norway), a subsidiary of the KB Group (Norway).



Sharing passion & productivity

Through the pages of the 2020 edition of the BBR Network's magazine CONNÆCT, we are delighted to share with you some further insights into the latest BBR construction technology and the achievements of our international family, the BBR Network.

Without a doubt, BBR technology and techniques are contributing towards harnessing greater productivity for the construction industry. Among the features in the Portfolio section, you can read about how BBR post-tensioning and techniques enabled a reduced cycle time for bridge launching in Australia and about high-rise buildings in Singapore and New Zealand, as well as an innovative 'energy positive' building in Norway.

There are also articles on the strengthening of several dams where the world's largest capacity ground anchors are being deployed. The recently introduced geotechnical BBR Bar range is also proving popular around the world – the BBR H Bar system is being used for a bridge in the Philippines and a huge dam in Turkey.

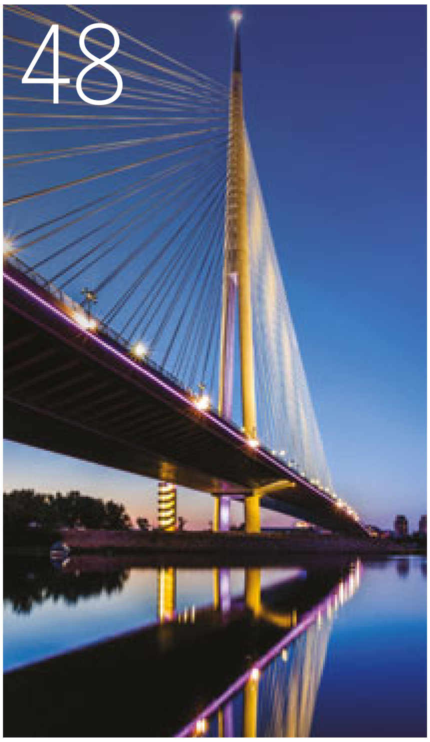
In a special feature celebrating the 60th Anniversary of BBR stay cable technology, you can also discover how, having created a number of 'world firsts', we have continued to refine and adapt our stay cable technology. Like us, you will surely conclude that the BBR HiAm CONA stay cable system is simply the best product on the international market place today.

The Technology section includes a major feature about the BBR VT CONA CMG strand ground anchor system which sets a new benchmark for the corrosion protection of strand ground anchors. Last but not least, don't miss the articles about automating construction with MSS technologies and developments in digital construction.

Over recent years, the BBR family has grown significantly – the range of BBR technologies has expanded and the BBR Network has also extended its reach into new territories. Maybe you will be reading this and considering joining the BBR Network. If you share our passion for the highest level of customer service and the finest construction technology, we would be pleased to hear from you!

Marcel Poser
Chairman, BBR VT International Ltd

José Manuel Illescas
Vice Chairman, BBR VT International Ltd



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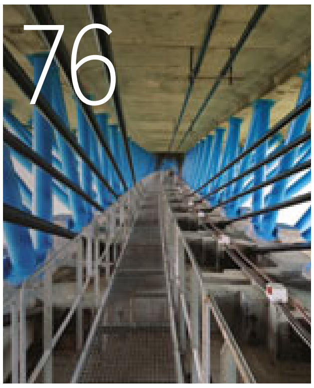

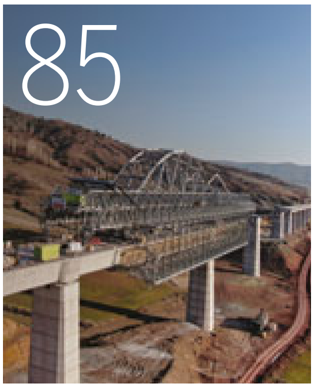

TECHNOLOGY

THINKING ALOUD

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SOURCES AND REFERENCES
Front cover image: The dramatically beautiful RAMA VIII Bridge in Bangkok, Thailand is one of the 430+ stay cable projects carried out by the BBR Network in the last six decades. See page 48 for the feature celebrating 60 years of BBR stay cable technology.

Portfolio section
Sparkling awards for bridge: https://www.iabse.org; http://www.merseygateway.co.uk
Span closure for record-breaking bridge: http://www.gov.me
Bridging the crossroads of Europe: https://www.d4r7.com; https://www.roadtraffic-technology.com
Bridge quintet in Norway: https://www.vegvesen.no; https://www.banenor.no
Shaping the Singapore skyline: https://global.ctbuh.org
The Green Diamond: https://snohetta.com, https://www.powerhouse.no, https://architizer.com
Making new connections: http://www.romfilatelia.ro
Standing the test of time: https://city-tourist.de; https://www.sueddeutsche.de; http://www.arcaro.org;
IABSE congress report (1972): Das Olympiadach in München, by Jörg Schlaich, H. Altmann, R. Bergermann, K. Gabriel, K. Horstkötter, K. Kleinhanss, P. Linhart, G. Mayr, J. Noesgen, U. Otto, H. Schmidt, Ingenieurbüro Leonhardt und Andrä, Stuttgart, Germany.
Safe storage for seeds: https://www.croptrust.org; https://www.theguardian.com; https://www.independent.co.uk
Renewed strength for vital infrastructure: https://www.tellerreport.com; https://structurae.net; https://fr.wikipedia.org

Technology section
The dawn of digital fabrication: http://dfabhouse.ch; *Die Parkhaus-Brücke über die Rämistrasse in Zürich* by O. Liechti, W. Glanzmann und J. Schneider, Bauingenieure, Zürich, published in Schweizerische Bauzeitung 20 July 1967; *Modular construction: From projects to products*, by Nick Bertram, Steffen Fuchs, Jan Mischke, Robert Palter, Gernot Strube & Jonathan Woetzel, published by McKinsey & Company, June 2019.

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Business Review Reflections & outlook from BBR VT International's CEO

Remaining relevant, comprehensive & value-adding

One of the key issues for any company or brand is ensuring that their offering remains relevant – both in the context of the marketplace in which they operate and also to all stakeholders. Juan Maier, CEO of BBR VT International Ltd, reflects on how relevance of its construction engineering technology and associated services has always been high on the agenda at BBR – and shares some insight into how this will continue in the future.

Even in regions where European approval is not mandatory, we have still been able to demonstrate the value-add that a BBR franchise offers.

When Messrs Birkenmaier, Brandestini and Roš founded BBR in 1944, they instilled an extra special blend of entrepreneurial spirit, innovative Swiss engineering and customer focus into the company ethos. In the years to follow, they cleverly constructed a vertically integrated offering whereby new technologies were developed by Bureau BBR, as the business was then known. Practical and commercial experience of installation was gained by Stahlton with Birkenmaier as its full-time MD, while design of pre- and post-tensioned structures was performed by Roš's design engineering firm. Later Brandestini created Proceq for the production of machines and equipment to allow the easy handling and installation of the technologies. There are certainly many parallels with the developments underway today at BBR and, in many ways, this is how we see the BBR Network progressing – vertically integrated and covering all aspects of the built environment.

Adding value with a BBR franchise

In recent years, the BBR Network has expanded its footprint by attracting four new franchisees. What's more, these new Members operate in some of the toughest markets in the world – where pricing is extremely keen and where there are many different market players. Even in regions where European Technical Approval is not mandatory, we have still been able to demonstrate the value-add that a BBR franchise offers. This success is all the more impressive when you consider that our business model requires high upfront commitments from both the franchisee – and, of course, the franchisor too.

The numbers speak for themselves. The BBR Network Member for Indonesia, PCI, was able to double its revenues and active projects within 12 months of becoming a Member. As well as this, their business model changed significantly from having to actively chase project work to having customers approach them. Meanwhile, in less than two years, BBR franchisee BBR STI in Saudi Arabia went from having a market share in building PT works of less than 10% to becoming the undisputed market leader in Saudi Arabia. In Egypt, ESPT together with BBR, has been lobbying the local construction market to adopt European Approved post-tensioning systems with great success resulting in rapid business growth capturing over 400,000m^2 of commercial and residential floor slabs in less than twelve months of joining the BBR Network.

It has always been our strategy to stay at the cutting edge, not just in terms of core products, but also how we go about our business.

Opportunities have opened up too for Kappa in Turkey who are in the running for several landmark infrastructure projects, underpinned by BBR's support to help them develop – and local customers who appreciate the benefits of BBR technology and services.

The BBR Network franchise concept was launched in 2006 and seen as being a mechanism through which certain functions – like R&D, supply chain, marketing & communications and business development – could be centralized, allowing individual businesses to focus on sales and installation in their local markets while leveraging the BBR reputation, technology and service. Now, almost 15 years later, it is really pleasing to see that the franchise is still an attractive proposition, is actively building momentum with a modest growth trajectory, is adding value to both existing and new Members, and most importantly is just as relevant today as when it was originally conceived.

Holistic approach

Taking a step back, even as little as two or three decades ago, post-tensioning was considered to be cutting edge technology. While it's still highly valued when it comes to disruptive design, we need to offer more than this today and therefore have ventured recently into geotechnical technologies, high strength threaded bars and structural accessories like bearings, joints, seismic devices and so forth. We are taking a continuous development approach and want to expand the franchise offering to provide complete holistic solutions – if you like, a one-stop-shop with an ample toolkit – for BBR franchisees and their customers to draw upon.

We are already seeing synergies taking place when, for example a BBR Network Member is offering post-tensioning on a bridge project, they can now also offer a complementary package including geotechnical anchors or self-drilling bars. When you look at a typical structure, our franchisees will increasingly be able to offer the complete range of what's required in the built environment. This not only helps them to diversify their income streams but also to increase their overall revenues and profitability which in combination helps to protect them from the usual construction economic cycles.

The holistic approach also plays well with customers who like to deal with a single supplier for a whole range of products and services, thus BBR franchisees will be in a stronger competitive position during project tendering and negotiations.

Best in class technologies

For us, it's not merely about copying the competition by introducing a 'me too' product onto the market, our technologies must always offer extra value. Take the new CONA CMG strand ground anchor range, for example. In creating this technology, we focused on improving the concept so that we could also offer key competitive advantages including an EAD and CE marking. We've set a new benchmark that will take strand ground anchors to the next level.

It's a similar story when you look at the CONA CMF S2 system. We went the extra mile here to create the best and most optimized system where the anchorages can be installed in the thinnest possible slabs using the least amount of anti-bursting reinforcement and with very low concrete stressing strengths promoting even faster cycle times which is particularly important for building construction. At the same time, we wanted to have simplicity to reduce stock-keeping by having common components that are compatible between 05" and 06" strand sizes without sacrificing on the system design or cost effectiveness. We achieved all of this while also providing the broadest range of anchorage sizes on the international market place.

Cutting edge business

It has always been our strategy to stay at the cutting edge, not just in terms of core products, but also how we go about our business. Leading the way has been our online e-commerce trading and QA platform, BBR E-Trace, which covers the full scope of procurement, quality control, stock management and installation record-keeping while incorporating further support functions such as an engineering database, 100% component traceability and communications platform enabling a fully integrated and digital factory production control (FPC) system for every single BBR product that is delivered to the international construction market.

Looking to the future, we are planning to add further related and complementary technologies which will add value to our existing technology portfolio. Take Tesla for example, at one time they just made powertrains for their cars – but now they make the entire car from A to Z. Think about Uber – they started as a luxury taxi company, now they offer a complete ride sharing taxi service and have also branched out recently into the Uber Eats service. In both cases, the new offerings relate to the companies' core business, which they united with complementary elements and brought to the market on a single platform ultimately offering synergies to both its existing and new business ventures.

The journey which we have embarked upon will take more than just a couple of years to accomplish. At BBR we carefully evaluate every offering, carrying out laboratory and market testing before we launch our new products and services. We have a reputation for seeking the highest level of quality that stretches back over three-quarters of a century – and we fully intend to ensure that this philosophy continues way into the future too.

Looking back at the values that our founding fathers established in 1944, I can genuinely say that it remains very pertinent more than 75 years later as our team still possesses a strong entrepreneurial spirit, we are still striving for innovative engineering and to bring world-class technologies to bear on the international marketplace – and we still have a relentless customer focus.

News Highlights Events & news from around the BBR Network

Events, activities and achievements

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Last year saw the 75th Anniversary of the founding of BBR and this certainly gave an extra sparkle to the events, activities and achievements around the BBR Network which were filled with glamor, excitement – and huge amounts of success. Here, we present some of the highlights from the last twelve months around the globe.

Sizzling time at BBR Euro PM Workshop
In October, the European 2019 BBR Project Managers' Workshop was held at the BBR Headquarters building in Zurich. Among other topics, the program included training and updates on the CONA CMF S2, CONA CMG systems and BBR Bar technologies, supply chain news and latest marketing and communication activities. A special highlight was the team visit to ETH in Zurich where the team was able to learn more about some of the newest techniques such as 3D printing and digital fabrication. The timing of the Workshop coincided with BBR HQ's quarterly Team Event, so a barbecue was organized during which delegates had the chance to network with the entire headquarters team too.

Bringing the BBR team up to date in Bangkok
The Asia Pacific 2019 BBR Project Managers' Workshop in Thailand was held in August. The focus for the technical session was on advanced PT systems and features, plus further presentations on stay cable technology and installation. Delegates were also updated on the BBR Bar family and BBR VT CONA CMG strand ground anchor system. News about our online trading platform BBR E-Trace and supply chain developments was also discussed. Other topics for the session included BBR Network marcom activities and BBR Network Member collaborations. There were lively Q&A sessions throughout and it was also a great opportunity for networking.

BBR supply solution wins friends in the Philippines
While visiting BBR Philippines Corporation early last year, BBR Deputy CEO Cezary Sternicki assisted in promoting the BBR brand and new BBR Bar range which includes hot-rolled threaded BBR H Bars, self-drilling BBR SDX Bars and, specifically for wind tower applications, BBR WT Bars. BBR Philippines had organized a program of meetings with key local construction industry players. The BBR Bar range was well-received, especially the BBR supply chain concept with its advanced quality control procedures and an innovative stocking concept. Convenience is a key requirement of our times and it appears that BBR, with its supply chain solution, is yet again right on time.

Major industry award for Mersey Gateway Bridge
The Mersey Gateway Bridge has been presented with one of the industry's most prestigious prizes – the Outstanding Structure Award from the International Association for Bridge and Structural Engineering (IABSE). See page 15 for the full story.

Two glittering awards in NZ
The Supreme Winner award for the massive Kaikōura Earthquake Recovery project was officially accepted by Steve Mutton of the NZ Transport Agency at Engineering New Zealand's inaugural ENVI Awards. BBR Contech and Australian BBR Network Member SRG Global were part of the specialist team brought together for the project by the NZ Transport Agency, KiwiRail & NCTIR Alliance.
The work of BBR Contech was also recognized at the Civil Contractors New Zealand – Auckland Branch Awards ceremony. Their project for the repair of Auckland's Wynyard Wharf attracted the Hynds Construction Award in the category for medium-sized projects.

Showtime around the BBR Network
The BBR Network message has traveled well in the last 12 months, around many different conferences and exhibitions. Teams of staff from local BBR Network Members have not only produced some excellent exhibition stands, but have also made some great contacts at the various shows. In Cairo, ESPT made a great impression at the Big 5 Construction Conference, while in Ankara Kappa took a highly technical approach to their appearance at the Road2Tunnel Conference. The annual conference for Norway's Department of Transport (Statens vegvesen) again offered an opportunity for Spennteknikk to offer some first-hand insights into the benefits of BBR technology. Meanwhile, in Auckland, New Zealand, the BBR Contech team attended the 2019 SESOC Conference where Marc Stewart also presented a paper on the design of elevated post-tensioned slabs.

New BBR technology brochures
BBR Network Members now have three new brochures for their marketing toolkits – one about BBR post-tensioning for slabs and the other two about BBR HiAm CONA stay cable and BBR VT CONA CMG strand ground anchoring technologies. As well as presenting the BBR technologies available, the brochures offer insights into their application and highlight the benefits of designing and constructing with these market leading systems. Copies of all brochures are available from your local BBR Network Member, or you can download your own copy from the BBR Network website.


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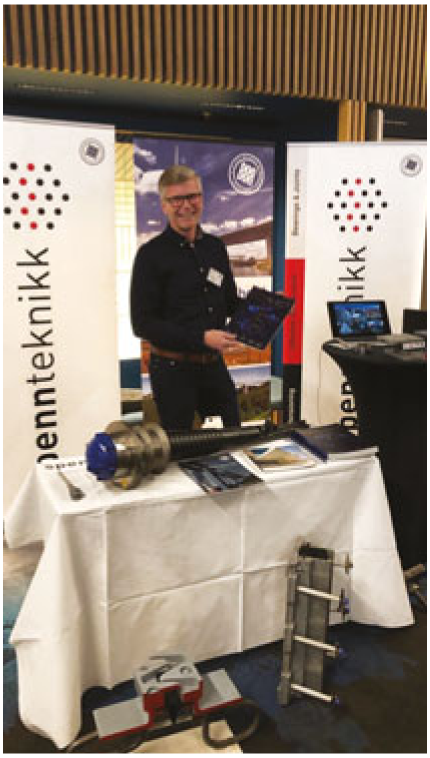
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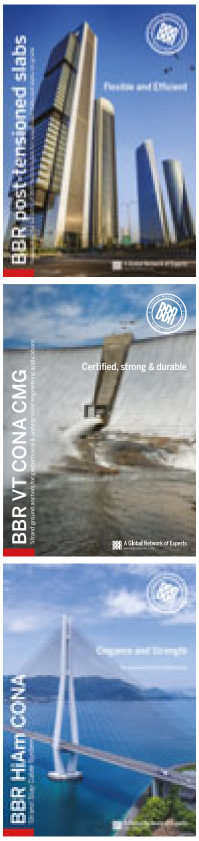

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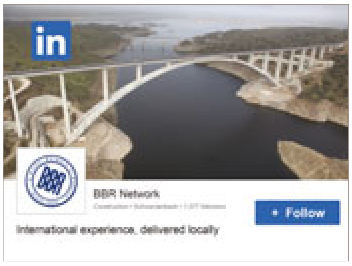

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BBR Project Finder

The BBR Project Finder has been updated. New functionalities have been implemented, usability improved and the database has been purged. There are now over 2,500 projects featured within this important reference system – a massive increase compared to a year ago.

BBR Network social media

There has been another huge leap in Followers of the BBR Network LinkedIn page – since February 2018, we have seen an increase of over 500%. Many thanks to BBR Network Members for sharing their stories and pictures. Meanwhile, you can keep up-to-date with events as they happen by following us – and liking, sharing or commenting on our posts on the BBR Network LinkedIn page.

BBR Network video premières

In recent months, seven videos have been uploaded to the BBR YouTube channel. These include BBR's 75th Anniversary video, 2019 BBR Network Highlights, BBR Network 2019 Project of the Year and two further videos with details of the shortlisted entries for the 2019 BBR CONNÆCT Awards for Best Article and for Best Photography.

As well as the above, three new BBR Network Technical Series videos about BBR technologies were also premièred. The video about the BBR VT CONA CME post-tensioning system and applications highlights the benefits of EIT – fully electrically isolated tendons, offering complete replaceability of tendons and the highest possible level of corrosion protection and inspectability according to *fib* guidelines PL3.

The BBR VT CONA CMF video showcases the system's advanced load transfer mechanism, especially developed for thin concrete slabs. This – in addition to the small tendon center spacing and minimum concrete edge distance which are major features across the whole CMX product range – offers the option of using the least amount of local anti-bursting reinforcement, in the form of either stirrups or helix, to produce the thinnest possible concrete slabs.

The BBR SDX Bar range video has also made its debut and describes the key components of the system and typical applications, as well as details of the rigorous testing undertaken to verify the properties of the BBR SDX Bars. Also contained within the film are details of the all-important options available for corrosion protection systems.

As CONNÆCT 2020 goes to print, further videos are being prepared which will mean that BBR Network Technical Series videos will be available on all BBR technologies.

1 Delegates attending the 2019 European BBR Project Managers' Workshop, held at BBR HQ in Zurich, had a special visit to ETH in Zurich where they learnt more about the newest construction techniques, such as 3D printing and digital fabrication.
2 Some 25 BBR engineers from the region attended the 2019 Asia Pacific BBR Project Managers' Workshop in Thailand. There were lively Q&A sessions throughout and, of course, it was a great opportunity for networking too.
3 In Manila, BBR Deputy CEO Cezary Sternicki assisted BBR Philippines in promoting the BBR brand and new BBR Bar range to key construction industry players within the local market.
4 During the opening of IABSE's 2019 Congress in New York City, the President of IABSE, Fernando Branco (far right), presented the 2019 IABSE Outstanding Structure Award for the Mersey Gateway Bridge project to representatives from COWI, Fhecor and FCC Construcción.
5 This new accolade for the massive Kaikōura Recovery project in New Zealand follows on from two earlier international awards.
6 BBR Contech has been recognized with an industry award for their work at Auckland's Wynyard Wharf. Pictured here (left to right) are Adrien Marteddu, Mark Kurtovich and Mole Powles.
7 Egyptian BBR Network Member ESPT made a great impression at the Big 5 Construction Conference in Cairo.
8 Stig Solbjør shows off a copy of the BBR 75th Anniversary edition of CONNÆCT at the Spennteknikk booth during the annual conference for Norway's Department of Transport (Statens vegvesen).
9 On the BBR Contech stand at the SESOC 2019 Conference in New Zealand are (left to right) Adam O'Dea of SRG Global, with BBR Contech's Marc Stewart and Derek Bilby.
10 Kappa took a highly technical approach to their appearance at the Road2Tunnel Conference in Ankara, Turkey.
11 Three new BBR brochures are now available – one about BBR post-tensioning for slabs and the other two about BBR HiAm CONA stay cable and BBR VT CONA CMG strand ground anchoring technologies.
12 BBR Network videos now on YouTube include BBR's 75th Anniversary video and three new BBR Network Technical Series videos.
13 After a recent campaign on the social media front, the BBR Network LinkedIn page has attracted a staggering 500% increase in Followers.
14 The BBR Project Finder, on the BBR Network website, has been updated and now features over 2,500 projects.

More information

Downloads available here

Global BBR Conference 2019 goes to

Zurich, Switzerland

It was most appropriate that, in BBR's 75th Anniversary year, delegates from around the world came together for the 2019 Global Annual BBR Conference in BBR's homeland – Switzerland.

One of the most important components of the Annual Global BBR Conference is the opportunity for networking which, alongside business breakout sessions, is promoted by a variety of social or cultural activities. This year, the welcome event was a cruise on Lake Zurich in the company of a pirate crew which led to some great teamwork in solving knotty problems, but resulted in at least one BBR Network delegate getting all tied up!

After welcoming all delegates to Zurich, BBR VT International's CEO Juan Maier, Cezary Sternicki and Daniel Cuerdo presented the latest news from BBR HQ. Next, Behzad Manshadi gave details of recent supply chain happenings, while Xiaomeng Wang and Haifeng Fan made presentations on BBR geotechnical and post-tensioning technology. There were also special introductory presentations by Murat Kutay of Kappa and Mohamed Ashour of ESPT whose companies had recently joined the BBR Network. On the second day, special guest Benjamin Dillenburger from ETH Zurich gave a presentation entitled 'Digitalization in Construction: A look to the future' which was followed by a networking and discussion session.

For a further cultural experience, delegates headed due south from Zurich to the Titlis glacier. After a journey in a revolving panoramic cable car to the top of the mountain 3,041m above sea level, their courage was further tested by a walk across Europe's highest suspension bridge which is 100m long, yet only one meter wide. Next, they walked through the glacier cave, with its eerie natural lighting, where the ice is up to 5,000 years old and the temperature is a constant -1.5°C.

At the BBR Gala Dinner, Svein Finstad from BBR shareholder KB Spennteknikk managed – with a little help from his partner Iris Liriano – to cut the massive BBR 75th Anniversary cake. He presented the first slice to Claudia Valsangiacomo, wife of Bruno Valsangiacomo and daughter of Antonio Brandestini, one of the three BBR founders.

BBR VT International CEO, Juan Maier, presented a check to Manuela Stier of the Association for Children with Rare Diseases. With the generosity of BBR Network Members and suppliers, this substantial donation will be put to good use helping some 350,000 children and adolescents in Switzerland who are affected by a rare disease. The Association provides direct financial help, creates free family events to connect affected families and works to raise the profile of the subject of rare diseases publicly. Thanks to everyone for their generosity which has enabled us to support this locally-based registered charity to continue its vital work.

Bruno Valsangiacomo, Executive Chairman of the Tectus Group and BBR VT International's founding shareholder, addressed the delegates and guests at the BBR Gala Dinner. He talked about the original vision of the three BBR founders 75 years ago – and how delighted they would have been to know that it was still growing and being adapted to meet future needs globally by the BBR Network.

The **2019 BBR Network Project of the Year Award** went to the Fernando Reig Bridge where Spanish BBR Network Member, BBR PTE (FCC), replaced all 38 stay cables. After being presented with the award, a delighted Juan Linero (right) held the shining trophy up for all to admire.

The **BBR CONNÆCT 2019 Best Article Award** was presented by BBR VT International's Deputy CEO Cezary Sternicki (left) to Yok-Lin Voon of BBR Construction Systems Malaysia for his company's feature article about the KVMRT2 metro rail project.

Pictured here is Daniel Cuerdo (left), Business Development Manager, presenting Mathias Kaminski from French BBR Network Member ETIC with the **BBR CONNÆCT 2019 Best Photography Award.** This year, top honors in this category were shared with New Zealand-based BBR Contech.

