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Edition 16 | 2022

CONNECT

THE MAGAZINE OF THE GLOBAL BBR NETWORK OF EXPERTS

TOWARDS CARBON ZERO
BBR CEO's reflections on smart use of construction technology

WORLD'S FIRST ETA APPROVED STRAND GROUND ANCHOR
BBR VT CONA CMG unique in the market place

TRADITION MEETS MODERNITY
Malaysia's newest stay cable icon

TWINNING IN TOURAINE
Motorway viaduct twinning in France

THREE MILLION MILESTONE
BBR ground slab achievement in NZ

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.

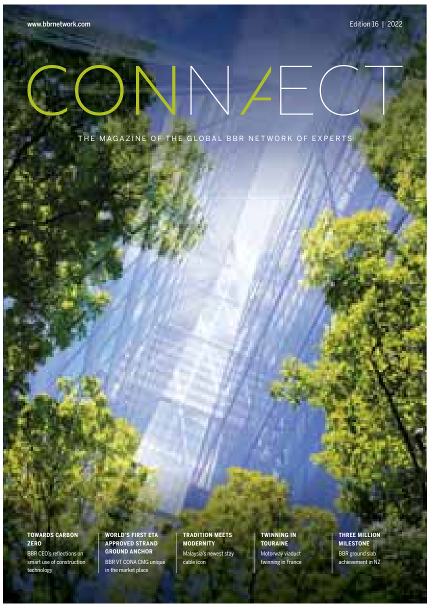
ACTIVITIES OF THE NETWORK

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).



Together we can make a difference

It is our great pleasure to welcome you to the 2022 edition of CONNÆCT – the BBR Network's annual magazine. This time around we bring you some interesting insights, useful background information and some great news about BBR technologies. There is something within these pages for everyone!

In the bridge construction arena, the BBR Network has provided latest technologies and techniques not only to speed construction, but also to make the structures themselves leaner and more durable. You can read about high level motorway viaducts flowing sleekly through narrow valleys, city center viaducts whose durability has been assured with electrically isolated PT tendons and still more bridges providing practical yet aesthetically pleasing river crossings.

The excellence of BBR technologies and skills can be in no doubt when you see the major achievements in the ground slab market in New Zealand, the newest landmark building in Poland and the latest projects for the retail sector in Croatia and Slovenia. All over the world, the BBR Network is raising the standard of spaces designed for people.

In the Special Applications and MRR sections, awesome achievement meets fascinating facts! There are features which tell of how BBR teams and technologies have created important new facilities and prolonged the life – or assured the continued safe operation – of various structures.

However, we've saved the best news for last – in the Technology section! Here, you'll see how BBR's campaigning has resulted in greater regulation, hence durability, in the strand ground anchor field and how the BBR VT CONA CMG strand ground anchor system has become the first in the world to be accredited with a European Technical Approval (ETA).

Before closing the magazine, do please take a few moments to read the feature on the importance of carbon reduction in the construction sector and the value this creates. The techniques described are all very familiar to the BBR Network, so let's work to reduce embodied carbon in our built environment – together we can make a difference.

Marcel Poser
Chairman, BBR VT International Ltd

José Manuel Illescas
Vice Chairman, BBR VT International Ltd

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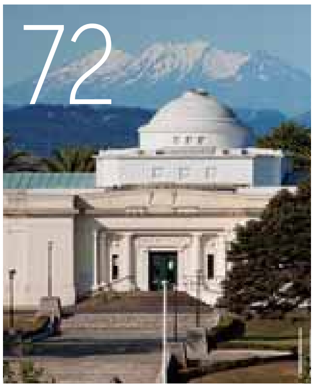

TECHNOLOGY

BBR DIRECTORY

Editorial, sources and references

EDITORIAL OFFICE
BBR VT International Ltd
Technical Headquarters and Business Development Centre, Switzerland
www.bbrnetwork.com
info@bbrnetwork.com

EDITOR
Jane Sandy
CONTRIBUTING EDITOR
Marco Zucconi
DESIGNER
Jenny Chillingworth
PUBLISHER
BBR VT International Ltd

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CONTRIBUTORS
Jaki Arthur, Mateusz Banasik, Derek Bilby, Zelimir Bodiroga, Sarah Brown, Cédric Brunner, Dejan Buha, Aurélie Caron, Daniel Cuerdo, Enis Dauti, Antoine Dupré, Dr. Haifeng Fan, Charlie Green, Goh Hiang Miang, Peter Higgins, Htun Zaw, Tarnya Inglis, Tomasz Jendernal, Sean Kelly, Prof. Johann Kollegger, Ivan Kušt, Lee Chuen Lin, Dickson Liew, Juan Maier, Dr. Behzad Manshadi, Jeff Marchant, Valentina Mihajlovic, Claude Néant, Marcin Ornat, Sam Pearce, Prof. Predrag Presečki, Bojan Radosavljevic, Faerdaus Rohaizad, Suzana Sapina-Dubravac, Mark Sinclair, Marek Strzoda, Jackie Voon, Dr. Xiaomeng Wang, Paul Wymer.

SOURCES AND REFERENCES
Front cover image: The construction sector is responsible for 38% of global carbon emissions and now faces the dual challenges of building infrastructure for the future and reducing its carbon footprint. See Page 88 for a special feature about how the construction industry can create significant value while reducing embodied carbon.

Talking BBR section
Making innovation successful: Preisinger, Clemens (2006), PhD-Thesis: Numerical and experimental investigations regarding the transformation of flat slabs to double curved shells, TU Wien.
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Setting standards for Slovenia's largest car park: https://seenews.com
New generation of retail experience: https://www.vecernji.hr
Pioneering stay cable landmark: https://www.jb-honshi.co.jp
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Building and Infrastructure Consumption Emissions In Focus, published by University of Leeds, ARUP & C40 Cities, August 2019.

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

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

Towards carbon zero

Our planet is rapidly overheating – never before has the need to reduce carbon emissions been so great. The pressure is on to reduce embodied CO_2 in new structures, while reducing wastage and further CO_2 emissions by extending the lifetimes of existing structures. BBR VT International CEO Juan Maier shares his thoughts about how the construction industry and, specifically, how the BBR Network can provide sustainable solutions based on latest technology and innovative techniques.

Over the past couple of years, we have seen the scientists and medical communities worldwide rise to confront the challenges presented by the insidious Covid-19 virus. They have worked tirelessly and under immense pressure to save lives and to find ways of helping us get back to a more normal way of living.

Now, it's our turn. We must work together to tackle climate change – and with some urgency. Human activity – and the carbon footprint we create – is impacting how our ecosystem functions. The effects can be seen in the extreme weather events we have experienced globally. It's time for us all to consider more carefully the macro-implications of our individual actions – each one of us has it within our power to make a difference.

At the same time, increasingly investors, shareholders, employers and even employees are demanding that organizations should be more sustainable, should look beyond financial factors when analyzing and evaluating business decisions and should become more environmentally and socially responsible. Strong environmental, social and governance (ESG) agendas are fast becoming a necessity to achieving enhanced value creation. As a result, the organizations that respond the quickest and most holistically to meet this challenge will ultimately be the most successful in generating value for all stakeholders. For more on reducing embodied carbon while creating significant value, turn to page 88.

Pioneering change

The BBR offering – and indeed reputation – was founded on low carbon principles. At the time that the first BBR post-tensioning system was conceived, the challenges were mostly about shortages of materials and speed of construction for rebuilding infrastructure and cities in the aftermath of the Second World War. While global warming was still a largely unproven and little publicized notion at that time, post-tensioning permitted communities and nations to rebuild quickly, with less steel and concrete materials and at a lower overall cost.

Fast forward to the present day, the construction industry is massive – and accounts for 40% of global carbon emissions. The industry's needs drive many other industries and its role in pioneering change continues to be significant. We have seen many governments around the world set green benchmarks for the design and construction of new buildings – and more-and-more, the strategic decisions of major institutions and companies are being driven by sustainability. While the construction industry has responded, there's still more to be done.

According to a recent report from the World Business Council for Sustainable Development, depending upon the type of building and its usage, embodied CO_2 can account for up to 50% of the total carbon emissions during a building's life cycle. This cannot be simply ignored.

Buildings and structural solutions which take a post-tensioned approach have significantly lower embodied carbon – the consequent reduction in materials consumption can lead to reductions of around 40% in a new building's embodied CO_2. Of course, this is the best of all worlds for developers and investors because they also benefit from reduced overall construction time and costs, as well as from an increased net-rentable floor area. A compelling value proposition from every angle.

Meanwhile, our R&D team is focused on ever-leaner solutions and BBR Network engineers work with other professionals to evolve best practice construction engineering design and application.

Promoting better design & construction

Take the BBR VT CONA CMX post-tensioning range, for example. It was developed, completely from scratch, in the early 2000s. While all the learning and benefits of the earlier BBR systems are incorporated, it features many newer concepts such as the advanced load transfer mechanism which effectively promotes smaller and more efficient structural cross-sections through its small tendon center spacings and concrete edge distances. A further feature is that the CONA CMX range requires less anti-bursting reinforcement at the anchorages and this, in turn, dramatically reduces the carbon footprint, as steel produces around 25 times more CO_2 than cement. Added to these advantages – and rather than adopting a potentially wasteful 'one-size-fits-all' approach – we offer the widest range of sizes, so that only the materials actually needed are used for each project.

Going a step further, by making a 'smart swap' and using low carbon concrete in conjunction with CONA CMX post-tensioning, embodied CO_2 can be reduced even more. >

Winning combinations

As many BBR Network Members already know, there are great advantages to using BBR technologies in combination with specialist techniques, most prominently in the bridge construction sector.

For example, a massive reduction in CO_2 was recently achieved through the use of Moveable Scaffold System (MSS) technology. On page 90, you can see how BBR Network Member Kappa deployed their world record breaking MSS to deliver an astonishing 46% reduction in embodied carbon, along with equally impressive material and cost savings too.

Then there is the incremental launching method (ILM) which reduces not only the need for scaffolding and single-use formwork, but also the amount of materials used and is less intrusive on the local environment. In the last edition of CONNÆCT, you'll have seen how BBR Polska used this method for two bridges in Norway. More recent examples are featured in the Bridges section and yet more are currently in the early stages of planning or construction.

Another great partnership is with the wind power market. Here, post-tensioned anchors have a vital role to play in holding down the tower to the foundations and, in turn, the foundations are secured by strand ground anchors. The BBR portfolio contains post-tensioning tendons and strand ground anchors with impeccable European Technical Approval credentials – and further unique features – making them the perfect and most durable solution for ensuring high performance in the quest for green, sustainable energy generation.

Extending lifetimes

In a carbon conscientious world, the best thing one can do is to stop constructing, however that would not be a very pragmatic nor realistic approach so the next best thing we can do is to maintain, repair, retrofit (MRR) and strengthen existing buildings and infrastructure in order to extend the lifetime of these structures. Tragic events over the past few years have highlighted the importance of good design and construction, along with strategic structural monitoring, inspection and maintenance regimes. Many countries still rely on infrastructure which is nearing the end of its original design life – but this can often be extended by using technologies and techniques employed by BBR Network Members. The CONA CMB post-tensioning system, for example, is frequently applied externally to bridges and viaducts to strengthen them, thus effectively lengthening their lifetime – and massively reducing the carbon footprint that would have been created by their demolition and subsequent replacement.

In fact, our 2020 BBR Network Project of the Year – the Echinghen Viaduct in France – is one such example of where the excellence of BBR technology for infrastructure retrofit schemes and the great technical innovation offered by the BBR Network can be applied to achieve a sustainable, low carbon impact solution.

In fact, our 2020 BBR Network Project of the Year – the Echinghen Viaduct in France – is one such example of where the excellence of BBR technology for infrastructure retrofit schemes and the great technical innovation offered by the BBR Network can be applied to achieve a sustainable, low carbon impact solution. This project made use of the CONA CME external post-tensioning system featuring 'future-proof' exchangeable tendons and monostrands for extra durability and corrosion protection. These, along with other fully exchangeable post-tensioning tendons in the BBR portfolio, allow for inspection and full replacement at any time in the future – and with only minimally invasive works to the original structure. So, not only can CO_2 emissions be saved now, but the BBR post-tensioning technologies featuring exchangeable tendons will further reduce CO_2 emissions should they subsequently need to be upgraded.

Further techniques aimed at strengthening structures include the application of carbon fiber products and, again, some of the BBR Network's most recent projects can be seen in the MRR section.

Shaping the future

Industrialization and new ways of building will enable assembly line manufacturing in construction and boost productivity tenfold. With the arrival of new technologies, innovative construction techniques are gaining steam worldwide.

For example, off-site prefabrication and modular construction uses less materials and energy compared to traditional methods thus reducing wastage and embodied CO_2.

Complete submodules of a larger building are put together in a factory or nearby yard before final assembly at the construction site. Construction is carried out in a controlled environment improving quality control and increasing productivity which further reduces the cost and time of construction with fewer defects to correct. As construction is taking place primarily off-site, deliveries to site can also be significantly reduced which in turn reduces emissions from transportation. In fact the BBR Network has particular expertise in this field, having worked with these methods for around 70 years, and would welcome the wider adoption of off-site prefabrication and modular construction.

Another example is the 3D printing of concrete structures before assembly and internal work which could transform the industry with respect to design, cost, time and CO_2 emissions. 3D printing may also optimize the placement and usage of materials, not only reducing material usage but also potentially allowing construction of architectural forms that would otherwise be impossible to build using traditional methods. This further reduces wastage and embodied CO_2 while leveraging the massive productivity gains from automated production. Now imagine combining the benefits of 3D printing with the strength and efficiency of post-tensioning. Well, BBR has done exactly that and with fantastic results as showcased in CONNÆCT 2020 (page 80) where we examined a project using 3D printing and BBR post-tensioning technology.

In closing, I urge everyone to not be complacent and in particular to not be prepared to settle for less when it comes to protecting our environment, our people and ultimately our planet. As a leading force in the construction industry, we must continue to innovate and reimagine the future to ensure that our customers and professional partners have access to the latest and most sustainable solutions. Let's work together to make the world a better place for us – and future generations.

News-in-brief

Achievements from around the BBR Network

We are delighted to be able to present some short news items about the excellent achievements and developments around the BBR Network and at BBR HQ during the past 12 months. The BBR Network is fully charged with great technology, great people and great customer solutions.

NEW BBR NETWORK MEMBER

WELCOME TO BECOMAR IN MOROCCO

We are delighted to announce that Becomar – based in Berrechid, Morocco – has joined the BBR Network. Founded almost 20 years ago, Becomar has established a reputation for the manufacture of concrete products such as prestressed hollow slabs, beams, walls and now has its sights set on expanding operations as a specialist contractor in the field of post-tensioning and other related construction engineering. With a newly-hired expert PT team in place and the BBR Network induction having been completed, Becomar is now working on a regional expansion program with offices in Tangier, Casablanca and Agadir which will enable the business to best serve the needs of their customers throughout the country.

ACCOLADES & APPLAUDS

EARTH AWARD FOR EXCELLENCE

Congratulations to Australian BBR Network Member SRG Global and their joint venture (JV) partner WBHO Infrastructure who have been presented with the 2021 CCF WA Earth Award for Excellence in Civil Construction in the A$30m to A$75m project value category. This prestigious award from the Civil Contractors Federation Western Australia was made for the Wanneroo Road Ocean Reef Road Interchange Project for client Main Roads Western Australia. The JV was head contractor for the design and construction of the new grade separated interchange and surrounding road improvement at the intersection of Wanneroo Road and Ocean Reef Road in Perth's northern suburbs.

OUTSTANDING RESULTS IN PT DESIGN

Professor Predrag Presečki, head of the BBR Adria project office, has been recognized with a major national award. The KOLOS 2021 Award, presented by the Croatian Chamber of Engineers is for outstanding results in the design of prestressed concrete structures. In the recent past, Predrag has provided designs for three structures with roof spans of over 20m – the Royal Hotel in Opatija, Solaris Convention Center in Šibenik (both in Croatia) and Hotel Grand in Neum (Bosnia-Herzegovina). All are designed to provide conference facilities with clear, column-free spaces – as well as accommodating a variety of roof-loading characteristics which have even included a swimming pool.

LIVE & ONLINE

JOINING HANDS AROUND THE GLOBE

This exclusive two day BBR Network Global Webinar 2021, held last June, was for senior managers from around the BBR Network. Highlights of the live online event included news about the successful testing to *fib* Bulletin 89 recommendations of the BBR HiAm CONA Pin Connector, as well as an update on the EAD for BBR VT CONA CMG strand ground anchors – set to be the first ETA issued for this technology type! Special events featured the announcement of winners of the BBR Network Awards and a business-oriented workshop and technical presentations with guest presenters. Also, there was a round-up of further technical, supply chain, marketing and business news to keep Members up to date with latest developments.

TALKING TECHNICAL

Continuing restrictions on international travel made it impossible to hold face-to-face training, so BBR HQ organized a special training online event for staff within the BBR Network. Held in a series of two hour live sessions on three consecutive days in October, the BBR Network Project Manager's Webinar delivered BBR HQ news updates, marketing support, BBR e-Trace and supply chain scenarios, there was a blend of basic and advanced technical subject matter – including some exciting design detailing aspects. The basic training elements were targeted towards introducing new staff to the BBR post-tensioning, stay cable and geotechnical ranges – and acting as a refresher for existing team members. Meanwhile, special advanced training on the BBR geotechnical and stay cable technologies was designed to offer deeper, more detailed knowledge of these specialist areas.

MAKING MOVIES

UNIQUE ADVANTAGES WITH CONA CMG STRAND GROUND ANCHORS

Our new Technical Series video about the BBR VT CONA CMG strand ground anchor system is now live on the BBR YouTube channel. The video takes you through all the main features of this state-of-the-art system with its unique-to-the-market advantages. As well as being the only proven double corrosion protected system on the market, CONA CMG offers advanced leak-tightness and sealed GT monostrand (resisting up to 3.5 bars of water pressure). Great performance – and only requiring one layer of corrugated duct! Proven by testing, CONA CMG was the first strand ground anchor system to be successfully tested under confined conditions to EAD and EN1537 recommendations. The proposition becomes even more compelling when you know that the CONA CMG system also offers the widest range of strand ground anchors on the market. After you've seen the video, don't forget to share the link/URL with your colleagues and business contacts!

BBR NETWORK VIDEO RESOURCES

The BBR Network YouTube Channel now contains 29 videos covering technical information about the BBR technology range, axial fatigue testing of the massive 91-strand HiAm CONA stay cable system, as well as BBR Network Project of the Year and other awards, annual Highlights videos – and, to keep this important subject front-of-mind, there's even a whole grouting seminar. If you haven't already done so, it's certainly worth taking a few minutes to have a look at the wealth of information which is instantly available.

OUT & ABOUT

STRIDING OUT AT SOLSCOPE

At the end of June, BBR HQ joined French BBR Network Member ÆVIA at the SOLSCOPE 2021 exhibition at Lyon Eurexpo. This two day event draws a large audience from the geotechnical, drilling and special foundations sectors, so offered many opportunities to raise the profile of the BBR GT product range.

SPREADING THE WORD

BBR Contech sponsored the informative Concrete NZ seminar series entitled Prestressed Concrete 101. The well-attended series, held towards the end of June, comprised three seminars – in Auckland, Wellington and Christchurch – which were presented by Alessandro Palermo and Moustafa Al-Ani. The local BBR Contech team was on hand at each seminar to show off some of the technology to the attendees and distribute technical support materials.

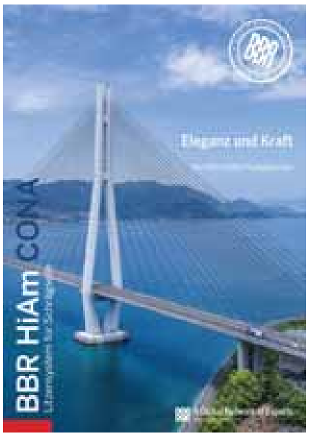
TAKING THE STAGE @ INDIS 2021

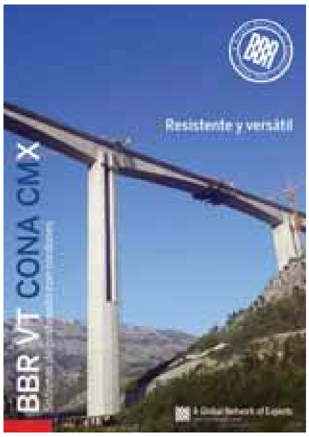
At the end of November, BBR VT International CEO Juan Maier gave a presentation at the INDIS 2021 Conference in Novi Sad, Serbia, as part of BBR Adria's sponsorship of the event. His subject was BBR technologies and how their use contributes to the global quest for carbon reduction. INDIS 2021 was the 15th International Conference on planning, design, construction and building renewal. The Conference provides a forum for domestic and international experts to discuss and exchange experiences and information about latest achievements in a number of fields. BBR HQ is always happy to support BBR Network Members at such events.

LATEST PUBLICATIONS

MULTILINGUAL BROCHURES

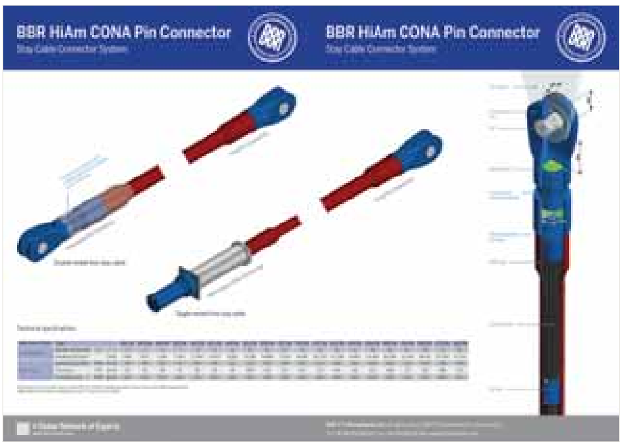
In the last 12 months, brochures about two major product ranges within the BBR portfolio have been produced in French, German and Spanish, alongside the original English versions. The BBR VT CONA CMX brochure is the ultimate guide to all things CONA CMX – it covers not only the wide range of post-tensioning systems and solutions, but also presents aspects of specification and design detailing. The BBR HiAm CONA brochure makes full information about this leading stay cable technology more readily accessible to many further customers. We look forward to welcoming even more readers who we invite to download their own personal copy from the BBR Network website – or contact their local BBR Network Member to obtain a hard copy.





FLYING HIGH

The new updated BBR Pin Connector Flyer is available for download from the BBR Network website. As you may already know, the BBR HiAm CONA stay cable solutions range now includes the single- or double-ended, fixed or adjustable BBR Pin Connector. While promoting an aesthetically pleasing appearance and use of a smaller pylon, the BBR Pin Connector is a technically superior solution which offers a number of unique advantages – and complies with the latest *fib* Bulletin 89, PTI and CIP (Setra) recommendations.



BBR Awards 2021 Outstanding achievements by BBR Network Members

Awards for excellence

The BBR Awards, an extra-special highlight in the BBR calendar, are presented to BBR Network Members who have achieved outstanding performance during the past year. All awards recognize excellence in innovation, engineering and customer service which reflects on the entire BBR Network globally.