2019 BBR Award Winners

BBR PROJECT OF THE YEAR 2019

Fernando Reig Bridge, Spain – innovative and technically challenging replacement of 38 stay cables by BBR PTE (FCC)

BBR CONNÆCT BEST ARTICLE AWARD

Winner: BBR Construction Systems (Malaysia)
Title: Building a bridge to a new future (KVMRT2)

Runner up: BBR Construction Systems (Singapore)
Title: Innovative construction combination (Wisteria Condominium & Mall)

Highly commended: ETIC (France)
Title: Widening the motorway (A9 viaduct strengthening)

BBR CONNÆCT BEST PHOTOGRAPHY AWARD

Joint Winner: BBR Contech (New Zealand)
Title: ICE People's Choice Award 2018 (News item)

Joint Winner: ETIC (France)
Title: Signature stay cables (Saint Jacques Bridge, Montréal, Canada)

Highly commended: BBR Adria (Croatia)
Title: Time, materials & cost savings (Max Stoja Shopping Center)

More about
BBR Project of the Year

Perspective Delivery of stakeholder value through shared understandings

Creating visions of success

For this edition of CONNÆCT, we are delighted to welcome as our guest Steve Mutton, Director Regional Relationships (Upper North Island) for the New Zealand Transport Agency (NZTA). Steve is a project board member for large alliance projects underway in New Zealand and has a reputation not only for getting the job done, but also for effective management of stakeholder relationships. He presents us with some thoughts about the importance of shared visions.

What does success look like? The answer to this question can be hugely empowering. It creates a vision not only of the goal a person is aiming at, but also of that individual's role in achieving that objective. Take this to the next level and consider what can be achieved when a team of people share the same vision, then, as we discovered in New Zealand, they can quite literally move mountains.

Three centered approach

The NZ Transport Agency is focused on creating a transport system that is safer, provides stronger community connections, supports better access to economic and employment opportunities – and that is resilient to withstand extreme weather events. Transport is such a critical part of daily life for all New Zealanders. We use transport for access to services, freight, travel to work, education, health and for visiting family and friends. Transport networks allow businesses, regions and urban areas to be well-connected and productive. To ensure that everyone benefits from changes happening in transport, we have adopted a three strand approach which involves a system response, people-centric response and community response. All of these are targeted on delivering real value for New Zealand – and keeping our customer promise of facilitating great journeys to keep New Zealand moving.

Our strategy was challenged to the maximum in the aftermath of the November 2016 earthquake which severed vital access routes in the Kaikōura region of New Zealand's South Island. Even before construction could begin, mountains actually did need to be moved and fractured hillsides made safe. At least 40 landslides blocked the 63km coastal transport network between Clarence and Oaro.

Unifying vision

The North Canterbury Transport Infrastructure Recovery (NCTIR) alliance was established to restore the transport networks, and keep traffic moving on alternate routes. This partnership between the NZ Transport Agency and KiwiRail was new territory, as was the collaboration with construction firms and professional service organizations on such a large scale. The mandate of the NCTIR alliance was made clear in its vision 'Moving mountains to reconnect communities'. This was a great unifying vision which helped everyone understand why we were there and who we were doing it all for.

Having this strong vision of reconnecting communities helped to motivate a massive team to achieve outstanding results. The work that went into getting the rail, harbor and road open, in just 13 months, is a testament to the professionalism, tenacity and sheer determination of the workers involved, who wanted to make this happen for a community that had suffered as a result of the earthquake. By December 2017, 1,700 people had worked more than two million hours to move mountains and reconnect the communities isolated by the earthquake.

Driving success – understanding 'the why'

It's not all about asphalt, concrete and steel – people are at the heart of achievements. The key that drives success is to ensure that you create an environment within which people want to do their best and can do their best. It is about making sure that everyone on your project – from the project board to the laborers – understands why they are doing what they are doing ('the why') and understands the important role they themselves play in achieving this.

When our then new CEO asked a laborer on the back of a traffic management truck what he did, the laborer replied "I keep customers moving". It was clear that we had created an environment that motivated the team. Rather than saying that his job was putting cones out on the road, he understood his 'why' – why he came to work every day – to ensure customers were able to travel through a work site safely and efficiently.

Looking ahead

The next challenge is about how to become an agile organization to meet the changing demands being thrown at us. The world is changing at such a fast rate at the moment, not only as a result of technical advancements, but also of people's expectations of instant communications and real-time information.

It's about engaging with people and sharing visions of the future. On the construction site, we find that making a connection with the workers about 'the why' leads ultimately to an improved culture, bringing with it health and safety, quality and productivity benefits. Whether you are a client, consultant or contractor, it's about having early conversations – about the value which is expected to be achieved by the project. Taking time to talk about 'the why' will certainly set everyone up for success and provide the best possible solutions for the community as a whole for generations to come.

Mersey Gateway Bridge, Cheshire, England UK's first long span cable-supported concrete bridge

Sparkling awards for bridge

The spectacular cascade of fireworks which heralded the official opening of the UK's new Mersey Gateway Bridge in October 2017 may seem, in hindsight, to have also anticipated the many accolades that this new structure would attract. In recent months, this stunning bridge project across the Mersey estuary in North West England has been presented with a third major industry award. Juan Linero of BBR PTE (FCC) reviews the project and the BBR Network's work on this important scheme.

In the last edition of CONNÆCT, we were pleased to report that this landmark bridge had attracted two awards – Outright Winner of the 2018 Concrete Society Awards and also the Infrastructure Award from the Royal Institution of Chartered Surveyors (RICS). Now, the structure has been presented with the Outstanding Structure Award by the International Association for Bridge and Structural Engineering (IABSE) who commented: "The Mersey Gateway Bridge is an elegantly integrated bridge, the first long span cable-supported concrete bridge constructed in the UK which marks a significant advancement in the use of concrete for similar applications in the future." The bridge is the dramatic centerpiece of a major highway scheme which was designed as a catalyst for regeneration and to attract investment into the region. This is the UK's only long-span cable-supported bridge to be constructed primarily using cast in-situ concrete – post-tensioned with BBR VT CONA CMI and BBR VT CONA CME internal and external systems. Not only was the Mersey Gateway Bridge opened ahead of program after three-and-a-half years' construction work, but the whole scheme was also delivered in within budget. This was a great achievement considering that it was the largest infrastructure project underway in England, outside of London. >

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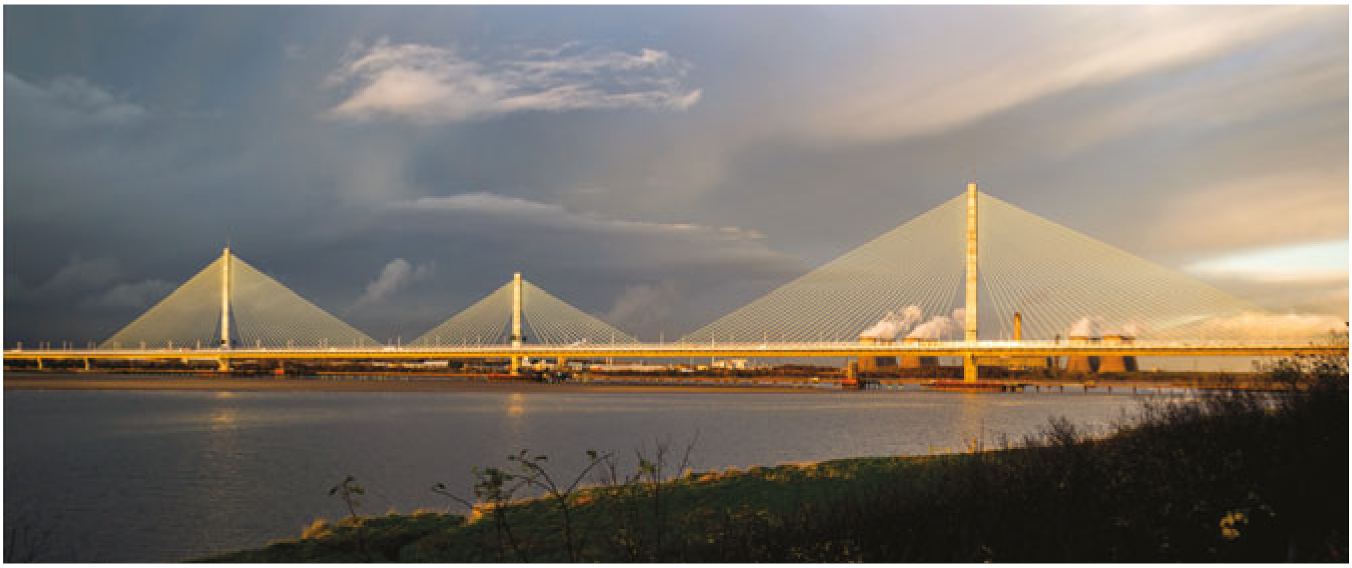

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Structural overview

The bridge is 2,248m long in total, with a central cable-stayed section of around a kilometer in length, plus two access viaducts. The central section has four bays supported by three pylons founded in the Mersey estuary. Each of the pylons is a different height, adding to the uniqueness of the structure's form. The central pylon is 80m high, while the other two pylons are higher – 110m on the north side and 125m on the south. The pylons connect with the bridge deck via 146 stay cables, with a combined total length of 1,296km.

The new road network includes a total of 12 bridges and seven new or upgraded junctions along a 9.2km route through the towns of Runcorn and Widnes. In all, 127,425m^3 of concrete was used for the scheme. The highest environmental standards have been applied to the project and, with bridge design focused on minimal environmental impact, almost 1.5 million tons of material was recovered from the site and reused in construction.

The construction joint venture was made up of Kier Infrastructure and Overseas Limited (UK), Samsung C&T Corporation (South Korea) and FCC Construcción S.A (Spain). Its equity partners were UK-based BBGI, FCC Construcción from Spain and Macquarie Capital Group Limited from Australia.

Specialist services

Specialist companies BBR PTE (FCC), Structural Systems (UK) Ltd and VSL Systems (UK) Ltd formed a joint venture known as 'BSV Mersey JV' in order to deliver the most highly skilled and optimized specialist services within our field to the Mersey Gateway project.

The post-tensioning for the 17-span approach viaducts – with spans up to 65m long – was executed by an experienced multicultural team. A two stage process was adopted using both the BBR VT CONA CMI internal and CONA CME external systems. Firstly, longitudinal tendons were installed from a Movable Scaffold System (MSS) and secondly, the transversal tendons were installed from a wing traveler.

For the main bridge, temporary vertical tendons were used to reinforce and give stability to the hammerheads during pylon construction – these were later de-stressed. We also installed permanent transversal tendons during the form traveler stage and external tendons to reinforce and give continuity to the main bridge and approach viaducts after the deck sections had been joined.

The Mersey Gateway Bridge is an elegantly integrated bridge, the first long span cable-supported concrete bridge constructed in the UK which marks a significant advancement in the use of concrete for similar applications in the future.

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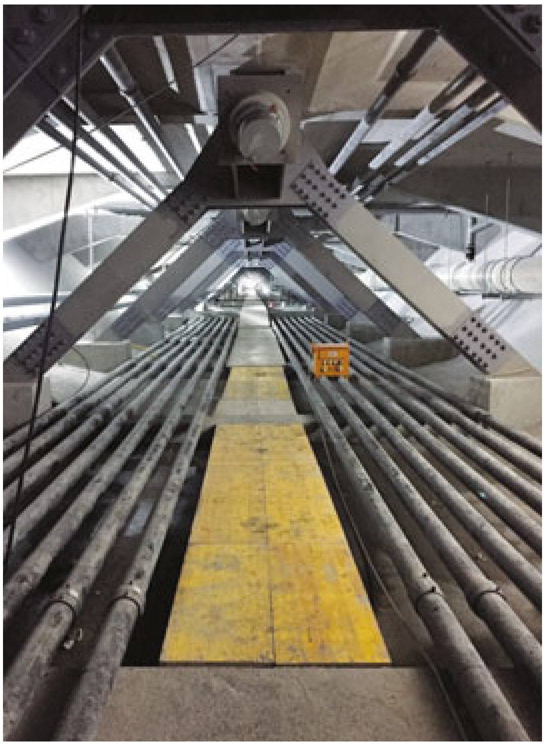

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Construction milestones

June 2017 was a month of milestones for the project. We celebrated completion of both the final concrete pour and, less than two weeks later, the first joining of the bridge with an approach viaduct.

The new bridge deck was built in three separate sections, working outwards from each of the three pylons at a rate of around six meters each week. The north and south main bridge deck sections then had to be connected to the approach roads – which are, in essence, viaducts built over a saltmarsh and canals.

The final concrete pour also signaled the departure of 'Webster', the 1,700t Movable Scaffold System (MSS) which had been working on the South Approach Viaduct for some ten months. The final pour took place over a 28-hour period and saw over 1,133m^3 of concrete being poured into formwork to complete the deck.

Meanwhile a few days later on the other side of the River Mersey, the construction team created a further project milestone. They connected two sections of deck to link the North Approach Viaduct to the north pylon deck span – the first of four joins to take place during the summer months.

The decks were closed with four steel restraint struts and a concrete pour. After the concrete had cured – around 18 hours later – the decks were further locked together with external post-tensioning tendons.

Engineered advantages

The Mersey Gateway Bridge is already fulfilling its creators' vision. The most recently released figures show that between October and December 2018, six million journeys were made across the bridge – saving around 20 minutes on previous journey times. Also, the hoped-for inward investment and job creation in the area is also beginning to be seen. For the BBR Network, this has been a project which has brought together some of the leading players on the construction scene and where some great teamwork and collaboration developed to deliver not just a fine piece of infrastructure, but also some real economic and social advantages.

1 A cascade of fireworks heralded the opening of the Mersey Gateway Bridge. Image courtesy of The Mersey Gateway.
2 The 1,000m long central cable-stayed section of the Mersey Gateway Bridge.
3 Stressing operations underway on the lateral post-tensioning tendons in the bridge decks. Image courtesy of The Mersey Gateway.
4 View inside the deck of the main bridge, showing the ducts (top and bottom) containing the longitudinal BBR VT CONA CME tendons. At the apex of the steel frames, the lower stay cable anchorages can also be seen.
5 Stressing of BBR VT CONA CMI tendons for one of the approach viaduct segments.

TEAM & TECHNOLOGY

DBFO – Merseylink Limited

Main contractor – Merseylink Civil Contractors Joint Venture: Kier Infrastructure and Overseas Limited, Samsung C&T ECUK Limited and FCC Construcción S.A.

Structural designers – Merseylink Design Joint Venture: COWI, Flint & Neill, Aecom, Eptisa and Fhecor

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

BBR Network Member – Structural Systems (UK) Limited & BBR PTE (FCC) (Spain)

KVMRT2, Kuala Lumpur, Malaysia Technology & techniques for long span crossing

Technical expertise overcomes challenges

Long Span Crossing 4 is one of the precast balanced cantilever bridges on the KVMRT2 SSP Line which is under construction across the heart of the busiest town in Malaysia – Kuala Lumpur. With the various technical issues anticipated along the way, BBR Construction Systems (M) has proven itself to be a great choice as launching contractor and PT specialist for this part of the project. Zuhair Rawi, BBR Construction Systems' Senior Design Engineer for the project now takes us on a journey to explore the inside story of the challenges that have been overcome during the construction of this special bridge type.

In the last edition of CONNÆCT, we described how BBR Construction Systems had been selected to work on package V202 of the KVMRT2 SSP Line as post-tensioning and launching specialist. We have been working with the team to produce three different structures for the new metro viaduct – standard spans, T-shaped piers and long span crossings. Now, in this edition, we would like to share further details of our work on Long Span Crossing 4. The longest span of this crossing is more than 45m from pier-to-pier and cannot be accessed by the launching gantry due to obstructions – either caused by live traffic or landscape features. To overcome the obstruction issues, this type of structure is typically constructed by the balanced cantilever method.

Tight spaces

Long Span Crossing 4 is a four-span bridge with a slender segment profile and a constant segment height of 2.45m along the four spans. The span length configuration of this bridge is 36m-46m-46m-36m and in total there are 15 segments for each cantilever span.

We opted for a direct launching method involving the use of a mobile crane for erecting each segment. Behind this decision, there had been a lot of brainstorming between the client and ourselves about the best method for constructing the crossing. The major challenge here was that one of the bridge spans needed to sit directly under an existing bridge which only allowed us a clear working height of 5.2m. Initially, there had been another option – that of using a segment erector. The 5.2m gap would not have presented any problem for fitting the segment erector and the restricted clearance would have been fine for the launching operation. However, the idea was shelved because of installation issues. It would have been difficult to install a segment erector – and a lot more complex in terms of works co-ordination. In this respect, other options involving installation on top of a segment were also discounted.

With that in mind, we then focused on the direct launching method involving the use of a mobile crane with a special set-up for the lifting frame to fit into this restricted 5.2m gap. The whole brainstorming process took almost a year – discussions started at the end of 2017 and physical segment launching works only began in November 2018. This sort of back-and-forth discussion happened within BBR internally, with the client and also with the crane supplier to ensure that everything had been considered as regards suitability and compatibility for each stage of the lifting process.

Configuring the lifting frame

The main objective in designing a lifting frame is to stabilize and properly distribute the weight of the segment during the lifting process. In this way, the segment could be lifted in a safe and stable position and the lifting frame would ease the lifting process especially during segment placing and jointing.

At the same time, there was the issue of the restricted headroom – or clearance gap – under the existing bridge. Therefore, the lifting pin on the lifting frame could only be placed in a very low position – positioning was limited to a maximum gap of 500mm between the pin and top surface of the segment. This gap was designed to allow for the thickness of the crane hook. Several visits were made to the crane supplier's yard to test the compatibility and the requirements of the crane supplier to ensure that the entire process was sound.

The other factor considered was the spacing of the lifting points. The positions of lifting points were determined by the center of gravity of the segment. Since every segment for other bridges has different dimensions and profiles, the lifting point spacings for each type of segment are different.

To fabricate a special frame which was only suitable for one bridge would have been a costly idea. So, the team arrived at the idea of having a non-fixed lifting point that could fit with any type of segment. After combining all of the factors being considered, we designed a steel frame with a combination of I-beams and channels. It is a simple frame but it certainly serves its purpose perfectly. Before the frame was actually used, trial lifting tests were conducted to further check whether any further modifications were required.

The testing

Immediately after the frame was fabricated, it was taken, together with a segment, to the crane supplier's yard where tests were carried out.

There were several objectives to the testing. Firstly, we needed to ensure that the frame was safe to be used for segment lifting in terms of its capacity. Secondly, we wanted to make sure that all links were well connected – especially the pin which was to be hooked directly onto the crane. Lastly, we needed to measure the exact minimum working height that we could achieve to satisfy the site requirements – here, the goal was that the gap between the top surface of the segment and the tip of the crane should be less than 5.2m.

The first thing that we noticed during early stage testing was that the frame was not self-stable. This was because of a very low lifting point which was below its own center of gravity. However, after the frame was connected to the top of the segment by prestressed bars – and each of the bars had been stressed to the required jacking force – the segment was then lifted in a stable position. This happened because, once the frame and segment were properly connected by the prestressed bars, they became a single monolithic element and brought the center of gravity down to below the lifting point – meaning that the segment could remain stable during lifting.

After everything was set up, the segment was then lifted to the desired height. The working height was measured and the crane was set to ensure that the minimum height of 5.2m was achievable. This trial-and-error effort of crane positioning and setting was finally brought to a positive conclusion and the lifting plan for the actual segment lifting was drafted accordingly.

On site, all of the segments were safely launched and placed without any issue. The success of the project is primarily due to the huge efforts and great co-ordination applied by the team throughout the process.

1 Segment placing and jointing was supported on temporary steel props.

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)

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Moračica Bridge, Republic of Montenegro Cantilever bridge construction across valleys

Span closure for record-breaking bridge

The deck of the mighty Moračica Bridge in Montenegro, the tallest bridge in the former Yugoslavia region, has been completed with the help of BBR VT CONA CMI internal and CONA CME external post-tensioning. Tomislav Lozančić of BBR Adria provides a brief overview of the project and an update on progress during the past year.

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1&2 The balanced cantilever construction of the 180m high Moračica Bridge in Montenegro has been completed. The project features both BBR VT CONA CME and CONA CMI post-tensioning.

TEAM & TECHNOLOGY

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)

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The joining of all the spans of the massive Moračica Bridge was celebrated in October 2019 by a visit from Duško Marković the Prime Minister of Montenegro. He expressed his satisfaction with the progress and described it as a "special day for Montenegro", while thanking all those involved in the project.

Moračica Bridge is the largest structure on the priority section of the Bar-Boljare motorway and is believed to be the third largest bridge in Europe. Stretching elegantly across the Moraca River valley and plateau below, the 960m long bridge has six spans. The bridge deck is supported on five piers, the tallest of which is 180m.

Climbing formwork was used to construct the bridge piers and the bridge deck was constructed by the balanced cantilever method. The balanced cantilever sections feature BBR VT CONA CMI internal post-tensioning, while CONA CME external post-tensioning was installed following deck segment completion.

The bridge will be fully completed in early 2020, in time for the opening of this first section of the motorway in the summer. When the whole 170km long scheme, known as pan-European Corridor XI, is complete it will offer a ferry and motorway link between Bari in Italy and Bucharest, Romania.

Windsor Bridge, NSW, Australia Post-tensioning & incremental launching

Talent for increasing productivity

Thirty years on from their first launched bridges in the 1980s, Australian BBR Network Member SRG Global are still delivering sound specialist bridge construction services to their clients. Sean Kelly, Civil Manager in Eastern Australia provides this report on the successful completion of post-tensioning and incremental launching for a 157m five span, twin concrete girder bridge over the Hawkesbury River in Windsor, 50km north-west of Sydney.

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Windsor is the third-oldest place of British settlement on the Australian continent, with settlement at the location first established in approximately 1791. At over 140 years old, the existing Windsor Bridge – built for horse-drawn vehicles and foot traffic – has recently been replaced to ensure a safer journey for vehicles and pedestrians, with the former reaching 19,000 daily.

Incremental launching girder

We modified our existing launch girders which had previously been used to deliver the incrementally launched Mandurah and Seaford Bridges. Due to the shallower deck profile needed for the 31m continuous spans, the launch girder consisted of only the front three of the four sections used for Mandurah Bridge. To ensure the design loadings were appropriately managed, significant modifications were made at the girder connection. A completely new girder connection section was full penetration-welded to the existing 32mm web, both vertically and horizontally.

Each launch girder was stressed onto the first segment by ten 50mm diameter high tensile stress bars, each stressed to a load of 1,375kN at lock off (68% of MBL). In addition to ensuring the pivotal connection of the stiff launch girder to the first segment, the bottom row of girder connection bars was then used to fix the bridge longitudinally to facilitate the permanent bearing installation process after launching.

Launch bearings

The designers made a conscious effort to detail the permanent works in a manner which complemented the temporary works requirements. An example of this was the adoption of permanent bearings, which were capable of being used as temporary bearings during launching. The decision to use large reinforced elastomeric bearings, with top and bottom steel plates, saved time and cost post-launch by simplifying the transition to permanent bearings.

PTFE sliding pads were still adopted to ensure the launching forces were managed appropriately and these were located between the bridge soffit and stainless steel upper plate of the elastomeric bearing.

To guide the bridge transversely during the launch, reinforced concrete nibs were built into the pier heads that allowed guidance via the inner webs. In addition, conventional side guide rollers were adopted at the abutments and in the casting yard. >

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The staggered concentric tendons are coupled together with BBR VT CONA CMI Type K couplers at every second segment.

Launching equipment

The bridge was launched on a 1.296% uphill gradient, making the lift-and-shift launching solution viable over other techniques such as strand pulling systems. A brake saddle was incorporated into the launching equipment thrust block for simplicity, with the tail end of the bridge transferring over to a temporary hydraulic jack brake saddle during the final meters of the last launch.

The bridge weight and gradient meant the horizontal shifting force would not be the governing factor when selecting the appropriate launching equipment. The support locations dictated that the vertical lift requirements would drive the decision in the selection of launching equipment. The critical lift was during segment three, which resulted in the choice of a system that furnished each girder with launching equipment capable of a 785t lift and 3,040kN shift. The incremental launching of a segment was able to reach a rate of approximately 4.7m per hour – meaning that on occasions segment launches took the team less than four hours.

Post-tensioning

The twin concrete girder bridge is made up of two 2m wide by 1.85m deep beams, monolithically stitched together by a nominally 350mm thick deck which is 14.9m wide. The bridge is typically constructed using 34 concentric post-tensioned tendons, with sizes varying between five and 19 strands. The staggered concentric tendons are coupled together with the BBR VT CONA CMI Type K couplers at every second segment.

At the completion of launching and for the final loading conditions, a total of six – three per girder – 25-strand continuity tendons were pushed, stressed and grouted. The tendons run the full 157m of the bridge and are stressed at both ends to manage the friction losses.

For the final three segments of the bridge, the deck widens up to 19.5m to make provision for the road and pedestrian approaches. As a result, there was a requirement to install a total of 52 five-strand transverse flat slab tendons to manage the additional cantilever loading.

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1 Overview during segment three construction of the new Windsor Bridge which replaces the adjacent upstream bridge.
2 With nine of the 10 segments constructed, the launch girder closes in on Abutment A.
3 Permanent bearings were used as temporary bearings during launching – saving time and costs. Here, beneath the launching girder, the reinforced elastomeric bearings with top and bottom steel plates can be seen.
4 Stressing of the BBR VT CONA CMI tendons underway.
5 (Top) Launch girder nose jacks approaching the Abutment A bearings for the final launch. (Middle) Launch girder nose jacks retracted, ready to be extended to take up the deflection over the 30m span. (Bottom) Launch girder nose jacks extended to take up the deflection over the 30m span.

Cycle time

Various efficiencies were gained as a result of both the permanent works design and temporary works measures. These enabled the working day cycle time to be as low as six days between launches.

Firstly, we adopted a single pour per segment approach. Due to the closed girder and slab arrangement, each 15.7m segment could be executed in just a single pour, which ensured optimum cycle time. Launch bridges are more typically designed as box girders, that often require the segment pours to be split in two.

Another efficiency was achieved through our instigation of adopting stressing gantries, which enabled cranes to be freed up for other activities during stressing. The design meant that on average 16 to 18 multistrand tendons required stressing before the launch. The gantries were located over each girder to allow simultaneous stressing of girders. The gantries allowed the jacks to travel transversely, longitudinally and vertically which enabled segments to be stressed in only two to three hours. Front pulling multistrand hydraulic jacks were also adopted for their speed and simplicity of installation.

This was an excellent project from so many angles – technically challenging, great teamwork within the wider professional team and a first class result for our customer – and, of course, the traveling public. Our whole team is now looking forward to the next opportunity to bring that extra value-add to a project with our specialist knowledge and techniques.

TEAM & TECHNOLOGY

Client – Roads and Maritime Services
Main contractor – Georgiou Group
Consulting engineer – Jacobs Engineering Group
Technology – BBR VT CONA CMI internal, Incremental launching
BBR Network Member – SRG Global (Australia)

Santa Monica-Lawton Bridge, Metro Manila, Philippines

Trio of BBR technologies speed bridge construction

River crossing with latest BBR technology

With the Philippine economy expanding at an average annual rate of around six percent since 2010, vehicles have become more affordable to a greater number of people. The Government is hard-pressed to keep up with the creation of additional road infrastructure to meet the resultant surge in traffic volumes. Rey Singh of BBR Philippines Corporation tells the story of how, with the very latest BBR post-tensioning and bar technology, his company is supporting the efficient creation of an important new highway bridge.

The capital city of the Philippines is Manila and, together with another 15 cities and a lone municipality, it comprises the Greater Manila/Metropolitan Manila Area. With an estimated daytime population of approximately 15 million people crammed into an area of only 620km^2 – equivalent to around 40m^2 per person – congestion is definitely a problem. Metro Manila has been listed as the fourth most populous urban area in the world after Tokyo-Yokohama in Japan, Jakarta in Indonesia and Delhi in India.

Manila is a city built on a bay and, consequently, its major roads radiate outwards from the center towards Circumferential Roads. The most important artery in Metro Manila's road network is EDSA (Epifanio De Los Santos Avenue) also known as Circumferential Road 4 (C4) and it has already been supplemented by Circumferential Roads 5 and 6 (C5 and C6 Roads). Unfortunately, the C6 Road is the last that could be built as it runs right on the shores of the massive freshwater Laguna Lake which extends across much of the island of Luzon at this point.

Metro Manila is divided by the Pasig River which runs from the lake to Manila Bay. Thus, to ease the pressure on the Circumferential Roads, especially EDSA, bridges need to be constructed across the Pasig River.

One such scheme commissioned by the Government, through its infrastructure arm, the Department of Public Works and Highways (DPWH), is the Bonifacio Global City (BGC) to Ortigas Center Road Link Project. >

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This is the first time that BBR VT CONA CMI internal, BBR VT CONA CMF S2 flat and BBR H Bar technologies are being used here in the Philippines.

Project outline

The aim of the project is to connect the business districts of BGC which lie south of the Pasig River and Ortigas Center to the north.

New infrastructure includes a 408m viaduct and 157m approach road on the southern side, a 210m balanced cantilever bridge to cross the Pasig River and a 69m viaduct and 160m approach road on the northern section. The new roadway will be just over a kilometer long.

The balanced cantilever bridge is the Santa Monica-Lawton Bridge. It is named after the streets which it will join – Santa Monica Street on the northern riverbank and Lawton Avenue on the south side.

Technical aspects

The original plans for the balanced cantilever bridge called for two side spans of 60m each and a center span of 90m. However, this configuration would have placed the pier substructures right in the middle of the river and therefore taken up more valuable program time to design and construct.

As there is some urgency to relieve traffic congestion on the EDSA and C5 Roads, it was proposed that the bridge center span be increased to 105m and the side spans reduced to 52.50m each. This is sufficient to cross the approximately 100m-wide Pasig River and locate the substructures on land.

The bridge has a four lane roadway with sidewalks and a total width of 19m. At its largest cross-section at the pier substructures, it has a box girder depth of six meters with a lower slab thickness of one meter. Its smallest cross-section is in the center span, where it has a box girder depth of 2.80m with a lower slab thickness of 300mm. The two barrel box girders have webs with thicknesses of 500mm. Each half of the bridge has 29 segments with equal lengths of 3.10m.

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New BBR technologies

BBR Philippines Corporation helped the main contractor to achieve optimum design efficiency for the bridge superstructure. The longitudinal post-tensioning tendons were made to be uniform BBR VT CONA CMI internal 1906 tendons instead of the previously specified CONA CMI 3106 tendons. This allowed the use of smaller stressing jacks and increased production rates on site. The shortest longitudinal tendon is 12.20m, while the longest is 102.10m. There are 60 upper tendons and 28 lower tendons in the center span, while in the side spans there are 16 lower tendons.

Transverse post-tensioning was also introduced using BBR VT CONA CMF flat 0406 tendons spaced at 900mm centers in the top slab. All transverse tendons are 19m long. The total post-tensioning tonnage for the balanced cantilever bridge superstructure is around 252t. Add to that approximately 761t of reinforcing steel bars and 4,803m^3 of ready-mixed concrete and seasoned engineers will have a fairly good idea of what the superstructure works involve.

Also, 348 threaded 40mm diameter BBR H930 Bars are being used for permanent stressing. They are being installed in the webs of the two barrel box girders. The BBR H Bars will range from 2.826 to 5.861m long and the total weight of bars required is almost 24t. To speed up delivery and installation, the BBR H930 Bars were pre-customized in the BBR production facility – cut to length and bundled in the required sequence – thus our work on site was reduced and some time savings were generated. An extra benefit for the project was the BBR pre-delivery inspection (PDI) process which is carried out for every BBR component or system. This meant that potential mistakes in the quantity or packing sequence were ruled out and we were able to adhere to the tight delivery and installation schedule.

As an added service to the main contractor, our work also includes operation of their form travelers.

This is the first time that BBR VT CONA CMI internal, BBR VT CONA CMF S2 flat and BBR H Bar technologies are being used here in the Philippines. Even in the face of fierce local competition, we were able to secure this project based on our ability to provide a competitive service and a single source for major components. We now look forward to the successful completion of the Santa Monica-Lawton Bridge – and can reflect that, with these new BBR technologies and our specialist experience, the team from BBR Philippines Corporation is helping the Government to cross the Pasig River.

1 The 210m balanced cantilever bridge will cross the Pasig River, joining Santa Monica Street on the northern riverbank with Lawton Avenue on the south.
2 Construction is underway for the new Santa Monica-Lawton Bridge in Metro Manila, Philippines, part of the Bonifacio Global City to Ortigas Center Road Link Project which will connect two of the city's business districts.
3 The new bridge approaches the halfway point across the Pasig River.
4 The bridge will have a total of 58 segments with equal lengths of 3.10m.

TEAM & TECHNOLOGY

Owner – Department of Public Works and Highways, Republic of the Philippines (DPWH)
Main contractor – Persan Construction, Inc.
Technology – BBR VT CONA CMI internal, BBR VT CONA CMF flat, BBR H Bar
BBR Network Member – BBR Philippines Corporation

Bratislava Bypass, Slovakia BBR post-tensioning for five bridges

Bridging the crossroads of Europe

By the time CONNÆCT 2020 is published, the team from BBR Polska will have finished their work on the southern part of the Bratislava Bypass which will link the west and east of Slovakia. Pawel Surman provides this account of the work his company is undertaking on the post-tensioning of five bridges along the route.

Bratislava, situated on both banks of the River Danube, has the unique distinction of being the only national capital which borders two countries – Austria and Hungary – and its central location is regarded as a crossroads of Europe. With strong economic growth in the 2000s, the Bratislava region currently benefits from not only increased inward investment, but also the many government institutions which are headquartered there. In this climate, the construction industry is burgeoning too, with many building projects underway.

1

Transport network improvements

Improvements to the transportation network have been undertaken – with some still underway – to support this commercial growth.

One such project is the Bratislava Bypass which is part of the southern expressway network. It is being constructed as a Public Private Partnership (PPP), the 30-year design-build-finance-operate (DBFO) concession for which was awarded to Zero Bypass Ltd – a consortium involving Cintra, Macquarie Capital and PORR AG – by the Slovakian Ministry of Transport, Construction and Regional Development.

In turn, Zero Bypass Ltd appointed D4R7 Construction s.r.o. – a consortium formed between Ferrovial Agroman and PORR – as the main contractor for the design and build of the new highway.

New highway link

The new highway link which is expected to carry some 45,000 vehicles each day will increase transport capacity and improve local connectivity. It is envisaged that traffic between Austria, Hungary, the Czech Republic and Poland, which currently travels through urban areas, will be accommodated on the bypass.

Work began on the project – estimated to be valued at €1.46bn – in November 2016. The scheme involves the construction of a new 27km long section of the D4 motorway, plus a 32km long expressway, the R7. The dual two lane D4 motorway will serve as a bypass to eastern Bratislava and the new R7 radial expressway will have up to three lanes in each direction and run south-eastwards from Bratislava.

PT installation

BBR Polska has been tasked with the supply, installation and stressing of post-tensioning systems for five bridges over the Bratislava to Galanta railway line, as part of the Jarovce-Ivanka-Sever section of the project. Our work here will see the installation of a total of 276 BBR VT CONA CMI internal tendons for which almost 225t of prestressing steel and over 10,000m of steel ducting will be used.

The BBR Polska team's work is being carried out over live railway lines, therefore there are additional health and safety requirements. Our experience from many similar projects around railway infrastructure in Poland and from international contracts has enabled us to quickly adapt to the locally applicable requirements.

As a multinational project, the interface with very different environments and cultures, codes and work standards was one of the major challenges. The presence and the support of resident technicians and engineers proved to be a decisive leverage which promoted speedier familiarization with the specific requirements and has broadened our own outlook, not only in terms of work experience on an international basis, but also of cross-cultural co-operation. This all gives BBR Polska yet more important experience upon which we will base the exploration of further international projects in the future.

2

3

1 BBR Polska is providing post-tensioning for five bridges, all over railway lines, for the Bratislava Bypass project in Slovakia. Photograph courtesy of D4R7 Construction s.r.o.
2 The team from BBR Polska is installing a total of 276 BBR VT CONA CMI internal post-tensioning tendons for their contract for five bridges.
3 Visualization of the Ivanca-Sever Interchange on the Bratislava Bypass, along with new bridges over railway lines. Image courtesy of D4R7 Construction s.r.o.

TEAM & TECHNOLOGY

Client – Zero Bypass Ltd
Main contractor – D4R7 Construction s.r.o.
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR Polska Sp. z.o.o.

Highway & rail bridges, Norway Post-tensioning & incremental launching for bridges

Bridge quintet in Norway

Recent months have seen the award of five contracts for work on major road or railway bridge schemes to Norwegian BBR Network Member KB Spennteknikk AS. CTO, Stig Solbjør offers some background to the projects and describes how BBR technology and expertise is contributing to their realization.

Norway is famed for its spectacular fjords, islands, lakes and mountains, but while we – and many tourists too – enjoy these geological features, this complex geography presents challenges for those who need to travel around the country.

Free cantilevered bridge

The huge project to improve the around 1,100km-long E39 Coastal Highway Route between Kristiansand in the south of Norway and Trondheim in the north will reduce travel time by half. The time savings will be achieved by replacing seven current ferry crossings with tunnels or bridges, as well as upgrading a number of existing stretches of road. Along the route, there are eight fjords one of which is the Trysfjord, where we will be supplying post-tensioning services for a new 520m-long free cantilevered bridge. The bridge has a main span of 260m, making it one of the longest concrete cantilever spans in the world.

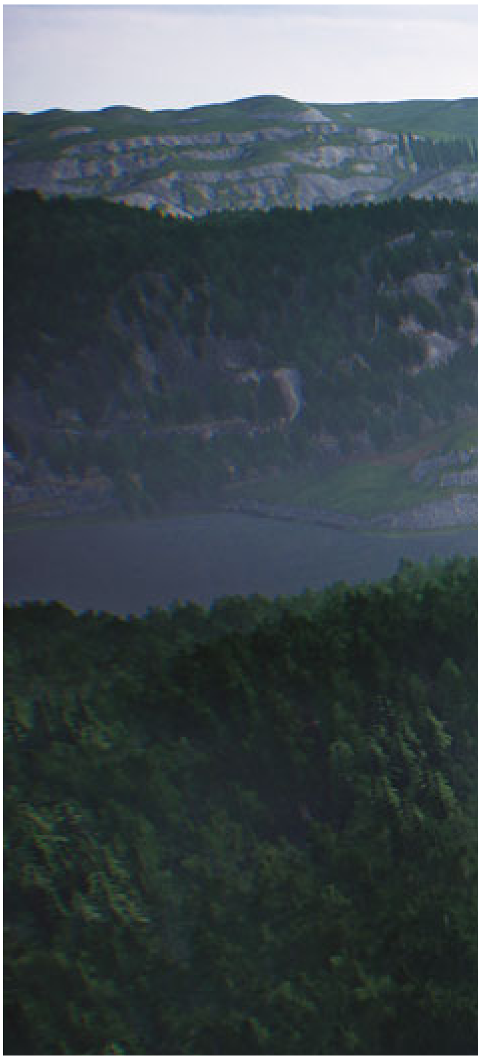
Incremental launching

After we had won the above contract, the great strength and extensive expertise of the BBR Network was again proven – by the award of a project for four incrementally launched bridges, in the face of strong competition from a large worldwide supplier offering total service capabilities. We invited our customer to visit BBR Polska in Warsaw and see bridge launching operations in progress there. The combination of our excellent local knowledge, being a long-established locally based business, plus our ability to offer of a package including incremental launching, installation of the launching nose and post-tensioning were decisive in winning the contract.

Now, we look forward to our co-operation with BBR Polska on the E39 Kristiansand Vest-Mandal Øst project for the bridges at Monan and Rossevann. The work at Rossevann is particularly sensitive because the bridge will stretch across a drinking water source which must be protected. This is why the incremental launching method is most suitable – there will be no concrete casting over the water.

New stretch of E6

A further route under construction is a new section of the E6 between Kolomoen and Moelv which passes close to the city of Lillehammer, site of the 1994 Winter Olympic Games. The E6 is a European route and the main north-south road through Norway and the west coast of Sweden, covering a total of 3,000km.



E39 Coastal Highway Route: Visualization of the new Trysfjord Bridge which will feature one of the world's longest free cantilever spans.
Image published with kind permission of Nye Veier, Norconsult & AF Gruppen.

There are around 30 bridges on the route of this new four lane highway, including some on the highway itself as well as overpasses which require post-tensioning. To meet the requirements, we are installing the BBR VT CONA CMI BT system in three different sizes – 15, 19 and 22 strand systems, all using 15.7 mm diameter prestressing strands.

Northern Islands bridges

At the same time, on the west coast of Norway, near Ålesund, we are also working on the construction of two post-tensioned concrete bridges – Hamnaskjersund and Lauke Bridges – as part of the FV.659 Nordøyvegen project. The three span Lauke Bridge will be 110m long and lies just south of the islands of Lauka and Lisjelauka. It will have a 41m long main span and two side spans of 34m long each. The overall width of the bridge will be 12.1m. The 200m long Hamnaskjersund Bridge will have seven spans, ranging in length from 21m to 38m, and a total width of 11.1m. We will be installing the BBR VT CONA CMI BT 1906 system for both bridges.

BBR technology package right on track

Meanwhile, a mixed package of BBR technology and services is being delivered for the Venjar to Eidsvoll Nord Intercity Rail Project – a major rail improvement scheme in the east of Norway. The terrain is challenging and features a hilly ravine landscape with loose rock and demanding ground conditions. Around a third of the route will travel on bridges or in tunnels.

Over the two year period of our contract, we will be providing post-tensioning for the four bridges on the line, as well as bearings, PT bars and special bearings. We will be using BBR VT CONA CMI internal post-tensioning of differing sizes, chosen to meet the varying requirements. We will also be supplying and installing TOBE Bearings, plus a series of special bearings for high horizontal loads.

Our ability to provide a range of technologies and services for this project greatly enhanced our position when tendering. We are finding that customers prefer to have a single point of responsibility for multiple services.

TEAM & TECHNOLOGY

E39 KRISTIANSAND VEST-MANDAL ØST

Client – Nye Veier AS
Main contractor – AF Gruppen
Specialist subcontractor – Kruse Smith Entreprenør
Consulting engineer – Norconsult
Technology – BBR VT CONA CMI internal, Pot bearings, Incremental launching
BBR Network Members – KB Spennteknikk AS (Norway) + BBR Polska Sp. z.o.o. (Poland)

E6 KOLOMOEN-MOELV

Client – Nye Veier AS
Main contractors – Hæhre Entreprenør AS & Veidekke Entreprenør AS
Technology – BBR VT CONA CMI internal, Pot bearings
BBR Network Member – KB Spennteknikk AS (Norway)

FV659 NORDOYVEGEN

Client – Statens Vegvesen
Main contractors – Skanska Norge AS
Consulting engineer – Statens Vegvesen
Technology – BBR VT CONA CMI internal
BBR Network Member – KB Spennteknikk AS (Norway)

VENJAR-EIDSVOLL NORD INTERCITY RAIL PROJECT

Client – Bane Nor
Main contractor – NCC Norge AS
Technology – BBR VT CONA CMI internal, Pot bearings
BBR Network Member – KB Spennteknikk AS (Norway)

Shaping the Singapore skyline

In recent years, BBR Construction Systems (Singapore) has delivered technology and services for no less than FOUR major skyscraper projects which are shaping the island nation's skyline. In previous editions of CONNÆCT, we have only been able to publish either artist's impressions of the finished structures or photographs of work in progress to illustrate technical articles about the construction of these challenging projects. Now, we are taking the opportunity to revisit Singapore and, using recent photographs, show these amazing high rise structures in their completed forms. All projects are Green Mark Platinum rated by the Buildings and Construction Authority (BCA) of Singapore, highlighting their environmental and sustainability credentials – to which BBR post-tensioning, with its materials, time and cost saving features, has contributed.

1

The beams, constructed using BBR CONA internal PT tendons, are 700mm deep and vary in width from 1,000mm to 3,000mm.

2

1 Guoco Tower
At 290m high, this is the tallest building in Singapore and sits above the Tanjong Pagar MRT Station.
This mixed-use scheme features a six storey podium building and two towers – one with 64 storeys, the other with 20. This spectacular high profile development has attracted some of the best-known and most prestigious businesses in the world as tenants. They are accommodated on 38 floors of the main tower which also features 26 floors of residential apartments. The 20-storey tower is a 200-room hotel now operated by Sofitel Hotels & Resorts.
One way post-tensioned beams with deep deck system slabs were adopted for the main tower. The beams, constructed using BBR CONA internal PT tendons, are 700mm deep and vary in width from 1,000mm to 3,000mm. The deep deck system comprises 1.2mm thick steel sheets formed into tapered ribs of 250mm deep and 100-190mm wide at 600mm spacing, with a 150 to 180mm thick structural topping. There is a seven meter maximum clear span between beams.

2 Asia Square Towers

This development consisting of two towers in Singapore's Marina Bay Business and Financial Centre was the subject of an article in CONNÆCT 2012. Asia Square 1 is 229m tall and was opened in 2011, while Asia Square 2 is 221.5m high and was inaugurated in 2013. Together, the towers offer 190,000m^2 of office space, over 30 entertainment and restaurant venues, plus the largest gym in the CBD.

Asia Square was also the first commercial development in Singapore to be integrated with a business hotel, The Westin Singapore. Each tower provides a highly efficient, column-free floor plate consisting of beams and slabs, post-tensioned with the BBR CONA flat system, supported by external columns and core walls. Using a climbing formwork system, BBR Construction Systems created a record of their own when they achieved a seven day cycle time for each pour – the fastest achieved locally at that point.

3 Marina One

Officially opened in January 2018, Marina One includes two 200m tall, 34-storey residential towers and two 30-storey office towers, plus a retail podium called 'The Heart', featuring lush greenery and landscaping. Situated directly opposite Asia Square Towers, each of the two office buildings offer 226,165m^2 of floor space while the two 34-level residential towers contain 1,042 apartments with a total floor area of around 1.23 million square feet.

BBR Construction Systems provided design services for the post-tensioned beams and slabs, right from the project tender stage. BBR CONA flat post-tensioning was adopted for the lower podium levels and also to support the mega-trusses on the 28th to 30th floors of the office towers.

3

4

5

1 The famous Singapore skyline features several new skyscrapers, created in recent years with BBR technology and services.
2 Guoco Tower – Singapore's tallest building, efficiently realized with BBR CONA flat technology.
3 Asia Square Towers – construction of beams and slabs post-tensioned with BBR CONA flat tendons, supported by external columns and core walls created a highly efficient, column-free floor plate.
4 Marina One – BBR CONA flat post-tensioning was adopted for the lower podium levels and also to support the mega-trusses on the 28th to 30th floors of the office towers.
5 South Beach – additional BBR CONA flat PT tendons were installed to tie inclined columns back to the vertical core.

4 South Beach

Completed in 2016, the two towers of Singapore South Beach – both 218m tall – are strategically located on Beach Road, bordering the CBD. The two distinctively sloped towers are part of a wider scheme which incorporates four historic buildings already on the site.

The horizontal transfer tendons were planned for the sky garden levels where there was large headroom, allowing for structural slabs to be up to 600 millimeters thick without affecting the architectural intent.

Extract from Schnizer R, Gallou I, Davis A (Foster + Partners), Wah Kam Chia, (Arup), Weng Hin Ho, (Studio Lapis) in South Beach Towers, Singapore, Council for Tall Buildings & Urban Habitat (CTBUH) Journal 2017 Issue II

The project involved a total gross floor area of 146,827m^2 in two towers. The 35-storey North Tower contains office space while, in the 45 storeys of the South Tower, hotel and residential accommodation was created. Walkways and public spaces within the development are sheltered from the tropical climate by a state-of-the-art environmental canopy.

In general, the 265-375mm thick post-tensioned floor slabs were constructed using BBR CONA flat tendons, with post-tensioned banded beams at the perimeter. The slabs for the North Tower's 'Sky Garden' were 600mm thick and, for the hotel floor in the South Tower, there was a reinforced concrete floor slab with a post-tensioned banded beam and transfer beam. The six storey podium also featured a post-tensioned beam and slab scheme.

There were some interesting challenges for the BBR Construction Systems team in Singapore. For example, the inclination of some of the columns meant that the vertical load from upper floors created a 'kick-out' force when columns changed direction of incline. Thus, additional horizontal BBR CONA flat tendons were installed at the 10th to 12th storeys of the North Tower and 14th to 16th, 22nd and 32nd floors of the South Tower to tie these inclined columns back to the vertical core. Formwork also required special considerations during design, as well as additional precautions and supervision during the erection stage to ensure capacity and safety. Part of the formwork was designed to be free-standing – because, after the 11th storey, the building edge extends outwards before inclining inwards again.

TEAM & TECHNOLOGY

1 GUOCO TOWER
Developer – Guocoland Limited
Architect – Skidmore, Owings & Merrill LLP (SOM)
C&S consultant – Arup (Singapore) Pte. Ltd
Main contractor – Samsung C&T Corporation
Technology – BBR CONA internal
BBR Network Member – BBR Construction Systems Pte. Ltd. (Singapore)

2 ASIA SQUARE TOWERS
Owner – MGPA
Main contractor – Hyundai Engineering & Construction
Structural consultant – Meinhardt (S) Pte Ltd
Technology – BBR CONA flat
BBR Network Member – BBR Construction Systems Pte. Ltd. (Singapore)

3 MARINA ONE
Owner – M+S Pte Ltd
Main contractors – Hyundai Engineering & Construction and GS Engineering & Construction JV
Architect – Ingenhoven architects
Structural consultant & M&E engineer – Beca Carter Hollings & Ferner (SE Asia) Pte Ltd
Technology – BBR CONA flat
BBR Network Member – BBR Construction Systems Pte. Ltd. (Singapore)

4 SOUTH BEACH
Owner – South Beach Consortium
Architect – Foster + Partners
Main contractor – Hyundai Engineering & Construction Co. Ltd
C&S consultant – Arup (Singapore) Pte Ltd
Technology – BBR CONA internal, BBR CONA flat
BBR Network Member – BBR Construction Systems Pte. Ltd. (Singapore)

Elevated slabs, New Zealand Multi-storey buildings with BBR post-tensioned slabs

Rise-and-rise of elevated PT

Elevated post-tensioned slabs are increasingly becoming construction components of choice for multi-level commercial, retail, residential and car park buildings in New Zealand. BBR Contech currently has three projects underway in partnership with its Australian counterpart SRG Global and with a further two projects awarded recently, the prospects are looking good.

"More and more clients are recognizing the cost, labor and time saving advantages of elevated PT slabs over traditional reinforced and precast concrete," says Marc Stewart, Business Development Manager at BBR Contech. "They enable thinner floors and therefore reduced building heights and weights, allowing for wider spans between supports. As well as greater architectural freedom, this adds up to less reinforcing steel and concrete, along with other benefits, including reduced craneage. They're also particularly useful on sites where space is tight, often enabling developments that wouldn't otherwise be feasible."

1 Pacifica Tower

The New Zealand projects are all based in the heart of the city of Auckland. The largest of these is the Pacifica Tower, a striking new apartment, hotel and retail development that, at 57 storeys high, will be the city's second-tallest building. The BBR Contech/SRG Global team is responsible for designing, procuring and installing the BBR CONA flat post-tensioning for all floors. The development is progressing well and is due for completion by the end of 2020, just in time for the America's Cup yacht regatta on the Waitematā Harbour, where there is also a project involving BBR Contech – see page 79.

The other two projects continue the theme of accommodation – one is a two-tower development designed to meet Auckland's burgeoning demand for purpose-built student accommodation and the other is a dual-branded hotel that will cater for international and local visitors to Auckland, including those seeking a "holistic wellness experience".

1

2

2 Student accommodation

The two-tower development, featuring towers of 17 and 18 storeys, is located in the center of the Auckland University of Technology campus. Once complete it will offer 641 self-catered apartments for students, as well as retail and hospitality services and student facilities that include fitness centers, a basketball court and a health and wellness center.

The BBR Contech/SRG Global partnership is installing 33 floors, post-tensioned with BBR VT CONA CMF S2 tendons, at one pour per floor, spanning a total area of 14,078m^2 – and it's keeping them busy, as completion is due before the first semester of 2021.

3 First of a kind hotel

Across town, work has begun on a new 490-room, 39-storey hotel which will house a 290-room Holiday Inn Express on the lower levels and a 200-room Even Hotel above. The requirement here is for a total of 21,562m^2 of elevated post-tensioned flooring.