BBR PROJECT OF THE YEAR 2021

The jewel in the crown of the annual BBR Awards is the presentation of the Project of the Year Award. In 2021, there was no doubt at all among those on the international judging panel – Austrian BBR Network Member KB VT scooped the trophy for their work on the Lahnbach & Lafnitz Bridges. Constructed using the new 'balanced lowering' method, the realization of these two motorway bridges required innovative use of post-tensioning technology and practical application of deep technical experience. The runner-up was SRG Global's Bolivia Hill Upgrade project in New South Wales, Australia. Here, the highly skilled team produced a great result – and set a new national record as the project featured the steepest gradient to be constructed by balanced cantilever.

A 'highly commended' citation was awarded to BBR Polska's Borusowa Bridge in southern Poland. The central bridge span was constructed by the free cantilever method, using form travelers – and BBR VT CONA CMI internal and CONA CME external post-tensioning.

The full background to all of these projects can be found in CONNÆCT 2021 – which is downloadable from the BBR Network website.

BBR CONNÆCT BEST ARTICLE AWARD

BBR CONNÆCT BEST PHOTOGRAPHY AWARD

2021 BBR Award Winners

BBR PROJECT OF THE YEAR 2021

Lahnbach & Lafnitz Bridges, Austria – successful application of the innovative balanced lowering bridge construction method, drawing on deep technical skills available within BBR Network Member KB VT.

BBR CONNÆCT BEST ARTICLE AWARD

Winner: SRG Global (Australia)
Title: Improving road safety & efficiency (Bolivia Hill, Australia)

Runner-up: BBR Polska (Poland)
Title: High productivity for new bridge (Borusowa-Nowy Korczyn Bridge, Poland)

Highly Commended: BBR Construction Systems (Malaysia)
Title: Embracing change saves time (KVMRT2, Malaysia)

BBR CONNÆCT BEST PHOTOGRAPHY AWARD

Winner: KB Spennteknikk (Norway)
Title: Still strong after 45 years (Ringhals Nuclear Plant, Sweden)

Runner-up: Kappa (Turkey)
Title: Transferring load with BBR H Bars (Yusufeli Dam, Turkey)

Highly Commended: ÆVIA Câbles et Manutention (France)
Title: Stressing in the sun (Highway Interchange, La Réunion, France)

More about
BBR Project of the Year

Special BBR Network Award New BBR PT Grand Master

Lifetime of achievement

A few months ago, the rank of BBR PT Grand Master was conferred on BBR Contech's Jeff Marchant for his achievements in the field of post-tensioning. This is a very special award which is only presented to exceptional individuals. So, what is the Award about and why has Jeff been recognized in this way? Here, BBR VT International's Daniel Cuerdo offers some insights.

Within the BBR Network, there are many fine specialist construction engineers – all over the world. As well as the strong support they receive from their local management teams, BBR Headquarters also encourages their talent through training courses, knowledge sharing and international collaborations. We also recognize individual achievement through special awards, the most prestigious of these is the BBR PT Grand Master Award which is a lifetime achievement award for sustained and valuable contributions over a long period of time.

In fact, the award is so special that, in its 15-year history, it has only been presented four times – to Tommy Lindstrand of KB Spennteknikk (Norway), Kresimir Bogadi of BBR Adria (Croatia) and Rob Robinson of BBR Contech (New Zealand) and now to Jeff Marchant also of BBR Contech. The high level of expertize attained and demonstrated by these and other outstanding BBR engineers means that existing BBR Network Members can draw on an international pool of knowledge. New franchisees benefit from immediate access to this valuable resource – as well as having a path to gaining global recognition for their PT excellence.

Innovative leadership

In Jeff Marchant's case, there were many compelling reasons to recognize his achievement. The citation on his award certificate highlighted his leadership, excellence and innovation in the design and construction of post-tensioned slabs on grade. It also acknowledged Jeff's encouragement and mentoring of new BBR engineers, along with the respect and acknowledgement he has won from industry peers locally and internationally.

Innovation has been a recurrent feature of Jeff's approach – beginning with software development to automate and inform the post-tensioned slab design layout process, then followed by the creation of a methodology for constructing large and high-performing slabs, with a minimum of joints, up to 75,000m² in area.

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Formative years

Jeff, a graduate of the University of Auckland Engineering School, spent his early years working for the NZ government public works department where he was associated with design and construction activities on large civil projects. He also spent five years working for a UK-based consulting engineering practice and has, as a senior engineer, overseen design for projects in the UK, Europe and Middle East.

Back in 1998, when Jeff joined BBR Contech, the company was introducing post-tensioned slabs on grade to the New Zealand market and he became an integral member of the design and development team.

Massive portfolio

Since those early days, Jeff's designs have been applied to a range of buildings which now feature large general purpose warehouse floors, heavy duty external pavements, cool stores and special purpose heavily loaded storage facilities. Jeff has presided – either as designer or supervisor – over some 400 slab on grade projects covering more than three million square meters (see also pages 38-41).

While Jeff's PT knowledge was honed on slabs on grade, he has also contributed significantly to all other areas of post-tensioning in which BBR Contech operates. In New Zealand, he is accepted as the foremost technical leader in this field.

While several of his projects have been presented with awards, Jeff's work has most recently been recognized through Concrete New Zealand's Outstanding Contribution Award – a peer-nominated accolade presented to those who have made a 'visible difference' and whose efforts have supported the advancement of the concrete industry.

Inspiring others

Jeff has continued to refine and update his design processes and has been an excellent teacher for new engineers wishing to develop the skills. He regularly holds refresher sessions to ensure all design engineers are advancing their knowledge as required.

His reach as a mentor has extended beyond national boundaries too. Most notably, Jeff supervised BBR Polska's first ever slab on grade, allowing the team in Poland to refine their skills and successfully enter the market.

Jeff is in great company – BBR Contech's Rob Robinson was also presented with a BBR PT Grand Master Award back in 2013 at the anniversary of BBR Contech's 50 years of business operations. Looking forward to many further stunning achievements, we wish Jeff and his colleagues, both locally and globally, every success for the future!

1 Celebrating a new BBR PT Grand Master – (left to right) Paul Wymer, Jeff Marchant, Bojan Radosavljevic and Derek Bilby at BBR Contech's Auckland office.
2 No stranger to awards, back in 2007 Jeff was part of the team which collected the Supreme Award in the New Zealand Engineering Excellence Awards for BBR Contech's Transpower Tower Foundation Strengthening project, carried out as part of the Upper South Island Grid Upgrade. Pictured here (left to right) are: Rob Robinson, Bojan Radosavljevic, Peter Higgins, Jeff Marchant and Paul Wymer.
3 Always ready to help with customer technical enquiries, mentor other engineers and provide advice to BBR Network colleagues, Jeff has earned a reputation as a technical leader in his field.
4 Scaling new heights – Jeff joined BBR Network colleagues to make the famous Sydney Bridge climb back in 2008, during the BBR Global Annual Conference in Australia.

Perspective

Q&A

Making innovation successful

Innovation is the key to overcoming many challenges. In the construction sector, it's about building better – and for longer lifetimes, for lower costs and reduced environmental impacts. For this specially extended Perspective feature, we invited Professor Johann Kollegger from the Institute of Structural Engineering at the Technical University of Vienna (TU Wien), to answer some questions from around the BBR Network about his innovative methodologies.

Professor Johann Kollegger – serial construction engineering innovator – is based at the Institute of Structural Engineering, TU Wien, Austria.

MARK SINCLAIR

GENERAL MANAGER – ENGINEERING & TECHNICAL

SRG Global (Australia)

Q What was the greatest challenge that you have professionally faced, where the initial solution did not succeed, and an alternative solution was needed. Please explain how you took the learnings from the first unsuccessful attempt to turn it into success?

A While I cannot recall any one particular 'greatest challenge', on many of my developments alternatives have had to be found when initial solutions did not succeed. This goes with the territory when you are pushing at the boundaries.

For example, the idea of building reinforced concrete shells with a double curvature, such as domes, from flat plates occupied me from 2003 to 2017. From the start, it was clear that the concrete plate had to consist of segments and voids between the segments. Initially we filled the voids with expanded polystyrene foam. This worked nicely, but the foam remained in the completed shell. On the next attempt, we did not fill the voids at all, which unfortunately did not work out. Finally I had the idea to insert pneumatic wedges into the voids. This delivered a perfect solution and we were able to build two shell structures for ÖBB, the Austrian rail company.

CLAUDE NÉANT

FOUNDER OF ETIC & NOW CIVIL ENGINEER EXPERT

ETIC/ÆVIA-Groupe Eiffage (France)

Q The issue of reducing the carbon footprint of all our activities will again come into focus as the Covid-19 pandemic is brought under control. How does the balanced lowering method of bridge construction help to contribute to reducing carbon emissions?

A During the construction process, when the bridge girders are transformed from the vertical into a horizontal position, compression struts are needed. These compression struts become an integral part of the final bridge structure and reduce the spans. For example, the bridge over the Lafnitz river was originally planned as a steel-concrete composite bridge with a height of 4.6m in the cross-section. The post-tensioned concrete bridge erected with the balanced lowering method has a plate girder cross-section height of only 2m, because the span lengths could be reduced there due to the support provided by the compression struts. This resulted in a reduction of construction materials and savings in erection costs. In addition, the bridges turned out to be beautiful structures with more clear height under them compared to the original design.

Shell structures: Alternative solutions were needed for filling the voids while creating reinforced concrete double curvature shell structures. Ultimately, pneumatic wedges proved to be the perfect choice. Incidentally, KB VT, the BBR Network Member for Austria, carried out the post-tensioning works for the circumferential tendons during the transformation process from the flat plate to the shell structure. The smaller shell received a 'special mention' at the 2018 *fib* Congress in Melbourne.

PAUL WYMER

FORMER CEO & NOW NON-EXEC DIRECTOR

BBR Contech (New Zealand)

Q How does the balanced lowering method compare, in terms of cost and program, to other bridge building methods that are suited to the same sort of spans and traffic use?

A The balanced lowering method and also its counterpart the balanced lift method are applicable in span ranges of 50m to 80m (balanced lowering method) and 50m to 250m (balanced lift method). In these span ranges, incremental launching or the balanced cantilever methods are usually applied. My construction methods will enable cost-savings, if the topographical situation is favorable, for example high piers in the case of the balanced lift method. However, actual cost comparisons have only been carried out for the Lafnitz and Lahnbach bridges. For these two bridges, the main contractor's bid for the superstructure was approximately 25% lower than the costs which had been calculated for the steel-concrete-composite bridges. >

Professor Kollegger's balanced lowering bridge construction method was first applied to the Lahnbach and Lafnitz Bridges, using BBR post-tensioning technology. This innovative scheme was presented with the BBR Network Project of the Year Award 2021 – and a full project overview can be found in CONNÆCT 2021.

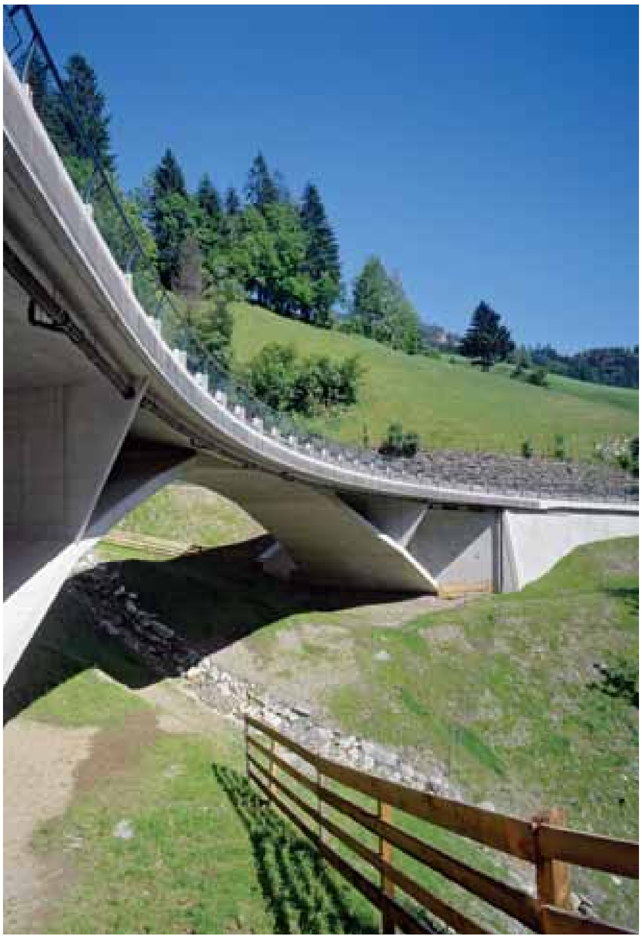
JACKIE VOON

DIRECTOR (OPERATIONS)
BBR Construction Systems (Malaysia)

Q **While the balanced lowering method was aimed at reducing falsework and construction time, were there other considerations to factor in – such as the logistical aspect of transporting the prefabricated girder, availability of space for precasting, requirement for higher capacity cranes to re-erect the girders and temporary works into position?**

A The invention of the balanced lowering/balance lifting methods was inspired by the lowering of arches method, originally proposed by Riccardo Morandi and nowadays used in Spain and Japan as well as occasionally in other countries.

At the beginning of our research projects to develop the balanced lowering/balanced lifting methods, we were planning to use climb-forming to build the bridge girders and compression struts in a vertical position, since this is the usual construction method for producing arch halves in a vertical position. Only when I started working on an alternative for the Lahnbach and Lafnitz bridges, did I realize that in my method the weight during the transforming process was important. Also, the usage of thin-walled prefabricated bridge girders and compression struts offered the opportunity to build bridges which, after filling the hollow parts with in situ concrete, would be of the same quality and durability as bridges built on site with conventional methods.



Austria's Egg Graben Bridge not only applied innovative features, but it was also declared Winner of the *fib* 2014 Outstanding Concrete Structure Award in the Civil Engineering Structures category. Image courtesy of Pez Hejduk www.pezhejduk.at.

JUAN MAIER

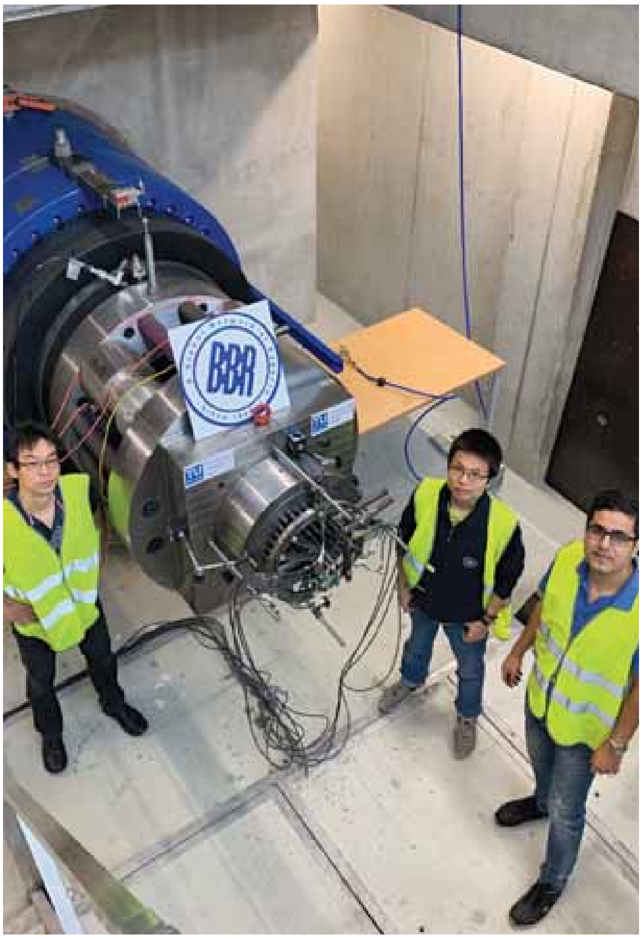
CEO
BBR VT International

Q **Where do you get your inspiration from and how do you transform an innovative idea into a real project? Then, how do you convince construction clients to adopt new, untried construction techniques?**

A In order to come up with something new, I need a problem which has to be solved. In the case of the shell project, I asked myself: How can a shell with double curvature be built from a flat reinforced concrete plate? The starting question for the balanced lowering/lifting method was: How can a bridge be built with bridge girders that are originally vertical?

The transformation of an idea into a real project takes a lot of work. First, our new construction methods are rigorously tested during research projects at TU Wien. Fortunately, there is support from construction companies, infrastructure operators and a federal funding agency (FFG) available here in Austria. When we get a chance to apply a new method for a real project, we work very hard to ensure that things function as they should and go well on site.

It does not always take more than 10 years from the initial idea to the finished first projects, as was the case for the shells and the balanced lowering bridge method. Realization was faster on other projects, like our high speed resonant testing facility for stay cables – which is



The high speed resonant testing facility for stay cables – which is frequently used by BBR VT International – is a great example of where innovation has been swiftly applied.

The Sunniberg Bridge, Klosters, Switzerland with its BBR DINA stay cables: Professor Kollegger received a first-hand account of its design and construction from eminent bridge engineer Christian Menn during their collaboration for the Handbuch Brücken (Design Handbook for Bridges).

frequently used by BBR VT International – or in the case of our expansion joint for long integral bridges, which was successfully installed at the Satzengraben Bridge. Then there was the Egg Graben Bridge, featuring PT tendons fully encapsulated in ducting and where the slab was built without reinforcing steel – this project was recognized by *fib* with the 2014 Outstanding Structure award. In all these latter cases, we were able to transform a new idea into a real application within a few years.

Meanwhile, most people do not like to try out new things in their projects. I can understand that, because if something goes wrong, they will be made responsible. Construction projects also have a large price tag – for example, the two shell structures for ÖBB cost about €5m and the two bridges about €12m.

Sometimes I have been lucky in meeting people who were interested in trying out something new and who were willing to take a chance. I am very grateful to these people for sharing my vision and enthusiasm for driving forward innovative construction methods.

DR. BEHZAD MANSHADI

CTO
BBR VT International

Q What recent material technology innovation or construction technique advancements do you think will disrupt the construction industry?

A Currently, I'm working on two new construction techniques. The first technique is concerned with the erection of the deck slab of bridges. In the construction of the Lahnbach and Lafnitz bridges, the erection of the webs with the balanced lowering method worked well and was quite fast. However, the construction of the deck slab was a slow process, because a conventional formwork carriage was used, which permits one section per week. In my new method, thin-walled prefabricated deck slab elements are used and a 15m section of the deck slab can be built every day. This method is currently under consideration for the construction of the deck slab of a large steel-concrete-composite bridge in Austria.

The second technique is concerned with the construction of post-tensioned concrete bridges in the 30 to 60m span range. In this method, the prefabricated deck slab elements mentioned above and prefabricated trough shaped bridge girders – similar to those applied for the Lahnbach and Lafnitz bridges – are used. It is envisaged that one bridge span can be built per week and that this method will be able to compete with segmental construction.

There's a fair chance that this second technique could disrupt the construction industry. It could reduce the market share of segmental bridges, because material can be saved and the bridge will have no joints. These bridges will be like monolithic bridges built with in situ concrete, with the additional advantage that the high quality finish of the prefabricated panels will be visible on the external surfaces.

JANE SANDY

EDITOR
BBR Network CONNÆCT magazine

Q Can you tell us about your collaboration with the late Christian Menn on the 'Handbuch Brücken' (Design Handbook for Bridges)?

A Back in the year 2000, I organized a lecture by Christian Menn and an exhibition about his bridges which was first shown at the ETH in Zurich and then at several other universities, including TU Wien. My thesis supervisor, Professor Gerhard Mehlhorn, asked Christian Menn to write a chapter on conceptual design for the Handbuch Brücken. Menn agreed, but requested support from a university institute to complete the task – when asked to provide this, I jumped at the opportunity!

During the preparation of his chapter and also afterwards, I visited Menn several times at his house in Chur where his wife had always prepared a wonderful lunch for us. The discussions with him were very inspiring for my later work and I certainly learned a lot during those visits. The most memorable moment was perhaps when he took me to his Sunniberg Bridge project and later, over a beer at a nearby restaurant, told me stories about its design and construction.

Courtineau Viaduct, A10, France
Cast in situ balanced cantilever construction

Twinning in Touraine

The Autoroute A10 – known as 'L'Aquitaine' – is France's longest motorway and runs some 549km from the south of Paris to Bordeaux. French BBR Network Member ÆVIA is part of the team working on the widening of the motorway in a challenging viaduct twinning scheme featuring latest BBR post-tensioning technology. Cédric Brunner, Principal Engineer, gives an insight into the project and its progress.

France's longest motorway, the Autoroute A10, is being widened with the addition of the new Courtineau Viaduct.


ETPO
ETPO
ETPO

A great technical solution is being delivered to increase motorway capacity here in the Touraine region. The widening of the A10 motorway involves the construction of a third viaduct, to carry an additional two traffic lanes plus an emergency lane, alongside the two existing structures.

An important architectural consideration was that the new viaduct should reflect the two viaducts built in the 1970s, thereby giving a certain homogeneity to the infrastructure and perhaps creating the impression that the new viaduct had always been there.

The new €15 million viaduct is 210m long, 30m high and comprises three spans – of 56, 94 and 60m – which are supported by two piers and two abutments. The viaduct deck is a two core concrete box section which is being constructed using successive cast in situ segments cantilevering outwards from the piers.

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Balanced cantilever segmental construction

The cast in situ balanced cantilever construction method was chosen because there is insufficient space on site for installation of a launching beam and also because access to this narrow valley site, which contains a watercourse, is challenging.

In total, 52 segments were required to complete the viaduct deck. The first segment was cast on a pier and was the largest and most complex segment to be formed. It was secured to the pier by a fixing system consisting of BBR VT CONA CMI BT 1906 post-tensioning tendons. This approach prevented the beam from tilting when a new deck section was added.

Successive segments, consisting of two corbelled beams, were then cast in situ in pairs using mobile formwork. When all segments were constructed and post-tensioned together, they formed the viaduct deck.

Movable formwork

The movable formwork, called a C-beam, was fixed to the previous segment and served as a support for the outer formwork which supported the upper slab, the outer faces of the webs and the underside of the lower slab.

The interior formwork of the segment – corresponding to the underside of the upper slab, as well as the internal faces of the webs – was supported by cantilever beams also fixed to the preceding segment. >

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Four roles for PT

We used post-tensioning for four different functions on this project.

As well as installing tendons for the first pier segment, we also installed tendons in the beams to allow two pairs of segments to be cast on the viaduct piers.

Next, as will be familiar to most BBR Network Members, we post-tensioned the segments together. BBR VT CONA CMI internal tendons were being used for these three purposes.

Last but not least, BBR VT CONA CME BT 2706 exchangeable external tendons were installed inside the box sections to accommodate both dead and live loads from the structure after it had been completed.

Great teamwork

This was a technically challenging and extremely satisfying project where excellent teamwork with the main contractor and other professionals greatly contributed to a successful result. Our work finished with the stressing of the final box girder segments in September, however other work continues to complete the whole project. Meanwhile, we look forward to the opening of the viaduct in summer 2023.