The Even Hotel will be the first of its kind outside North America and the first of a planned 10-15 hotels in Australasia. It offers a unique four-star package of pampering founded on an "eat well, rest easy, keep active" philosophy that includes best-in-class fitness facilities, aromatherapy amenities, in-room exercise zones and nutritionally healthy menus.

The BBR Contech/SRG Global team, together with concrete construction and formwork specialist Marin Construction, is responsible for designing and coordinating the installation of the elevated PT floors.

Given Auckland Council's commitment to urban intensification, there are likely to be more exciting opportunities for this construction approach.

1 Time-lapse images showing the rise of Pacifica Tower, from left to right, in July 2018, October 2018, February 2019, April 2019 and May 2019.

2 Visualization of the two completed towers of student accommodation on the Auckland University of Technology campus where the BBR Contech/SRG Global partnership is installing 33 post-tensioned floors.

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 STUDENT ACCOMMODATION

Developer – Cedar Pacific
Architect – Marchese Partners
Main contractor – Icon Co Pty (NZ) Ltd
Technology – BBR VT CONA CMF flat
BBR Network Members – BBR Contech (New Zealand) & SRG Global (Australia)

3 HOLIDAY INN EXPRESS AND EVEN HOTEL

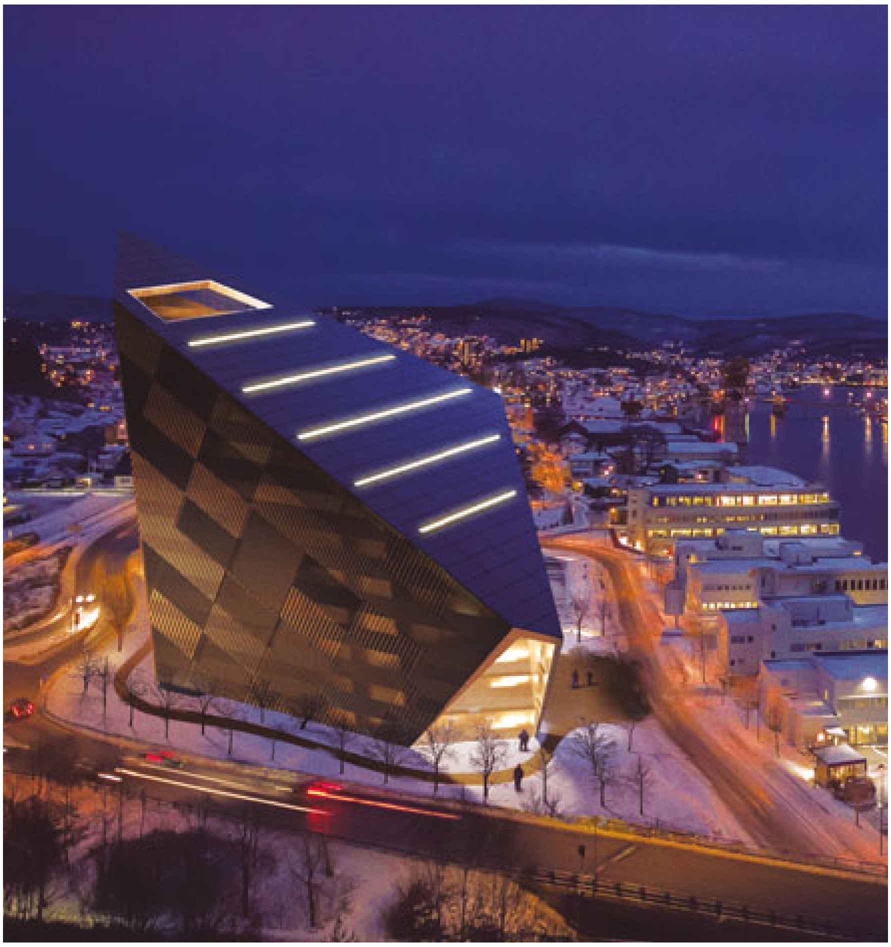
Developer – Pro-Invest
Architect – SJB
Main contractor – Icon Co Pty (NZ) Ltd
Technology – BBR VT CONA CMF flat
BBR Network Members – BBR Contech (New Zealand) & SRG Global (Australia)

Powerhouse Telemark, Norway BBR VT CONA CMM PT for suspended slabs & beams

The Green Diamond

A new generation of 'energy positive buildings' is springing up in Norway. The aim is that they should generate more energy than they will consume during their lifetime. With such credentials, it is therefore appropriate that lean and green BBR post-tensioning technology has been chosen for the floor slabs. Kristoffer Kalland, Project Manager for BBR Network Member KB Spennteknikk AS, takes us through the philosophy and creation of the spectacular Powerhouse Telemark project.

1



2

A Powerhouse is an energy-positive building that in the course of a 60-year period generates more renewable energy than the total amount of energy that would be required to sustain daily operations and to build, produce materials and demolish the building.

www.powerhouse.no

Powerhouse Telemark – known as the Green Diamond – will be no ordinary office building. It will create a hugely impressive architectural highlight for the area and contribute to the environment through its 'energy positive' approach. This landmark development Is underway in a highly visible location – near the city of Porsgrunn's Kulltang Bridge in the Telemark region of south east Norway.

Collaborative roots

The project owes its reality to a collaboration between property company Entra, major international contracting firm Skanska, the environmental organization ZERO, the globally renowned Snøhetta architecture and design house and Asplan Viak, one of Norway's largest consulting engineering and architectural practices. This team has already produced three Powerhouse buildings – the Powerhouse Brattørkaia office building in Trondheim, the Powerhouse Drøbak Montessori school in Drøbak and Powerhouse Kjørbo in Sandvika.

Project overview

The 11-storey building – featuring beams and slabs post-tensioned with the BBR VT CONA CMM monostrand system – will offer space of just over 8,313m^2 mainly dedicated to office accommodation, but also including a fitness room, locker and shower rooms, plus a lobby, canteen and an exclusive rooftop space. Such is the acclaim of the new development, much of the space has already been pre-let although construction is not scheduled for completion until spring 2020.

Green credentials

Features which contribute to the Powerhouse Telemark's BREEAM NOR Excellent rating include its design which has been optimized to harvest energy from the sun and projected reduction in net energy consumption by as much as 66%.

As many readers will already know, post-tensioning allows for thinner slabs and thus less concrete – this was essential to the Powerhouse concept as it contributes to a reduced carbon footprint.

Spennteknikk has been responsible for slab design, supply of post-tensioning tendons and stressing. Due to the shape of the building and lack of parallel slab edges, tendon layout was challenging but, working closely with Asplan Viak and Skanska, an excellent solution was devised.

1 Visualization of the completed 11-storey Powerhouse Telemark structure which will feature beams and slabs post-tensioned with BBR VT CONA CMM monostrand technology. Image courtesy of Snøhetta.

2 Night-time view of the completed Powerhouse Telemark building, set to become a local landmark with its 'energy positive' approach and reduced carbon footprint – the latter strongly supported by the use of PT which promotes thinner slabs and thus less requires less concrete. Visualization courtesy of R8 Property.

TEAM & TECHNOLOGY

Owner – R8 Property
Main contractor – Skanska Norge AS
Consulting engineer – Asplan Viak
Technology – BBR VT CONA CMM monostrand
BBR Network Member – KB Spennteknikk AS (Norway)

Urban regeneration, Western Australia Solutions with versatile BBR post-tensioning systems & services

Great innings for BBR

Just a mention of 'The Oval' is sure to capture the attention of cricket fans worldwide. However, for BBR Network Member SRG Global, any recent conversation including these two words is all about construction – at the Subiaco Oval and the Claremont Oval. Mahesh Nayak reports on two high-scoring regeneration projects currently underway in Western Australia.

Both of SRG Global's projects are part of more extensive renewal schemes – one is for a commercial and residential development and the other is for a brand new secondary school.

1 Claremont on the Park

Claremont on the Park is an inner city urban regeneration development in western Perth that is transforming under-utilized land areas around the existing Claremont Oval by creating opportunities for high density residential and commercial building developments. The 9.4-hectare site is a master-planned project that will deliver more than 750 homes for about 2,000 future residents.

Claremont Oval is an Australian Rules Football (AFL) stadium located in Perth which originally opened in 1905. The new development will see the Claremont Football Club's ground and facility at the heart of the precinct with new residences and businesses overlooking the historic football oval. The development also includes a significant amount of public open space to promote foot traffic and access to local facilities connecting the community across the railway tracks.

Specialist services

BBR Network Member for Australia, SRG Global, delivered the post-tensioning works on this project which included the coordination and development of shop drawings to PT design, supply, installation, stressing and grouting of 240t of BBR CONA flat post-tensioning.

Suspended slabs associated with Lots 504 & 505 were post-tensioned (Basement 1 to Level 7) to accommodate car parking and 234 apartment units. In order to allow associated structural movements, we installed over 6,500 TMJ (temporary movement joint) dowels and subsequently grouted them.

Project challenges

Project challenges included extensive coordination during development of PT shop drawings with designers and other related trades, logistics associated with just-in-time material deliveries and on site coordination of activities, as the works were simultaneously carried out on both blocks and at multiple fronts to meet the construction schedule.

SRG Global's ability to source materials in large volumes coupled with its in-house production facility of specialist items helped to contain project cost inflation associated with an additional scope of works entrusted during its design development.

1

❷ Bob Hawke College

Bob Hawke College is a brand-new government secondary school being constructed on Kitchener Park, in the inner Perth suburb of Subiaco. Originally known as Inner City College, the school was renamed Bob Hawke College in May 2019 to honor the late former Australian Prime Minister.

Central hub

The college will be a central hub for the Subiaco community with shared facilities, such as Subiaco Oval and the college's playing courts and gymnasium. The college's environmental footprint will be minimized through the use of three and four storey buildings that are universally accessible and incorporate passive solar design principles. The college is part of the exciting new Subi East renewal project that will transform Subiaco Oval and its surroundings, along with the old Princess Margaret Hospital site, into a vibrant place for living, learning and leisure.

2

PT installation

SRG Global delivered the post-tensioning services on this project which included the coordination and development of shop drawings to PT design, supply, installation, stressing and grouting of 108t of post-tensioning. Specialist post-tensioning works also included use of BBR VT CONA CMI internal 2206 multistrand tendons in an 18m high shear wall supporting two suspended levels which have a 6.4m cantilever. Some 15,000m^2 of post-tensioning works were spread over five sectors of the project, with 23 pours carried out over a five month period.

We also supplied and installed our innovative SureLok 200S system in temporary movement joints (TMJs) which permitted free movement of the structure in two horizontal directions to allow initial shrinkage of the concrete to take place. Grouting of the system was carried out after 90 days to establish continuity. Use of SureLok 200S facilitated pour strip free construction, improved job safety and obviated the need for props along the underside of the TMJ. These two projects yet again demonstrate the ability of our team to deliver complete customer service and satisfaction – making the complex simple for all involved.

1 Claremont on the Park: Australian BBR Network Member SRG Global has provided timely and cost-effective specialist services for this residential and commercial regeneration project.
2 Bob Hawke College: SRG Global delivered PT services for this project which included coordination and development of shop drawings to PT design, supply, installation, stressing and grouting of 108t of post-tensioning.
3 Bob Hawke College: specialist post-tensioning works included use of BBR VT CONA CMI internal 2206 multistrand tendons in an 18m high shear wall.

3

TEAM & TECHNOLOGY

❶ CLAREMONT ON THE PARK
Owner – Mirvac (WA) Pty Ltd
Design & build contractor – Broad Construction Services
Technology – BBR CONA flat
BBR Network Member – SRG Global (Australia)

❷ BOB HAWKE COLLEGE
Owner – Dept of Finance, Government of Western Australia
Design & build contractor – PACT Construction Pty Ltd
Technology – BBR CONA flat, BBR VT CONA CMI internal
BBR Network Member – SRG Global (Australia)

New capital city, Egypt BBR VT CONA CMF flat post-tensioning for major schemes

Meeting demands of dynamic growth

The Egyptian construction market entered a dynamic growth phase following the announcement in March 2015 by the Egyptian Government of expansive plans for a new capital city, as well as the creation of three further new cities. Mohamad Al-Shal, Business Development Manager of Cairo-based BBR Network Member ESPT, provides some further background and an overview of his company's growing portfolio of work on this prestigious scheme.

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The new city – which will be the new administrative and financial capital of Egypt – is under construction some 45km to the east of Cairo, bounded on the north by the Cairo to Suez road and by the Cairo to Al Ain Sokhna road to the south. It will house the main government departments and ministries, as well as over 50 foreign embassies. Designed to relieve congestion in Cairo, the city covers an area of 700km² and is expected to have a population of between five to seven million people.

The scheme's consultants have utilized every possible technique across the whole new administrative capital city site to meet the Government's vision of a 2023 completion date. For example, they have embraced post-tensioning for the construction of governmental and residential buildings, as well as precast prestressed construction for sporting facilities such as the seven 40,000 seat stadiums. The majority of construction work will be for commercial, office and residential facilities where post-tensioned concrete has been chosen for almost every project – to deliver larger living or working spaces, along with a fast construction program.

Vision for finest technology

The use of European approved post-tensioning technology for the new capital city project had been stipulated by the local consulting engineers. In a direct response to this, ESPT was established in December 2018. Our new business can now not only draw on around 12 years' experience from within its parent company, the e-solution Construction & Engineering group, but also benefit from the strengths of the BBR Network.

The vision of the company's founders, Amr Al-Taher, Mohammed Ashour and Mohammed Ayad, was to create a specialist construction engineering unit, based on latest European approved BBR technology, along with existing skills in tilt-up and other concrete construction techniques. This vision is being realized with the support of BBR VT International who, as ETA holder, facilitated the approval stage with the local consulting engineers. In fact, seeing the potential for even greater business opportunities, marketing activities actually began during the final stage of contract negotiations with BBR VT International.

First project award

Our first project award was for a cluster in Zone 06, a 100,000m² residential project which was forecast to require some 500t of prestressing steel over an 18-month period. After contract award, the design and construction team worked simultaneously. Design activities for the layout of the BBR VT CONA CMF flat PT tendons ran in parallel with placing orders and on-site mobilization. We wanted to be ready to provide the main contractor with extended services before casting of the columns to support the basement slab. In addition, BIM models processed by Marwa Rami were supplied to the main contractor to smooth the coordination.

In less than 45 days, our design team, led by Mona Al-Kersh, completed the design for all seven structures, as all the buildings are founded on one shared basement and ground slab. In the basement and at ground floor level, the total slab area was 20,000m². The project is part of larger residential development with a total area of 700,000m² of post-tensioned slabs in seven clusters. >

Second success

Just two months after our first slab was cast, we were awarded a second cluster contract, again based on using the CONA CMF PT system. This added a further 500t of prestressing steel – and another victory over our competitors – to our portfolio. Our challenges then were to continue working closely with our client to resolve issues on site as quickly as possible and to ensure that deliveries to site arrived in time to keep construction activities moving ahead on program.

It was vital that mobilization and supply chain activities ran smoothly as both the main contractor and consultant were handling many other developments in the same area. We have really appreciated the excellent supply chain support, while the seminars and training sessions organized by the BBR Headquarters team added much value to the whole process.

Future growth

The ESPT development team is now building on the practical advice offered and useful presentations given by the BBR Headquarters team and is forging further connections with clients. The marketing effort has already brought an additional contract, requiring 600t of prestressing steel, in a neighboring development in the new administrative capital. Our development team was able to use the success achieved in the first two clusters, in Zone 06, as a showcase to clients of how quickly we could mobilize site teams, organize supplies and produce designs.

Meanwhile, back at Zone 06, the main contractor awarded us an additional contract – involving a further 500t of prestressing steel. This brings our total supply and install scenario to 1,500t of prestressing steel across three clusters in less than six months from receiving the first contract award.

Our site team, led by Mohammed Rizk, is meeting all the challenges of these major post-tensioning projects with great professionalism. The excellent work of our site team and design department, backed by the quality of the BBR technology, service and support, has placed us in a strongly competitive position with regard to winning further contracts. Even in the face of fierce competition in our marketplace here, we are confident that we will be able to announce many more contract awards in the coming months.

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1 View across part of the construction site for the new Egyptian capital city showing one of the projects currently being carried out there by BBR Network Member ESPT.
2 Overview of the Zone 06 construction site which is expected to require some 500t of prestressing steel over an 18-month period.
3 Visualization of part of the cluster in Zone 06, where ESPT has been supporting the main contractor with post-tensioning design using the BBR VT CONA CMF flat system and construction services for a 100,000m^2 residential project.
4 Support from the BBR Headquarters team with marketing activities such as on our exhibition stand at the Big Five Construct Conference in Cairo, has helped ESPT to win more work.
5 BBR Headquarters and ESPT team members during a site visit to the new Egyptian capital city. Left to right: Cezary Sternicki, Ahmed Albarbary, Daniel Cuerdo, Mohamad AlShal, Moamen Eltawel & Mohammed Rizk.

TEAM & TECHNOLOGY

Client – New Administrative Capital
Main contractors – Hassan Allam Construction
Consulting engineer – ECG consultant
Technology – BBR VT CONA CMF flat
BBR Network Member – ESPT (Egypt)

Distribution warehouse, Auckland, New Zealand First use of CONA CMF S2 slab system in NZ

Double landmark

BBR Contech is celebrating two landmarks in one project – a contract to design the largest-yet post-tensioned floor slab in New Zealand and the chance to use the BBR VT CONA CMF S2 slab system for the first time.

The record-breaking floor which covers an area of 7.4 hectares – the equivalent of over seven rugby pitches – will be part of a new distribution center being built by Auckland International Airport for Foodstuffs, New Zealand's biggest grocery distributor and one of the country's largest organizations. Produce will be kept at ambient temperature in the warehouse and then shipped to stores throughout the upper North Island.

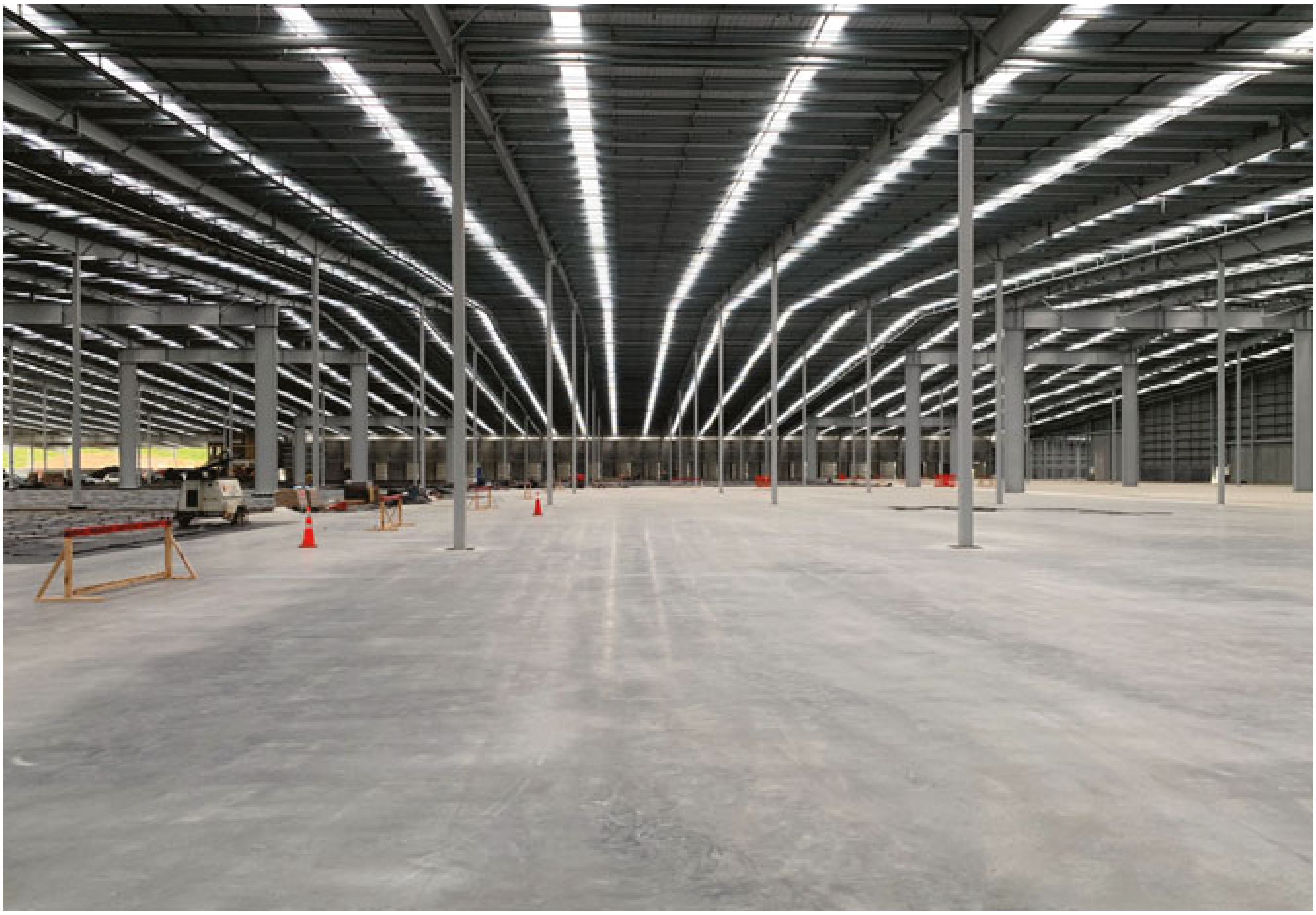
Use of the BBR VT CONA CMF S2 flat system with its optimized componentry including universal mono barrel anchorages, simplified load bearing components and minimal need for reinforcement streamlined the installation and allowed the site team to make excellent progress against schedule.

Over the years, BBR Contech has become a market leader with its expertise in constructing leading edge, low maintenance ground slabs. A combination of excellent partnerships with concrete specialists and latest BBR post-tensioning technology has further supported the company's achievements.

1 The BBR VT CONA CMF S2 system with its optimized componentry including universal mono barrel anchorages, simplified load bearing components and minimal need for reinforcement streamlined the installation of this record-breaking 7.4 hectare floor.

TEAM & TECHNOLOGY

Owner – Auckland International Airport Ltd
Main contractor – Macrennie Commercial Construction
Floor contractor – Conslab
Structural engineer – Tony Day Consultants
Technology – BBR VT CONA CMF flat
BBR Network Member – BBR Contech (New Zealand)



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SPECIAL FEATURE

60th Anniversary of BBR stay cable technology

Staying strong for six decades

BBR has been installing its stay cable technology around the world for over 60 years and, in this time, has not only completed some of the world's leading projects but has also continued to develop both the technology and techniques for its application. In this special feature, we recognize the world records our teams and technologies have created, as well as taking another look at some of the 430 major structures to which the versatile, durable and strong BBR stay cable technology has been applied.

Ada Bridge, Serbia

Europe's largest single pylon cable-stayed bridge. By revising strand installation procedures for the 80 BBR HiAm CONA stay cables, the BBR Network saved six months on the original 18-month program.

Tatara Bridge, Japan

World's longest cable-stayed bridge main span in the 20th century. This bridge features features 84 BBR HiAm CONA stay cables, installed in a two-lane multi-fan configuration, which support the 890m main span.

The earliest form of stay cable bridge is generally accepted to have been built in the 17th century, however the modern age of cable-stayed bridges really began in the mid-1900s. German engineers pioneered the design of contemporary stay cable bridges when looking for new, innovative and inexpensive bridge designs to meet the challenge of replacing most of the bridges over the River Rhine which had been destroyed during World War II.

Since then, a whole new generation of cable-stayed bridges has taken shape on landscapes around the globe. Cable-stayed bridges are unique in terms of slenderness and elegance, while giving designers the freedom to emphasize architectural and aesthetic features in ways that no other bridge type allows.

While many stay cable suppliers built their first major cable-supported structures in the late 1970s and early 1980s, BBR stay cable technology was used for the first time in the late 1950s. Since those days, BBR has continued to set the standard in the field of stay cables. Pioneering BBR technology enabled construction teams to be the first to use wire stay cables, first to use strand stay cables and first to use carbon stay cables.

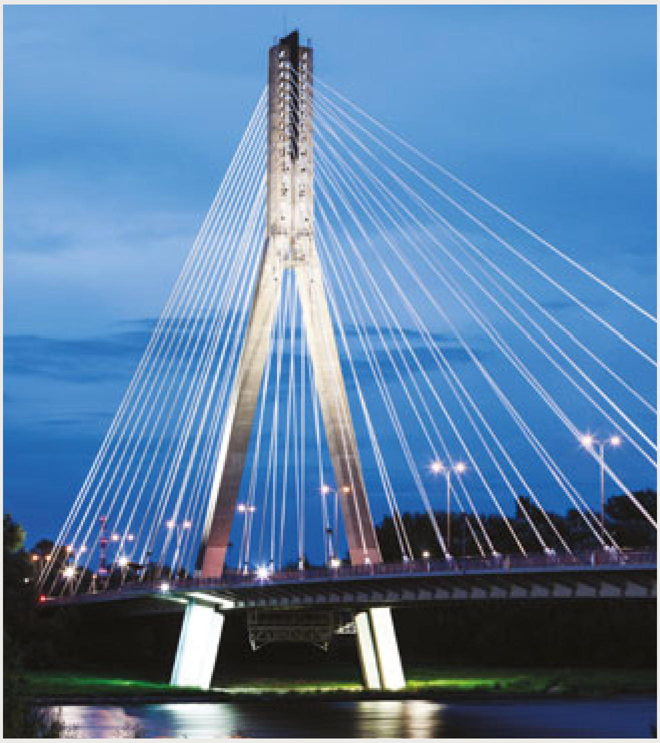
Typically, BBR stay cable technology is used for cable-stayed bridges, arch bridges, roofs – of grandstands, stadiums, aircraft hangars and other lightweight wide-span structures – and for stabilizing towers, such as for communication facilities, chimneys and antennas, as well as wind power stations. Its flexibility, robustness and high resistance to fatigue make BBR stay cable technology an ideal choice for many industrial and temporary applications too.

60th

Anniversary of BBR stay cable technology

Eleanor Schonell Bridge, Australia

Australia's first bridge designed exclusively for buses, cyclists & pedestrians has 64 BBR CONA stay cables between 20m and 100m long.