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1 The new viaduct takes shape, seen here during balanced cantilever construction.
2 BBR post-tensioning was used for a total of four different functions on this project.
3 View inside the box section of the new viaduct where CONA CME tendons were used to stress the segments together.
4 The CONA CMI BT system was used to secure the first – and most complex – segment to the pier.
5 The cast in situ balanced cantilever method of construction was chosen for this viaduct twinning scheme because of site constraints.
6 Stressing of one of the CONA CME BT 2706 exchangeable external tendons underway.

TEAM & TECHNOLOGY

Owner/client – Vinci Autoroutes
Main contractor – ETPO/NGE
Technology – BBR VT CONA CMI internal, BBR VT CONA CME external
BBR Network Member – ÆVIA Câbles et Manutention (France)

La Voulte Viaduct, Ardêche, France Pioneering prestressed precast segmental construction

First of its kind – with BBR technology

While the highly skilled BBR engineers working on the Courtineau Viaduct today meet the challenges of balanced cantilever construction using prestressed segments cast in situ, they – along with other readers – might wish to contemplate the record-breaking pioneering achievement of BBR engineers some 70 years ago.

Many readers will be familiar with the technique of bridge construction using post-tensioned precast segments and the benefits it offers, but may not know that this concept was pioneered for major structures using BBR technology.

World record bridge

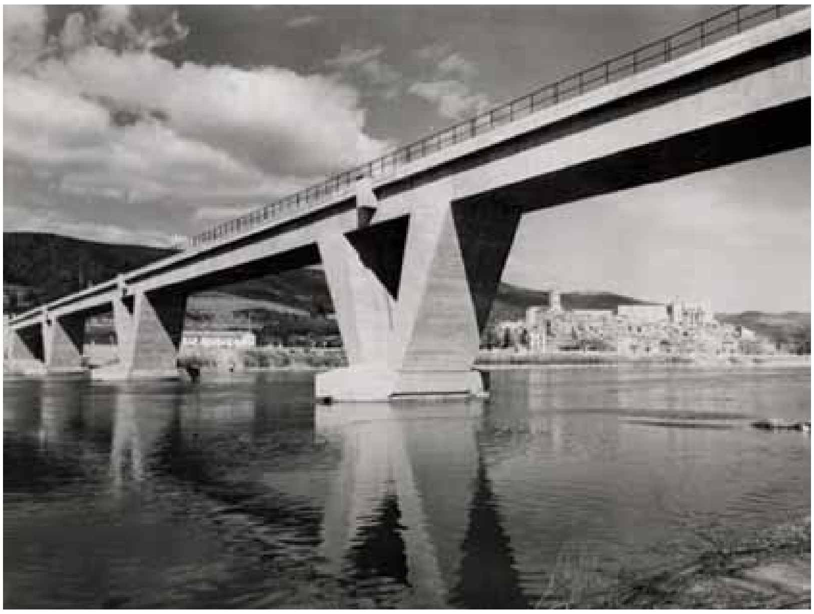
In 1952, construction began on a bridge which was to create a new world record. At the time of its construction, France's La Voulte Viaduct was the longest prestressed precast segmental bridge of its type in the world.

This elegant and durable railway bridge owes its realization to the engineering brilliance of leading French designer Nicolas Esquillan, confidence of French rail operator SNCF in the proposed solution – and also to the great strength of BBR post-tensioning.

Project background

The story of La Voulte Viaduct goes back to the early 1860s when construction began on an imposing bridge structure with five metal arches, founded on four piles and masonry abutments on each river bank. This landmark bridge served for many years as an important single-track railway connection across the River Rhône, until it was destroyed by Allied bombing during enemy occupation of France in 1944.

After the Second World War, SNCF made plans for replacing the bridge and work began on site in 1948. However, financial difficulties halted the work and four years later, in 1952, the contract was awarded to main contractor Boussiron.



At the time of its construction, back in 1952, the La Voulte Viaduct in France was the world's longest prestressed precast segmental bridge – and it featured BBR post-tensioning technology.

Alternative design with BBR PT

The latter – where Esquillan was now Technical Director – took the opportunity of presenting an alternative design based on supporting the bridge deck with struts instead of arches. This had the advantage of offering a uniform bridge height above the river, in turn allowing the required passage for river traffic.

However, the design required the use of post-tensioning and this was a major issue for SNCF as they had no confidence in systems relying on friction anchorages. After evaluations were carried out jointly with the main contractor, they were convinced that the BBR system with its innovative cold formed button head anchorage design would be of sufficient strength for the task.

Construction methodology

Work began from the right bank and involved the repetition of five identical construction cycles, span-by-span. First, the angled struts were built by means of a vertical scaffolding and stay cables to retain the formwork.

Then the spans were constructed using 2.75m long segments which were installed in cantilever fashion, symmetrically from each pier. A sliding formwork was used and this was supported by a Bailey bridge which was launched from pile-to-pile. Segments were lifted into position using an arched gantry crane, then joints were filled and the PT tendons were stressed. After all segments were in place, the final tension of the PT tendons throughout the whole structure was verified.

This innovative approach to constructing a major bridge was so successful that it was repeated for Boussiron's next bridge project – the Félix Houphouët-Boigny Bridge in Abidjan, Ivory Coast. Since then, precast segmental construction has become a regular feature of many BBR Network projects throughout the world.

Bridge construction, S7 Expressway, Poland Incremental launching & PT

Poland's longest expressway

Over recent years, BBR Polska has provided specialist technology and services to four different construction contracts along the route of Poland's ambitious S7 Expressway project. Each contract has featured latest BBR technology and the most recent project – for the Szczepanowice-Widoma section – has required both internal and external post-tensioning, as well as incremental launching. Engineers Marcin Ornat and Marek Strzoda take us on a journey through the project.

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Our work scope included the post-tensioning of six structures over the new highway and also the post-tensioning and incremental launching of the largest structure on the route ...

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The aim of the S7 Expressway scheme is to improve north-south transport links with the port of Gdańsk on the Baltic coast in northern Poland to the border with Slovakia in the south of the country. It will directly connect Gdańsk, Warsaw and Kraków, while shortening travel time, increasing traffic capacity and flow, improving traffic safety and reducing impacts on neighboring cities. With a total planned length of 720km and much of the route being built by upgrading the existing DK7 National Road, this is certainly no ordinary project.

Earlier projects

Our relationship with the S7 scheme started in 2009 on the Skarżysko-Kamienna Bypass, where we were responsible for the post-tensioning of 17 large civil engineering structures, including a 290m long, eight span flyover – for this element alone, we used 690t of prestressing steel. Then, in 2015, we began work on installing the BBR VT CONA CMI 1206, 1906 and 2206 post-tensioning systems for 13 viaducts on the Jędrzejów section of the S7 Expressway. Our next major project on the route was in 2017 for the Niepodległości Bridge near Ostróda – a 340m-long, three span, three arch bridge over the Pauzeński Channel. Here, our solution involved the installation 84 BBR stay cables – 28 stay cables on each arch – and featured use of BBR HiAm CONA Uni-Head Short Socket anchorage technology to deliver a compact, durable and economical solution. You can read more about these projects in CONNÆCT 2011 and 2018.

Latest challenge

In early 2020, BBR Polska started work on another part of the S7 Expressway, this time it was between Kraków and Warsaw, on the Szczepanowice-Widoma section.
Our work scope included the post-tensioning of six structures over the new highway and also the post-tensioning and incremental launching of the largest structure on the route – the twin deck ES-02 Overpass. >

FACTS & FIGURES – ES-02 OVERPASS

NUMBER OF DECKS/STRUCTURES
2

DEPTH OF PT BOX GIRDER CROSS-SECTION
3.6m

WIDTH OF PT BOX GIRDER CROSS-SECTION
16.33m

NUMBER OF SPANS
13

3

LEFT DECK
TOTAL LENGTH
679.44m
Span lengths: 38.6m + 2 x 57.5m + 4 x 57.35m + 5 x 51.5m + 38.93m

RIGHT DECK
TOTAL LENGTH
687.3m
Span lengths: 36.7m + 51.15m + 5 x 57.5m + 51.15m + 4 x 56m + 36.8m

INCREMENTAL LAUNCHING OPERATION
NUMBER OF LAUNCHED STAGES PER STRUCTURE
25
LAUNCHED SEGMENT LENGTHS
22.75m-28.75m
TOTAL WEIGHT LAUNCHED
21,150t

Mobilizing for ILM

For BBR Polska – along with other BBR Network Members too – the construction of a bridge using the incremental launching method (ILM) is almost an everyday task. ILM is widely accepted as being a construction methodology that lessens the impact on the local environment, while at the same time speeding the construction program.

Excellent advanced technical preparation and the right equipment is essential. Therefore, our work included consultations regarding the technological aspects and a high level of communication with the main contractor and other stakeholders.

From our own resources, we delivered, installed and ultimately dismantled the slide bearings, as well as the launching equipment which we also operated. Prestressing rods and traditional supports for the launching nose were also delivered by our team who carried out its prestressing prior to launching too.

An associated task was the replacement of the temporary bearings for permanent ones at the end of our work.

ES-02 Overpass

The twin deck structures for this sleek new overpass were constructed over the railway tracks connecting Warsaw and Kraków – and also across the Piotrówka river.

The superstructure is a continuous 13-span beam with a 3.6m deep and 16.33m wide box girder cross-section constructed with post-tensioned concrete.

The span lengths for each of the two decks were slightly different and were arranged as shown in the adjacent table.

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1 After launching operations were completed and external CONA CME external PT had been stressed, the BBR Polska team replaced the temporary slide bearings with permanent ones.
2 BBR Polska's work scope also included the post-tensioning of a further six structures over the new S7 highway.
3 A total of 25 segments were launched for each deck of the overpass.
4 With a total weight of over 21t to launch, the operation was carefully controlled and coordinated from a central console.
5 The twin carriageways of the ES-02 Overpass on the Szczepanowice-Widoma section of the S7 Expressway featured both CONA CMI internal and CONA CME external post-tensioning, as well as incremental launching – all executed by BBR Polska.
6 The ES-02 Overpass spans over the main Warsaw to Kraków railway tracks and also a river.

Launching operations

Each deck was launched in 25 stages – a total weight of 21,150t was launched for the structure.

Our site team's work began in March 2020 with the installation of the slide bearings and the launching gear. Launching and prestressing work started in May 2020 and continued through until November.

After the first three segments of each deck were completed, we implemented a weekly schedule whereby we worked simultaneously on both decks. All of our work on the overpass was completed by April 2021.

PT requirements

A significant amount of post-tensioning was required for this huge overpass structure and also elsewhere on the project.

For the overpass, we supplied and installed four different sizes – 1906, 1506, 1206, 0706 – of BBR VT CONA CMI internal post-tensioning tendons, plus 1906 CONA CME external PT tendons – requiring a total of 772t of steel prestressing strand. The external post-tensioning tendons were stressed after the temporary slide bearings had been replaced.

Meanwhile for the six road bridges, we installed CONA CMI post-tensioning, requiring a total of 89t of steel prestressing strand.

This was a great project with excellent collaboration among the whole of the site team – and it also provided the perfect opportunity for us to familiarize new BBR Polska technical staff members with the way we work on site.

While our work on the ES-02 Overpass was still underway, BBR Polska embarked on a new challenge, namely the S3 highway project near the Czech border where we are simultaneously stressing and launching six structures – but that's going to be a story for the 2023 edition of CONNÆCT!

TEAM & TECHNOLOGY

Owner/client – GDDKiA (General Directorate for National Roads and Motorways)

Main contractor – Mota-Engil Central Europe S.A.

Structural engineers – MP RB Sp. z o.o. & Arcadis Sp. z o.o. (WD structures), Top Projekt (Estakada ES-02)

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

BBR Network Member – BBR Polska Sp. z o.o. (Poland)

Počitelj Bridge, Bosnia & Herzegovina PT for balanced cantilever construction

Bridge to prosperity

Hot on the heels of their achievements in Montenegro for the Moračica and UVAC 4 Bridges, BBR Adria are now supplying BBR post-tensioning technology and techniques to another major structure – the Počitelj Bridge in Bosnia and Herzegovina. The new bridge is part of a larger scheme which is expected to contribute to economic and social development in the region.

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As dramatic and beautiful as its surroundings, the new Počitelj Bridge will carry the European Vc Corridor across the River Neretva in southern Bosnia. Close of the medieval town of Počitelj, the bridge will stand up to 100m above the river landscape and its 945m length will be supported by six sleekly designed piers.

Highway scheme

This new 325km trans-European motorway will connect the port of Ploče in Croatia with Budapest, the Hungarian capital city. Construction work is divided into a number of packages and the 11.75km long Počitelj-Zvirovići section is further broken down into Lots 1 and 2. Lot 2, including construction of the Počitelj Bridge – the largest structure on the entire motorway – is expected to be completed by mid-2024.

Structural form

Under construction by the free cantilever method, the bridge features five main spans, all 147m long, plus two side spans which are both 105m long. The continuous prestressed reinforced concrete bridge deck has an almost 22m wide cross-section consisting of a single cell box girder of varying depth. Near the abutments, the box section for the side spans will have a constant 3.6m depth, while the depth varies from a minimum of 3.6m at span centers and a maximum of 8m at piers.

The four tallest piers rise from piled foundations while the bridge abutments and adjacent piers are founded on traditionally reinforced shallow foundations. Ranging from 66m to 97m in height, the piers were constructed using hollow thin-walled concrete segments. They are connected monolithically to the bridge superstructure.

Completion of the Vc Corridor will not only connect the north and south of Bosnia and Herzegovina, but also create a transport link accelerating the country's integration with the European Union. More than 1.5 million people in the region live along the Vc Corridor and this important new route will open the way for their greater future prosperity.

1 BBR Adria are supplying BBR post-tensioning technology and techniques for construction of the Počitelj Bridge in Bosnia-Herzegovina.

2 The bridge features five main spans, all 147m long, plus two smaller side spans. The four tallest piers rise from piled foundations while the bridge abutments and adjacent piers are founded on traditionally reinforced shallow foundations.

3 Ranging from 66m to 97m in height, the piers were constructed using hollow thin-walled concrete segments.

TEAM & TECHNOLOGY

Owner – Autoceste FBiH

Main contractor – Azvirt LLC, Sinohydro Corporation Limited & Powerchina Roadbridge Group Co. Ltd

Bridge subcontractor – Hering Široki Brijeg

Technology – BBR VT CONA CMI internal

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

Visualization of the new bridge across the River Seine which will provide access to the Athletes Village during the 2024 Olympic Games in France. Image courtesy of Artelia, Lavigne & Chéron and Philippon Kalt.

New access bridge, Île Saint-Denis, France Post-tensioning for steel bridge

Striding across the Seine

An elegant new bridge for pedestrians, cyclists and buses will soon be taking shape across the River Seine to the north of Paris and ÆVIA, the BBR Network Member for France will be installing the post-tensioning. For many reasons, this is no ordinary bridge – read the account below from Cédric Brunner of ÆVIA to discover more!

The new €26m bridge will provide access across the Seine to the Île-Saint-Denis from the very heart of the Athletes Village currently under construction for the 2024 Olympic Games. Realization of the structure, which is 140m long and 16m wide, will draw upon expertise from many areas of the Eiffage Group, parent company of ÆVIA.

Led by the Île-de-France teams of Eiffage Génie Civil, the consortium is made up of Eiffage Métal for the metal framework, Eiffage Fondations for the piles, bars and injections under each of the three supports, ETMF for the implementation of sheet piles, ÆVIA for post-tensioning, AER who specialize in the implementation of road equipment and concrete pavement construction for operations close to the site and Eiffage Énergie Systèmes for lighting.

We will be using the BBR VT CONA CMI BT 4206 system for post-tensioning the bridge abutments and installing CONA CME 3706 external tendons for the steel deck.

Design studies are currently underway with BIEP, our in-house design team and the first construction work is expected to be undertaken in July 2022, leading to the placing by barge of the steel bridge deck during the summer. The whole bridge is scheduled for completion by March 2023.

TEAM & TECHNOLOGY

Owner/client – Le Conseil départemental de Seine-Saint-Denis

Designers – Artelia Ville & Transport

Architects – Lavigne & Chéron + Philippon Kalt

Main contractor – Groupe Eiffage

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

BBR Network Member – ÆVIA Câbles et Manutention (France)

Punggol Central (West Extension) Bridge, Singapore Cast in situ balanced cantilever construction

Balanced approach for river crossing

A new bridge is taking shape across Singapore's Punggol River and Dickson Liew has sent this report about how the team from BBR Construction Systems Pte Ltd is installing latest BBR post-tensioning technology to harness the benefits for this cast in situ balanced cantilever construction project.

Punggol River, known locally as Sungei Punggol, is one of the few natural rivers of Singapore. Originating from the northern part of central Singapore, Punggol River dissects five towns in a north-easterly direction and flows to the Straits of Johore which separate Singapore and Malaysia. Since the late 1990s, the river has been canalized and much of its banks reclaimed to create residential estates. Today, Punggol River forms part of Punggol Reservoir and also features riverside promenades and green spaces for leisure activities.

New bridge

This project is a bi-directional vehicular bridge serving as extension to a main arterial road within the Punggol Estate. Aimed at providing an alternative access route to the northern part of Singapore and the Tampines Expressway, Punggol Central (West Extension) will allow commuters greater freedom of choice when traveling through the Punggol Estate.

To achieve the clearance of 180m across the banks, the bridge has been designed as two parallel single box girders in a three span configuration over four piers located near the banks of the river. This configuration allows for greater clearance between piers in the waterway, but results in a longer central span and the required structural depth of the bridge is more than four meters.

Bridge construction

In the interests of nature preservation and lessening disruption to the waterway, rather than using conventional construction methods, the balanced cantilever approach was chosen.

The option of using precast segments was not feasible because of the large segment depth which would present a challenge for transportation. Hence, a cast in-situ segmental balanced cantilever method was finally adopted.

The form traveler provides the form work needed for the casting of the individual segments. It is designed to support the structure while it is being cast, as well as providing necessary gangways and platforms for reinforcement and post-tensioning tendon installation. After the segment is cast and tendons stressed, the form traveler is advanced to the position for the next segment and thus it is possible to construct the bridge without the use of conventional staging and formworks across the river.

Using BBR CONA CMI BT, we are able to provide the necessary force required for a balanced cantilever construction, while at the same time as providing smaller edge distances and center spacing to accommodate the fixings required by the form traveler system.

We look forward to seeing the completed bridge in the third quarter of 2022 – and to sharing more photographs and details in CONNÆCT 2023.

The new Punggol River Bridge in Singapore is taking shape with the help of BBR VT CONA CMI internal post-tensioning to provide the necessary force for the balanced cantilever construction.

TEAM & TECHNOLOGY

Client – Housing & Development Board
Civil & structural consultant – Surbana Jurong Pte Ltd
Main contractor – Guan Joo Construction Pte Ltd
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR Construction Systems PTE Ltd (Singapore)

Bridge 08-MS, S19 Expressway, Poland Free cantilever construction

Spanning the River San

Poland's S19 Expressway is the most easterly highway on EU territory, however it is also a key component of a larger scheme – the Via Carpathia. BBR Polska's Marcin Ornat and Mateusz Banasik reveal more details about this major trans-European connectivity plan – and their work on several structures, including a large river bridge, on the S19.

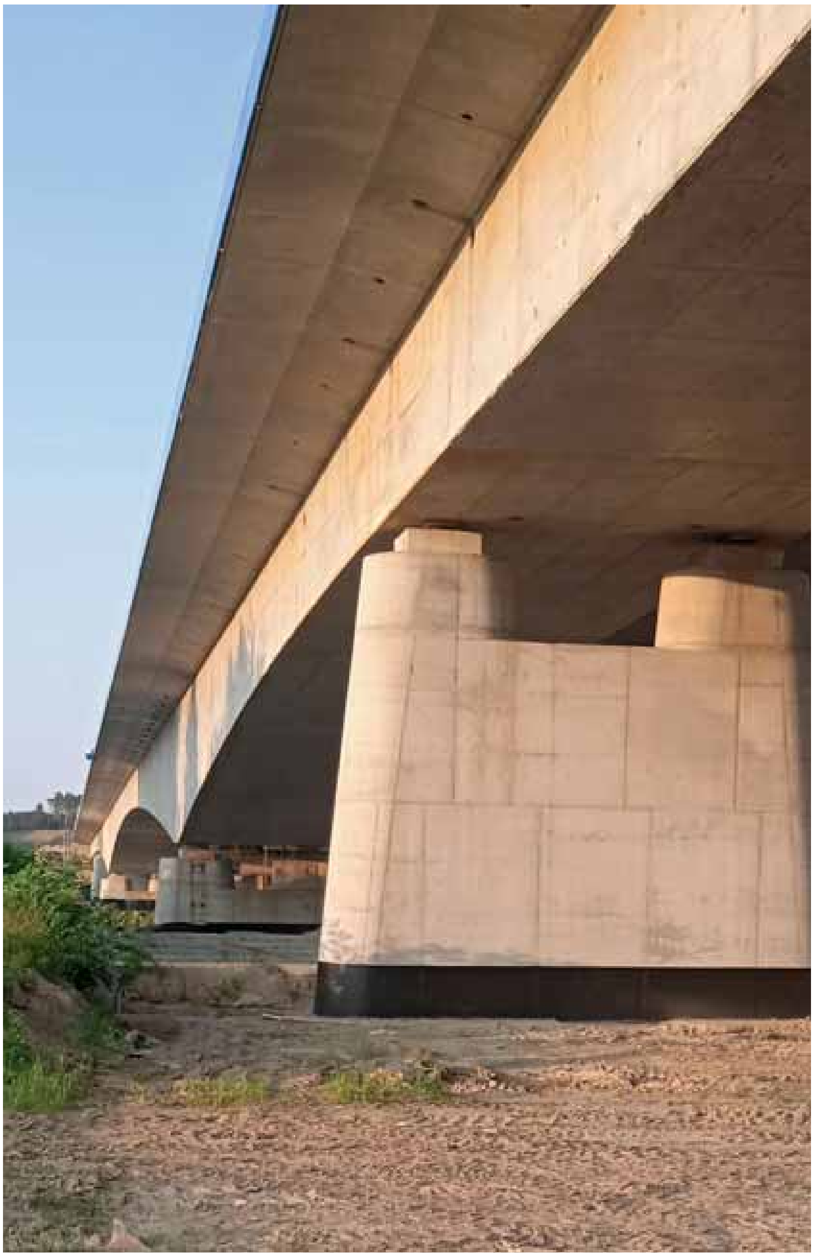
While its name may sound like something from the ancient history books, the Via Carpathia is very much a project of the current era. Its aim is to provide a road connection between the Baltic Sea and the Mediterranean, starting in Lithuania, traversing Poland, Hungary, Romania – crossing the River Danube via an earlier BBR Network project, the New Europe Bridge at Calafat – and into Bulgaria before terminating in northern Greece. Two spurs leading towards the Black Sea are also in the masterplan.

S19 work scope

Here, in Poland, BBR Polska has provided services for various main contractors – Strabag, MotaEngil CE and Mostly Łódź – covering a total of six stretches of the S19. We were responsible for the post-tensioning of 19 viaducts along and over the S19 Expressway, as well as a twin deck bridge (08MS) which takes the S19 over the San river. In the course of our work, we have used the BBR VT CONA CMI internal 1906, 2206 and 2706 post-tensioning systems – as well as drawing on our long experience in free cantilever construction.

Free cantilever bridge

Bridge 08MS was the largest structure undertaken by BBR Polska on the S19 project. The bridge is on the stretch of highway between Lublin and Rzeszów and it passes over the San river near the city of Nisko.
Construction considerations had to accommodate the nearby broad gauge LHS railway track, as well as the needs of large animals from conservation areas whose migratory routes pass beneath the bridge structure.



The largest structure on Poland's S19 Expressway, Bridge 08-MS, was constructed using a blended method which included free cantilevering, along with execution of CONA CMI internal and CONA CME external post-tensioning.

Structural details

The bridge comprises two independent superstructures, both of post-tensioned concrete construction. Each superstructure is a single cell box cantilever with cross-sections varying in depth in the main span and internal spans, while being of a constant depth in the external spans. In the longitudinal direction, the bridge structure is a continuous 390m-long beam with span lengths of 44m + 64m + 142m + 76m + 64m. The structure is 7.10m deep over the river supports and 3.20m deep in the middle of the river span.

Construction method & PT

The bridge was built using blended technology. The external spans were constructed in two stages using stationary scaffolding (stage 1: span 2-3 and 4-5, stage 2: span 1-2 and 5-6), and the span 3-4 was constructed using the free cantilever method (2x15 segments, plus a stitch segment).
Stressing of the post-tensioning was performed in five phases:

- **Phase 1** – BBR VT CONA CMI 1906 tendons in spans 2-3 and 4-5 (tendons in the bridge web).
- **Phase 2** – BBR VT CONA CMI 1906 tendons in spans 1-2 and 5-6 (tendons in the bridge web) and BBR VT CONA CME 1906 tendons in span 1-2.
- **Phase 3** – BBR VT CONA CMI 1506 and 1906 tendons along with execution of the following segments using the free cantilever method (the upper slab tendons).
- **Phase 4** – BBR VT CONA CMI 1906 and BBR VT CONA CME 1906 tendons in span 3-4.
- **Phase 5** – BBR VT CONA CMI 1906 tendons in span 1-2 (the bottom slab tendons) and BBR VT CONA CME 1906 tendons in span 5-6.

We began work on the first bridge deck in August 2020 and continued through to November 2020. Construction of the second deck of the bridge started in March 2021 and was completed in August.

TEAM & TECHNOLOGY

Client – GDDKiA (General Directorate for National Roads and Motorways)
Main contractor – Mosty Łódź S.A.
Structural engineers – Pomost Warszawa sp. z o.o.
Technology – BBR VT CONA CMI internal, BBR VT CONA CME external, Free cantilever
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

Step-by-Step Guide

1

September 2020: The first deck sections are emerging from the abutments, ready for BBR Polska to begin the cantilever construction of the main span.

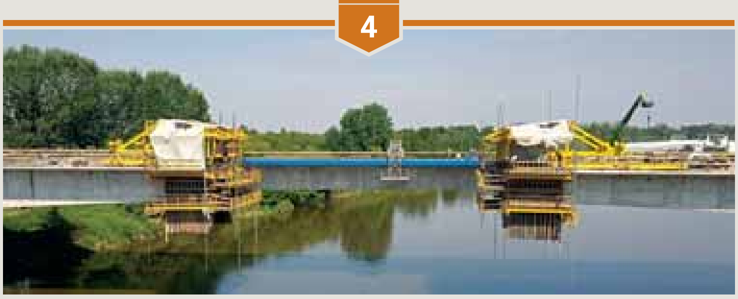
2

October 2020: First segments have been placed for the main span.

3

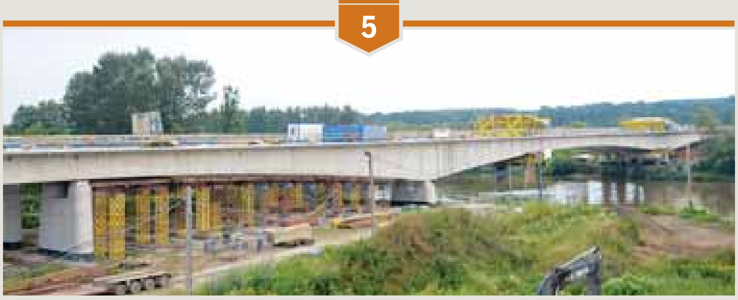
January 2021: Pictured here is the 142m main span of the first bridge superstructure nearing completion.

4



June 2021: The second bridge superstructure is well-advanced.

5



August 2021: Both decks of the bridge are now complete.

KVLRT3, Klang Valley, Malaysia Specialist PT services with CONA CMI

Harnessing benefits of top-notch expertise

In response to the ever-increasing demand for better mobility in the heart of Malaysia's busiest town – Klang Valley – construction of the third extension of the Klang Valley Light Rail Transit (KVLRT) network is underway. BBR Malaysia's Lee Chuen Lin and Ahmad Zuhair outline the project and report on the expert post-tensioning services the team is delivering.

BBR Malaysia has been appointed as the post-tensioning specialist for work package 2 (GS02) of the KVLRT3 project.

The KVLRT3 project will extend the current KVLRT lines by 37km – thus, by 2024, the whole network will be 129km long and have a total of 99 stations throughout the Klang Valley. The success of this project will bring an immense improvement to local transport services in the Klang Valley.

KVLRT3 consists of a fully-elevated railway that will be seamlessly connected to the already operational KVLRT1&2 lines, as well as to lines 1&2 of the Klang Valley Mass Rapid Transit (KVMRT) system.

The client has divided this new project into 10 separate work packages. BBR Construction Systems (M) Sdn Bhd (BBR Malaysia) was appointed by main contractor WCT Construction Sdn Bhd as the post-tensioning specialist for work package 2 (GS02).

The work scope encompasses the supply and installation of post-tensioning systems for 47 pier caps and two types of long span viaduct. Equipped with strong skills and expertise, plus our long experience, BBR Malaysia is ready to provide the best service for the job.

Adopting the best technology

In addition to the driverless communications-based train control system, one of the unique features of KVLRT3 is that it will be the first railway in Malaysia to adopt a U-trough girder for some of the viaducts.

U-trough girders are not an uncommon type of girder when it comes to metro viaducts. It was introduced in the '90s and since then has been further developed through wide use in large cities worldwide. This type of girder offers the option for a low longitudinal profile of the rail line and the web wall can serve as a noise barrier. These features make it a perfect fit for the KVLRT3 line.

Versatile PT system

There are two different types of girder – precast box girders and U-trough girders – as well as different types of precast pier caps. For the post-tensioning, BBR Malaysia proposed the state-of-the-art BBR VT CONA CMI internal system for the KVLRT3 work package 2. With its compact build and easy-to-install features, the CONA CMI systems fits best – even in heavily rebar congested segments, as well as on the slender and thin segments of the U-trough girder. The tendon sizes adopted in this work package ranges from seven up to 22 strands at the largest and, with a wide range of availability of CONA CMI as a standard option, procurement is easy.

Utilizing expertise

There will certainly be challenges during the installation and performing the prestressing works especially in the busiest part of the town. With our past experience, excellent coordination skill and the breadth of expertise within the BBR Malaysia team, each challenge will be addressed efficiently.

Most of the pier caps within this work package are precast segments with heights ranging from five to 22m – and most of them are located right next to a busy expressway. Proper temporary platforms have been designed and are being used to allow the works to be executed safely at each pier.

Stressing

We adopted a three stage stressing program for the pier cap structures to facilitate and control load transfer to pile caps during construction. In the first stage, stressing force is only applied to a proportion of the full force required after the segment is launched. The force is then progressively increased in the second and third stages until the final designed stressing force is achieved following the launch of the U-trough girder onto the top of the pier cap.

Span construction

The two long span viaducts are being constructed with two different types of cross-section. These are box girders for Long Span 2 (LS2) and U-trough girders for Long Span 3 (LS3).

Both long span viaducts adopted an integral monolithic hammer head design for the pier caps and spans are constructed using precast segments. Careful steps are taken at the interfaces between precast and in-situ hammerhead pier caps to minimize the offset of tendon profiles that could otherwise affect the threading process. The works are carried out using a special template to match the tendon position as cast at the casting yard. All of the precast segments are launched following balanced cantilever methodology by using a segment erector. The team is using the built-in working platform on the segment erector from which to conduct post-tensioning works on the segment. As the long spans are spanning across a major expressway – one of them is even located on top of the existing KVLRT2 transit line – the time frame for the works on each segment is limited to avoid major disruption to the public. Good, practical and effective planning is indeed crucial to execute the works with minimal error. Each of the procedures was carefully reviewed and detailed in advance.

Strengthening the reputation

BBR Malaysia is always among the names at the top of the list when it comes to complex specialist construction work. With this project, we have again proved our strength, expertise, perseverance and capability to deliver the works magnificently. We are dedicated to maintaining top-notch service quality and are always prepared for our next challenge.

TEAM & TECHNOLOGY

Developer/operator – Prasarana Malaysia Bhd
Main contractor – WCT Construction Sdn Bhd (WCT)
Technology – BBR VT CONA CMI internal, Balanced cantilever
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

SBB Liestal Extension Program, Switzerland
Implementation of BBR CONA CMI EIT tendons

Electrically isolated tendons for railway overpass

Swiss BBR Network Member, Stahlton, recently deployed one of its specialist teams to install electrically isolated tendons for a railway overpass bridge in Liestal, within a major SBB expansion program.

As part of a four-track extension project, SBB Infrastructure is expanding the platform and track systems in the station and its approach tracks, thereby defusing the conflicts at train crossings. This is expected to improve train punctuality and reduce the susceptibility of rail traffic to disruptions on the Basel-Olten line.

Bridge modification

As a result of the expansion plan, the Seltisbergstrasse bridge which passes over the railway tracks, needed to be widened and lengthened. The work was scheduled in two stages thus allowing single lane traffic to continue to use the bridge. The first stage, on the eastern side of the overpass, was rebuilt in winter 2019-20 and the second stage was completed in spring 2021.

Electrically isolated PT tendons

Since both parts of the bridge run over the SBB railway line, the post-tensioning was executed using BBR VT CONA CMI electrically isolated tendons (EIT). The team used a total of 16 CONA CMI tendons comprising 12 strands of 1,860mm² cross-section and the tendons were stressed alternately. Two measuring boxes, each with 16 measuring terminals, were installed – one on either side of the bridge – to monitor the long term effectiveness of the electrically isolated PT system.

Reliable electrical isolation, such as that offered by the European approved CONA CMI EIT system, protects the steel post-tensioning strands from potential damage caused by sparking of any stray current passing through the tendon. The risk of stray currents arises mainly when the post-tensioned structure is located near to railway tracks and especially around installations using direct current (DC), such as rail or tramways.

As construction work at Liestal becomes a distant memory, SBB – and indeed the traveling public – may rest assured that this newly extended structure will continue to serve them well for many years to come.

TEAM & TECHNOLOGY

Client – SBB AG
Main contractor – Implenia AG
Consulting engineer – Bänziger Partner AG
Technology – BBR VT CONA CMI EIT
BBR Network Member – Stahlton AG (Switzerland)

PT Ground Slabs, New Zealand High performance PT ground slabs

Three million milestone

For New Zealand-based BBR Contech, 2021 was a milestone year. Just three years short of its 60th anniversary, the company celebrated the completion of 3,000,000m² post-tensioned ground slabs!

3,000,000m²
High performance
PT slabs

1

There's a great story behind this awesome achievement. It tells of people with vision who recognized the potential of this ground-breaking approach, clients who had the faith to run with it, staff who had the talent to implement it – and industry partners who had the enthusiasm to share and contribute to the journey. Underpinning the whole achievement has been a company commitment to continual innovation that has seen PT slabs adapt to constantly changing times.

The story

The story of BBR Contech and PT slabs began in the mid-1960s, when the company's founders, Rob Irwin and Rob Robinson, heard about and saw the benefits of PT slabs and introduced them to the market for specialist applications. Back then, most buildings were constructed with conventional reinforced concrete slabs and regular construction joints.

About 30 years later – when the use of PT slabs was still in its infancy – Paul Wymer and then Jeff Marchant joined the team, with the latter particularly interested in producing PT slab designs using traditional design chart methods. At the time, the commercial building market was starting to look for higher quality warehouse slabs, so Paul and Jeff worked together to streamline the design and construction process with the aim of delivering high performance slabs. The pair developed flowcharts in-house to document the overall design process, then Jeff converted the charts into an automated, and therefore faster, design process. This in turn enabled the development of alternative slab layouts.

2002 signaled a major step forward when a client, Progressive Enterprises (now Woolworths New Zealand), commissioned BBR Contech and Allied Concrete to deliver a full delivery flooring project for a distribution center (DC). The two companies recognized the need for a new model that ensured the delivery of premium quality floors with certainty of performance and a single point of responsibility. Together they designed and delivered a high performing, high quality DC that turned out to be the springboard for further PT floor projects at scale.

Word quickly spread about the advantages and results of the new delivery model – and this in turn led to a rapid increase in the number of PT floors delivered each year. Allied Concrete established a specialist flooring contractor – Conslab – to focus on delivering projects, while Jeff kept developing and refining the design process and integrating more elements with the BBR Contech in-house software.

2

3

These included:

- building-consent submissions
- CAD drawings
- job costings
- racking and forklift designs
- tendon/joint locations, so that manufacturers of perimeter-wall panels could proceed seamlessly ahead of the physical building-construction program.

Other innovations included the introduction of couplers to minimize the number of movement joints in large floors. Couplers are still in use today, while a range of processes and products have been enhanced to allow the analysis of more complicated floor layouts and loading applications.

Derek Bilby, CEO of BBR Contech, is quick to point out that the success and overall development of PT floors by BBR Contech and the wider New Zealand construction market could only have been made possible through the collective effort of the wider BBR Contech team.

"They included our founding employees, technical material experts, BBR VT International anchorage and component experts, design engineers, project engineers, regional managers, supervisors and field operatives. Without their insights, efforts and commitment, we wouldn't have evolved to where we are today."

He also acknowledges the Conslab team, who work closely with BBR Contech in designing, configuring and constructing PT floors that meet building owners' requirements for quality and performance. "Conslab has been involved in about half of our projects since 2000," says Derek. "We consider them an invaluable part of the team."

The highlights

So far, BBR Contech has installed PT floors in about 420 building projects, with the largest to date – and the largest floor slab ever produced in New Zealand in a single project – being a 74,000m² floor for a brand new Foodstuffs distribution center (see CONNÆCT 2021, page 42).

About a third of all the PT floors are in buildings with floor areas ranging from 15,000m² to 74,000m². That's in stark contrast to one of the earliest PT floors of just 2,000m², which was installed in 1983 to create a roller-skating rink in Auckland for commercial builder Haydn & Rollett – who, incidentally, is still one of BBR Contech's key customers.

The future

Just as it has always done, BBR Contech is looking to and preparing for the future, particularly in terms of New Zealand's path to a low-emission, climate-resilient future.

The NZ Government has committed to NET zero CO_2 by 2050 and BBR Contech – along with its colleagues in the wider building sector – is exploring all options to help achieve that goal. Areas of particular focus include:

- increasing the efficiency of the material used in buildings
- reducing the impacts of buildings' structural elements
- reducing whole-of-life carbon footprints
- improving buildings' ability to withstand climate-change events
- improving the building lifecycle – from buildings' placement to their design and construction and considerations for their re-use and ultimate disposal
- reducing emissions that result from repairing and replacing building elements damaged in earthquakes – this includes balancing the carbon cost of seismic repairs, refurbishment work and seismic strengthening with doing nothing or building new
- ensuring that design solutions are both resilient and materially efficient, while exploiting opportunities to reduce the whole-of-life embodied carbon in buildings in New Zealand.

Given BBR Contech's success with post-tensioning and the technique's many and considerable advantages over more traditional methods – especially its potential in helping New Zealand to meet its zero-carbon goal – we expect the company's commitment to innovation to continue. Watch this space!

4


5

6

Underpinning the whole achievement has been a company commitment to continual innovation that has seen PT slabs adapt to constantly changing times.

1 BBR Contech has built a reputation for the construction of high performance slabs. Pictured here is the super-flatness of the floor at the James Pascoe Group Distribution Centre being measured using a FACE profileograph – a tool designed to replicate the wheel configuration and movement of materials handling equipment.
2 This logistics center in Highbrook, Auckland for Courier Post was the first large-scale use of PT couplers to join pours – the entire 20,000m² floor was completed with no free-movement joints.
3 A greenfield milk processing facility for Fonterra Darfield began in 2012 with two drystores totaling 50,500m². The overall tally of PT slabs constructed at this facility now stands at 80,900m² and includes two packing stores, coolstore and an external heavy-duty pavement area.
4 The James Pascoe Group Distribution Centre in East Tamaki. This 25,000m² award-winning VNA super-flat PT floor was constructed in 2014 by Conslab, with specialist PT expertise from BBR Contech who helped to deliver the best floor flatness level in the world.
5 In 2002, the work of BBR Contech and Allied Concrete on the full delivery flooring project for a distribution center for Progressive Enterprises (now Woolworths New Zealand) was the 'springboard' project for further PT floor projects at scale.
6 In 2006, the 50,000m² Fonterra Hamilton drystore and heavy-duty load-out apron became the largest PT floor constructed, as well as the first heavy-duty PT load-out apron.

Highlights

There's not enough room here to mention all the projects that add up to BBR Contech's amazing 3,000,000m² ground slab landmark. So here are some highlights:

1993 and 1995

Total 8,000m²

Two large dairy storage facilities at the Port of Tauranga. These were the first of many drystore and warehouse PT floors delivered for dairy companies in New Zealand.

2000

8,000m²

The Warehouse at Eastgate, Christchurch. This was the first floor constructed for client Naylor Love, who was looking for high performance and low maintenance. BBR Contech has since installed PT floors in 30 Warehouse stores (total area 210,000m²).

2002

23,000m²

A Woolworths New Zealand DC in Māngere, Auckland, designed and installed in a collaboration between Allied Concrete and BBR Contech. This floor was the first of what was to become the most trusted high performance floor product on the market.

2003

20,000m²

A PrimePort Timaru dairy product storage facility. The was the first large-scale dairy store in New Zealand built by Calder Stewart. It became one of more than 50 dairy product storage buildings built in New Zealand after 1993, covering a total floor area of some 500,000m².

2006

50,000m²

A Fonterra drystore and heavy-duty load-out apron in Hamilton, for Haydn & Rollett and with Conslab as the delivery contractor. It was the largest PT floor constructed at the time and the first heavy-duty PT load-out apron.

2008

20,000m²

A Courier Post logistics center in Highbrook, Auckland for Goodman. This was the first large-scale use of PT couplers to join pours – the entire floor was completed with no free-movement joints.

2012

50,500m²

Two Fonterra Darfield drystores. These were the first PT floors constructed at this facility – and the total now stands at 80,900m² (50,500m² drystore warehousing, 3,750m² two packing stores, 2,800m² coolstore and 23,850m² external heavy-duty pavement area)

2014

25,000m²

James Pascoe Group Distribution Centre, East Tamaki. The award-winning floor was constructed by Conslab and is an example of a VNA super-flat PT floor. BBR Contech's involvement with the James Pascoe Group has seen the delivery of the best floor flatness level in the world.

2019

74,000m²

A Foodstuffs DC in Auckland, built by Macrennie Commercial Construction and Conslab. This was BBR Contech's largest single-level PT floor – and the first use of the BBR CONA CMF S2 flat post-tensioning system.

2021

46,000m²

Synlait Drystore 4 and heavy duty load-out aprons. This is the most recent dairy project for Synlait – and brings the total PT slab area at the Dunsandel facility to 86,844m².

KTWII Skyscraper, Katowice, Poland Maximizing potential with CONA CMF

Creating landmarks in Katowice

The reconstruction of the heart of Katowice – the capital of the Silesian province – began in 2004. Since then, BBR Polska has delivered a range of technologies and services to a number of the landmark projects which have contributed to the city's regeneration. Now, Marek Strzoda and Marcin Ornat reveal the company's role in the realization of the latest addition to the cityscape – the stunning KTW skyscraper.

Katowice has been transformed from an industrial city with its coal mines and steel mills into a cultural and financial hub. During the first phase of the reconstruction, the road network was upgraded with the construction of the city tunnel on the DTŚ road, which connects cities within the Silesian agglomeration and passes right next to the Spodek – Katowice's flying saucer-shaped sports and entertainment arena.

Early regeneration phases

As part of this first phase of regeneration, BBR Polska participated in the construction of the footbridge over the DTŚ road. Here, we used the BBR DINA wire stay cable system and – for the first time in Poland – we installed the BBR VT CONA CMI 3106 internal post-tensioning system.

In 2012, during a further phase of city center reconstruction, we took part in the construction of the new Silesian Museum building, which is located on the site of a former coal mine. The structure was built underground to reflect the city's industrial and mining past. In the years which followed, the Congress Center – which hosted the 2018 United Nations Climate Change Conference – and Polish Radio's National Symphony Orchestra buildings were constructed between the museum and Spodek, creating the cultural district of the city.

1

1 The play of natural lighting on the dramatic black façade of the KTW I & II buildings seems literally to reflect the city's hard coal mining history.

2 Finishing touches are being put to the new KTW II office building which features BBR VT CONA CMF BT post-tensioning, installed by BBR Polska.

KTW I & II offices

Two distinctive office buildings have also been constructed – KTW I (2017) and KTW II (2020-2021). Their architect, the Medusa Group, described the structural design concept as resembling boxes stacked on top of one another and being slightly offset – which synchronizes perfectly with the city's heritage. The buildings are connected by three underground stories. The structural floors are post-tensioned. KTW I has 14 above-ground stories, which were post-tensioned using BBR VT CONA CMF BT tendons.

KTW II, on the other hand, has 31 stories and is 133m high – in fact, it is the tallest office building in the Silesian region. Here again, we installed CONA CMF BT flat tendons. The construction of one storey was fast – taking only around eight to nine days. The characteristic overhangs are located between the eighth and ninth floors and also between the 19th and 20th floors. The structures are fitted with six and 12 elevator shafts respectively.

KTW I was commissioned in 2018, while KTW II is to be commissioned in 2022 – providing Katowice with 42,000m^2 of extra office space. As the buildings are located in the very center of Katowice, the logistics of building materials and organization of works on the building site posed a tremendous challenge. Construction work continued around the clock. Self-climbing hydraulic formwork was used to construct the tower buildings.

City skyline

The KTW buildings are a great addition to Katowice's skyline and contrast beautifully with other surrounding structures, at the same time as complementing them. The buildings house financial institutions, medical centers, restaurants and offer huge amounts of high quality office space.

The east-west alignment of the longer sides of the towers maximizes the play of lighting at various times of day on the dramatic black façade of the buildings – literally reflecting the city's history which is so closely related to the mining of 'black gold' – hard coal.

Now, only the architecture of the city reminds residents and visitors alike of Katowice's industrial past – and how with good planning and latest technology, we can adapt our world to create sustainable landmarks for the future.