Swietokrzyski Bridge, Poland

Poland's first cable-stayed bridge features 48 BBR HiAm CONA stay cables anchored at a 90m high pylon.

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60th Anniversary of BBR stay cable technology Stay cable bridges

Making new connections

Bridges connect people and places, as well as providing continuity of travel – they can bring vital economic and social advantages too. In the case of a stay cable bridge, other quite special opportunities arise – such as making bold architectural statements or creating new emblems for cities or definitions for landscapes. As the global demand for infrastructure has grown and evolved, so too has BBR stay cable technology which includes the finest products available.

Since the 1950s, cable-stayed bridges have been built in ever increasing numbers and are especially suitable for medium to long spans of 100 to 1,000m, where this solution can deliver technical and economic advantages. Their advantages lie mainly in increased aerodynamic stability, reduced costs for the abutments, easier construction and light overall structures. For smaller bridges, other parameters may be decisive in the choice of a cable-stayed solution – such as reduced depth of deck, construction methodology and aesthetics.

First BBR stay cables

The earliest stay cable technology available to provide the required static strength and high amplitude fatigue resistance was parallel wire cables. The first installation of such high amplitude fatigue resistant wire cables was carried out by BBR in 1960 on the Schillersteg bridge in Stuttgart, Germany.

Now officially known as the Ferdinand-Leitner Steg, the 100m long pedestrian bridge was conceived as an architectural centerpiece and a link across a main road between the two sections of the 1961 Federal Garden Show.

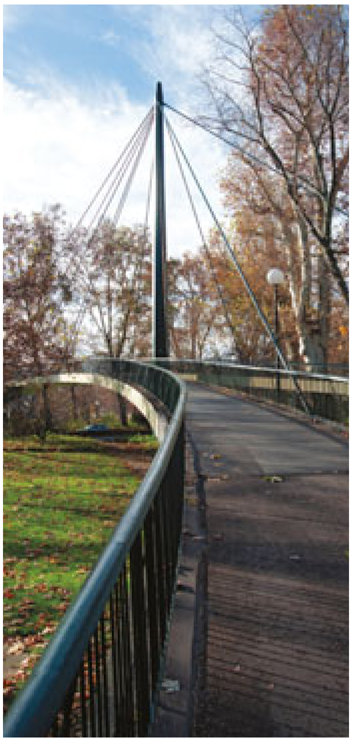
1 2000 – world's first combined arch and stay cable bridge spanning a lake, Seri Saujana Bridge, Putrajaya, Thailand. The 42m high pylon forms the upper anchorage point for the 84 BBR CONA STAY cables.

2 2011 – world's first stay cable bridge incorporating a railway station – Basarab Bridge, Bucharest, Romania. This is a five span cable-stayed bridge with 60 BBR HiAm CONA stay cables and also features BBR VT CONA CMI internal post-tensioning.

3 1997 – longest bridge in Finland, the Raippaluoto, or Replot, Bridge – features 64 BBR HiAm CONA stay cables anchored at two A-shaped concrete pylons. Given the harsh subarctic winter conditions here, the concept of factory prefabricated stay cables proved invaluable to timely project completion.

4 1960 – world's first parallel wire stay cables – Schillersteg (now known as Ferdinand Leitner Steg) in Stuttgart, Germany. The 10 BBR stay cables, encapsulated in a polyethylene pipe and injected with cement grout, are still performing well – 60 years after their installation. Image courtesy of Landesamt für Denkmalpflege im Regierungspräsidium Stuttgart, photograph by Felix Pilz.

5 1994 – world's first combined stay cable & floating bridge – Nordhordland Bridge, Bergen, Norway. The cable-stayed span features 48 BBR HiAm CONA stay cables and is connected to the floating part of the bridge by a transition pier. Image by Kim Rasmussen, licensed under CC BY-SA 3.0, via Wikimedia Commons.



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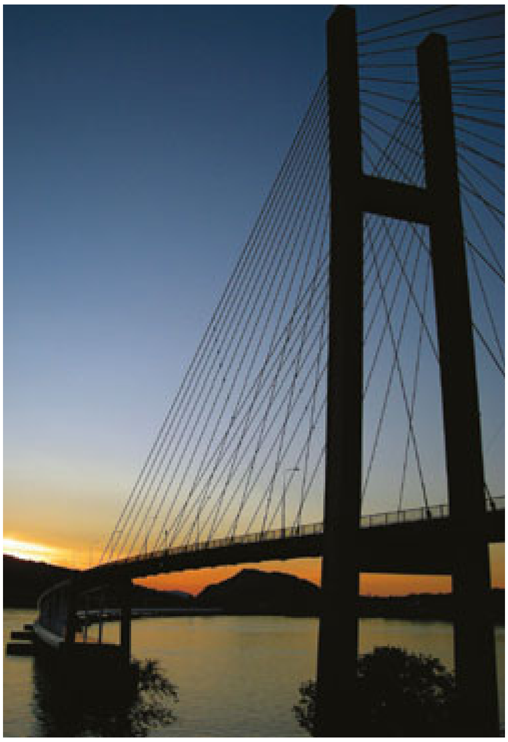

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The 10 BBR wire stay cables consist of bundles of up to 90 parallel 6mm diameter prestressing wires encapsulated in a polyethylene pipe and injected with cement grout. While the heritage-listed bridge has received major refurbishment generally, ultrasound testing has shown that the BBR stay cables are still performing well.

The concept of connecting people with cultural spaces via stay cable bridges has continued down the years – such as Bell's Bridge over the River Clyde in Glasgow, Scotland and more recently, Assut de l'Or (or Serreria) Bridge in Valencia, Spain.

High amplitude fatigue resistant strand stay cables found their first major application in the early 1970s for the new Olympic Stadium in Munich with its cable-supported membrane roof structure, subjected to high cyclic wind loads. Even while work was still underway in Munich, the BBR HiAm CONA stay cable system was also being applied to the Kurt Schumacher Bridge in Mannheim.

Types of stay cable

As wire stay cables are generally prefabricated and strand stay cables are more commonly assembled on site using the strand-by-strand installation method, the choice of the most suitable cable system for a particular project depends on many factors.

It has often been considered that prefabricated cables are best suited to smaller bridges. On site fabricated stay cables are usually suited to longer spans. However, each project should be individually evaluated – taking into account erection requirements and the overall economics.

World leading BBR stay cable technology

Today, with its superior fatigue resistance and high corrosion protection, the BBR HiAm CONA parallel strand stay cable system represents state-of-the-art technology. It is the best product on the international market place – with the highest capacity, most compact and widest range of anchorages available. As with all BBR technologies, the BBR HiAm CONA system has been thoroughly tested – to parameters exceeding the traditional requirements of *fib* and PTI criteria – and is continuously maintained by BBR engineers in Switzerland. When this pedigree is combined with the installation expertise of the BBR Network, backed by the Engineering and Special Projects Team from the Swiss BBR Headquarters, the BBR HiAm CONA system is simply unrivaled anywhere on the planet.

World Records with BBR stay cables

1960 World's first use of wire stay cables – Schillersteg, Stuttgart, Germany

1971 World's first high amplitude wire stay cable bridge – Kurt-Schumacher Bridge, Mannheim, Germany

1972 World's largest roof supported with strand stay cables – Munich Olympic Stadium, Germany

1977 World's first long span cable-stayed railway bridge – Zarate Largo Bridges, Argentina

1977 World's first earth-anchored cable-stayed bridge – Indiano Bridge, Florence, Italy

1978 World's first cable-net supported tower – Sydney Tower, Australia

1988 World's longest cable-stayed pedestrian swing bridge – Bell's Bridge, Glasgow, Scotland

1987 World's longest transit skytrain-only bridge – ALRT Skybridge, Canada

1994 World's first combined stay cable & floating bridge – Nordhordland Bridge, Bergen, Norway

1996 World's first bridge to use carbon stay cable technology – Storchenbrücke, Switzerland

1999 World's longest cable-stayed bridge span in 20th Century – Tatara Bridge, Japan

2000 World's first combined arch and stay cable bridge spanning a lake – Seri Saujana Bridge, Putrajaya, Thailand

2005 World's longest free span & curved stay cable bridge – Langkawi Skybridge, Malaysia

2005 World's first cable-stayed bridge to be built twice & world's largest cable-stayed bridge reconstruction project – Sloboda Bridge, Novi Sad, Serbia

2011 World's first stay cable bridge incorporating a railway station – Basarab Bridge, Bucharest, Romania

Extra special bridge structures

Often described as a cross between a box-girder bridge and a cable-stayed bridge, extradosed bridges have been built in increasing numbers since the 1980s. As their popularity steadily grew, so the BBR HQ team developed and launched the new BBR HiEx CONA saddle system to completely overcome the challenges associated with standard friction saddles. In this article, we examine the extradosed bridge concept, look at some projects and delve deeper into the BBR technology.

Extradosed bridges are a hybrid type of bridge believed to have first appeared in the 1980s. The most obvious difference between a cable-stayed bridge and an extradosed bridge is that the latter has a self-supporting deck.
The extradosed bridge type was a favored style of the late great Christian Menn, an outstanding bridge engineer and close friend of the BBR Network. One of the most famous bridges created with his insight and BBR technology was the award-winning Sunniberg Bridge, near Klosters in Switzerland.

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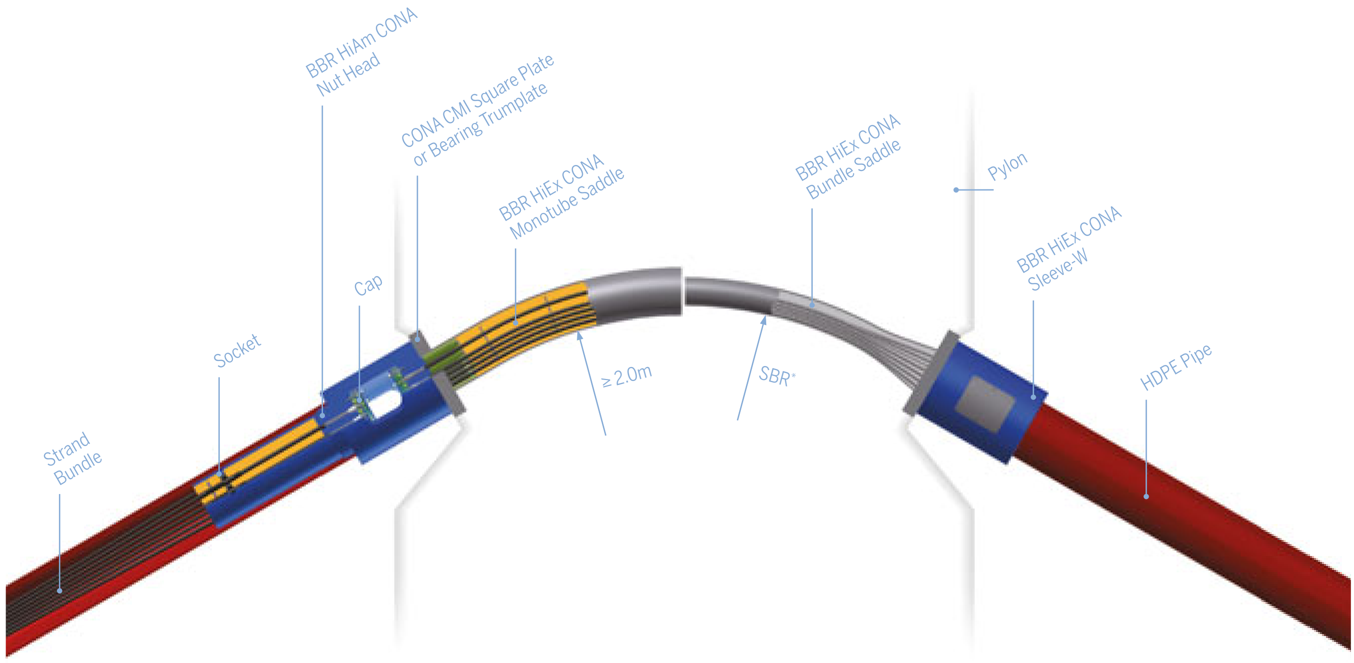

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Design advantages

Depending on the specific situation, extradosed bridges might offer advantages including:

- cost savings – for medium length bridges
- reduced tower height – in proximity to airports, for example
- reduced girder depth – enabling a longer span without impacting bridge deck profile.

With a typical cable-stayed bridge, most of the live load – from vehicular traffic – is carried through the stay cables, while the rest is supported by the deck. In an extradosed bridge, due to the higher stiffness of the deck, the proportions are significantly reduced allowing for a more equal redistribution of the loads and lower live loads transferring to the stays. This offers great advantages in terms of reducing the effects of fatigue on the stays and the anchorages, increasing the material efficiency level.

The deck of an extradosed bridge is directly supported by resting on part of the tower – so that, in close proximity to the tower, the deck can act as a continuous structural element.

In extradosed bridges, the stay cables are continuous and pass, via a saddle, over the top of the bridge piers. The tension exerted by the cables acts more to compress the bridge deck horizontally than to support it vertically, because of the lower angles of intersection with the tower and deck. The cable stays thus act as prestressing cables for the concrete deck.

The end result is a highly efficient load-bearing bridge, with striking visual qualities offered by the exposed cables and concrete towers above the road surface.

Saddle system solution

The BBR HiEx CONA saddle system completely eliminates the problems associated with standard friction saddles and, at the same time, allows for a compact and slender pylon. Unlike traditional friction saddles – that try to compensate differential cable forces with friction between the strand and the inner saddle material – the HiEx CONA saddle is a fixed structural point which ensures no slippage and full load transmission between the stay cable and the saddle. The technical solution results from the combination of the European Approved CONA CMI internal post-tensioning system with the HiAm CONA strand stay cable system.

Creating global dialogues

One of the reasons that BBR technologies have remained relevant and sought after over the years is that BBR has always participated in international dialogues about improving construction technology and techniques. Most recently, we contributed to the new *fib* Bulletin 89: Acceptance of stay cable systems using prestressing steels, issued in 2019 – this is directly relevant to extradosed bridges.

BENEFITS OF BBR HiEx CONA SADDLE

- Zero fretting fatigue at any point in the saddle
- Very low minimum radius of curvature of 2.0m
- Allows compact & slender pylon
- No slippage and full load transmission between stay cable & saddle at all times
- Inspection/replacement of individual strands
- Highest level of corrosion protection

1 The extradosed design of the Puch Bridge over the River Drava in Ptuj, Slovenia featured BBR VT CONA CMI and CONA CME, internal and external, post-tensioning tendons.

2 The New Europe Bridge crosses the River Danube between Romania and Bulgaria. The construction of this massive bridge featured the first use of the BBR HiEx CONA saddle system.

3 Sunniberg Bridge, near Klosters in Switzerland – an extradosed bridge project involving both Christian Menn and BBR technology. The bridge was presented with the 2001 IABSE Outstanding Structure Award.

4 Image showing the two configurations in which the BBR HiEx CONA saddle is available. On the left, is the BBR HiEx CONA Monotube Saddle and on the right is the BBR HiEx CONA Bundle Saddle. This solution ensures no slippage and full load transmission between the stay cable and the saddle. It overcomes problems associated with standard friction saddles while, at the same time, allows for a compact and slender pylon.

* The minimum radius of the BBR HiEx CONA Bundle Saddle configuration depends on the degree of filling and maximum contact pressure permitted at the place of use.

60th Anniversary of BBR stay cable technology
Efficient temporary works with stay cables

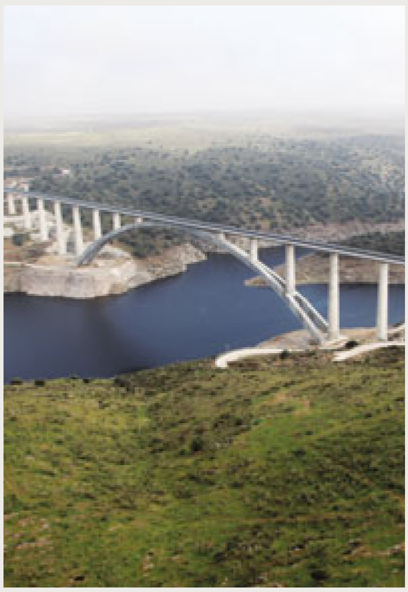
Secrets of success

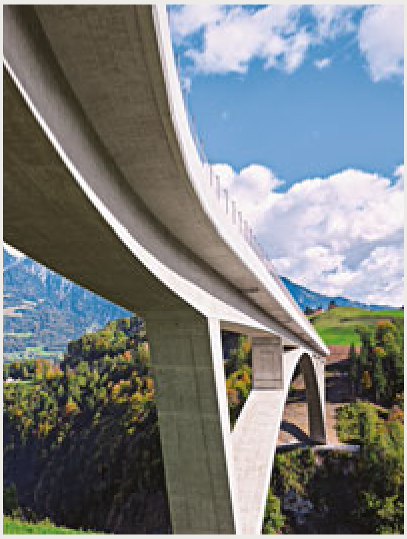
The strength and special techniques associated with BBR stay cable technology have, over the years, been harnessed to support the construction of several arch bridge projects. BBR Network Members' use of stay cables in these situations substantially reduced the need for expensive temporary works, minimized environmental impacts and contributed to program savings too. After completion of the projects the stay cables were carefully de-stressed and dismantled, following preplanned sequences and involving structural calculations and checks. Today, these bridges stand proud in their landscapes – and perhaps only they, and their creators, can testify to the secret behind their realization.

Almonte Viaduct

Extramadura, Spain

Completed in 2016, the 996m long Almonte Viaduct is the most prominent structure on the AVE high speed railway line from Madrid to Extremadura which will connect Spain and Portugal. The viaduct holds the world record for having the longest span for an arched high speed railway bridge. For the construction of the arch, a total of 208 BBR HiAm CONA 5506 and 3706 stay cables were used as temporary supports while the arch segments were being cast in sequence. With the concreting of the final segment, the arch became self-supporting and the stay cables were progressively and carefully de-stressed before being dismantled.





Tamina Bridge

St Gallen, Switzerland

The completed Tamina Bridge opened to traffic in 2017, forming the first ever direct connection across the Tamina Gorge between the Alpine villages of Pfäfers and Valens.

The arch springs across the gorge from two massive abutments and, during construction, was supported from the up to 100m high temporary pylons by stay cables – 31 pairs on the arch side and 24 pairs on the back span, a total of 110 stay cables.

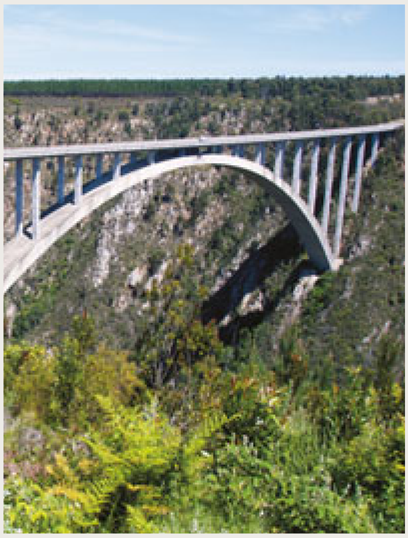
Image of Tamina Bridge under construction courtesy of Tiefbauamt St Gallen. Image of completed Tamina Bridge by Rüdiger Nehmzow, courtesy of LafargeHolcim Ltd, accessed at www.lafargeholcim.com.

Bloukrans Bridge

near Nature's Valley, South Africa

The Bloukrans Bridge in South Africa was constructed from 1980 to 1983. With an arch span of 272m, the bridge crosses a 216m deep gorge on the Garden Route between Cape Town and Port Elizabeth. The arch was constructed simultaneously from both banks in stages of approximately six meter segments, using the suspended cantilevering system with temporary stay and tie-back cables.

The picture shows one half of the arch during construction with the temporary stays, the temporary pylon above the arch springing column, the tieback cables, as well as the moveable formwork at the tip of the arch.



Third Godavari Railway Bridge

near Rajahmundry, India

Constructed from 1993 to 1996, the bridge is 2,731m long and has 28 identical spans of 97.55m. The simply supported bowstring girders consist of a slender twin concrete arch, tied at the bottom by a stiff centrically prestressed box girder which is continuously suspended to the arch by twelve pairs of hanger cables. The twin concrete arches were erected by the balanced suspended cantilever construction method using temporary stay cables fixed to a temporary steel tower erected on top of the pier. Stay cable release followed a detailed stressing program to ensure opposing forces were kept in balance at each step.

Orchestrated spans

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BBR stay cables – along with much other BBR Network technology and know-how – have been applied to bowstring arch bridges. This musical sounding style of bridge is distinguished by its arch which is 'stringed' like a musician's bow, with stay cables tying the arch to the bridge deck – thus providing resistance to the upward thrusting forces of the arch.

1 **2004** City Bridge, Newport, Wales – part of a 9.3km bypass around the city, this 195m long bridge over the River Usk was installed with 34 BBR stay cables.

2 **2006** Pulao Bunting Bridge, Kedah, Malaysia – forming part of a 2km access bridge from the Kedah coast to Bunting Island, the 80m span bowstring arch bridge is stayed with 26 BBR DINA wire stay cables and was floated into position on barges.

3 **2006** Navia River Bridge, Asturias, Spain – the twin arches of this bridge are vertically inclined by 5° and were designed to work in a curved plane. The structure features 34 pairs of BBR DINA stay cables, along with precast segmental construction and both internal and external BBR post-tensioning technology. The project won both the 2010 *fib* Outstanding Structure Award and the 2007 BBR Network Project of the Year Award.

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60th Anniversary of BBR stay cable technology
Innovative solutions for industry

Industrial strength technology

BBR Network Members around the world have developed a reputation for finding innovative new ways to use BBR technology and deliver solutions to customer challenges. In recent years, three such challenges resulted in unconventional, yet practical BBR stay cable solutions.

1 Eight cable stays – with sockets weighing over 370kg – were fabricated, installed and stressed to support conveyors at the Mount Whaleback Mine Ore Handling Facility in Newman, Western Australia. This huge weight required new systems to be developed for the installation of the stays. All stay cables were fabricated at ground level and lifted into position.

2 A further eight cable stays were designed, supplied and installed for the Karara Iron Ore Project, also in Western Australia. Each BBR HiAm CONA stay cable consists of a forked clevis connection at the top with an adjustable lower anchorage. Here, the stay cables are permanently loaded and support the cantilevered section of the stacking conveyor. Loads are variable, according to conveyor belt operating capacity, wind and seismic activity.

3 Meanwhile, on the other side of the country, in Melbourne, stay cables are literally keeping the lid on things at Melbourne Water's Western Treatment Plant in Werribee. A treatment lagoon cover – which captures biogas for conversion to electricity – was being replaced. To secure the cover in place, a series of 11 BBR HiAm CONA stay cables which traverse the lagoon in a convex and concave pattern were designed, supplied and installed.


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60th Anniversary of BBR stay cable technology Landmark structures

Standing the test of time

Any review of BBR stay cable achievements and capabilities would be incomplete without at least another brief look at two now very familiar projects – the tented roof of the Olympic Stadium in Munich, Germany and the iconic Sydney Tower in Australia. Both structures have not only stood the test of time, but they have also become 'destinations' offering experiences beyond their original purposes during their long lifetimes.

The two structures have longevity in common – both have exceeded the expectations of their owners in terms of durability. They have also been developed and reenergized to present new challenges to the many visitors that flock to see them every year. In Munich, visitors can now take daily tours involving climbing and abseiling from the famous 'tented roofs' of the stadium built for the 1972 Olympic Games. The stadium itself also hosts an impressive array of concerts and many other events. Meanwhile, the Sydney Tower Eye offers tourists a 360 degree view of the city from its internal observation deck, along with a new Skywalk attraction featuring an open-air glass-floored platform, as well as a 4D cinema experience. In addition, each year there is a special charity race event – Sydney Tower Stair Challenge – when up to 750 entrants race up some 1,504 steps to get to the top of the tower.

Olympic Stadium Roof

The creative vision for the tented roof of Munich's distinctive stadium lay in the concept of unifying all the different spaces for the 1972 Olympic Games with a continuous, lightweight and translucent roof. Architect Frei Otto, whose earlier much smaller tented roof for the German Pavilion at Expo '67 in Montreal served as inspiration, collaborated with the Behnisch & Partner architectural practice and the consulting engineering firm founded by Fritz Leonhardt and Wolfhart Andrä (now known as LAP) on the massive cable-net roof project in Munich.

The then new BBR HiAm parallel strand stay cable system – in total some 488 individual stay cables – was installed to support the almost 75,000m² roof structure which covers the west grandstand of the stadium, indoor pool and gymnastic area. The stay cables are anchored at cable-stayed towers which range in height between 70 and 80m. In addition, the stadium roof is tensioned by a single curved parallel strand cable running along the inner edge. All elements of the cable-net roof structures were first assembled on the ground and then lifted into position.

Since 1998, along with the rest of the Olympic Park, the stunning cable-net roof enjoys the status of being a protected national monument.

Sydney Tower

Like the Olympic Stadium in Munich, Sydney Tower has become a much loved emblem of its home city. Opened to the public in August 1981, whichever way you look at it, Sydney Tower has more than delivered on its promises for the vibrant Australian city. Originally constructed as a telecommunications tower and the defining architectural feature of the Centrepoint commercial development, today – almost 40 years since its opening – the 309m high tower still remains Sydney's tallest structure.

Its unique supporting net structure, created with BBR DINA stay cables, sets it apart from the crowd. The steel tower rises 230m above the roof of the central Sydney 12-level office building. Its shaft is stayed by a system of 56 BBR parallel-wire prestressing cables arranged in a hyperboloid of revolution. The tower is topped by a turret of five levels accommodating two revolving restaurants and two observation decks.

Many comparisons have been made about the dimensions of the tower. For the Global BBR Network, the most interesting may be the analogy that if the stay cables securing the tower were laid end-to-end, they would stretch some 2,395km – roughly the same distance as Zurich to Ankara, or Oslo to Madrid and, in fact, further than Auckland to Sydney, New York to Houston and just a little further than Singapore to Manila.

Skillful selection of the distribution of prestressing forces in the cable nets permitted, like no other building methodology, the achievement of as perfect an adaptation of the roof forms to the architects' idea and the diversity of the terrain and substructures, as was possible and necessary for the Olympic roof.