TEAM & TECHNOLOGY

Client – TDJ Estate
Main contractor – REMAX CONSTRUCT Sp. z o.o.
Designer – Medusa Group
Technology – BBR VT CONA CMF flat
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

2

Residential developments, Bosnia & Herzegovina and Croatia PT for floors

Rooms with a view

From a vibrant city center location, to the blue Adriatic coastline, BBR Adria has recently been providing more post-tensioned solutions for residential developments. Dejan Buha and Ivan Kušt present an overview of two recent projects – one in Bosnia and Herzegovina, the other in Croatia.

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The benefits of taking a post-tensioned approach to multi-storey commercial or residential developments are many, including PT slabs that are up to 30% thinner and can reduce the building height or allow more floors within the original building envelope, while at the same time promoting faster installation and cost savings. There are so many more advantages too – simplicity of construction, large clear spans, as well as lower maintenance and environmental impacts. For full details, you might like to take a look at the BBR PT Slabs brochure, available as a download from the BBR Network website – or call your local BBR Network Member.

1 SPO 'Malta', Banja Luka

This was our first housing project in Bosnia and Herzegovina using BBR post-tensioning technology. The facility is located in the city of Banja Luka and was built according to EU standards. The building consists of an underground garage, three business premises on the ground floor and 75 apartments on the upper floors.

We hope that this will be the first of many projects in Bosnia and Herzegovina where developers can harness the benefits of European approved BBR post-tensioning for their residential developments.

2 Projekt RIO, Rijeka

Meanwhile, over 300km away, on the coast of Croatia, Projekt RIO is underway to construct a residential and business complex. Three buildings, with 13, 8 and 10 floors, will house a total of 273 apartments – including penthouses with expansive roof terraces. On the ground floor, there will be a shopping center and underneath the whole development, there will be two levels of car parking.

Our role in the project began with participation in the preparation of the static analysis of the post-tensioned slab. For the post-tensioning, we chose the BBR VT CONA CMM monostrand system which has again proven its high quality on this site. In total, we installed over 150t of steel prestressing strand for the PT tendons.

These two projects clearly demonstrate the advantages that post-tensioned construction can bring to residential developments and we look forward to applying BBR technologies and techniques to many more similar schemes in the coming months.

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1 SPO 'Malta', Banja Luka – BBR Adria's first housing project in Bosnia and Herzegovina.
2 Projekt RIO in Rijeka, Croatia – a major commercial and residential development for which BBR Adria have harnessed the benefits of BBR VT CONA CMM post-tensioning.
3 The Projekt RIO development consists of three buildings housing a total of 273 apartments – including penthouses with expansive roof terraces. On the ground floor, there will be a shopping center and beneath the whole development, there will be two levels of car parking.

TEAM & TECHNOLOGY

1 SPO MALTA

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

2 PROJEKT RIO

Owner – Rio projekti d.o.o.
Main contractor – Kamgrad d.d.
PT design – Stabilnost d.o.o. & BBR Adria d.o.o.
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o. (Croatia)

Block E7, National University of Singapore CONA CMF PT for floor slabs

New research hub @ NUS

A front-runner in research fields between Engineering and Medicine, the National University of Singapore (NUS) commissioned the new Block E7 structure, containing 16,000m^2 over eight floors and sited within its campus. BBR Construction Systems Pte Ltd has contributed design and construction expertise based on an alternative solution for the floor slab using post-tensioning.

Block E7 will house the Biomedical Institute for Global Healthcare Research & Technology which is aimed at bridging research between engineering and medical fields and also at developing advanced medical technology for the future. Thoroughly equipped with state-of-the-art facilities, technologically advanced laboratories and interactive spaces for research discussions, NUS E7 will serve as a hub for collaboration between researchers and industries.

The intended use for high tech laboratories and the 10 meter grids prompted a collaboration between BBR Construction Systems and main contractor Lian Soon Construction Pte Ltd resulting in the proposal of a post-tensioned flat slab structural system as an alternative to the conventional reinforced concrete flat slab originally envisaged. This alternative proposal achieved a slab thickness reduction, improved serviceability performance and reduction in construction cycle time – all great benefits for the project. Finite element analysis was used in the design to overcome the limitations of traditional sub-frame analysis methods in accommodating the various large openings necessitated by client requirements.

TEAM & TECHNOLOGY

Client – National University of Singapore, Office of Estate & Development

Architect – Architects 61 Pte Ltd

Civil & structural consultant – KTP Consultants Pte Ltd

Main contractor – Lian Soon Construction Pte Ltd

Technology – BBR VT CONA CMF flat

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

E Leclerc & Supernova Car Park, Ljubljana, Slovenia BBR PT support for sustainable approach

Setting standards for Slovenia's largest car park

A massive expansion scheme is underway at the Supernova Ljubljana Rudnik shopping center in Slovenia and, in a cooperation with the neighboring E Leclerc superstore, a new landmark car park is emerging. Thanks to the expert post-tensioning services of BBR Adria, the development's green credentials are further enhanced.

The 1,800-space, four-level car park – believed to be the largest in Slovenia – has been designed as a semi-open structure with a green façade. The latter will, when the planting scheme has matured, offer natural shade and a pleasant environment.

Working alongside main contractor Strabag, BBR Adria has helped the team to capitalize on the advantages of using BBR post-tensioning – particularly for lowering materials consumption and speeding up the construction program.

Meanwhile, the Supernova Ljubljana Rudnik shopping center itself is being extended and when fully opened in Spring this year will include a further 60 stores, as well as a new seven screen cinema complex. Visitors may now look forward to a comfortable parking experience, as well as the prospect of many new options for retail and leisure.

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1 BBR Adria installed CONA CMM monostrand post-tensioning for this 1,800-space, four-level car park.

2 The Supernova & E Leclerc shopping center car park is believed to be Slovenia's largest car park.

TEAM & TECHNOLOGY

Owner – Supernova
Main contractor – Strabag
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o. (Croatia)

Countdown Distribution Centers, New Zealand Leading edge BBR slab construction technology

Enabling an industry revolution

The credentials of BBR Contech as an expert in post-tensioned flooring gained even more traction in 2021, when the company helped to build not one but two massive distribution centers for Countdown, New Zealand's leading supermarket brand.

Owned by Woolworths New Zealand, Countdown operates 180 stores and online distribution. The stores are supported by specialist distribution regional centers, with three centers transporting dry groceries, three fresh produce and three chilled and frozen foods. The drivers responsible for moving these products to Countdown stores travel more than 12 million kilometers a year and make more than 250,000 deliveries. New technologies are transforming the way these centers operate, enabling efficiencies in storage, warehouse management and product tracking, improvements in product safety, reliability, accuracy and delivery speed, and reductions in product spoilage and holding, pick-up and delivery times. The new distribution centers reflect these advances, providing Countdown with a leading edge in this highly competitive market.

1 Auckland

Countdown's new fresh-produce distribution center in Wiri, near Auckland, has replaced a similar facility in nearby Mt Wellington and another in Palmerston North (about 500km south). Bigger and more technologically sophisticated than its predecessors, it provides refrigerated storage and dispatch services to all Countdown stores in the North Island and can handle 350,000 crates of fresh produce at a time.

The NZ$150m center has delivered a game-changer for the company. In centralizing its fresh product operations and operating 24 hours-a-day, seven days-a-week, it has reduced its operating costs, increased efficiency and improved the service it offers its customers. Product quality has also improved, as the temperature-controlled building is chilled in zones – 2°C for leafy vegetables, grapes and apples; 7°C for citrus and capsicums and 13°C for avocados, bananas, tomatoes and potatoes. There's even a ripening area for avocados and bananas too.

Countdown has also reduced its emissions and achieved economies of scale by establishing a physical link between the distribution center and Hilton Foods, a state-of-the-art meat-processing factory with which the company developed a partnership in 2017. Via an airbridge containing an automated conveyor belt, packaged meat products are delivered to the distribution center to be loaded onto the trucks carrying fresh produce – saving time, money and, critically, reducing the number of trucks on the roads.

BBR Contech's role in building the technologically sophisticated distribution center involved

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installing a flat and level wearing surface on top of a pre-installed 14,000m² concrete floor slab that was covered by insulation. The wearing surface will help the surfaces below to withstand the loads, heat and vibration generated by vehicles in the building – and therefore help to ensure that this giant refrigerator and all the technology and energy systems driving it perform at their best.

According to BBR Contech's Project Engineer, Cris Tagaća, the process was reasonably straightforward, but the working conditions – in a dark, fully enclosed, fully insulated building – were strangely oppressive.

Today, the new distribution center – standing 17m high and spanning 20,000m² – is fully operational. A large solar array on the roof is providing power to the site and the company has achieved its goal of gaining a 4 Green Star Built rating using the new Green Star Design & As Built NZ v1.0 rating tool. The tool will be used to evaluate the facility's design and construction based on criteria such as energy and water efficiency, indoor environmental quality and resource conservation.

2 Palmerston North

Countdown's new, purpose-built distribution center in Palmerston North is also a step up in quality, capacity and competitive advantage. Located close to Palmerston North Airport, the center is a hub for deliveries of food and other essentials to Countdown, FreshChoice and SuperValue stores in locations from Gisborne in the north to Wellington in the south. At 40,000m² – three times the size of the previous facility, the center will enable the company to meet customer demand for many years to come. It's already moving about 450,000 cartons of food a week – and that number is expected to grow.

Once again, BBR Contech and partner Conslab were responsible for installing and post-tensioning the building's floor slab. While the process itself was more straightforward than that for the Wiri building, it required 16 pours in just 16 weeks – but with previous experience of providing post-tensioning services for other local customers – such as EziBuy and Foodstuffs (distribution centers) and DKSH New Zealand (a warehouse) – all logistical issues were easily overcome by the team.

1 Countdown's new fresh-produce distribution center in Wiri, near Auckland.
2 Countdown's new, purpose-built distribution center in Palmerston North is a step up in quality, capacity and competitive advantage.

TEAM & TECHNOLOGY

1 COUNTDOWN AUCKLAND

Client – Woolworths New Zealand
Consulting engineer – Sylvester/Clark Consulting Engineers
Main contractor – Macrennie Commercial Construction
Specialist flooring contractor – Conslab
Technology – BBR VT CONA CMF flat
BBR Network Member – BBR Contech (New Zealand)

2 COUNTDOWN PALMERSTON NORTH

Client – Woolworths New Zealand
Main contractor – Watts and Hughes
Specialist flooring contractor – Conslab
Technology – BBR VT CONA CMF flat
BBR Network Member – BBR Contech (New Zealand)

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Z centar, Zagreb, Croatia BBR PT for shopping center

New generation of retail experience

A state-of-the-art retail mall and car park have been constructed in Špansko, a suburb to the west of Zagreb and, as well as capturing the imagination of the local citizens, it has also scooped a European Property Award for Best Commercial Real Estate Project in Croatia. The adventurous architectural design and swift construction program was supported by the use of post-tensioning, expertly installed by local BBR Network Member BBR Adria.

The vision for the Z centar development extends way beyond shopping. As well as featuring major national and international brands in over 60 stores, the retail park has also been designed to provide leisure activities and meeting spaces, complete with many coffee bars and restaurant facilities.

The scheme

The new complex has more than 75,000m^2 of usable space and its realization is valued at over €82 million. The shopping center 'North' and the 'South' retail park are connected by an outdoor heated square which will serve as a meeting place and events space. Meanwhile, there is a sports field on the roof and two children's playgrounds. Visitors will have access to some 1,300 parking spaces and the underground garage will house a free charging station for charging up to eight electric cars.

Perfect project for PT

The sense of openness and space is enhanced by cantilevered walkways and external canopies, along with glass skylights in the roof. The inspirational design of the Z centar has proven to be an ideal opportunity to showcase the benefits of taking a post-tensioned approach to construction – large column-free spaces, sleek architectural details, along with savings on program, cost and materials. The BBR Adria team installed 2,712 post-tensioning tendons – using a blend of BBR VT CONA CMI internal and BBR VT CONA CMM Two/Four systems and around 179t of steel prestressing strand.

This was a tight construction program and BBR Adria is proud to have helped to promote high productivity on the site through its efficient PT services. The team also greatly enjoyed the excellent collaboration with other members of the professional team in producing this new generation of retail experience.

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1 With increased productivity on site and reduction in embodied carbon, compared to traditional RC construction, the Z centar retail mall is a showcase for the benefits of PT construction.
2 BBR Adria installed a blend of CONA CMI and CONA CMM Two/Four PT systems for the project using some 179t of prestressing steel.
3 Located in the western suburbs of Zagreb, the new retail mall has been recognized with a European Property Award for Best Commercial Real Estate Project in Croatia.
4 Architectural design features include cantilevered walkways, wide open column-free spaces and external canopies – all achieved by using a PT approach.

TEAM & TECHNOLOGY

Developer – Sensa Nekretnine d.o.o.
Architect – PULS-AR
Main contractor – Kamgrad d.o.o.
Technology – BBR VT CONA CMM Two/Four, BBR VT CONA CMI internal
BBR Network Member – BBR Adria d.o.o.

Pulau Poh Bridge, Terengganu, Malaysia
BBR HiAm CONA stay cables & much more

Tradition meets modernity

Spanning across Lake Kenyir, the largest man-made lake in Southeast Asia, the Pulau Poh cable-stayed bridge was conceived to be an iconic structure, further enhancing Lake Kenyir's reputation as an eco-tourism hot-spot in the State of Terengganu. The client not only wanted a bridge that was modern, but also one that would reflect the unique heritage for which the State is famous. Jackie Voon, Goh Hiang Miang and Faerdaus Rohaizad tell how, with these criteria in mind, the designer, together with BBR Malaysia, proposed a cable-stayed bridge featuring latest BBR HiAm CONA technology, as well as incorporating design elements which link the bridge firmly to its local roots.

A total of 27 pairs of BBR HiAm CONA stay cables were installed for the bridge.

FACTS & FIGURES
PULAU POH BRIDGE

133m
BRIDGE LENGTH

61.5m
PYLON HEIGHT

30º
PYLON INCLINATION

20 pairs
FRONT STAY CABLES

7 pairs
BACK STAY CABLES

22m to 118m
FRONT STAY CABLE LENGTH

64m to 88m
BACK STAY CABLE LENGTH

Background

Cable stayed bridges have always been considered spectacular – with their distinctive pylons soaring high and stay cables forming aesthetically pleasing lines and patterns. BBR Malaysia's solution of using the HiAm CONA stay cable system was well-received by our client. With a huge international portfolio of landmark structures which rely on BBR stay cable technology, the client had no hesitation about the system. However, this was not enough for creating the one-of-a-kind bridge to which our client aspired.

The solution revolved around an important economic activity that was synonymous with the livelihood of the locals – fishing. The State of Terengganu has a long history of fishing and boat-building. As well as being a means to earn a living, the traditional wooden boats built were also a showcase for art and aesthetics. Drawing inspiration from artistic 'bangau' motifs – a kind of figurehead – found on traditional fishing boats, BBR Malaysia and the designer proposed that a representation of this unique feature should be constructed at the top of the pylon.

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The pylon

The A-shaped pylon itself is a unique structure. It curves In two planes – towards the bridge deck and each leg also curves inwards towards the other. Originally planned as a reinforced concrete structure, the team proposed an innovative alternative approach whereby the upper section was constructed using composite steel. The advantages this offered included:

- off-site fabrication of the upper pylon, ensuring progress even during monsoon weather conditions
- enhanced construction tolerances with steel fabrication, thus reducing geometry control uncertainties
- less overall reinforcement, as outer pylon plates are part of the structural design
- working platforms could be integrated over the full height of the pylon at predetermined positions.

Production of the bangau

To be visible, the bangau needed to be of a large scale. At 6.4m high and 7.05m wide, the bangau would be cantilevering from the top of the pylon at 61.5m above the pylon base.

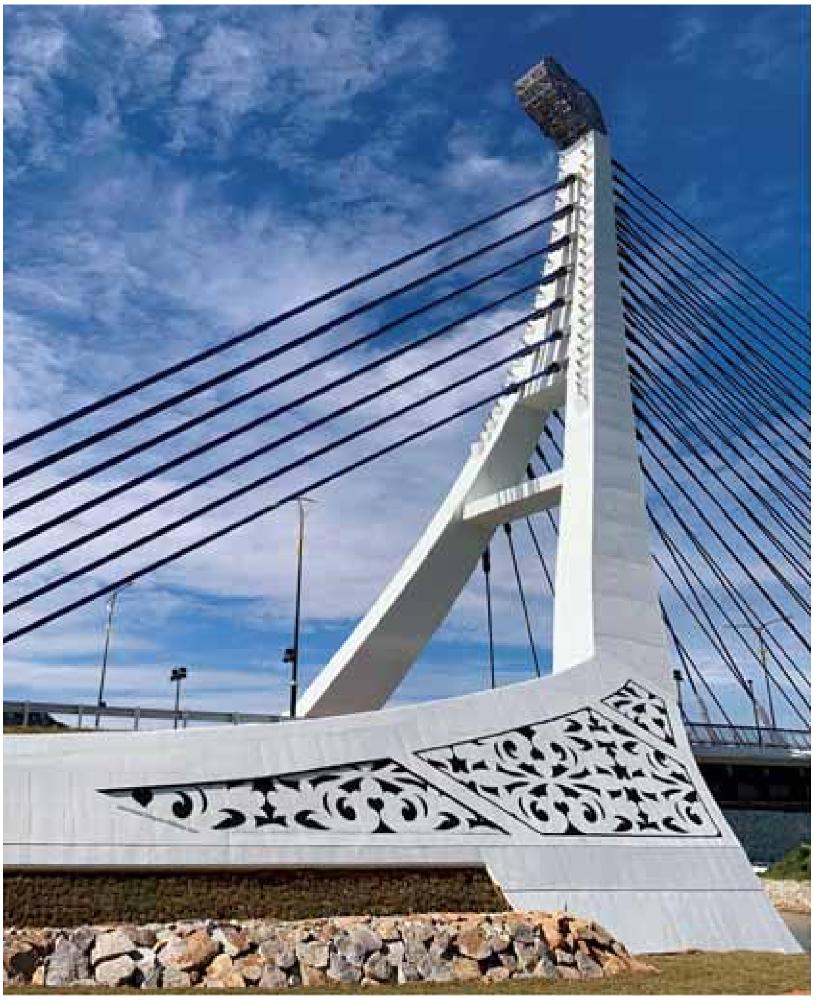
Several types of material were evaluated, taking into account the construction method, lifting and transportation limitation, safety, durability, environmental and maintenance aspects of the structure once erected into place. We proposed that the bangau should be split into several modules, fabricated using mild steel and galvanized for durability.

The intricacy of the bangau design demanded a mix of engineering and artistic approaches. With the availability of modern steel fabrication equipment, the unique pattern of the bangau was pre-cut and pre-assembled into modules. The four modules which make up the bangau were fabricated off-site in a factory and trial-fitted prior to delivery to site. Throughout the fabrication, BBR Malaysia carried out stringent quality checks on the workmanship, dimensioning, weldments and galvanizing process.

Installation of the bangau was completed within a week and signaled the completion of the pylon construction works.

1 BBR HiAm CONA stay cables rise to meet the pylon which is curved in two planes.
2 The completed Pulau Poh Bridge spans Lake Kenyir, the largest man-made lake in Southeast Asia.
3 BBR Malaysia approached a local mural artist to create an artwork design with native elements for the base of the pylon.

2



3

Traditional touches

Although at BBR Malaysia we have an international outlook, we also value our local roots greatly. For this reason, we were delighted to have the opportunity of leveraging the talent of a local artist to add value to this iconic bridge. Working collaboratively with a local mural artist, we proposed the pylon base should be further embellished with elements native to Terengganu. Hand-painted traditional patterns fill the inclined surface of both sides of the pylon base – a true showcase of local artistic talent on a modern cable-stayed bridge. The blend of these modern and traditional elements was the perfect solution which addressed the needs of our client perfectly. Now, our work here is complete and this new structure has begun its working life – while we look forward to further similarly exciting projects.

TEAM & TECHNOLOGY

Owner – Jabatan Kerja Raya Negeri Terengganu (Public Works Department of Terengganu State)
Main contractor – Casa Hartamas Sdn Bhd
Designer – Roadnet Solutions Sdn Bhd
Technology – BBR HiAm CONA stay
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

Seri Saujana Bridge, Putrajaya, Malaysia Performing well after 18 years' service

Masterpiece from all angles

No matter which way you look at it, the Seri Saujana Bridge in the city of Putrajaya, Malaysia is a masterpiece of modern construction design and engineering. In recent months, Jackie Voon and Htun Zaw from BBR Malaysia made an inspection visit to this amazing bridge which, since its opening in 2003, has become a local landmark.

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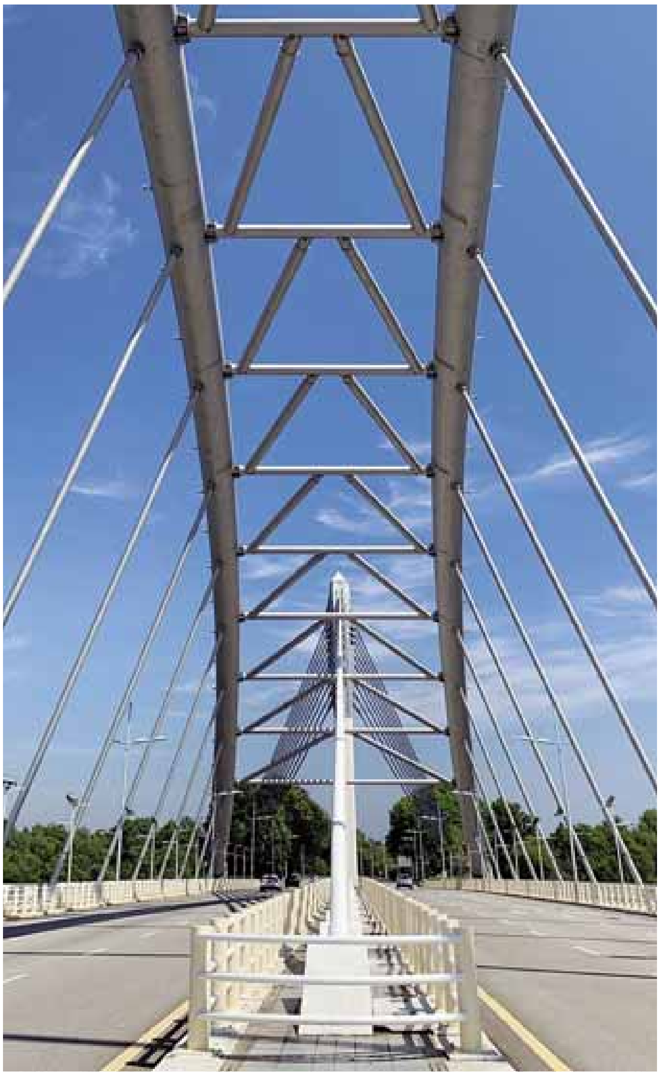

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Putrajaya, now the seat of government for Malaysia, is a new city created some 30km south of the nation's capital Kuala Lumpur. As well as wide boulevards and expansive green spaces, there are also many grand architectural masterpieces – such as the Seri Saujana Bridge.

Originally known as Bridge No.8 (BR8), the Seri Saujana was built to span the 650 hectare artificial lake built as a natural cooling system for the city, as well as for leisure activities.

Bridge design

Adopting a hybrid through-arch plus symmetrical cable-stayed bridge concept, the design was applauded as revolutionary at the start of the 21st century. Inclined away from the main span, there are two 73m high A-shaped pylons which are each restrained by 10 pairs of BBR CONA back stays in two planes. A further 22 BBR CONA main stay cables are arranged in a fan shape and pass through the arch towards their anchorages in the center of the deck.

The massive steel arch above the 300m center span supports the outer edges of the bridge deck by inclined hangers. The combined effects of both stay cables and hangers enabled a more slender deck profile to be achieved.

BBR Malaysia was the specialist contractor appointed to supply and install the stay cables and prestressed bar elements for this bridge.

Coming of age

After 18 years in service, we recently re-visited this memorable project to get a first-hand view of the bridge. Suffice to say, the Seri Saujana Bridge still looks stunning, despite some expected wear and tear.

In August and September 2021, many landmarks across the country, including the Seri Saujana Bridge, were lit in red, blue and yellow – the colors of the Malaysian flag – to celebrate Malaysia's National Day. Following the lockdowns and other restrictions brought about by the Covid-19 pandemic, our independence celebrations took on an extra special meaning last year– while the Seri Saujana Bridge decked out in glowing colors proudly declared her own independence, as a young adult.

1 The Seri Saujana Bridge spans the 650 hectare artificial lake built as a natural cooling system for the city of Putrajaya, as well as for leisure activities.
2 The hybrid through-arch plus symmetrical cable-stayed bridge design features two 73m high A-shaped pylons which are each restrained by 10 pairs of BBR CONA back stays in two planes. A further 22 BBR CONA main stay cables are arranged in a fan shape and pass through the arch towards their anchorages in the center of the deck.
3 BBR Malaysia was the specialist contractor appointed to supply and install the stay cables and prestressed bar elements for this bridge.

TEAM & TECHNOLOGY

Owner – Perbadanan Putrajaya
Main contractor – Road Builder-Hasrat Sedaya JV
Designer – PJSI Consultants
Technology – BBR CONA stay
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

Tatara Bridge, Japan
Longest cable-stayed main span in the 20th century

Pioneering stay cable landmark

In November 2022, it will be 30 years since construction started for Japan's Tatara Bridge. Looking back, it becomes clear that the project not only embraced all the learning and technological developments that had gone before, but also set a benchmark for the future too. On the following pages, we take another look at this breathtaking bridge which features the longest cable-stayed main span constructed in the 20th century – and, of course, BBR HiAm CONA technology.

Its form has been described as being like a graceful white bird spreading its wings – and with its slender, minimalist lines, Tatara Bridge has simply blended into the landscape. Its cable-stayed design was preferred over the originally proposed suspension bridge concept as it would reduce impact on the environmentally sensitive setting within the Seto Inland Sea National Park. Today, the bridge is just one component of the Honshu-Shikoku Expressway – a huge project which has increased the country's trunk road and railway network. However, Tatara Bridge has become so much more than just a highway – it is a major destination, particularly for the many cycling tourists who include the bridge on their itineraries. >

With its 168 BBR HiAm CONA stay cables, Tatara Bridge features the longest cable-stayed main span constructed in the 20th century.

Family relationships

The story really began with the construction of the Ikuchi Bridge for the Nishi-Seto Expressway, on the north eastern side of Ikuchi island – some of the techniques used there were later used in building Tatara Bridge on the opposite side of the island. A quick glance at Ikuchi Bridge reveals the similarities. This is a composite box girder cable stayed bridge with three continuous spans covering a total length of 790m and supported by 112 BBR HiAm CONA stay cables. Incidentally, when it opened in December 1991, Ikuchi Bridge was the world's longest cable-stayed bridge – a record which was overtaken by Tatara Bridge eight years later.

So, back to Tatara Bridge. Designed by eminent local construction consultancy Chodai, it sits astride the channel between Ikuchi and Omishima islands. Structurally, it is a steel-concrete hybrid cable stayed bridge, measuring 1,480m in total length, with an 890m main span. When opened, this bridge had the longest center span in the world – surpassing not only Ikuchi Bridge, but also its sister bridge, the Pont de Normandie in France, which is 2,141m long with a center span of 856m.

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Bridge design & construction

The fact that Tatara Bridge was to be located in the Seto Inland Sea National Park prompted a design rethink to re-evaluate the originally planned 890m mid-span suspension bridge. Enormous excavations for suspension bridge anchorages would leave clear scars on this picture-perfect scenery. However, a cable-stayed bridge would mean the longest cable-stayed bridge span in the world – in a region where seismic activity and typhoon weather conditions were frequently experienced. Results from a technical feasibility study proved that a cable-stayed bridge could not only reduce the excavations needed for foundation works, but also reduce construction costs and the construction period, with the added advantage of increased aerodynamic stability.

Tatara Bridge was constructed with concrete girders in the 270m and 320m long side spans and steel girders in the 890m center span. The design concept of a structural system that supports lightweight steel girders in the center span – by making the side span heavy and rigid with concrete girders and intermediate piers – delivers several advantages:

- sectional forces acting on the girders and towers are reduced
- vertical displacements of the girders are well-controlled
- fluctuations in cable tension are reduced.

The deck is 30.6m wide and carries two lanes of traffic in each direction, as well as additional lanes for bicycles, motorbikes and pedestrians. The two inverted Y-shaped steel pylons are 220m high and their form was chosen after examining wind resistance, structural efficiency and aesthetics. A full aero-elastic model of a pylon was tested in a wind tunnel to optimize its shape and rectangular section – the notched corners reduce vortex shedding. After completion of the bridge piers, deck erection progressed on cantilevering principles – without requiring temporary supports in the water during the process. The deck girders were raised from their sea transport by a traveling crane positioned at the forward edge of the girder overhang. This work relied on maintaining a balance between the side and main girders at the pylons. Construction was accomplished without any accidents – although a typhoon came along while the center span was at its furthest extension during installation of the final segment.

Stay cable installation

The 168 BBR HiAm CONA stay cables were installed in a two-plane multi-fan configuration. Each tendon – produced and assembled in the workshop – consisted of a semi-parallel bundle of galvanized steel strands. The strands are protected by a black HDPE pipe – which is very durable in exposed conditions – and this was then filled with a corrosion protection compound. The outer surface of the stay pipe is dimpled so that it repels rainwater and breaks up gusts of wind which would cause the cable to vibrate. The high amplitude fatigue resistant anchor sockets are completely sealed with no internal voids. The largest tendons are 460m long with a diameter of 170mm. The ends of the strands are secured in anchor sockets which are sufficiently resistant to fatigue from bending vibration, as well as axial force.

Tatara Bridge was officially opened to traffic on 1 May 1999, while its design and construction opened the way for bridges with large cable stayed spans in excess of 1,000m. Meanwhile, the continuously updated and extended BBR HiAm CONA stay cable system has firmly established its position as a global benchmark for durability, strength and quality.

The ends of the strands are secured in anchor sockets which are sufficiently resistant to fatigue from bending vibration, as well as axial force.

1 The BBR HiAm CONA stay cables are anchored at two 220m Y-shaped steel pylons which were aero-dynamically tested and refined to reduce vortex shedding.
2 Likened to a graceful white bird spreading its wings, Tatara Bridge has blended seamlessly into its setting.
3 The design concept of Tatara Bridge harnesses the advantages of a steel-concrete composite structural system.

3

Viaduct B, Rose de Cherbourg project, France Heavy lifting for bearing replacement

Raising the viaduct

A few months ago, French BBR Network Member ÆVIA set a new 'personal best' in the field of heavy lifting and also – in an astonishingly fast program – they strengthened another bridge within the scope of the same scheme. Project manager Antoine Dupré shares some insights into the scale of their work, as well as into this visionary regeneration project which is now nearing completion.

5,000t
Bridge deck lifted

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The viaduct was elevated with the help of ÆVIA's computer assisted lifting system based on 33 jacking points and the use of 80 coordinated hydraulic jacks.

The ambitious Rose de Cherbourg scheme is aimed at rebuilding links between the city of Puteaux and the La Défense business district to the northwest of Paris, effectively providing a superior entrance to the area. This scheme is also aimed at traffic-calming, safe pedestrian access and unifying existing or creating new green spaces. A common theme running throughout this project is the conservation of existing infrastructure – and this is where our work comes in.

This urban transformation scheme takes its name from the 1960s built circular interchange on the N1013 which has become known as the Rose de Cherbourg. As the car now gives way to vegetation, this name seems especially appropriate. Taking inspiration from the New York 'High Line', some 400 to 500m of the interchange is being repurposed into a public promenade, complete with planting.

Viaduct raising

Before taking on its new role, maintenance and other work was required on Viaduct B – including bearing replacement. For the latter to be successfully completed, we undertook a complex bridge jacking operation to raise around 5,000t of bridge deck – although our jacks were capable of lifting 8,000t.

Before fitting the jacks, we installed large concrete beams with PT bars around the bridge piers. The viaduct was elevated with the help of ÆVIA's computer assisted lifting system based on 33 jacking points and the use of 80 coordinated hydraulic jacks. The maximum difference between two jacking points during lifting was +/-0.5mm. The viaduct was raised 20mm in order to fit the new thicker elastomeric bearings.

After the lift, the ÆVIA team cut the top of three piles to make room for the largest bearings. They then repaired the bearing plates on other piles, reinforcing the upper ones before installing the new bearings and unloading the jacks. >

3

Bridge strengthening

In another part of the Rose de Cherbourg project, the ÆVIA team has strengthened a road bridge over a railway line, where increasing the thickness of the slab was not an option. The reinforcement was necessary to cope with the change in road geometry and to accommodate loads on sections of the bridge not previously used by traffic.

In a two week period, the team applied around 500m of CFRP – working on top of the bridge during the day and underneath the bridge during night-time possessions of the railway line. Effective program management was key here, because the railway infrastructure had to be handed back promptly at 0400hrs every day. The CFRP strips were applied in five meter lengths, so the installation process required two operatives working together from two different elevated platforms.

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1 On the Rose de Cherbourg urban transformation project, the team from French BBR Network Member ÆVIA successfully raised around 5,000t of viaduct enabling the bearings to be replaced.
2&5 Visualizations of the completed transformation of the Rose de Cherbourg interchange – from urban highway viaduct to elevated green walkway. Image courtesy of Paris La Défense, AM Environnement, Agence Quatre Vingt Douze.
3 During a night-time railway possession, work is underway, using CFRP, to strengthen a road bridge to accommodate altered traffic loading as a result of the Rose de Cherbourg scheme.
4 The ÆVIA team worked from mobile platforms adapted for use on railway lines which enabled them to apply CFRP strips for strengthening the road bridge.
6 Pioneering in its day, like its near-neighbor the Rose de Cherbourg project, the 1950s-built CNIT holds the world record for the highest self-supported vaulted roof – constructed using BBR post-tensioning.

6

Pioneering approach

This area of Paris is no stranger to pioneering projects – in fact, it was also the location for a much earlier landmark development featuring BBR technology and techniques, the CNIT building. This now well-established and highly distinctive structure lies just a few hundred meters away from the elevated promenade of the Rose de Cherbourg and features the world's highest self-supported vaulted roof, which was created in the late 1950s with the help of BBR post-tensioning.

Now, when this recent initiative has been completed later this year it will breathe new life into the area and will play its role in bringing not only nature, but also people, into this otherwise urban landscape. It has been a privilege to be part of this wonderful scheme which, like the CNIT, is certain to become an important destination in its own right.

TEAM & TECHNOLOGY

Owner/client – Paris la Défense
Consultants – AME (landscape), Lombardi Group (civil engineering), Ingérop (road and utilities)
Main contractor – RAZEL-BEC
Technology – Heavy lifting, PT bars, MRR range
BBR Network Member – ÆVIA Câbles et Manutention (France)


VOLVO

Merredin Water Storage Tank, Western Australia
Efficiencies with CONA CMI post-tensioning

Making new history in Merredin

The Merredin Water Storage Tank project is located 260km east of Perth, Western Australia. The project involves the design and construction of a new 42 million liter potable water tank on the historic Goldfields Water Supply Scheme pipeline to improve water quality and supply to the area. Sam Pearce from BBR Network Member SRG Global has provided this fascinating account of a challenging project.

As part of the works, SRG are installing new pipework and connections to the historic Goldfields Water Supply Scheme pipeline – originally constructed in 1903.

The Goldfields Water Supply Scheme is a significant engineering feat that was completed in 1903 and provides water to areas east of Perth along the Great Eastern Highway servicing Western Australia's key agriculture and mining industries, critical to the state's economy. SRG Global were contracted by the Water Corporation (West Australian Government) to undertake the design and construction of the new post-tensioned concrete water storage tank. The scope also included the construction of a new chemical dosing facility, new pipework and valves to connect to the pipeline and site civil works such as road surfacing and drainage.

Base slab construction

The concrete construction of the tank allowed the team to achieve the 100-year design life required by the client. At approximately 73m in diameter and over 13m in height, the water tank is the largest constructed by SRG Global. Numerous technical and logistical challenges were identified in the design of the structure including the risk of cracks developing in the concrete base and enabling a water leakage path. Utilizing SRG Global's experience in designing large flat slabs across many applications, this potential risk was addressed by incorporating our flat slab post tensioning system into the concrete base pour. The result enabled a significant reduction in concrete and reinforcement quantities in the base slab and a substantially more robust construction technique to resist cracks developing.

The base slab was cast in a single concrete pour to eliminate joints that could provide a water path during its service life. This challenging operation in a semi-remote regional area of Western Australia required over 4,000m^2 of concrete to be installed and use of an on site batching plant to provide the near 700m^3 of concrete. On site concrete batching enabled strict control of the quality of the mix and, by reducing travel time, ensured the longest possible concrete workability time for the placing crews. In order to complete the tank's large surface area, a powered laser screeding machine was used to finish the tank base to the tight level tolerance and significantly reduce the manual operations and risks associated with such a large pour.

The CONA CMI post-tensioning system enabled panel thickness to be minimized to 325mm. The efficiencies resulted in a 23% reduction from the original concept design ...

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PT improves efficiencies in design

SRG designed the wall structure to include 17 hoop tendons to provide the strength necessary to counteract the water pressure forces during operation. Using a series of 12-strand BBR VT CONA CMI internal tendons, the wall panels were stressed together at specially fabricated buttress panels to house the anchorages and distribute the load into the structure.

The CONA CMI post-tensioning system enabled panel thickness to be minimized to 325mm. The efficiencies resulted in a 23% reduction from the original concept design, reducing construction costs and allowing a lighter panel. Among the many significant benefits of the CONA CMI system, the lighter panel enabled safer construction for the site crew and lower lifted panel weights for the crane.

Advantages of precast tank construction

Using a specialist facility in Perth, all panels, columns, beams and roof panels for the project were precast at a dedicated factory – rather than casting the panels on site, where local resources were limited. The design of lighter panels and the prefabrication process provided increased quality control which enabled the 100-year design life to be achieved. By casting the wall panels in a factory environment, it was possible to ensure that panels were free from defects, enabling a better site outcome for the client – and some cost efficiencies – to be obtained.

The precast panels were installed and the walls completed using concreted stitches to join the panels together. Once this was finished, the team installed waterproofing membranes to the concrete joints to ensure these are water-tight to prevent leakage. Secondary waterproofing was incorporated into the construction where the stitch pour concrete included specific admixtures. These admixtures create a non-soluble crystalline formation in the pores and capillary tracts of the concrete to seal the concrete against water penetration. A concrete roof was added to the structure to meet the specified design life and ensure the water quality is secure from contaminates.

The historic Goldfields Water Supply Scheme has been listed as a National Engineering Landmark by Engineers Australia as part of its Engineering Heritage Recognition Program and also as an International Historic Civil Engineering Landmark by the American Society of Civil Engineers. When our work here is complete, we hope that one day this massive water tank may also be similarly recognized for its excellence in engineering design and construction.

1 Panel thickness could be reduced by incorporating BBR VT CONA CMI internal 1206 post tensioning tendons.

2 Installation of the precast roof beams. SRG Global undertook all design works associated with the project including the design of the beam system. Instead of simply supported beams, the design adopted a continuous beam design to reduce the amount of reinforcement required at the column connections.

TEAM & TECHNOLOGY

Owner – Water Corporation (Western Australia)
Design & build contractor – SRG Global (Australia)
Structural engineer – SRG Global (Australia)
Technology – BBR VT CONA CMI internal
BBR Network Member – SRG Global (Australia)

Cement storage silo, Queensland, Australia Slipforming & post-tensioning

Slipping around the clock

Since the 1970s, Australian BBR Network Member SRG Global have built an impressive portfolio of slipform projects – and have recently added a new name to the list. The team was commissioned by main contractor John Beever Australia to undertake slipform and post-tensioning works for Cement Australia's new powder storage silo, located at their Fisherman's Landing facility in Gladstone, Queensland.

SRG Global were responsible for the design, supply and operation of the slipform formwork system for the construction of the 53m high, 21m diameter storage silo. The scope also included the installation, stressing and grouting of BBR VT CONA CMI internal multistrand post-tensioning.

The silo has capacity for 15,000t of product and includes the conventional inverted cone which is supported on the wall change at the interface between the low-rise and high-rise.

Formwork system & slipform operations

The formwork system for the silo was assembled and in place in just three weeks, with the subsequent slipform construction operations being conducted during 14 days – and nights – of around the clock shift-working.

The slipform design consisted of a double jack arrangement for the construction of the 850mm thick low-rise wall. In total, 80 three tonne slipform jacks were used for the eight meters of low-rise wall section. After completion of the low-rise wall, the inner slipform formwork panels were reconfigured for construction of the 400mm thick high-rise wall to the final silo height of 53m. The jack configuration was reduced to 40 three tonne slipform jacks.

The slipform system advanced at a rate of anywhere between 150mm and 250mm per hour, depending on the rate of concrete supply to the work face at that time. The work was undertaken from three different levels, which consisted of:

1. Top deck for vertical reinforcement and jacking rod installation.
2. Working deck for concrete placement, horizontal reinforcement installation, post-tensioning installation and slipform operation.
3. Trailing deck for concrete finishing.

The SRG Global site team celebrate completion of Cement Australia's new 53m high powder storage silo which included CONA CMI internal post-tensioning.

During the slipform construction, 220 anchorage castings were installed, along with approximately 3,500m of galvanized spiral duct.

Approach for PT installation & stressing
During the slipform construction, 220 anchorage castings were installed, along with approximately 3,500m of galvanized spiral duct. At the completion of the slipform construction, 75t of 15.7mm diameter steel stressing strand was pushed into the duct from mast climbers mounted at each of the four buttresses.
The multistrand tendons, consisting of between seven and 19-strands, were stressed from each anchorage point utilizing SRG Global's front-pulling hydraulic stressing jacks ranging in capacity from 1,700kN to 4,800kN. Stressing was carried out simultaneously from each end and in a specific sequence to manage the load distribution on the structure. SRG Global designed and installed bespoke gantries at the top of the buttresses to remove the need for cranes during stressing operations.
Since the completion of this slipform project, SRG Global have also been engaged to undertake slipform works on another three complex projects. Most notably, this includes the construction of a 45,000t capacity multicell concrete storage silo, which at 33.8m in diameter standing 72m tall, makes it one of the largest multicell concrete storage silos in the world.

TEAM & TECHNOLOGY

Owner – Cement Australia
Design & build contractor – John Beever Australia
Structural engineer – Aurecon
Technology – BBR VT CONA CMI internal, Slipform construction
BBR Network Member – SRG Global (Australia)

Felsenegg Harbor, Gersau, Switzerland PT for floating jetties

Maritime makeover

In early January 2018, Storm Eleanor – known in Switzerland and Germany as Cyclone Burglind – swept through western Europe leaving a trail of destruction in its wake. Among the structural casualties was Felsenegg Harbor on the shores of Lake Lucerne in Gersau. Swiss BBR Network Member Stahlton was part of the construction team which, with the help of latest technologies and techniques, worked to reinstate the small port and bring it back to operational status.

Following the massive storm damage, assessments were carried out to determine the best course of action. In the end, there was only one sensible option – and that was to totally rebuild the small port.

Project overview
New concrete jetty segments were manufactured by Christen AG in nearby Küssnacht am Rigi. These were floated in January 2021 and transported across the lake from Küssnacht to Gersau. Once at the harbor location, they were coupled, post-tensioned together and anchored. After this task was completed, the interior of the harbor could be reconstructed with floating jetties and embankment walkways.

Jetty segments
During prefabrication of the jetty segments, ducts with special transitions had been installed in the corners. These would later allow for the insertion of eight 1206 CONA CMI tendons which would secure them together. The 13 segments, with a total length of 150m, were first pulled together with bars and then the joints between the elements were filled. The strands were then pushed in from one side with the strand pusher and stressed. The joints between the ducts had to be sealed so that no mortar from the joint could get into the pipes. An equally careful approach was required for injecting the tendons, to prevent grout from escaping into the lake. The end result is stunning – a new harbor with elegant wooden walkways, which are all wheelchair accessible, and lighting on the floating piers. With a relocated entrance and a new breakwater too, the harbor is also protected from cross-waves during any further extreme weather conditions in the future. The new harbor was officially declared open in spring 2021, with a special celebration to mark the occasion.

TEAM & TECHNOLOGY

Client – Bootshafen Felsenegg AG
Precast concrete – Christen AG
Consulting engineer – Willy Stäbli Ing. AG
Technology – BBR VT CONA CMI internal
BBR Network Member – Stahlton AG (Switzerland)

Sarjeant Gallery Te Whare o Rehua, Whanganui, New Zealand
Seismic strengthening & protection

Art at the heart

It will have been a long eight years of anticipation, but in 2023 art enthusiasts in New Zealand and around the world will welcome the re-opening of one of the country's foremost art galleries and an iconic heritage building to boot – finally restored and ready for another 100 years of performance, with a lot of help from the BBR Contech team.

The Sarjeant Gallery/Te Whare o Rehua Whanganui ('House of Inspiration') is located in the city of Whanganui on the North Island's west coast. It first opened its doors in 1919 thanks to the generosity of local farmer and landowner Henry Sarjeant, who bequeathed £32,000 – more than NZ$70 million in today's terms – "as a means of inspiration for ourselves and those who come after us".

The gallery was built in a neo-classical Greek-cross style and clad in Oamaru stone. The building remains the most prominent and elegant sculptural feature on the city's skyline. It's also one of the country's oldest purpose-built galleries and is identified on the New Zealand Heritage List/Rārangi Kōrero as 'of special or outstanding historical or cultural significance or value'.