IABSE congress report (1972): Das Olympiadach in München, by Jörg Schlaich, H. Altmann, R. Bergermann, K. Gabriel, K. Horstkötter, K. Kleinhanss, P. Linhart, G. Mayr, J. Noesgen, U. Otto, H. Schmidt, Ingenieurbüro Leonhardt und Andrä, Stuttgart, Germany.

SCAN ME

Use your smartphone to scan the code and learn more about BBR stay cable technology. Or visit **www.bbrnetwork.com/downloads/brochures** and download the brochure on the BBR HiAm CONA strand stay cable system.

Keepit Dam, NSW, Australia Dam strengthening work

World record capacity anchors

Keepit Dam, owned and operated by WaterNSW, is situated on the Namoi River, 30km upstream of Gunnedah on the north west slopes of the New South Wales Northern Tablelands. The 55m high dam has a capacity of 425,000Ml – making it nearly as large as Sydney Harbour. Mark Sinclair and Sam Pearce from Australian BBR Network Member SRG Global take us on a tour of the dam strengthening project which again uses world record capacity BBR CONA SOL+ ground anchors.

As principal contractor for the project, SRG Global are undertaking the works required for the installation of 67 permanent ground anchors to stabilize the 533m wide dam which originally began its service life in 1960.

Work scope

As part of the operations, there are significant civil works associated with the upgrading project. Our scope includes localized demolition, concrete works, drilling of 350mm holes and permanent anchoring operations. Each of the 67 permanent anchors is made up of 15.7mm strands of varying lengths – the largest anchors being 91 strands and approximately 88m long. This is the fifth dam project to use these world record capacity 91-strand anchors – with all such anchors for previous projects having been supplied and installed by SRG Global. We have manufactured new equipment for this project to allow us to use it to install even larger 127-strand tendons with breaking loads of over 35,000kN which we have developed in-house.

Quality anchoring approach

We fabricated all of the anchors on site with purpose-built equipment to enable the high quality standards to be achieved. This has included the use of over 664t of strand and anchors with installed lengths totaling 3,300m. The anchors were delivered to the anchor hole from the fabrication area using a specially designed 90m long trolley system enabling the anchor to travel over 1km – including around bends and gradients along the road. >

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World record capacity

CONA SOL+ anchors

Protection against corrosion

Corrosion protection is critical to the life of the anchors installed in the harsh environment of the dam. Some 20 of the anchors are located within the spillway of the dam and subject to inundation during spillway operation. The BBR CONA SOL+ anchorage components enable the anchors to be monitored and restressed over their 100-year design life. Corrosion protection measures included the use of HDPE duct with simultaneous single stage grouting, both inside and outside of the duct, over the full height of the anchor. The bespoke corrugated HDPE duct over the bond zone ensures both full protection of the bare strand and maximum load transfer. The anchor head region is protected by injecting hot grease to eliminate internal voids and then a final protection cap is placed over the assembly.

Spillway pier anchors

Complex inclined pier anchors were installed into each of the five spillway piers – each pier has four nominal 20m long, 65-strand anchors. The extremely difficult access required the drilling works to be undertaken using a specifically manufactured drilling rig, initially diamond coring to approximately 10m to get past the significant reinforcement within the concrete and then swapping to complete the hole using down-the-hole hammering techniques.

In a world first, the largest permanent load cells have been installed on selected anchors to enable the client to monitor the residual anchor load easily without direct access to the 65-strand anchors.

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1 Keepit Dam, New South Wales, Australia – where strengthening works were carried out using world record capacity BBR CONA SOL+ anchors. Seen here in yellow are the custom-designed and built access and working systems which give access to the spillway and pier permanent anchors.

2 The 91-strand anchors in the spillway were stressed to a proof load of over 19,000kN.

3 Complex concrete pier extension works were completed against the existing concrete piers to enable the anchoring operations to follow. These bearing pads were required to distribute the new anchor loads into the pier concrete.

TEAM & TECHNOLOGY

Owner – WaterNSW
Design & build contractor – SRG Global
Owners' design engineer – SMEC
Technology – BBR CONA SOL+
BBR Network Member – SRG Global (Australia)

Windprojekt Åmot-Lingbo, Sweden Strand anchor installation

Harnessing the wind

BBR Network Member **Spännteknik SLF AB** has been providing services and technology for the Åmot-Lingbo Wind Farm in northeastern Sweden. Jonas Larsson, Sales Manager for Sweden, tells us that the team delivered, installed, grouted and stressed a total of 336 15.3m long BBR CONA SOL+ strand ground anchors for the foundations of 24 wind towers. Svevia AB, are the main contractor for the infrastructure, while Vestas are the main contractor for the erection of the towers and finishing of the windmills ready for operation.

TEAM & TECHNOLOGY

Main contractor (infrastructure) – Svevia AB
Main contractor (tower erection) – Vestas
Technology – BBR CONA SOL+
BBR Network Member – Spännteknik SLF AB (Sweden)

Toru Apartments, New Zealand Installation of seismically-resistant PRESSS technology

New apartments get the PRESSS treatment

While the team at New Zealand's BBR Contech often have the opportunity to work in beautiful scenic surroundings, some of them win work that has the others turning positively green with envy. This is certainly the case with a project currently underway in the South Island resort town of Queenstown, where BBR's Christchurch team is helping to build a new apartment complex with amazing views of The Remarkables mountain range and beyond.

TEAM & TECHNOLOGY

Owner – New Ground Living (Remarkables Park)
Structural engineer – Kirk Roberts Consulting
Project manager – Aecom New Zealand
Main contractor – Naylor Love Central
BBR Network Member – BBR Contech (New Zealand)

The complex, named 'Toru' (the Māori name for 'three') has been designed by Mason + Wales Architects to meet the burgeoning demand for affordable housing in Queenstown. It will comprise three seven-storey, campus-style apartment buildings and offer 236 one-, two- and three-bedroom apartments for sale and rent, as well as communal lounges, commercial spaces and on-site parking.

The buildings' design has been driven by a focus on prefabrication and modularization to ensure both quality and cost-effectiveness. Components such as wall and ceiling panels and bathroom pods are prefabricated off-site then assembled into completed modules on-site, and in situ floors are poured at each level as the structure progresses upwards.

BBR Contech has been commissioned by Naylor Love to install the post-tensioning for the C-shaped, precast-concrete structural walls that are positioned in sets of opposing pairs to form the buildings' core – enclosing stairs, lifts and service areas at each end. The walls are constructed using the PREcast Seismic Structural System (PRESSS) technique, in which unbonded post-tensioned, corrosion-protected tendons are installed through precast concrete shear walls, then anchored at foundation level and tensioned at the top. The system provides seismic protection – enabling a controlled rocking mechanism during an earthquake that returns the building to upright without significant structural damage.

In 1983, BBR Contech was the first in New Zealand to use PRESSS for a multi-storey building. This work, on Wellington's Alan MacDiarmid Building, went on to earn the company a New Zealand Concrete Society Concrete and Technology Award.

Visualization of the completed Toru Apartments which are under construction using the seismically-resistant PRESSS system.

Yusufeli Hydroelectric Dam Sluiceway Bridge, Turkey Load transfer with BBR H Bars

BBR H Bars take the load

The Yusufeli Hydroelectric Dam is under construction in north east Turkey. It is here that the team from local BBR Network Member Kappa has an interesting challenge – to supply and install BBR H Bars to effect the load transfer of the steel sluiceway bridge.

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The Yusufeli Hydroelectric Dam has a design power output of 1.88 billion kilowatt-hours (kWh) per year, which is projected to supply 0.7% of Turkey's total electricity demand.

When completed, the 275m high Yusufeli Dam will be the highest arch dam in Turkey – and will be the world's third highest double curvature concrete arch dam. It is currently under construction and will be part of a system of hydroelectric plants on the Çoruh River, in the Artvin Province of Turkey.

The damming of the Çoruh River means that three villages within the Yusufeli Region will be flooded. Therefore, work is underway to relocate these local settlements.

The concreting of the arch dam embankment is being carried out using purpose-designed and manufactured climbing formwork.

Sluiceway bridge

A steel bridge design was preferred for the access road to the sluiceway. In addition to its ease of installation and maintenance, such a design will allow the contractor to fabricate the access road without interrupting the main dam body construction.

The steel bridge is to have a total length of 110m, comprising 14 individual modules. Additionally, the 6.5m width of the bridge will be sufficient to permit the passage of two H30-S24 trucks.

Each bridge module will rest on the body of the dam through a steel truss system. The tensile load on the truss system will be transferred to the dam body using BBR H500 40mm diameter bars. The truss system will have permanent platforms to allow for bridge maintenance.

1 Aerial view of construction work underway for the Yusufeli Dam.
2 Local BBR Network Member Kappa has an interesting challenge at Yusufeli Dam, to supply and install BBR H Bars to effect the load transfer of a steel sluiceway bridge.

TEAM & TECHNOLOGY

Client – DSİ (Devlet Su İleri) – General Directorate of State Hydraulic Works
Main contractor – Limak Construction A.S.
Climbing formwork specialist – ÇEKA Beton Kalibi Ltd. Sti.
Technology – BBR H Bar
BBR Network Member – Kappa AS (Turkey)

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Al Zour LNG Import Terminal, Kuwait Cryogenic post-tensioning of eight LNG tanks

Tanking up for LNG

The Al Zour Import Terminal Project, now well underway, includes the construction of a large-scale liquefied natural gas (LNG) plant, including eight LNG storage tanks, located 90km south of Kuwait. Rusper Patel from BBR Network Member SRG Global describes his company's work on the post-tensioning of the eight LNG storage tanks which are a core part of the scheme.

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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.

Dimensions & technology

Each tank has a capacity of 225,500m³ with a height of 47.65m, diameter of 97m and 750mm wall thickness. SRG Global are using the BBR VT CONA CMI internal post-tensioning system which features tendons with 27 steel strands of 15.2mm diameter – in total, the project will use 10,000t of prestressing steel. The installation includes 96m long vertical loop tendons and 150m long horizontal loop tendons. The BBR VT CONA CMI post-tensioning system is fully certified for operations under cryogenic conditions according to EAD16. Certification testing for the CONA CMI system included static and load transfer testing of single and multistrand tendons under full cryogenic conditions. The successful test results verified the ductility and load transfer performance of the CONA CMI system with normal grade anti-bursting reinforcement when subjected to extreme temperature conditions (-196°C) and proved that it is in full compliance with the EAD16 requirements, for use in both temporary and permanent cryogenic conditions, without any need for costly low temperature grade reinforcement and thus delivering significant material cost savings. For this project, the design temperature for reinforcement steel is -145°C and prestressing steel -85°C.

Progress in extreme heat

At the time of writing, SRG Global have completed approximately 40% of the stressing works and are focused on completion of the work by the end of 2020. The construction regime is intense and requires the team to push approximately 80t of strand each day. Between 600 and 800 bags of cement are used for grouting each day. The extreme temperatures (40 to 50°C) mean that six tonnes of ice are needed to maintain the grout mix temperatures within specified tolerances. In order to help maintain tolerances, most work is done at night.

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1 Night-time view across the site where eight LNG tanks are under construction for the Al Zour Import Terminal Project in Kuwait.
2 Aerial view of the site showing all eight LNG tanks under construction at the same time.
3 For each of the eight tanks, the team from SRG Global is installing 96m long vertical loop tendons and 150m long horizontal loop tendons.

TEAM & TECHNOLOGY

Owner – Kuwait National Petroleum Company (KNPC)
Design & build contractor – Hyundai Engineering and Construction Co., Ltd
Technology – BBR VT CONA CMI internal
BBR Network Member – SRG Global (Middle East)

Kangaroo Creek & Fairbairn Dams, Australia Slipforming & anchoring solutions with BBR H Bars & BBR CONA SOL+

Specialist techniques for water

BBR Network Member for Australia, SRG Global continue the delivery of specialist construction techniques into bulk water infrastructure, through their ground anchoring and slipform operations. Like many other ageing dams in Australia, the Kangaroo Creek and Fairbairn Dams were constructed across the 1960s and 1970s and have afforded SRG Global the opportunity to showcase its globally unique skillset – and to apply complementary BBR geotechnical technologies.

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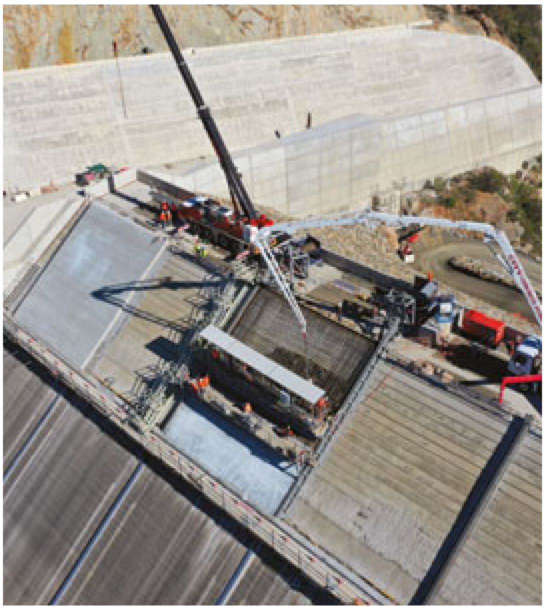

3

1 Kangaroo Creek Dam

Slipforming work on dams has most commonly been used as a mechanism to apply a reinforced concrete face to rockfill dams. The slipform technique allows concrete to be placed continuously on a grade, in approximately 12m wide panels. SRG Global's works on the Kangaroo Creek Dam Upgrade Project in South Australia consisted of slipform construction to two different areas of the dam.

Upstream embankment face slabs

The first was a total of 11 slipformed concrete slabs on the upstream embankment face. The embankment of the dam was being raised which involved the following staging of works:

- Rockfill and filter materials were raised in layers to the required height.
- Concrete kerbing was completed on the upstream face in corresponding layers to the rockfill and filter materials.
- Reinforcement was installed to the concrete kerb face, where the concrete kerb acted as a sacrificial foundation against which the slipformed slabs were cast.
- Finally, the slipform slabs were cast.

The slipformed concrete slabs were cast on a 35 degree gradient in panels typically 12.2m wide, 14m long at a slab thickness of 305mm. The advance rate achieved was up to two meters per hour.

Flip bucket slabs

The second area of slipform work involved the construction of six slabs for the widened flip bucket. As part of the upgrade, there was a significant widening of the spillway chute and flip bucket including relining the existing concrete slabs.

The added complexity for the flip bucket was that the gradient was variable, meaning that the winching system and access platforms had to cater for whether the slipform was operating in an upwards or downwards state. Conventional formwork techniques were considered, such as fixed steel panels, however the high quality achievable through adopting a slipform approach was compelling.

The slipformed concrete slabs were cast on gradients varying up to 42 degrees, typically 10m wide and 15m long. The thickness varied significantly due to the nature of the foundation excavated during the widening process, however the minimum required was 400mm.

Slipform details

The slipform system comprises a counterweighted screed which incorporates a working platform for concrete placement and external vibrators. The counterweights ensure that the screed does not float to a height above the intended finished level of concrete. The screed travels along temporary steel edge forms and is progressively winched via two 15t SWL electric man rider winches. These winches were designed and built especially for this project to cater for the line pull loads. In addition to the slipform screed and its working platform, there is a subsequent trailing deck which is used to complete the concrete finishes and apply the adopted curing technique. The trailing deck can be set at a pre-determined distance from the screed, based on the rate of set of the concrete. >

The ability to increase the capacity of ground anchors and reduce the number needed has meant that the program for the urgent works is shorter.

1 Kangaroo Creek Dam – on the upstream embankment face 11 slipformed concrete slabs were constructed.
2 Kangaroo Creek Dam – slipforming operations for the six slabs needed for the widened flip bucket had to cope with the added complexity of a varying gradient.
3 Kangaroo Creek Dam – the slipform system comprises a counterweighted screed which incorporates a working platform for concrete placement and external vibrators.
4 Fairbairn Dam – installation of one of the test anchors underway.
5 Fairbairn Dam – a total of 78 BBR CONA SOL+ ground anchors, with 23 or 21 strands, are now being drilled, fabricated and installed for this project.
6 Fairbairn Dam – drilling and installation of a series of test anchors was carried out to prove the ultimate ground conditions and enable optimization of the final post-tensioned ground anchor design.

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2 Fairbairn Dam
SRG Global were successful in an extended procurement process with asset owner Sunwater Limited for part of the Fairbairn Dam Improvement Project. The works saw SRG Global engaged exclusively to drill and install a series of test anchors in order to prove the ultimate ground conditions enabling optimization of the final post-tensioned ground anchor design.

BBR CONA SOL+ ground anchors
Three 31-strand ground anchors, with a deliberately short bond length, were installed for testing at a depth of approximately 35m just upstream of the dam's ogee crest. The bond zone of the anchor was taken to approximately 75% of the strands minimum breaking load (MBL) and held without failure. This meant that the bond stress performance of the ground exceeded the designer's expectations, enabling fewer larger anchors to be adopted for the final design to anchor down the crest. The ability to increase the capacity of ground anchors and reduce the number needed has meant that the program for the urgent works is shorter.

BBR H Bars as passive anchors
As part of their complementary geotechnical solution for the client, SRG Global also provided 137 50mm diameter BBR H500 Bars for installation as a passive anchor between the foundation and into the abutment side wall where steps were being retrofitted to the existing sloped dam side walls.
The customized bars were supplied cut to various lengths with couplers utilized to finalize the length required in the various sections of wall.
Installation was managed by Sunwater and their project team, with the BBR H500 Bars offering an economical alternative to other 500 grade bars.

Current activities
SRG Global are now on site and commencing permanent works which involves the drilling, fabrication and installation of 52 x 23-strand and 26 x 21-strand BBR CONA SOL+ ground anchors.
This project further strengthens SRG Global's long-standing capability as a world leader in high capacity ground anchors for dams.

TEAM & TECHNOLOGY

1 KANGAROO CREEK DAM
Client – SA Water
Main contractor – Bardavcol Pty Ltd
Consulting engineer – GHD
Technology – Slipform paving
BBR Network Member – SRG Global (Australia)

2 FAIRBAIRN DAM
Client – Sunwater Limited
Main contractor – SRG Global (Australia)
Consulting engineer – GHD
Technology – BBR CONA SOL+, BBR H Bar
BBR Network Member – SRG Global (Australia)

Tauweru & Waihenga Bridges, Wellington, New Zealand Increasing load capacity & repairs

New life for old bridges

Two early 20th century bridges in New Zealand have recently received some specialist attention from BBR Contech to ensure that they can continue to serve their communities well into the future.

As well as being similar in age, both bridges feature concrete piers and girders and both have their feet in riverbeds. In addition, they're only about 50km apart in New Zealand's Wairarapa region which sits at the south-eastern corner of the North Island. However, the similarities end there, as the bridges have very different uses.

The 1922 Tauweru Bridge is 73.5m long and services the farms and forests east of Masterton, Wairarapa's largest town. It carries the greater load, often bearing massive trucks taking heavy cargo to distant ports.

In sharp contrast, the 232m long, 22m span Waihenga Bridge built in 1912 is part of a rural state highway further south that is used by much lighter vehicles. As well as carrying local traffic, it often transports weekenders and tourists visiting the popular vineyards of Martinborough and the stores and cafés of nearby Featherston and Greytown.

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Given their age and purpose, it is easy to understand why BBR Contech spent a few months in the region in 2019. The Tauweru Bridge needed some strengthening to increase its load capacity, while Waihenga, after many years of service and a few problems with flooding, needed structural repairs.

The Tauweru project had its challenges as it had to remain open for the duration of the work – heavy-duty ear protection was required by those underneath! It involved adding three external, post-tensioned, greased and sheathed tendons each side of the two bridge beams, plus carbon fiber reinforced polymer (CFRP) reinforcement to the underside of the deck. A discovery of extensive cracking in the deck required some extra repairs which, while unexpected, will make a significant contribution to the bridge's long-term well-being.

As for the Waihenga Bridge, it emerged in much better shape after the BBR Contech team had removed spalled concrete with help from hydro-demolition experts, installed a protective coating on the reinforced steel and reinstated damaged and broken concrete using a dry-spray method. All the excavated material was collected, removed and disposed of off-site, reflecting BBR Contech's standard practice and complying with the local council-issued resource consent conditions.

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1 New Zealand's 73.5m long Tauweru Bridge, built in 1922, has received some specialist strengthening and repairs.

2 The Tauweru project involved adding three external, post-tensioned, greased and sheathed tendons each side of the two bridge beams.

3 Work at Waihenga Bridge included removing spalled concrete by hydro-demolition, installing a protective coating on the reinforced steel and reinstating damaged and broken concrete by dry-spraying.

TEAM & TECHNOLOGY

1 TAUWERU BRIDGE

Owner – Masterton District Council
Main Contractor – BBR Contech
Designer – WSP
Technology – BBR VT CONA CME external, MRR range
BBR Network Member – BBR Contech (New Zealand)

2 WAIHENGA BRIDGE

Owner – NZ Transport Agency
Main Contractor – BBR Contech
Designer – WSP
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

Global Seed Vault, Svalbard, Norway Post-tensioning for new entrance tunnel

Safe storage for seeds

When the Global Seed Vault – built into the permafrost in the remotely located archipelago of Svalbard – needed a strong, durable and fast solution for its new entrance tunnel, the team from Norwegian BBR Network Member KB Spennteknikk AS was ready to help. John Taraldsen, Operations Manager, describes this unusual project and its special challenges.

Background

The purpose of the Svalbard Global Seed Vault is to provide insurance against both incremental and catastrophic loss of crop diversity and to supplement and safeguard the work of some 1,700 traditional seed or gene banks around the world. Accessed through a narrow opening stretching into the mountain, the complex consists of three underground seed vaults. Construction of the project in 2008 was funded by the Norwegian government which, along with other institutions, continues to provide ongoing financial support. The Global Seed Vault is managed by The Crop Trust.

Svalbard was chosen for its location because it is remote but still accessible. Also, the position of the Global Seed Vault inside a mountain offers greater security and insulation and the area is geologically stable with low humidity. Meanwhile, the permafrost offers natural freezing which is not only cost-effective, but also a fail-safe method of conserving seeds. The facility was designed to be self-supporting, requiring little or no maintenance or oversight – apart from being opened twice-a-year for adding or removing seed packages.

Need for new entrance tunnel

This recent project came about because the entrance tunnel to the vault had been partially flooded with meltwater in January 2017 following an exceptionally warm winter. Luckily, this water froze and the ice was removed – there had been no damage to any of the seeds already in storage. The aim of this rehabilitation work was to create a 100m long tunnel sloping upwards into the vault, rather than downwards as the original had done, so that should flooding threaten again, the water will be channeled away from the seed vaults.

1 View above the entrance portal to the Global Seed Bank near the town of Longyearbyen on the Norwegian archipelago of Svalbard. Designed by architect Peter W Søderman of Barlindhaug Consulting, the concrete, steel and glass vault was constructed in 2008.

2 The Global Seed Vault complex is buried some 120m deep into the mountain – offering security and harnessing the natural freezing capabilities of the permafrost. Image courtesy of Crop Trust.

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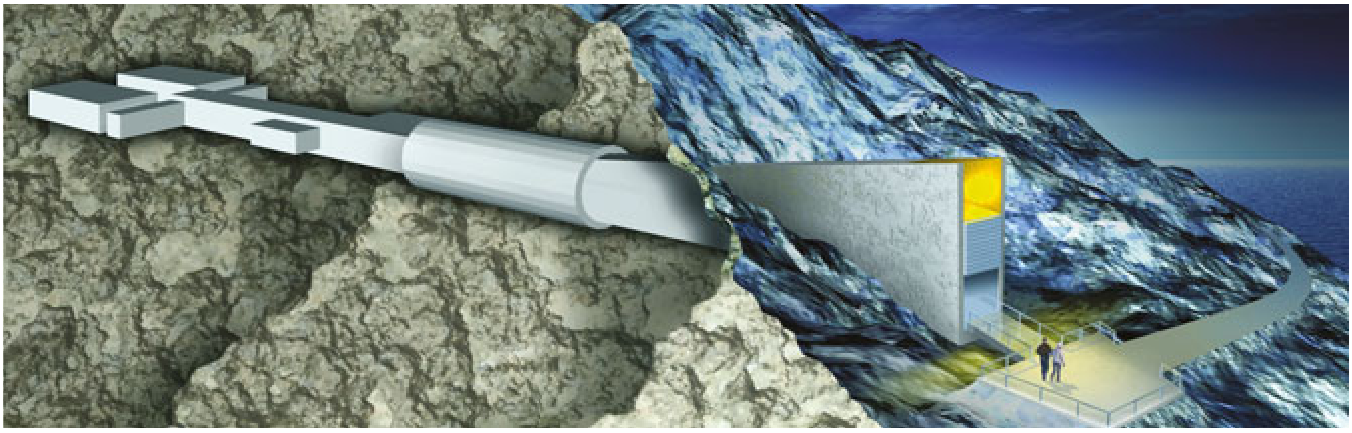

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Challenging specialist PT work

We arrived on site in April 2018 to carry out our work which involved the delivery and installation of 24 BBR VT CONA CMI internal 0706 post-tensioning tendons into the circumference of the new tunnel. The tunnel was built using 25 precast concrete elements with BBR plastic ducts, purpose-made to ensure the intended lifetime operation of 200 years. The elements were produced in Trondheim and transported to Svalbard for assembly, stressing and concreting. Svalbard is around 1,000km to the north of the Norwegian mainland – almost half-way to the North Pole – so supply logistics had to be carefully considered. As well as the remoteness of the location and confined working space, another challenge was working in the arctic environment where, even in summer, surface daytime temperatures only reach a maximum of around 6°C. A feature which helped us was that Longyearbyen has 127 days of 'midnight sun' between April and December – meaning that we had longer hours of light, rather than the dark polar winter, in which to carry out our above-ground preparatory work. Now, after these short few weeks of human intervention, the Global Seed Vault should be able to take care of itself once again and fulfill its role as an impregnable storage facility to ensure continued availability of precious food crop seeds.