There's value too in the gallery's collection, which is the largest of all the regional art galleries in New Zealand. It comprises about 8,300 pieces spanning 400 years of international and New Zealand art history – and was valued at NZ$30 million in 2019. The collection includes a wide range of media, from paintings and works on paper to photographs, sculptures, installations, ceramics and glass, which can be viewed at sarjeant.org.nz. >

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SARJEANT GALLERY

Track record

BBR Contech has helped to restore a number of New Zealand's historic buildings over the years, including:

- **Alfred Nathan House, Auckland** – 1906
- **Arts Centre of Christchurch** 1873
- **Auckland Art Gallery (Toi o Tāmaki)** – 1887
- **Christ's College Hare Memorial Library** – 1925
- **First Presbyterian Church** 1873
- **Huddart Parker Building, Wellington** – 1925
- **Knox Church Rebuild** 1904
- **Old Arts Building, University of Auckland** 1923-26
- **Sign of the Takahe** 1918
- **St Peter's Church** 1858
- **Textile Centre, Auckland** 1908-1922
- **Tui Brewery Tower, Mangatainoka** – 1931
- **University of Canterbury Staff Club, Christchurch** 1910

Time for (urgent) change

Sadly, the building had to be mothballed in 2014 when it was discovered that its structure met just 5% of the new NZ Building Code and therefore posed a severe earthquake risk. The situation was compounded by the fact that its basement, where most of the collection was held, lacked the environmental and temperature controls needed to protect the collection from cracking, flaking and warping – and that the lack of similar controls in the gallery spaces meant it didn't meet the stringent requirements for attracting national and international touring exhibitions.

As a result of these findings the gallery's staff, operations and collection were relocated to suitable temporary premises pending a resolution to the problems and, of course, an assessment of the associated costs.

After much debate and some delay, the redevelopment commenced in 2019. The Warren & Mahoney design will ultimately double the gallery's size by creating a brand-new wing to provide a state-of-the-art storage facility for the Sarjeant collection, additional exhibition spaces, education facilities, an auditorium and events space, a café, retail space and staff offices. In addition, and with the blessing of Te Rānanga o Tūpoho (the collective hapū [sub-tribe] of the Whanganui iwi [tribe]), the existing building would be restored through strengthening and restoration work. The total cost of the project would be about NZ$50m.

Strengthening & restoration

BBR Contech became involved early in the project, assisting structural engineers to develop the design for the work on the existing building, then working with main contractor McMillan & Lockwood to implement the chosen solution.

After undertaking pre-construction tests and trials, the team elected to drill down from the roof level into the core of the double-brick cavity walls in the building's interior, then install 300 stainless-steel stress bars through the core to create a virtual cage. The bars would be anchored in a new reinforced-concrete capping beam at roof level and secured at basement level within the existing concrete foundations. They would then be grouted in place and, when further work on the building was complete, stressed to the design load to ensure a 100-year design life.

The job was not without its challenges, as the original 'concrete' comprised boulders and small amounts of cement paste, so mostly just sand and stones remained. However, all team members enjoyed their role in contributing to a piece of New Zealand's history – and helping a grand old art gallery to be restored to its place as a national and architectural treasure and a must-see cultural attraction.

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1 The 100-year old Sarjeant Gallery is receiving specialist structural strengthening treatment from the BBR Contech team to ensure it meets the new NZ building code.
2 A closer look reveals a century's wear and tear – and the sheer elegance of the architecture.
3 The team drilled down from roof level into the core of the building's interior walls, then installed 300 stainless-steel stress bars through the core to create a virtual cage.

TEAM & TECHNOLOGY

Client – Sarjeant Gallery Redevelopment Project
Main contractor – McMillan & Lockwood
Consulting engineer – Clendon Burns and Park Ltd
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

Voice from the past

BBR Contech's role in this project took an exceptionally exciting turn in April 2021, when team member Richard Awa unearthed a glass time capsule while he was drilling for the steel tension rods.

While the capsule broke in the discovery process, its contents remained in pristine condition and were identified as having been hidden on 28 January 1918 by John Cornfoot Brodie – the clerk of works and supervisor of the original building project. The capsule contained a treasure trove including letters, photographs, editions of the local newspapers, seeds, a clay pipe and a rare copy of the original 1917 design specifications booklet.

Significantly, the capsule included a handwritten letter, in which Brodie mused about when the capsule would be found and expressed his concerns about the true identity of the Sarjeant's architect:

"I wonder if the vexed question as to who is really the designer of this building will have been settled by then. It is common report that the (man) who gets the credit and benefits did not, but that a young man killed in France should have all the kudos."

This is a reference to the fact that Edmund Anscombe – a prominent, Dunedin-based architect at the time – claimed responsibility for designing the gallery when in fact it was the work of 21-year-old Donald Hosie who was a clerk in his office. Anscombe was questioned about his role in the design and upheld his authorship if it. Hosie was also questioned and told the facilitator of the design competition Samuel Hurst Seager, that he was a "young man and would have his chance again".

Tragically though, Hosie was killed in the WW1 Battle of Passchendaele on 12 October 1917 – just three weeks after the gallery's foundation stone was laid, featuring Edmund Anscombe's name as designer.

In his letter Brodie said that others, including the foreman, contractors, chairman of the committee and leading solicitors had shared his opinion.

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1 Donald Hosie the rightful architect of the Sarjeant Gallery, pictured here (center) in early 1917 at Featherston Camp prior to embarkation for his fateful service on the WW1 battlefields.
2 BBR Contech's Richard Awa who found the time capsule while drilling holes for the steel tension rods during the Sarjeant's strengthening and restoration project.
3 Curator of the Sarjeant Gallery Collection, Jennifer Taylor Moore pictured here with the contents of the time capsule.

Herrensägen Gorge Bridge, St Peterzell, Switzerland Strengthening with CONA CMB

New life for road infrastructure

In the beautiful Appenzell region of Switzerland, motorists traveling between St Peterzell and Bächli rely on the Herrensägen Gorge Bridge as it is the only connection between these two towns. However, static inspections carried out in 2018, revealed that comprehensive renovations were needed – and local BBR Network Member Stahlton AG was on hand to provide expert strengthening services.

Originally built in 1961, the bridge needed upgrading and strengthening to support a payload of 40t. This work involved installation of 68 surface-bonded CFRP lamellas, plus six upper and eight lower level deviators which were glued or screwed to the two bridge girders. Over the deviators, Stahlton installed, stressed and grouted two BBR VT CONA CMB 1206 post-tensioning tendons per bridge girder.

One of the major challenges for the site team was the fact that they were working in live traffic conditions. During the entire construction period, the bridge had to remain accessible – based on a single traffic light controlled carriageway. In view of the extra load created by construction equipment, a maximum weight limit for vehicles of 12t was also imposed. The team is delighted to report that the project was completed ahead of program – and well before the onset of harsh winter weather.

TEAM & TECHNOLOGY

Client – Gemeinde Neckertal
Main contractor – Pozzi AG
Construction engineer – Schällibaum AG
Technology – BBR VT CONA CMB, MRR range
BBR Network Member – Stahlton AG (Switzerland)

Working in live traffic conditions, the Stahlton team installed CONA CMB post-tensioning tendons to strengthen the Herrensägen Gorge Bridge.

Taking in the panorama

These amazing photographs were taken by Enis Dauti, BBR Adria's engineering technologist, who carried out routine inspection testing on the BBR CONA SOL+ ground anchors which keeps the Dubrovnik Cable Car infrastructure firmly embedded in the landscape.

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Originally opened in 1969, the Dubrovnik Cable Car was the first cable car to be built in the Adriatic region. Sadly, it was damaged during the war in 1991, but opened again in 2010 following a €5m renovation program which included the installation of four vertical 14-strand BBR CONA SOL+ permanent ground anchors to secure the foundations of the intermediate pylon.

The inspection testing was necessary to verify the remaining load in the anchors. The process involved loading each anchor up to the specified design load of 1,600kN. All four anchors passed with flying colors – and are still holding well at the design load.

Now, it takes tourists less than four minutes to make the journey up or down the mountainside by cable car,which allows them to see the unrivaled views of Dubrovnik old town – and as far as 60km beyond. While Enis had to make the journey to the pylon on foot down the steep rocky mountainside and conduct his work in a remote location, we can see from these photographs that he too found a moment to appreciate the wonderful panorama!

1 View from the Dubrovnik Cable Car upper station, looking down onto the historic walled town.
2 Ground anchorage inspection at the intermediate pylon – which showed that all four anchors were still holding well at the design load.

TEAM & TECHNOLOGY

Owner/client – Excelsa Nekretnine d.d.
Technology – BBR CONA SOL+
BBR Network Member – BBR Adria d.o.o. (Croatia)

Waioeka Gorge Bridges, New Zealand Strengthening for six highway bridges

Smoothing the way for commerce

Given New Zealand's high ratio of bridges to roads, it's no surprise that BBR Contech has completed quite a few bridge-related projects in its almost 60 years in business. However, a recent project set a new record, with the team given the job of strengthening a total of six bridges in one NZ$1.4 million project – on a road steeped in history and long renowned as one of the most dangerous in the country.

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Located in the North Island, the 144km-long Waioeka Gorge is the main highway (State Highway 2) between Ōpōtiki, a small town in the north-eastern Bay of Plenty and a gateway to high commerce in Auckland, and Gisborne, a city to its south on the east coast. Drive it today and you'll enjoy a stunning journey that hugs the edges of the Waioeka River before following a winding range of steep-sided hills to its source high in the inland hills. Along the way you'll find a spectacular array of native trees and lush ferns, stunning river views and excellent opportunities for hunting, hiking, picnics, swimming, canoeing, rafting and fishing. There are 52 bridges along the Waioeka Gorge. The six included in BBR Contech's contract were, like many of the others, being damaged by an increasing number of large trucks carrying heavy cargo from Gisborne to export ports to the north. One company, a high-profile, Gisborne-based horticultural business alone runs 40 return trips per day in the peak season.

Investment for the people

BBR Contech was contracted by the NZ Transport Agency (Waka Kotahi) to repair the bridges and in so doing improve the resilience of the state highway network. When the repairs are complete, 'high productivity motor vehicles' (those weighing more than 44t) will be able to travel the route for the first time without needing permits and this, in turn, will enable increased freight capacity, reduce truck numbers and free up the road for businesses and residents. The project was funded by the National Land Transport Fund and the Government's NZ$300m Provincial Growth Fund, which supports projects that help New Zealand's regions to grow and thrive.

The bridges all had a similar design and therefore similar issues. BBR Contech's role was to survey their decks, identify any defects and, where appropriate, repair the undersides of the bridges with concrete spall repairs and crack injections, and then apply externally-bonded fiber-reinforced polymer (FRP) to strengthen the soffits. The areas beneath the bridges were fully scaffolded throughout the process and the team were required to work around the traffic to ensure minimal disruption. It was pretty much a typical job for them all, apart from the fact that they were kilometers away from mobile phone coverage and had to share a satellite phone instead!

Road drenched in history

The gorge has a checkered past. For hundreds of years Māori accessed the dense bush, created tracks and established temporary settlements on the banks of the Waioeka River. Then in the early 1900s Europeans settled there, felling the bush and establishing pasture for livestock. However, the conditions were not favorable for them and in the 1920s and '30s many farms were abandoned. The forest has been regenerating ever since – with much of it protected in the Waioeka Scenic Reserve.

A road between Gisborne and Ōpōtiki was an early priority for the settlers, but the gorge resisted every inch of the way. While a dray (cart) road was established between Ōpōtiki and the gorge mouth by the early 1900s, it wasn't until 1929 that, after a petition from local settlers, a single-lane road was finally created.

However, this was by no means a road by today's standards – it was little more than a bullock-and-dray track that crossed countless unbridged steams and was impassable in wet weather. According to an article in Motor World, "This road was only about 12 feet wide... The possibility of being trapped in the gorge by floods or rock falls had to be taken into serious account."

The road was originally used mainly for driving stock from the south to markets and exporters to north, but it proved a magnetic attraction to the owners of the early motor cars. Head-on collisions on the blind bends in the road were frequent!

As time passed the amount of traffic on the road increased and with it came increasing demands for improvements. Progress was stalled by the 1930s' Great Depression and World War II from 1939 to 1945, but post-war prosperity and a boom in wool prices led to the Government announcing in the early 1950s that it would upgrade the route to a six-meter-wide, two-lane, sealed highway. What's more, it would be done on a limitless budget – a decision that the Government might have later regretted, as the challenges included dropping a 50m-high cliff into the water, moving the river itself by more than 12m through solid rock – and lowering bulldozers down cliff faces on steel ropes to clear the debris of rock-blasting. Tragically, the work came at the loss of three lives, all drivers from the local Ngāti Ira iwi (tribe).

The widened road was finally opened in rain-drenched conditions on 15 December 1962. William Goosman, the Minister of Works of the time, said, "They say that if you give engineers enough money they will do anything. We have given them the money and they have done it."

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Modern improvements

In 2004, the Government began an extended improvement plan, with engineering and signage upgrades and the establishment of rest areas with glorious views, all accompanied with plaques telling the story of the gorge and the road that runs through it. While the highway still has a relatively large number of corners and care must be taken when driving the route, the gorge once known as 'notorious and dreadful' is now celebrated as an extraordinary construction achievement, in which the BBR Contech team was very proud to take part.

1 BBR Contech are working on a project to strengthen six bridges along the Waioeka Gorge in North Island, New Zealand.

2 BBR Contech's role was to survey the bridge decks, identify any defects and, where appropriate, repair the undersides of the bridges with concrete spall repairs and crack injections, and then apply externally-bonded fiber-reinforced polymer (FRP) to strengthen the soffits.

TEAM & TECHNOLOGY

Client – Waka Kotahi NZ Transport Agency
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

Building G2, Chapelle Internationale, Paris, France Structural strengthening with external PT

Uniquely placed reinforcement

Under the timeless gaze of the Sacré Cœur Basilica in Paris, the team from ÆVIA has successfully completed reinforcement work to Building G2 of the Chapelle Internationale complex. Principal Engineer Cédric Brunner describes the project and shares some photographs taken while work progressed.

Structural strengthening work underway on the roof of Building 2 of the Chapelle International development in Paris – with the famous Sacré Cœur Basilica in the background.

Step-by-Step Guide

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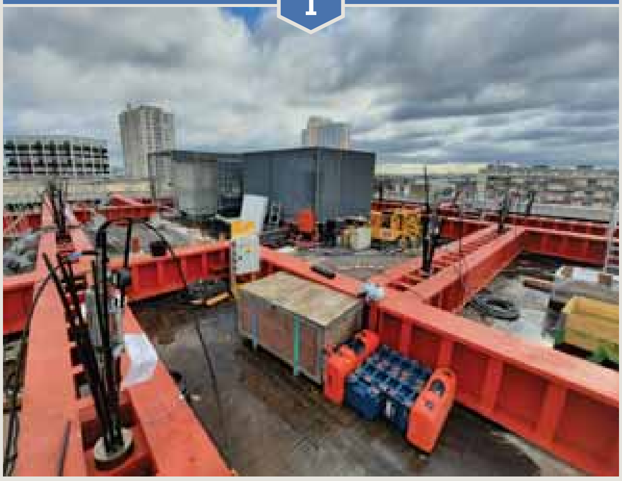


A network of steel frames was constructed on the rooftop to support installation of the BBR CONA CMB tendons to strengthen the building.

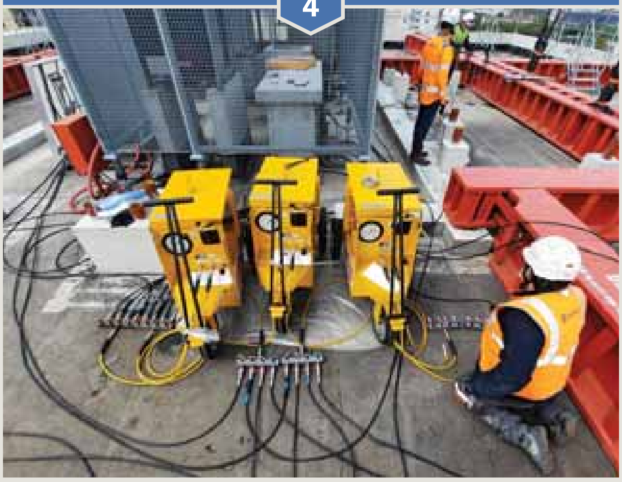
2

A unique feature of the project was that the individual strands of the PT tendons were anchored at different levels.

3

Here you can see the CONA CMB tendons installed vertically from floor-to-floor.

4



The PT tendons were stressed using 12 stressing jacks for monostrands, or 'monojacks'. These were operated simultaneously to ensure a uniform and controlled stressing process for each of the tendons. Pictured here are three monojacks being prepared for operational use.

The 18th Arrondissement of Paris, known as Butte-Montmartre, is characterized by a rich history intertwined with the development of late 18th Century European art. Artists were attracted to the famous Montmartre district which was also home to the renowned Moulin Rouge cabaret venue which still operates at the foot of the Montmartre hill. The massive Sacré Cœur Basilica, completed in 1914 after a construction program lasting almost 40 years, is now a famous landmark on the Parisian skyline and looks down on the whole district which has developed into a vibrant multicultural commercial and residential zone.

Our project, as unique and complex as its setting, consisted of reinforcing 12 floors on nine levels with external post-tensioning tendons installed vertically. We used 12 BBR VT CONA CMB monostrand tendons, each with 11 strands of 15mm diameter which were anchored to a metal frame on the flat roof. The PT tendons were installed following a very specific threading order and with the unusual feature of having each of their strands anchored at different levels. In order to ensure homogenous and controlled stressing, we used 12 monostrand stressing jacks operated simultaneously. The whole project was completed in just 10 weeks.

TEAM & TECHNOLOGY

Owner – Régie immobilière de la ville de Paris
Main contractor – Leon Grosse
Technology – BBR VT CONA CMB
BBR Network Member – ÆVIA Câbles et Manutention (France)

Research & Development First ever ETA approval for strand ground anchors

World's first ETA approved strand ground anchor

CONA CMG – world's first ETA approved strand ground anchor

The BBR VT CONA CMG system is the first strand ground anchor in the world to receive a European Technical Assessment (ETA). Dr. Xiaomeng Wang BBR VT International's Project Leader Geotechnical Systems, describes the company's leading role in establishing these important new standards and why the CONA CMG strand ground anchor is simply the finest product on the international market place.


Austrian Institute of Construction Engineering
Schenkenstrasse 4 | T +43 1 533 65 50
1010 Vienna | Austria | F +43 1 533 64 23
www.oib.or.at | mail@oib.or.at

Designated according to Article 29 of Regulation (EU) No 305/2011

Member of EOTA
www.eota.eu

European Technical Assessment — **ETA-21/1053 of 21.01.2022**

General part

Technical Assessment Body issuing the European Technical Assessment	Österreichisches Institut für Bautechnik (OIB) Austrian Institute of Construction Engineering
Trade name of the construction product	BBR VT CONA CMG ground strand anchor with 2 to 22 prestressing steel strands
Product family to which the construction product belongs	Kit for rock and soil anchors using prestressing steel strand
Manufacturer	BBR VT International Ltd Ringstrasse 2 8603 Schwerzenbach (ZH) Switzerland
Manufacturing plants	BBR VT International Ltd Ringstrasse 2 8603 Schwerzenbach (ZH) Switzerland
This European Technical Assessment contains	65 pages including Annexes 1 to 36, which form an integral part of this assessment.
This European Technical Assessment is issued in accordance with Regulation (EU) № 305/2011, on the basis of	European Assessment Document (EAD) 160071-00-0102 – Kit for rock and soil anchors using prestressing steel strand.

electronic copy

World's first ETA for strand ground anchors awarded to the BBR VT CONA CMG system.

BBR is well-known for its commitment to the development and testing of leading edge construction technologies while at the same time improving industry quality standards. This dedication has recently placed the BBR VT CONA CMG strand ground anchor system in a unique position on the global market place. Following successful extensive and innovative conformance testing, it is the world's first strand ground anchor system to be awarded an ETA by EOTA, the European Organisation for Technical Assessment.

The back story

While strand ground anchors have been used for many years in geotechnical applications such as slope stabilization, retaining structures, deep excavations, anti-lifting foundations and so on, there has been no internationally recognized standard regulating their quality and use.

Strand ground anchors are effectively a special kind of post-tensioning system which is used in a much more aggressive environment – soil or rock – than regular post-tensioning systems which are usually protected by concrete coverage. Thus it is all the more amazing that regulatory requirements on the corrosion protection of ground strand anchors has lagged so far behind those for PT systems. There had only been a standard for execution of strand ground anchors, but

Strand ground anchors play a critical role in retaining and prolonging the life of major structures, such as this underground car park in Switzerland. Photograph courtesy of Stahlton AG.

a proper standard or European Assessment Document (EAD) for strand ground anchor as a product was lacking. Therefore, a great number of strand ground anchors without appropriate corrosion protection were installed. As a consequence, failure of construction works due to corrosion of strands has been reported from time-to-time – the implications of these failures could potentially be fatal.
Barriers which impeded improvements to the durability regulation of strand ground anchors were not only the complexity and vast variety of strand anchor products, but also the difficulty in defining appropriate performance levels for these anchors against corrosion, as well as suitable testing methods for the necessary assessments.

New EAD for strand anchor

As a worldwide leader of post-tensioning technology – as well as strand ground anchors – BBR recognized the risks mentioned earlier and resolved to push the strand anchor industry further towards higher corrosion protection performance and thus greater sustainability.
After years of campaigning, the very first EAD for strand ground anchors – EAD 160071-00-0102: Kit for rock and soil anchors using prestressing steel strand – was approved by EOTA in 2021, backed by BBR. This has radically changed the horizon for the strand ground anchor industry.

Benefits of ETA

As with post-tensioning, the CE marking and European Technical Approval for strand ground anchor kits allows an accurate and up-to-date method of comparing like-with-like. From this, it is clear what specification the products fulfill, ensuring that all ETA systems provide the same minimum level of durability and safety.
CE marked post-tensioning and strand ground anchor systems installed by certified and responsible specialist companies – such as members of the Global BBR Network – provide the highest level of quality and ensure, for the owners of the structures to which the technologies are applied, that only high quality and state-of-the-art products are being used.

Corrosion protection & durability

The new EAD for strand ground anchors outlines strict and comprehensive requirements for mechanical and durability performance of strand ground anchor products, according to the intended use of the anchor.
Four types of corrosion protection option are defined for use in accordance with local environmental conditions and working life range requirements. The EAD defines the working life or durability of strand anchor kits as follows:

- more than 2 years and up to 100 years for permanent use
- up to 2 years for temporary use
- up to 7 years for temporary use with extended working life.

Comprehensive requirement of EAD

The new European Assessment Document sets out key criteria designed to ensure quality and performance of strand ground anchor kits bearing the all-important CE mark.
Levels of technical performance have been clearly set out. Alongside prescriptive requirements on the necessary components and anti-corrosion measures for each 'option' of anchor, a certain required initial type testing program with wide range and number of tests has been specified based on which the mechanical and durability performance can be precisely assessed – both qualitatively and quantitatively.
There are over 20 different types of test with a total of more than 100 tests specified – most relate to corrosion protection features and many of these are new. Areas where key corrosion protection performance must be proven by dedicated testing include:

- sealing resistance in the critical transition zones (e.g. from bond to free length and from free length to stressing anchorage)
- sealing and filling degree of assembled monostrand (strand protected by PE sheathing and filled using flexible corrosion protection filling material)
- sealing of the protection duct and end cap for ground anchors for permanent use
- crack width of inner cement grout for double layer corrosion protection of bond length
- electrical resistance of the transition zone component and that of the assembled full anchor, tested in factory and on-site, after each of key steps: primary grouting, post grouting, locking-off, and finishing.