SVALBARD GLOBAL SEED VAULT

120m
DEEP INSIDE PLATÅBERGET MOUNTAIN

4.5 million
VARIETIES OF CROP CAN BE STORED

983,500
SEED VARIETIES CONSERVED TODAY

2.5 billion
MAXIMUM SEED STORAGE CAPACITY

27m
LENGTH OF EACH VAULT

145.9m
DISTANCE FROM FRONT DOOR TO BACK OF VAULT

-18°C
STORAGE TEMPERATURE

TEAM & TECHNOLOGY

Owner – Statsbygg
Main contractor – Hæhre Arctic AS
Consulting engineer – Dr. Techn. Olav Olsen
Technology – BBR VT CONA CMI internal
BBR Network Member – KB Spennteknikk AS (Norway)

Strengthening work and repairs to the floors were carried out by BBR Contech at the Allied Telesis Labs New Zealand campus in Christchurch.

Allied Telesis Labs NZ, Christchurch, New Zealand
Seismic strengthening & repairs

Putting buildings on the level

Repairing or restoring a building often presents more challenges than constructing a new one, especially when the building is occupied and operational – and you have to do the work not only quickly, but quietly too! Such was the case for BBR Contech with their five-month project for technology company Allied Telesis Labs New Zealand (ATS).

Based in Christchurch, ATS is the largest research and development facility of the global Allied Telesis Group. It is responsible for developing a broad suite of computer networking and telecommunications equipment for a wide range of customers around the globe.

Fortunately, the ATS campus – which comprises two buildings, a swimming pool and pool house – emerged relatively unscathed from the 2011 earthquakes. However, the two main buildings required seismic strengthening to at least 67% of New Zealand's New Building Standard, as well as earthquake-related work, such as fixing sagging roof bracing and cracks in concrete.

BBR Contech was subcontracted by Westmore Construction to level the concrete floors on the first storey of one building and the second storey of the other, as they had dropped by between 3mm and 15mm as a result of the earthquakes. This involved:

- exposing the floors' underlying concrete substrate, which included tearing up floor coverings and creating openings in architectural partitions
- recessing the concrete slabs – this work had to be done between 4pm and 8am because of the noise involved in grinding the recesses
- strengthening the floors by applying three layers of carbon fiber strips – covering an area of 509m^2 in the first building and 498m^2 in the second
- completing extra tasks, such as fixing cracks by injecting epoxy through the lower-floor ceilings, to ensure the longevity of the floors and comply with the carbon fiber application guidelines
- covering the top layers with sand, in preparation for the floor-leveling compound and subsequent floor coverings.

To ensure that the building stayed operational, the work was undertaken in two separate phases – with staff moving from one building to the other as it was completed.

TEAM & TECHNOLOGY

Owner – Allied Telesis Labs New Zealand
Main contractor – Westmore Construction
Structural engineer – Structex Harvard
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

Viaduc d'Echinghen, Autoroute A16, Saint-Léonard, France
External PT using BBR VT CONA CME BT with monostrands

Renewed strength for vital infrastructure

The ultimate flexibility of BBR technology – as well as the innovation of the BBR Network – is demonstrated very clearly in projects which breathe new life into structures. One such example is the repair of a viaduct in Northern France, where French BBR Network Member, ETIC has recently had a further opportunity to showcase their expertise in installing external post-tensioning. Project Managers Victor Barray and Antoine Dupré report on the work their company is undertaking and the challenges of working in such an exposed location.

The Echinghen Viaduct was built in 1996, near the town of Saint-Léonard, close to Boulogne-sur-Mer in the Pas-de-Calais region of Northern France. It is part of the A16 motorway which runs along the French coast from the Channel ports – in a southerly direction to Amiens and the Paris area and northwards to the Belgian border. The Echinghen Viaduct and two other motorway bridges are together known locally as the 'Boulonnais Viaducts' or simply 'Le Boulonnais'. Today, this part of the A16 motorway is a toll road which is managed and maintained by Société des Autoroutes du Nord et de l'Est de la France (SANEF).
The 1,301m long Echinghen Viaduct is a post-tensioned concrete box girder construction with a main span of 110m and standing, at its tallest, 70m above the landscape. In 2017, during routine inspections, the viaduct was showing signs of ageing, thus after imposing speed limits and heavy vehicle restrictions, the operator SANEF commissioned renovation work.

Unique repair challenge
The team from ETIC is replacing 11 external post-tensioning tendons. The project is unique as it consists of replacing 19T15 bare strands with 15T15 BBR VT CONA CME BT tendons with monostrands. The strands need to be fitted within a 110mm diameter HDPE duct which means that the duct will be filled to around 60% of capacity – that alone is a tricky job! ›


1

Special component design

In addition, as some of the tendons need to be replaced after only 23 years' service, the client wanted a system with easily exchangeable tendons should the same defects arise again after a just few decades. However, the viaduct was built using a non-BBR post-tensioning system. This meant that the ETIC team had to find a way of adapting the new BBR VT CONA CME post-tensioning to the existing system.

To achieve this, ETIC designed a special component they called 'the lantern' – basically, this is a thick steel element screwed onto the old trumplate on one side and which holds the double layer of CONA CME post-tensioning on the other side. The idea is to use the old anchorages to install the new BBR anchorages, thereby avoiding the need to cast any concrete sections for installation of a complete BBR anchorage.

The project presented many challenges. For example, it was impossible to use the basic pushing method for strand installation since there was so little space in the duct. The solution was to pull all the 15 strands together into a bunch and then, using a winch, all the strands were pulled inside the duct.

Outlook & future challenges

As CONNÆCT 2020 goes to press, ETIC will be putting the final touches to their work – completion was carefully scheduled before winter really hits this region where climatic conditions would be very tough for the people working in such an exposed location. At the end of the external post-tensioning work, the motorway will be fully reopened to road traffic.

This project – along with our work on the two viaducts for the A9 motorway as reported in the last edition of CONNÆCT – will be an important reference for ETIC in the future, as there will be many projects like this in the coming years. In France, as in much of western Europe and indeed North America, most infrastructure has been in place for many years – and, as this project illustrates, the challenge now is now to maintain these important structures using the best and latest technology and techniques to ensure their continued service.

1 A vital infrastructure element, the Viaduct d'Echinghen in the Pas-de-Calais region of France, has been strengthened with BBR VT CONA CME BT external post-tensioning and given a new lease of life.

2 The program for strengthening work on the viaduct was carefully scheduled to avoid exposing the workforce to the harsh local winter conditions.

TEAM & TECHNOLOGY

Client – SANEF
Main contractor – ETIC SAS (France)
Technology – BBR VT CONA CME external
BBR Network Member – ETIC SAS (France)

2

1

2

Downtown wharfs, Auckland, New Zealand Repairs & strengthening work

Supporting a downtown transformation

Two major events scheduled for 2021 have driven a long-term wharf repair and strengthening project in Auckland, New Zealand – the America's Cup and the APEC 2021 Leaders' Week.

1 The Downtown Ferry Terminal in Auckland, New Zealand where BBR Contech have carried out repairs and strengthening work.
2 Repairs at the Downtown Ferry Terminal site included bracing to the underside of the wharf.

TEAM & TECHNOLOGY

Client – Downtown Joint Venture
Main contractor – BBR Contech
Structural engineer – Beca
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

In March 2021, Auckland will host the 36th America's Cup which, having been recognized for almost 170 years as the world's premium yachting event, is the oldest trophy in international sport. About 26,000 international and 175,000 domestic visitors are expected to travel to Auckland to watch Team New Zealand defend its title on the Waitematā Harbour, with the event likely to generate up to NZ$1 billion in value for New Zealand's economy.

Later in the year, Auckland will provide the venue for the APEC 2021 Leaders' Week – the culmination of a year-long event that will be the largest ever hosted by the New Zealand Government. An estimated 10,000 attendees are expected to be in the city for Leaders' Week, including world leaders, trade and foreign ministers, business leaders and international media. In preparation for these events, Auckland's waterfront and lower downtown area are being given a NZ$2 billion facelift – the biggest concentrated urban transformation ever undertaken in New Zealand. The aim is to provide the infrastructure for the America's Cup, an outstanding destination for visitors and a long-term legacy for the people of New Zealand. BBR Contech has been involved in repairing and upgrading Auckland's wharves and ferry terminals for more than 25 years. The company returned to the waterfront for this project in 2018 (see CONNÆCT 2019) which has included works at Wynyard Wharf, where four of the America's Cup challenger syndicates will be based.

More recently, the team undertook a package of repairs to upgrade a portion of the Downtown Ferry Terminal – the hub of an extensive ferry network that connects Auckland city to surrounding suburbs and islands in the Waitematā Harbour and Hauraki Gulf. The first of a number of projects that will upgrade the infrastructure in the area, the repairs have involved hydrodemolition, reinforcing steel repair and replacement, plus reinstatement through a combination of box-and-pour-and-spray-concrete techniques.

The challenges have been many – including the tides and the need to work around the ferry passengers and timetables. But with the likely increased use of the facility in 2021, it's work that's well worth doing – the transformation will not only boost Auckland's reputation on the world stage, but also help to create a truly international city for today's and future generations.

Research & Development BBR VT CONA CMG system – Geotechnical strand ground anchors

New international benchmark in GT technology

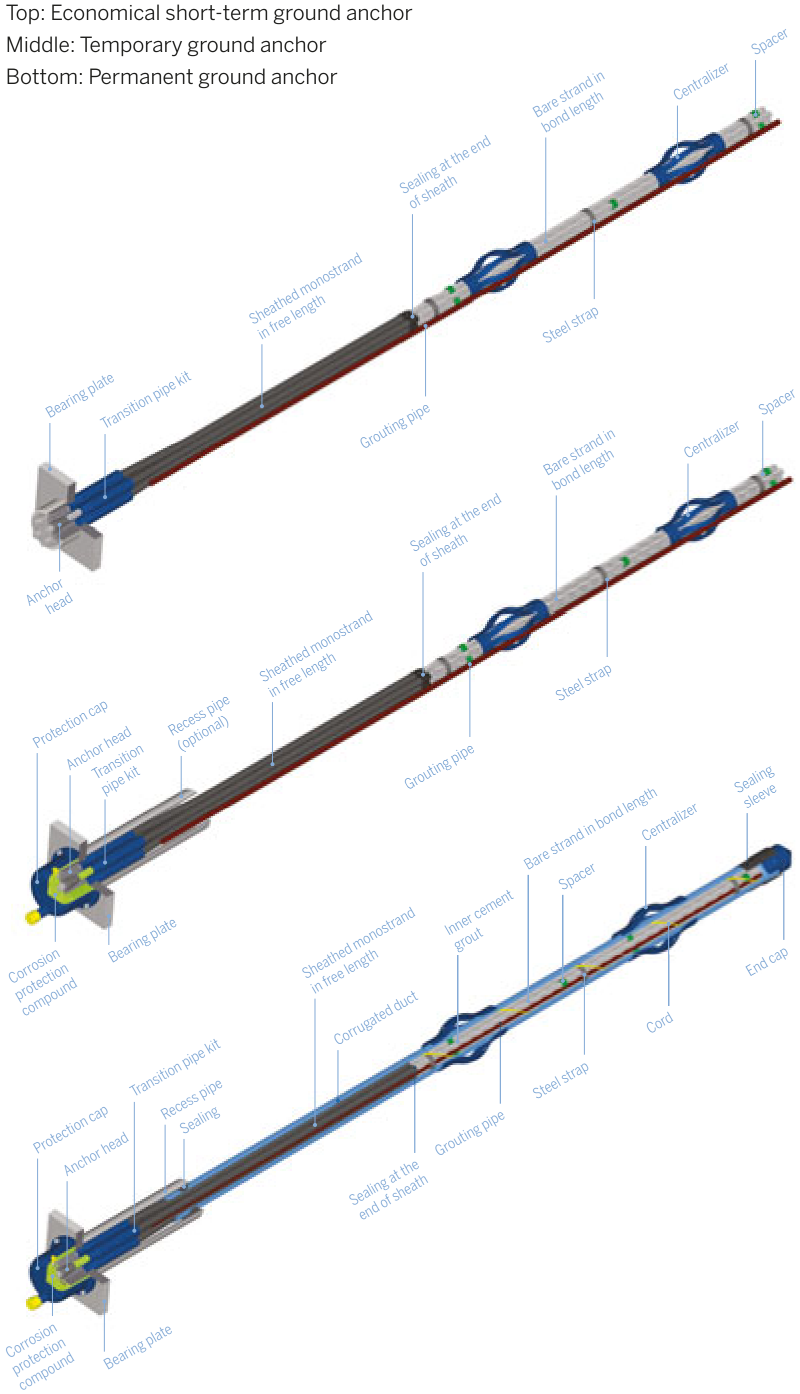
The BBR VT CONA CMG system is the very latest construction engineering technology which has been introduced to the international market with impeccable Swiss credentials – and proven high levels of corrosion protection. Dr. Ing. Xiaomeng Wang, BBR VT International's Senior R&D Engineer Geotechnical Systems, shares some details of this latest geotechnical system and the innovative and thorough testing process adopted.

The BBR VT CONA CMG strand ground anchor system offers state-of-the-art performance, including a wide size range across three different corrosion protection levels to allow customers to select the optimum force range and design life characteristics for specific projects. Designed for geotechnical applications, as soil or rock anchors, the system covers a maximum force range which aims to satisfy the major market demands.
The BBR VT CONA CMG anchor is an optimized system which has been designed to ensure both effective performance and economy. Our team has not only created a new benchmark in corrosion protection for ground anchors, but has also devised for the first time a method for measurement of grout cracking of a confined and stressed anchor under service load.

Main components & performance
The main components of the BBR VT CONA CMG system are:
- the anchorage & transition zone – including corrosion protection elements and a solution to lock-in the load bearing tendon elements
- the tendon in the free length – where the strands are unbonded, allowing free elongation
- the tendon in the bond length – where the strands are bonded to the surrounding ground by means of cementitious grout.

1

Solutions with BBR VT CONA CMG
Top: Economical short-term ground anchor
Middle: Temporary ground anchor
Bottom: Permanent ground anchor



2

BBR VT CONA CMG system: key benefits

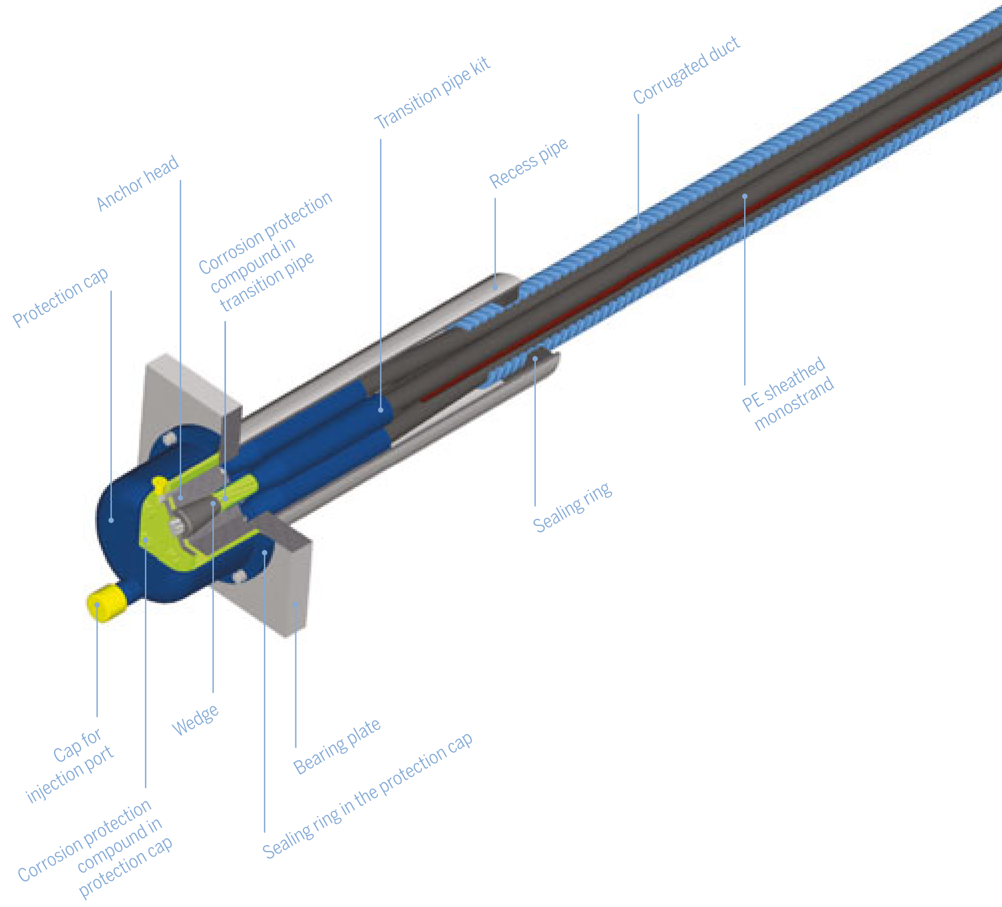
- Latest technology – engineered in response to recent market feedback mitigates drawbacks of existing solutions.
- Unique-in-the-market corrosion protection features – enhanced corrosion protection in transfer zone underneath the bearing plate and leak-tightness of the PE-sheathed strand, which meets the criteria of latest European Assessment Documents (EADs).
- Effective double corrosion protection solution – due to proven crack limitation of grout.
- Widest range of anchorage sizes – allows use of right size anchorage for each project, without needing to use oversized solutions.

Three solution kits

The BBR VT CONA CMG system provides three solution kits with different corrosion protection levels, designed for applications with different service lives – up to two years, extended use up to seven years and over seven years:

- Economical short-term ground anchor
  The BBR VT CONA CMG short-term solution is a temporary strand ground anchor for applications of up to two years and represents an economical solution. Key components are protected by a primary corrosion protection layer to guarantee the effective anchor performance through the limited duration of an application.
- Temporary ground anchor
  The BBR VT CONA CMG solution for temporary anchors is for applications requiring extended use of up to seven years. It offers at least one continuous corrosion protection layer around the periphery of the anchor. This solution is typically used to temporarily secure excavations as tie-backs on construction projects of longer duration.
- Highest durability permanent ground anchor
  The BBR VT CONA CMG permanent solution exhibits the highest corrosion protection level for a ground anchor of this type. It provides two complete corrosion protection layers, which form continuous barriers around the key steel components of the anchor.
  The fully tested and approved set-up of a BBR VT CONA CMG system ensures effective double corrosion protection through the corrugated duct and grout. Any potential cracking under service load is limited to a maximum of 0.1mm, as proven by testing and thus the grout is accepted as a corrosion protection layer.
  The BBR VT CONA CMG permanent solution is used for strand ground anchors which have a design life of over seven years as tie-back anchors, uplift control, slope stabilization or rockfall protection. >

New benchmark for corrosion protection
Corrosion protection of a ground anchor is crucial to achieving the desired performance, as the strand ground anchors are typically installed in ground conditions which vary in terms of density, porosity, water level and environmental aggressivity – and monitoring is impossible as the installed anchor effectively becomes invisible.
Since the 1980s, more-and-more attention has been drawn to the corrosion of strand anchors. A study from the *fib* working group on ground anchorages revealed that, among 42 failure incidents examined due to tendon corrosion, most of them occurred at the anchorage or transition zone (19 incidents) and in the free length (21 incidents), while only two incidents occurred in the bond length. The high risk of corrosion on the anchorage, transition zone and the free length has been confirmed by other recent studies such as those by Mothersille (Australia, 2011) and Liao (Taiwan, 2018).
The outcome of the studies on historical cases have been addressed within the BBR VT CONA CMG system which takes corrosion protection to a whole new level. Alongside common, robust corrosion protection methods, this system introduces a set of performance-enhancing measures which are totally new to the market. With these new corrosion features, the CONA CMG system has set a new global benchmark in the development of construction technology.

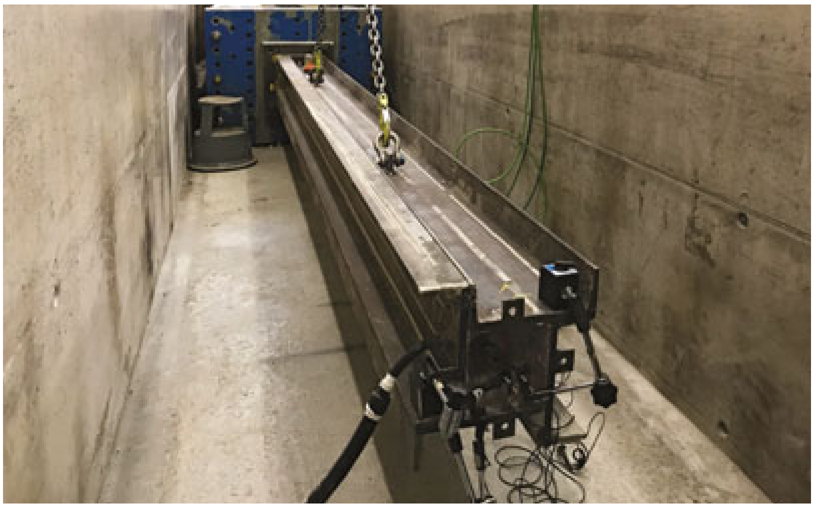


3

- **Transition zone sealing**
  It is now well-known that the transition zone beneath the anchorage zone bears the highest risk of corrosion. The PE sheath of the free length of monostrand ends in this zone and thus the bare surface of the strands can be exposed. Unlike many unsecured filling solutions applied in the market, the BBR VT CONA CMG system provides a fully sealed transition pipe kit for each individual monostrand. The transition pipe is sealed against water ingress up to 3.5 bars at the two ends. The space within the transition tube is filled with corrosion-inhibiting compound (optional for short-term solution).This solution minimizes the risk of full tendon failure as the bare strand protruding beyond the PE sheath is fully encapsulated by the transition tube and flexible anti-corrosion compound. Should one strand somehow become exposed to corrosion, all the other strands are still fully protected and isolated from the corrosion source. While maximizing corrosion protection, this unique solution can also minimize workload as the transition pipe kit is pre-assembled in the factory. The seal between the recess pipe and corrugated duct is yet another key feature of BBR's system. The solution is designed for BBR VT CONA CMG permanent anchors and tested accordingly.

- **Monostrand in free length**
  In a ground anchor, the free length of the tendon is unbonded from grout so as to transfer tensile force from the bond length to the anchorage. Lack of proper protection of the tensile element in the free length from alkaline cementitious grout exposes it to possible corrosion, such is often the case in existing solutions. In a monostrand, the free length of the strand is covered by a flexible and durable PE sheath and the cavity between the strands and PE sheath is filled with anti-corrosion compound. The monostrand is designed to be leak-tight (according to EAD 16) and the joint position between the free length and bond length is fully sealed up to 3.5 bar to avoid water or cementitious grout ingress.

- **Proven bond length protection**
  The BBR VT CONA CMG system is the very first strand anchor system in which the cementitious grout in the single layer corrugated duct has been designed and proven by testing to be an effective protection barrier against corrosion according to EN1537. This certified double-layer protection solution for BBR VT CONA CMG permanent anchors delivers a significant economic advantage when compared with other solutions on the market which typically feature two layers of corrugated ducting – requiring larger boreholes, bigger drilling equipment, more materials and other resources which mean additional costs– to achieve the same international standard requirements for corrosion protection.



4

... the CONA CMG system has set a new global benchmark in the development of construction technology.

Testing provisions for mechanical & corrosion protection performance

While testing and approval verifies that the BBR VT CONA CMG system meets all the requirements of EN1537, we apply the same strict approach to quality and performance to all of our technologies. The mechanical performance of the BBR VT CONA CMG system has been assessed, tested and proven as a member of the BBR VT CONA CMX system family range according to the latest European Assessment Document EAD 160004-00-0301 following all the testing provisions – static, fatigue and load transfer tests.

Assessment & verification of constancy of performance

The CONA CMG system has been assessed and proven in the same way as BBR ETA approved post-tensioning systems with the objective of establishing the CE mark for this product in the near future.

After the strict initial assessment of the system, the constancy of performance is ensured by yearly audit of component manufacturers as well as BBR Factory Production Control (FPC) which includes continuous surveillance and full traceability, as well as Pre-Delivery Inspection (PDI) before every order is dispatched.

1 The BBR VT CONA CMG strand ground anchor is an optimized system which ensures both effective performance and economy while setting a new benchmark in corrosion protection. Pictured here, ground anchors are being installed for a wind tower at the Årjäng & Tanum Wind Park in Norway.
2 (Top) The BBR VT CONA CMG short-term economical strand ground anchor solution. (Middle) The BBR VT CONA CMG temporary strand ground anchor solution. (Bottom) The BBR VT CONA CMG permanent solution – providing highest durability strand ground anchors.
3 Bare strand in the transition zone is fully encapsulated by a transition pipe and flexible anti-corrosion compound.
4 Advanced corrosion protection test B – with crack width assessment method.

Technical Update Renewal of ETA for BBR VT CONA CMF

European Assessment renewed for CONA CMF

The European Technical Assessment (ETA-12/0076) has been renewed for BBR VT CONA CMF post-tensioning technology and is available on the BBR Network website for download.

This ETA covers both the CONA CMF S1 system and the advanced next generation CONA CMF S2 system which offers the widest anchorage and coupler size range and the thinnest possible slab depths on the international market. Furthermore, the CONA CMF S2 system requires only one type of anti-bursting reinforcement – either helix or stirrup – and features the lowest reinforcement requirement of any system currently available.

The optimized design of the CONA CMF S2 system also achieves the smallest minimum center spacing and slab thickness at low concrete strength for all sizes on the market. The CONA CMF S2 system can be integrated with the CONA CMO system (ETA-15/0808) as the fixed anchorage, contributing to increased efficiency in terms of installation, a reduction in labor requirements and materials consumption.

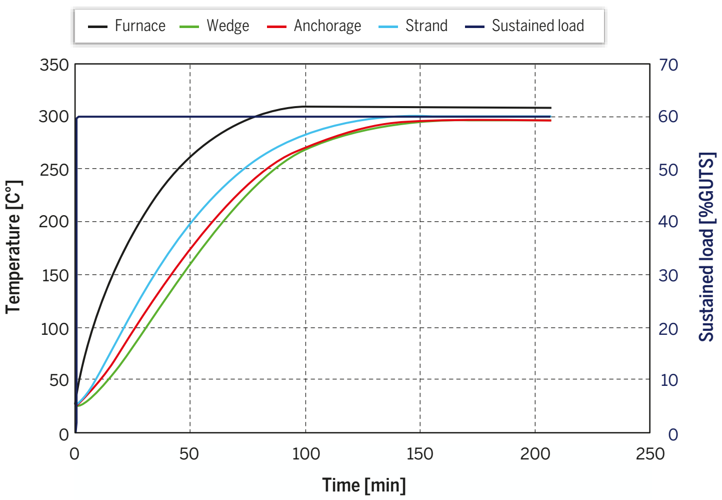
Research & Development High temperature behavior of BBR HiAm CONA system

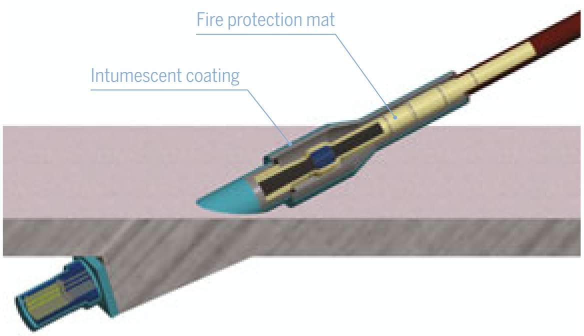
Outstanding fire resistance performance of stay cables

The BBR HiAm CONA stay cable system is state-of-the-art as far as stay cable technology is concerned. It also meets more stringent requirements in terms of high temperature behavior than are required by international recommendations.

The fire resistance of the main tensile elements in a stay cable bridge becomes a crucial factor in some situations – such as a tanker truck accident resulting in a hydrocarbon fire near a stay cable or when the bridge is located close to areas like fuel depots or oil refineries. The BBR HiAm CONA system shows a guaranteed performance even under such exceptional conditions.
Firstly, with a special fire protection system the temperature of the main tensile elements of the HiAm CONA system are designed to remain below 300°C for at least 30 minutes in the event of a hydrocarbon fire with a temperature of 1,100°C. Secondly, all the load-bearing components – including wedges, anchorages and strands – exhibit well over 30 minutes of fire resistance at a minimum temperature of 300°C and sustained load of 60% GUTS.
With these key features, the BBR HiAm CONA system meets more stringent requirements than those presented in international recommendations.

1 Graph showing high temperature mechanical resistance test results of BBR HiAm CONA system components.
2 BBR HiAm CONA fire protection system.

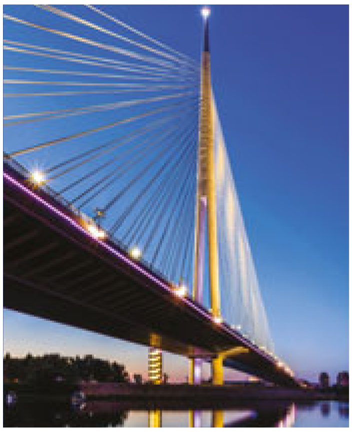




Research & Development Stay cable illumination

Lighting up landmarks

The design of modern bridges places more-and-more focus on aesthetical aspects of the structure. Compared to the traditional solution of installing wall-washer lights on bridge decks or pylons, the BBR HiAm CONA system offers a more advanced lighting system by either integrating durable, waterproof and replaceable LEDs into stay pipes or using self-illuminated stay pipes. Both solutions are simple to use and ensure dynamic and thermal performance of the stay cable. With a choice of different colors, the BBR HiAm CONA system keeps your landmark project shining in darkness.



Techniques Working with MSS Technologies

Automating the construction process

One of the hottest topics in the construction industry is productivity – and how to increase it. Without doubt, the use of smarter technologies and techniques plays a major role in speeding up the process. Efe Bayram from Turkey-based BBR Network Member, Kappa shares an insight into the massive time and materials savings his company has delivered for customers through the use of Movable Scaffolding Systems.

Over
650,000t
materials saved

1

2

The usage of MSS for a span of 90m is unprecedented – previously the largest bridge span constructed using MSS technology was 70m.

1 One of Kappa's Movable Scaffolding Systems (MSS) which significantly reduce the time needed to construct a bridge span.
2 The MSS in action on the Kayaş-Yerköy high speed railway viaduct project.
3 Shown here illuminated at night, the MSS-90 spans 152m from front-nose to rear-nose and makes use of a 'bowstring' type truss to overcome stresses associated with the large span size.

The Movable Scaffolding Systems (MSS) can be used in the span-by-span deck construction of viaducts and bridges. This technology can reduce self-weight in viaducts and bridges thereby cutting material usage by 40%. Automating the construction process cuts-down time allocated to non-value adding activities and eliminates the need for additional labor.

Enhanced safety & unprecedented spans

In addition to the time and material advantages it provides, the MSS can reduce operational risks and provide safer working conditions relative to traditional scaffolding systems.

We currently possess two systems – an MSS-55 and MSS-90 designed and manufactured by BERD – which are used for maximum spans of 55m and 90m respectively. The usage of MSS for a span of 90m is unprecedented – previously the largest bridge span constructed using MSS technology was 70m.

Recently, we have deployed our MSS technology for the Kayaş-Yerköy high speed railway viaduct project. The project consists of four individual viaducts with a total length of over 6km. The customer had originally planned to use traditional balanced cantilever construction methodology for the viaducts. On learning that we could provide them with huge savings on labor and material usage, they adapted their plan to take advantage of our MSS capability.

MSS overview

The MSS-90 spans 152m from front-nose to rear-nose. It has a height of 20m and a width of 18m. Structurally, it makes use of a 'bowstring' type truss to overcome stresses associated with the large span size.

Overhead crane system & locomotion

The overhead crane system is powered by two winches located on the MSS. The movement of free supports through the overhead crane system allows the MSS to perform pier-to-pier locomotion. Additionally, bridge deck reinforcement can be pre-assembled and brought to the work front using the same winches. This provides a tremendous time advantage over manual on-site assembly. The construction of each 90m span takes an average time of 13 days. Each deck span makes use of 70t of prestressing steel. This duration is much shorter when compared to other methodologies used for performing the same operation.

Kayaş-Yerköy High Speed Rail Viaduct Project			
Viaduct No	Width (m)	Length (m)	PT tendons (tons)
7	13.2	1,800	1,246
9	13.2	1,273	950
10	13.2	1,541	1,067
15	13.2	1,437	995
Totals		**6,051**	**4,258**

Organic Prestressing System

The MSS-90 makes use of an Organic Prestressing System (OPS) named after its biomimetic design. The OPS adaptively reduces deformations in a structure caused by varying live loads. In the case of the MSS-90, the PT tendon stresses are adjusted as concrete loads are added. The mid-span deflection is measured by means of pressure transducers located on the truss structure. When the transducers detect that mid-span deflection is greater than the pre-defined limit, the hydraulic cylinder stroke length is automatically adjusted to increase tension in the tendons.

Electrically powered concrete forms

The concrete forms used for the deck are electrically powered. This allows for shorter concrete pouring durations and greater reliability relative to hydraulically powered alternatives.

Eliminating dependency on geographical conditions

Ultimately, the MSS can eliminate dependency on geographical conditions. Additional spending on improving site conditions – such as creating access roads and improving ground conditions for scaffolding – can be greatly reduced. The advantages offered by the all-round performance of the latest MSS systems are compelling and will continue to deliver outstanding results for our customers.

Efficiency-oriented design for a green future

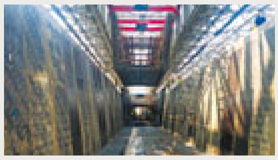
Through efficiency-oriented design, the MSS has reduced material usage by more than 50,000 trucks-worth of concrete and 45,000t of steel. This amounts to a 28,000t reduction in carbon dioxide emissions. Considering that cement production has been estimated to represent a massive 8% of all global carbon emissions annually, MSS technology is exemplary in its ability to considerably scale-down the carbon footprint associated with such projects for transportation infrastructure.

3

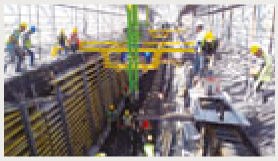
Step-by-Step Guide

Step 1: The MSS is brought to its initial concrete pouring position after pier-to-pier movement. The exterior concrete forms are closed.

Step 2: Pre-manufactured steel reinforcement fitted with PT tendon ducts is brought on-site using the overhead crane.

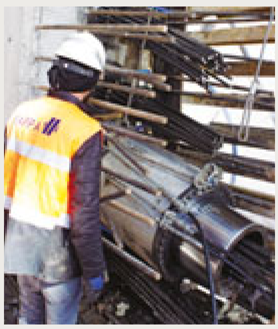


Step 3: Interior formwork is assembled and phase one (web) concrete is poured.



Step 4: Scaffolding for the concrete deck is installed. Deck reinforcement fitted with PT tendon ducts is brought on-site. Phase two (deck) concrete is poured.

Step 5: Once the deck concrete is cured, the PT tendons in the wall are stressed. After stressing, the concrete loads can be transferred from the MSS to the bridge deck itself.



Insight Leveraging latest technology for enhanced construction productivity

The dawn of digital fabrication

For some time now, it has been widely acknowledged that the construction industry is lagging behind other sectors in terms of productivity and it has also been singled out as the least digitized industry. As the industry strives to redress the balance, Dr. Behzad Manshadi, CTO of BBR VT International, examines what contribution BBR and the BBR Network have made and how they continue to adapt their approach to increasingly demanding customers and the fast-evolving digital environment.

1

BBR has always been a pioneer of new technologies to support the construction industry – in fact, this is the very reason the business was created. When the three BBR founders began their work to develop the then new technology of post-tensioning, they were driven by a materials shortage and need for speed in the post-war reconstruction process. Their investment quickly extended to securing factory facilities where some of the earliest modern prefabricated post-tensioned structural components were produced. They also invested in developing leading edge specialist equipment to measure and test structural integrity and to facilitate their work. This commitment to improving construction with latest technology, over 75 years on, is still a cornerstone of the BBR business.

2

3

Optimized technology

Over the years there have been many new BBR developments, but in the context of today's market the continual drive to optimize BBR technologies is perhaps the most relevant. Recognizing that ease of on-site installation is a crucial factor in achieving greater productivity, our R&D team has focused on refining our post-tensioning systems and accessories to promote program savings. For example, with the introduction of the BBR VT CONA CMM and CONA CMF S2 systems – as featured in the 2017 and 2019 editions of CONNÆCT, respectively – we offer an advanced generation of unbonded and bonded flat post-tensioning which features the lowest minimum center spacing and slab thickness at low concrete strength for all sizes on the market. This translates into a reduction of up to 36% in the amount of concrete used, thus cost saving on materials, plus reduced CO_2 emissions and related impacts on the environment.

Prefabricated Prefinished Volumetric Construction (PPVC)

Among the initiatives undertaken in the BBR Network has been the venture into PPVC in Singapore, whereby the prefabricated approach to housing is thought to increase productivity by up to 50%. BBR Construction Systems (Singapore) in conjunction with BBR Holdings' subsidiary Moderna Homes, were the first in Singapore to complete a residential project under the Government Land Sales (GLS) scheme using PPVC technology. Please refer to CONNÆCT 2019 for the full story. ›

4

Precast segmental construction

Meanwhile, for many years now, the BBR Network has been carrying out projects where precast post-tensioned segments have be used to create viaducts for metro rail systems. Off-site segment manufacture creates a greater opportunity for quality control, while just-in-time delivery promotes more effective working and less congestion on site.

Digital fabrication

Robotics have been used for years in other industries – for example the automotive industry – and now, combined with other technologies, this has been extended to the construction sector. In the last 12 months, here in the Zurich area not far from BBR Headquarters, we have seen the creation of the DFAB HOUSE.

The project is a collaborative demonstrator of the Swiss National Centre of Competence in Research (NCCR) Digital Fabrication and is sited on top of the NEST Building of Empa and Eawag. NEST (Next Evolution in Sustainable Building Technologies) is the world's first modular research and innovation building aimed at accelerating the innovation process in the construction sector.

As part of the full-featured building project, the DFAB HOUSE initiative has brought researchers from eight different disciplines within the Swiss Federal Institute of Technology (ETH Zurich) together with industrial partners and planning professionals in a unique way to not only digitally design and plan the buildings but also build using predominantly digital processes, both on-site and off-site with the help of robots and 3D printers.

BBR VT CONA CMM monostrand post-tensioning tendons were installed into the 'Smart Slab' – a 80m² post-tensioned concrete slab made up of eleven 7.4m-long segments. Every segment is unique and was prefabricated, using the 3D printed formwork, with special interface features which facilitated on-site connection through post-tensioning tendons. The Smart Slab's geometry is structurally optimized for its challenging load-case, involving cantilevers of up to 4.5m. The material is distributed in a hierarchical grid of curved ribs, which vary between 30 and 60cm in depth. In addition, the interstitial surfaces stabilize the grid and are only 1.5cm thick. Consequently, the slab only weighs 15t – almost 70% less than a conventional solid concrete slab.

5

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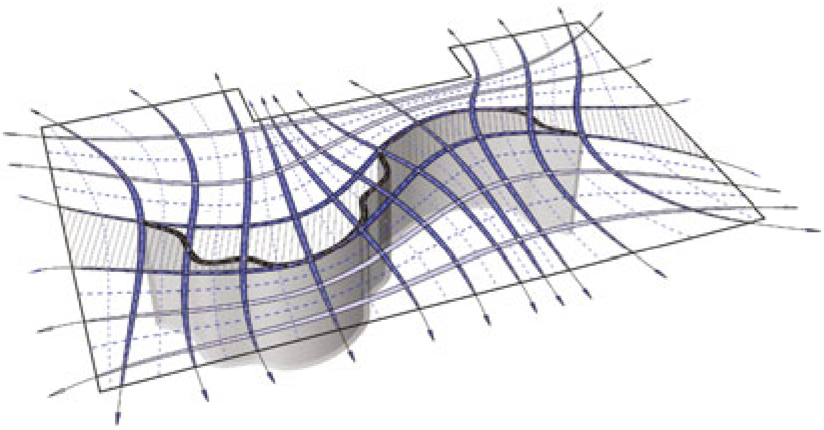

7

As well as a delicate concrete ceiling – cast in 3D printed formwork, the house features a curved concrete wall created by a construction robot, plus voice-activated domestic installations.

Although analysis of the DFAB HOUSE will be ongoing for some time yet, it is a foretaste of what our industry can and will achieve. It is significant that the project owes its reality to a cross-functional team and wider collaboration with industry. In this spirit, we have already shared this information by inviting the project's leading architect Dr. Benjamin Dillenburger, Assistant Professor for Digital Building Technologies at ETH Zurich, to present to delegates at the 2019 Annual Global BBR Network Conference.

The construction industry is at the dawn of digital fabrication, the widespread use of these novel techniques is still some way off in the future, however it can be envisaged that they will eventually extend to all types of structure. As we regard an increasingly digital outlook, the team at BBR Headquarters will always be ready to pioneer yet further new technologies and techniques to drive the agenda for improvements and optimization in our industry, while maximizing the benefits for the BBR Network and its customers.

For further information about the DFAB HOUSE, please visit www.dfabhouse.ch.

1 Inside the DFAB HOUSE – the world's first house to have been digitally planned and constructed largely digitally. Shown here is the completed Smart Slab which cantilevers from the double-curved Mesh Mould wall towards the façade.
2 1966: A BBR post-tensioned prefabricated component of a car park overbridge is lifted into place in Zürich. All components were manufactured in a controlled factory environment, transported and, finally, placed into position during a single night-time road closure. Image courtesy of ETH-Bibliothek Zürich, Bildarchiv, photographer Kurt Salvisberg, licensed under CC BY-SA 4.0, Com_L15-0555-0007-0002.
3 2018: BBR Construction Systems (Singapore) in conjunction with BBR Holdings' subsidiary Moderna Homes, were the first in Singapore to complete a residential project under the Government Land Sales (GLS) scheme using PPVC technology.
4 2013: BBR Malaysia used prefabricated segments to form the viaduct for the extension to the Kelana Jaya Metro system. Off-site manufacture of the segments allowed greater quality control and just-in-time delivery promoted more effective working during night-time road closures.
5 2019: Digitally planned and largely digitally constructed, the three storey DFAB HOUSE building sits on the NEST research and innovation building belonging to EMAP and Eawag in Dübendorf, near Zurich.
6 A segment of Smart Slab for the DFAB HOUSE being lifted into place, ready for stressing with BBR VT CONA CMI internal PT tendons.
7 The structural principle of the 80m² Smart Slab for the DFAB HOUSE is a hierarchical grid of post-tensioned ribs cantilevering from the curved Mesh Mould Wall.

Thinking Aloud Warwick Ironmonger, CEO of BBR Network Member Spennteknikk International AS & Member of the Board of BBR VT International Limited

Advantage of global dialogues

With more efficient travel options and increasingly more effective communication technologies at our disposal, the world has become a smaller place over the past few decades. This has opened up a wealth of opportunities not only for businesses to extend their reach, but also for individuals to adopt an international approach to their careers.

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Have you ever wondered how you came to be in your current job – or even in your current location? It's not something I had considered before being invited to present some thoughts for CONNÆCT. Looking around now, I can see that two major factors have played a role in shaping the paths of my own career and the businesses I have represented – advancing technology and the power of networking on a global scale. Of course, to be successful, you have to be committed and proficient within the fields you work too.

Capturing the imagination

I was born and educated in Sydney, Australia and never had any inclination to travel extensively abroad. However, my chosen field of civil and construction engineering has taken me to the Philippines, UK, Middle East and, more recently, to Scandinavia and Central Europe.

Some 27 years ago, as a newly-qualified engineer, I joined a leading consulting engineering practice in Sydney after becoming completely captivated by the images of fantastic buildings that they were involved with. It was only later that I discovered these projects were mostly overseas and it was seeing something larger than the local market that captured my imagination. After a few years of working in Australia, I was seconded first to a project in the Philippines and then, having volunteered to actively seek opportunities elsewhere, went onto Dubai. At that time, Dubai wasn't so well-known and I even had to look at an atlas to find out where it was.

Growth in the business in this new territory for the company came about through developing a reputation for good value engineering leading to alternative solutions and building trust while promoting the benefits of the business. Landmark projects included the Burj Al Arab and Emirates Towers.

The level of business success – and my own interest – meant that I stayed there for four years. This was what you might call a formative time – reputations and relationships were built in those years that have continued to deliver returns for the companies I worked for and for my own job satisfaction.

Renewing acquaintances

After a brief spell back in Australia, I began what has become a long and rewarding relationship with the BBR Network, by joining Structural Systems Limited – now known as SRG Global. Initially, this new role led me to be engaged on projects in England but it wasn't long before the company needed someone to further develop their business in the Middle East. This time, a map was not required! We could see opportunities all around us and tapped into them by actively networking with the managers of various leading contracting companies.

Expanding from our base in Dubai, we set up a business in Abu Dhabi primarily to support the LPG sector and also opened further businesses in Oman and Qatar to capitalize on infrastructure opportunities. After 16 years of being based in Dubai, the opportunity to take on some new challenges in a different part of the world, specifically Scandinavia, was too good to miss.

Mobile talent

My arrival in Scandinavia was preceded by a conversation with Svein Finstad, former CEO and now Board Member of Spennteknikk International AS. We had known each other for some years through the BBR Network and the mutual understanding which we had developed meant that I knew the level of business opportunity which existed and he believed that I had the right skill set for the job.

You can imagine my surprise when I discovered that one engineer I had earlier employed at SRG Global in Dubai is now involved in our business in Scandinavia. It is probably in the DNA of BBR Network engineers that they are highly mobile.

When you look around at the BBR Network Members, you can see that the individuals are very dedicated, they really do throw their all into the job. This is great to see, especially in an era when you sometimes hear of others taking a short cut here-and-there. The BBR Network certainly attracts and retains good people.

3

Sharing knowledge

The various BBR Global Conferences are a great forum for sharing information. The structure of the events themselves bring all BBR Network Members closer – and developing closer relations always opens your mind to things. Over time, we also gain an understanding of the capacity of other Members. For example, many of us at the last BBR Conference could see that there may be future potential to work together with the newest BBR Network Members, Kappa in Turkey and ESPT in Egypt.

Networking within the BBR Network has worked well for us as a group of specialist contractors in the past. A classic example is the Doha Metro Red Line project in Qatar. The opportunity there for SRG Global to be involved came via Spanish BBR Network Member BBR PTE whose parent company FCC was part of the main consortium building the project. Reaching out immediately to BBR PTE and FCC allowed SRG Global and BBR PTE to collectively develop the right proposal to jointly win the post-tensioning work for the 6.5km of elevated viaduct.

Mutually beneficial business

Quite recently, Spennteknikk were bidding for a major project involving several highway bridges in Norway. Spennteknikk have a wide reputation as a specialist construction engineering contractor in the local marketplace and BBR post-tensioning is well-received. However, within the scheme there are incrementally-launched bridges – a methodology in which BBR Polska has much experience. To cut a long story short, we ultimately secured the project after taking the client to Warsaw to meet the team and witness some professional bridge launching in progress. Without the support of BBR Polska, Spennteknikk may not have won the significant post-tensioning works on the launched bridges – and, in turn, without us, BBR Polska would not be planning for a major launched bridge project in Norway. Together, we now have the job to deliver Spennteknikk's largest-ever project in Norway. So, how did this happen? Quite simply, through networking – as both parties are BBR Network Members. Today, BBR Polska is a subsidiary of Spennteknikk International AS and a sister company of KB Spennteknikk AS, one of the shareholders in BBR VT International Limited – even this relationship has its roots in the BBR Network. Naturally, our client also shares our passion for quality construction engineering technology and services – and is, of course, delighted that they have a single source for the complete service they need.

Open mind & open dialogue

So much of this journey has been unplanned, but is no doubt the result of an underlying strategy to keep all kinds of dialogues open and keep an open mind. Depending on your location and destination, the culture, clients, geography and weather can be somewhat different, but the drive to transact successful business stays the same. Good communication and advanced technology, wherever you are in the world, are massively helpful and these are certainly two of the many strengths found in all parts of the BBR Network.

1 The Burj al Arab – a landmark project which was initially a contract for post-tensioned floor slab design and supervision, ultimately evolved to encompass general construction engineering support.

2 Other early projects included building movement control work on the Emirates Towers, pictured here, plus a range of value engineering projects – where a post-tensioned approach was often advocated – for other major international players.

3 Viaduct on the Doha Metro Red Line South – the award of this project was a classic example of how networking within the BBR Network promotes mutually beneficial business.

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.

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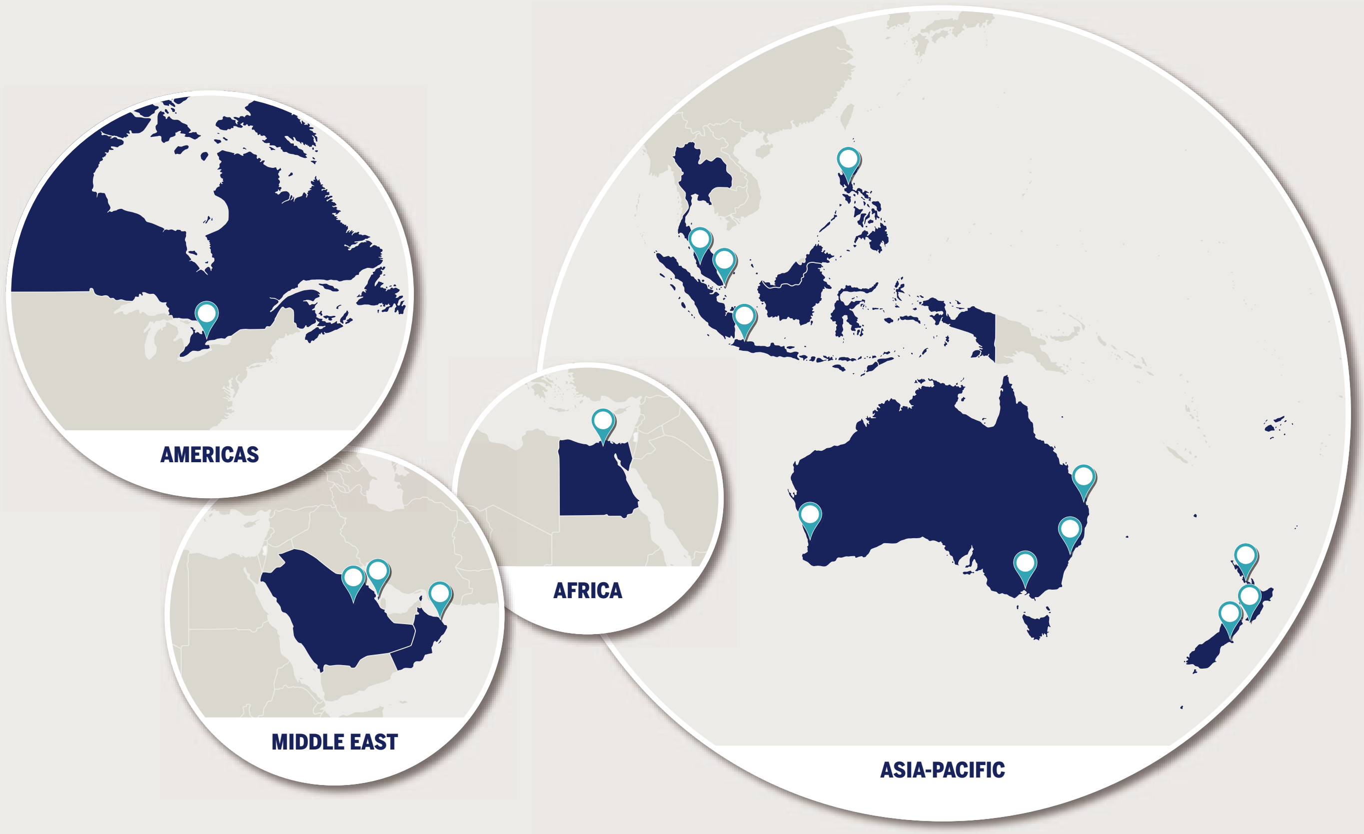

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