Quality Assurance

The EAD has outlined a detailed requirement for manufacturers to follow a Factory Production Control (FPC) plan. The test or control method includes the minimum number of samples and the minimum frequency of control for key features of each component which are clearly defined, to ensure the constant conformity of assembled anchors to the predefined performance criteria. ›

The BBR VT CONA CMG strand ground anchor system provides three solution kits with different corrosion Protection Levels (PLs), designed for applications with different service lives – up to two years, extended use up to seven years and over seven years.

Breaking new ground with CONA CMG

The BBR VT CONA CMG ground anchor system is the first in the world to have been tested and approved according to the EAD 160071-00-0102: Kit for rock and soil anchors – using the most stringent requirements.

The CONA CMG system offers state-of-the-art performance, including a wide size range (from 2 to 22 strands) across three different corrosion protection levels to allow customers to select the optimum force range and design life characteristics for specific projects. The system covers a large range of force (maximum force of tendon) up to 6,138kN, aiming to satisfy the major market demands.

New benchmarks

A number of innovations have been implemented to build the optimized system which is designed to ensure both effective performance and economy.

One of these is the innovative method of measuring the inner cement crack width of strand anchor under service load, developed by the BBR R&D department and its university partner. Thanks to the method, for the first time, this crack width was successfully and correctly measured. The result showed that cracks of the inner cement grout of the BBR VT CONA CMG PL2 system are less than 0.1mm under service load (the criteria according to EN1537) and therefore for this system grout is recognized as the second corrosion protection layer – on top of the corrugated duct which provides the first protection layer – for strands.

Another major highlight is the sealing device at the transition zone between the recess pipe and free length protection duct. The device which is made of flexible material can accommodate large axial tolerance, as well as angular tolerance, while its sealing performance is ensured. It is a totally unique solution in the market and is designed to overcome, with ease, any angular deviation problems occurring during and after installation of ground anchors on site.

In fact, several key innovations of the BBR VT CONA CMG strand ground anchor system have been patented.

BBR VT CONA CMG STRAND GROUND ANCHOR

Key tests

- ☑ Static tensile test
- ☑ Fatigue test
- ☑ Load transfer test
- ☑ Monostrand sealing test under injection pressure of 3.5 bar, at different temperature conditions, both coiled & uncoiled
- ☑ Monostrand friction test & impact test
- ☑ Monostrand filling degree & leak-tightness test, at different temperature conditions, both coiled & uncoiled
- ☑ Sealing test for transition anchorage to monostrand & anchorage to protection duct under external pressure of 1.5 bar
- ☑ Sealing test for protection duct & end cap, after various preconditioning, under inner pressure of 3.5 bar & external pressure of 1.5 bar
- ☑ Test of corrosion protection on bond length (on crack width of inner cement grout)

Comprehensive & successful testing

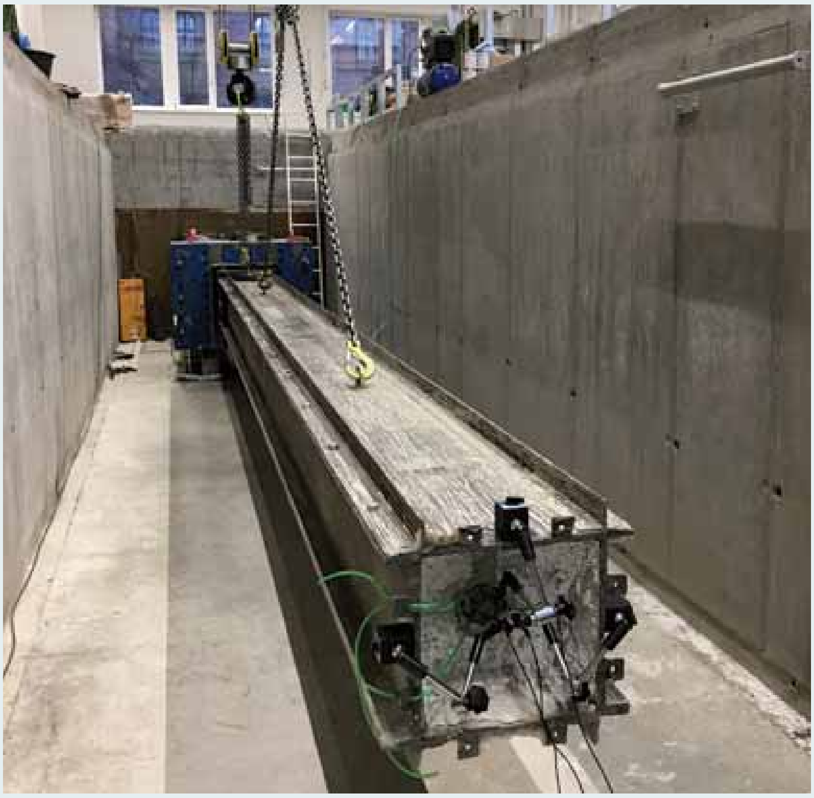
The BBR VT CONA CMG strand anchor system has been proven through the full initial type testing program according the requirements of the EAD 160071-00-0102: Kit for rock and soil anchors.

All of the tests were successfully passed. This has permitted the BBR VT CONA CMG system – including its double layer corrosion protection solution – to become the first strand ground anchor system to have an 'international passport' in the shape of an ETA accompanied by a CE mark.

QA & efficient procurement

After the initial assessment of the system, the constancy of performance is continuously under surveillance to ensure it continues to fulfill all requirements of its ETA. Factory Production Control (FPC) ensures quality of each component and the assembled tendon with full traceability. BBR's Pre-Delivery Inspection (PDI) is implemented before each dispatch of goods as an extra verification of the compliance of the CONA CMG strand ground anchors to BBR's product standard and project-based specifications such as size, length and so forth.

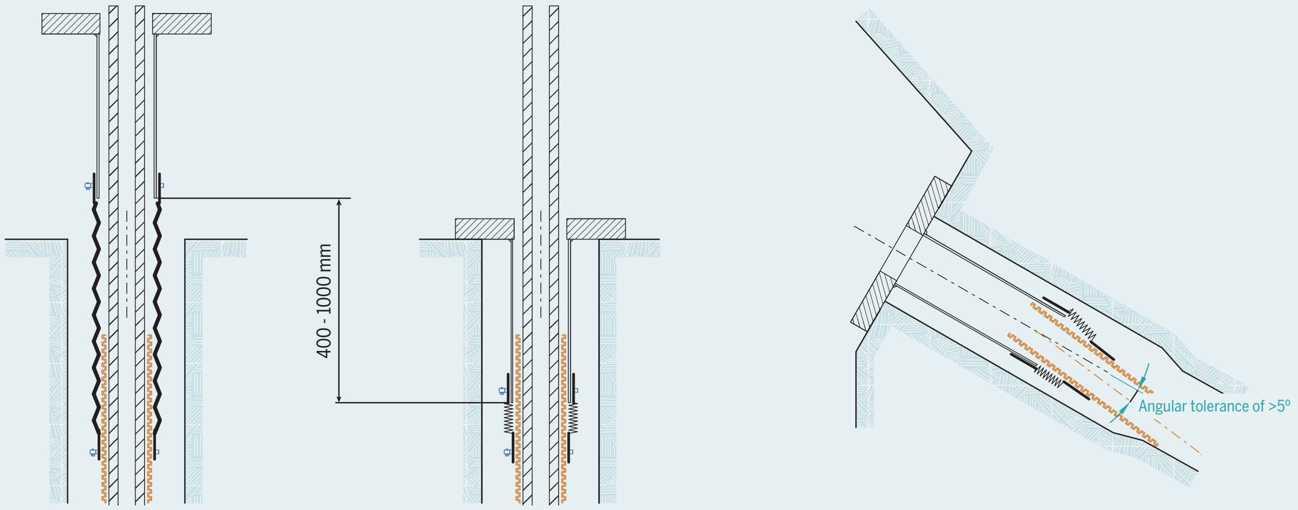
The CONA CMG system is now available for procurement through BBR's unique online trading and QA platform – BBR E-Trace. A wide range of optional components are provided, allowing clients to configure the anchor according to project need. The fully integrated digital QA process also ensures access to traceability information for each component and each anchor that is delivered to the international construction market.



BBR's extensive testing program according to the requirements of the EAD included an innovative test to prove the crack width of the inner cement grout under service load conditions – verifying that the grout acts as a corrosion protection layer.

Compelling proposition

We appreciate the great effort that has gone into producing a meaningful EAD for strand ground anchor kits and thank all involved in realizing this new and important regulatory framework. Now, for the first time, customers have the ability to make a genuine qualitative judgment when specifying strand ground anchoring work – and can also have greater confidence in the durability of their chosen solution. Meanwhile, the whole BBR team is proud to be the producer of the world's first ETA approved, double corrosion protected, strand ground anchor system – BBR VT CONA CMG – which, when combined with the skills and vast experience of the BBR Network, is a truly compelling proposition.



Schematic diagram showing the range of flexibility and tolerance built into CONA CMG's unique sealing device for ease of installation on site.

Research & Development CONA CMI & CONA CME optimization

Reducing congestion & carbon

With their newly optimized reinforcement requirements, the CONA CMI internal and CONA CME external post-tensioning technologies are the leanest and most compact systems on the market. Dr. Haifeng Fan Project Leader of the PT & Stay Cable Technologies Unit at BBR VT International examines how these two recently optimized BBR PT technologies can help to reduce congestion in the anchorage zone, while reducing a structure's carbon footprint – and the construction budget too.

Over recent years, structures have become more-and-more compact – with the help of continuous improvement in material quality and performance. Not only does this make a structure more aesthetically pleasing, but it also saves on material consumption which consequently helps to reduce embodied CO_2. Furthermore, the trend for precast structures with high-grade concrete, allowing slender structural profiles, has grown exponentially. With a compact structural design, the arrangement of reinforcement – particularly in the anchorage zone – becomes more challenging. The structural reinforcement, together with anti-bursting reinforcement, creates massive congestion in this region. This might not only affect the concreting quality, but can also increase the difficulty of ensuring a high installation quality – as well as leading to time and cost overruns should any amendments be needed after installation. One effective solution for reducing this congestion in the anchorage zone is to use a single layer of steel reinforcement instead of two as in conventional design – for example, only a helix or a stirrup.

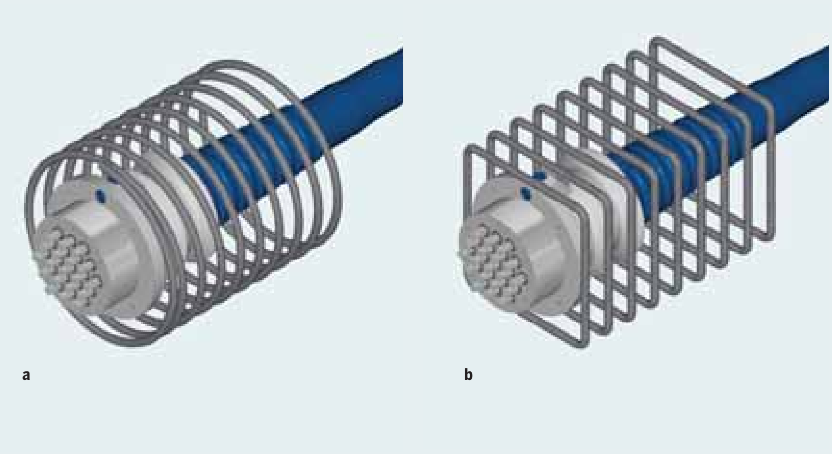
Congestion of reinforcement in the anchorage zone can lead to concrete quality issues and, ultimately, to time and budget overruns.

Responding to market needs

While continuing to listen to the market and respond to its needs, we have developed new single layer anchorage zone reinforcement options for the BBR VT CONA CMI internal and CONA CME external systems. These options for CONA CMI and CONA CME systems have been independently tested and approved in accordance with the test procedures specified in the European Assessment Document 16 (EAD 16) guidelines. They are currently being added to our ETAs for both systems and will be available for both 0.5" and 0.62" strands in bonded or unbonded applications.

As mentioned, these two systems will require only one layer of anti-bursting reinforcement – either helix or stirrup, as shown in the adjacent visualization. This advanced and optimized solution for CONA CMI and CONA CME systems offers the following advantages:

- includes helix-only and stirrup-only solutions that give freedom for designers to select and consequently reduce the complexity of the anchorage zone design
- medium to high concrete strengths for different applications, i.e. from 33/38MPa (cylinder/cube) to 50/60MPa
- widest size range on the market – from size 2 up to size 37
- most compact (lowest center spacing and reinforcement dimensions) design on the market
- great savings, because of the above optimization, in material and labor costs.



BBR solution for CONA CMI internal and CONA CME external post-tensioning systems – requiring only one layer of anti-bursting reinforcement, either helix (a) or stirrup (b).

Optimized & compact design

The adjacent graph (Figure 1) shows that compared to the existing solutions on the market, the optimized solution for CONA CMI and CONA CME systems offers the minimum reinforcement dimensions on the market for all sizes. This optimization in the anti-bursting reinforcement not only reduces the material consumption, but also gives more scope for engineers in designing the anchorage zone.

The center spacing required by the CONA CMI and CONA CME systems has also been compared to that of existing solutions on the market, as shown in Figure 2. It can be clearly seen that the CONA CMI and CONA CME systems offer the most compact design for all sizes.

Lower budget, lower carbon solution

Together with minimum reinforcement dimensions and reduced center spacing requirements, along with the possibility of using high grade concrete, the application of CONA CMI and CONA CME systems promotes savings in the amount of concrete and steel used – and consequently the material cost, as well as a reduction in CO_2 emissions and related impacts on the environment.

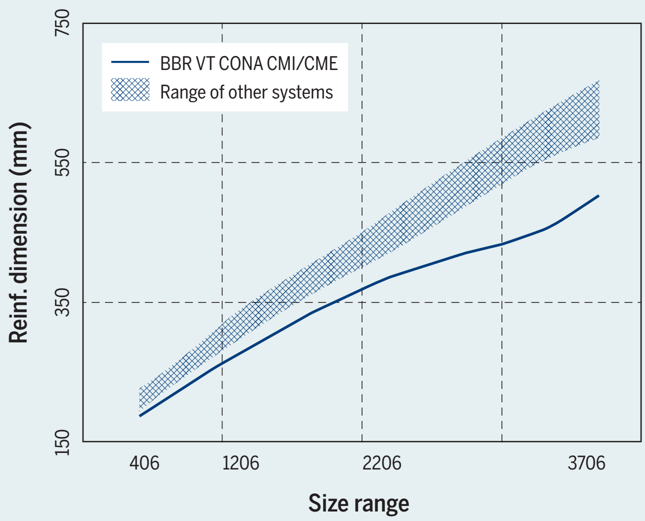


Figure 1

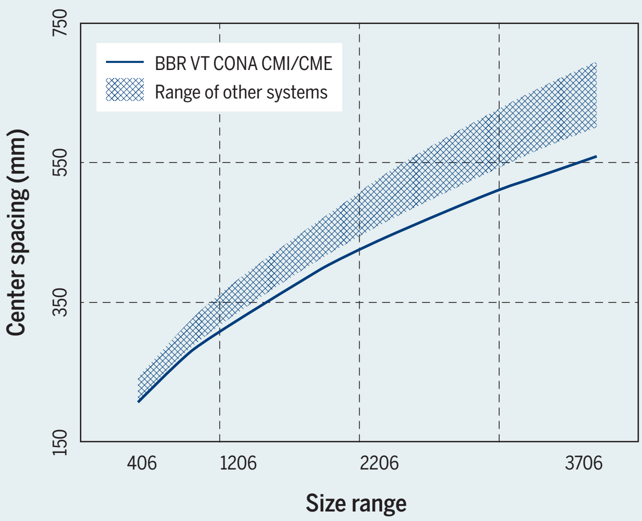


Figure 2

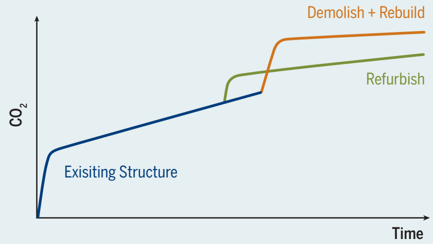
Figure 1 : Comparison of minimum reinforcement dimensions between optimized BBR VT CONA CMI and CONA CME solution and other solutions currently available on the market.
Figure 2 : Comparison of center spacing between the optimized BBR VT CONA CMI and CONA CME technology and other solutions currently available on the market.

Insight & Techniques Reducing embodied carbon while creating significant value for all stakeholders

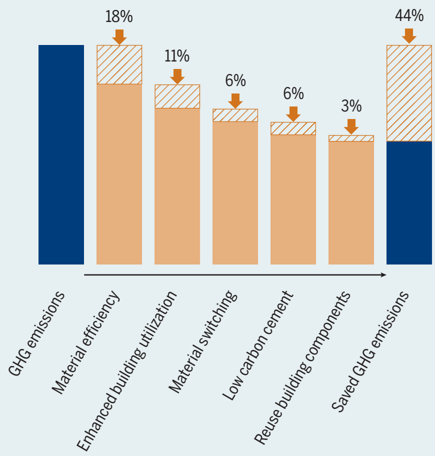
Reimagining our world

The UN has estimated that, by 2050, over 68% of the world's population will be living in urban areas and as soon as 2030, the world will have 43 megacities with over 10 million inhabitants. Massive building and infrastructure will be required to sustain these communities of the future, while at the same time we must work to reduce our carbon footprint and halt global warming. In this special feature, BBR VT International CEO Juan Maier explores the challenges involved and examines some solutions that the construction industry can already implement to facilitate this journey – while, at the same time, creating significant value for all stakeholders.

Fernando Reig Bridge, Spain – a stay cable replacement project requiring an innovative destressing technique was carried out by Spanish BBR Network Member, FCC Construcción, S.A.



Carbon emissions generated by the demolition and rebuilding of an existing structure, as compared with its refurbishment.



Potential reduction of GHG emissions associated with various interventions.

Construction currently accounts for around 40% of annual global CO_2 emissions. If we are to meet our global warming targets, a radical reimagining is required as to how we reuse and extend the lifetimes of existing buildings and infrastructure, as well as how we engineer and construct new structures.

While the best way to reduce carbon emissions would be to stop all construction activity, this is clearly not a realistic option. So, the next best solution is to reuse, repurpose and extend the lifecycle of existing structures. Then finally, when there is no other better alternative to building a new structure we should adopt clever engineering and design practices along with low embodied carbon materials in order to optimize the quantities consumed and ultimately the amount of embodied carbon.

Enhancing building utilization

Often, buildings are underutilized and effectively discarded way before they have reached the end of their useful lives. However, if cities could optimize the use of these existing structures, they would thus reduce the need for new buildings and potentially cut GHG (greenhouse gas) emissions by 11%. The adjacent chart (based on "Building and Infrastructure Consumption Emissions: In Focus", published by the University of Leeds, Arup & C40 Cities) shows that potential reductions in GHG emissions of up to 44% can be achieved in this and other areas, mentioned later in this feature. In addition, wherever possible we should embrace a circular economy and recycle and reuse building materials so that wastage is reduced.

Monitoring, inspection & innovation

Effective and timely maintenance of our built environment has never been more crucial. Building owners and operators now have access to digital twin models and digital technologies which can predict maintenance and provide early warning signals of impending repair works by using real-time digital monitoring and collection of sensor data combined with artificial intelligence to support interpretation of the data.

Further inspection of existing structures can give us an early assessment of their performance and highlight whether maintenance, repair or retrofitting (MRR) is needed. Monitoring, inspection and innovative MRR solutions help us to decide whether we can successfully and economically repurpose, reuse or extend the effective life of existing structures.

Extending lifetimes

BBR Network Members routinely apply their innovative construction engineering skills to extend the operational lifetime of a whole range of structures.

In France, for example, BBR VT CONA CME external post-tensioning tendons have been applied to a number of motorway viaducts to strengthen them and thus prolong their service life. What's more, is that exchangeable tendons can now be used – as was the case for the Echinghen Viaduct – so should it ever become necessary to replace them, the operation would be relatively simple.

Meanwhile in Spain, the innovative destressing and replacement of stay cables with latest generation BBR HiAm CONA technology has revitalized a major infrastructure connection. The technology and techniques applied for the Fernando Reig Bridge are eminently replicable and avoid the additional CO_2 emissions that building anew would generate. There are many more such bridges, originally built in the 1980s with what was then state-of-the-art construction technology and which may require similar treatment and renovation in the coming years. >

Optimizing new structures

When evaluating construction of a new structure, we need to consider a number of aspects – ranging from engineering design, materials selection through to on-site installation – to ensure it is optimized for carbon reduction and reap any further benefits from the process.

While timber is an excellent example of a low-carbon building material, it simply isn't available on a mass scale to meet the needs of future construction. Additionally, there are many issues that remain open with timber usage related to durability, fire safety, resilience and so on. In fact, the only construction material that currently exists – and is also available at scale – is concrete. Therefore, we have to look towards smarter engineering and construction practices with this material.

Immediate gains can be easily achieved by using lower-carbon cement to potentially cut embodied CO_2. Concrete is one of the most carbon-intensive construction materials as the production of its cement component requires extreme heat and releases a great deal of CO_2. Reducing the need for cement in concrete by using lower-carbon alternatives could potentially cut GHG emissions by 6%.

Smart design & engineering

Clever design and engineering can also contribute to reduced GHG emissions. From a design engineering perspective, we tend to limit ourselves to building code-derived elastic models and rarely go that step further of considering load redistribution, plastic theory of materials, non-linear and three-dimensional analysis. For instance, in typical building floorplates this would permit a significant reduction in material usage. The reduction in the self-weight of a superstructure would in turn have a domino effect on the size and consequently the associated material consumption of substructure elements, such as columns and foundations.

Often material is arbitrarily added to meet serviceability limit state criteria. However, by taking an intelligent engineering approach, a structural load path could be reconfigured to make it stiffer or the vibration/deflection limits could be relaxed – thereby creating not only a more cost-effective structure, but also one with lower embodied carbon. Studies have shown that through designing in greater materials efficiency, a reduction in GHG of up to 18% can be achieved on a construction project.

Clever solutions with PT

Another example of clever engineering is the usage of post-tensioned concrete which has the potential of saving typically between 30-40% of embodied carbon in buildings, compared to traditional forms of construction. When BBR Network Member, BBR Adria persuaded their client to adopt a post-tensioned concrete approach instead of a traditional reinforced concrete one to the construction of a shopping mall, they harnessed a number of benefits. The astonishing results included the reduction of embodied CO_2 by 33.5% – and also reductions of €1 million on the construction budget and 120 days from the program. Value creation from every angle. The adjacent Case Study shows in more detail the savings and value added by the post-tensioned solution.

World record-breaking viaduct in Turkey

Plans were afoot in Turkey to construct 1.4km of railway viaducts for the Kayas-Yerköy high speed railway by the balanced cantilever method. The local BBR Network Member, Kappa, proposed an ingenious alternative method utilizing a world record-breaking Movable Scaffolding System (MSS) which dramatically reduced the viaduct's self-weight and consequently the structure's embodied carbon by a staggering 46%. This optimized construction approach resulted in a net reduction of over 40,000 trucks-worth (around 300,000m^3) of concrete and 45,000t of steel. Naturally, an impressive cost saving of 42% was an attractive consideration too, resulting in a considerable value proposition for the asset owners.

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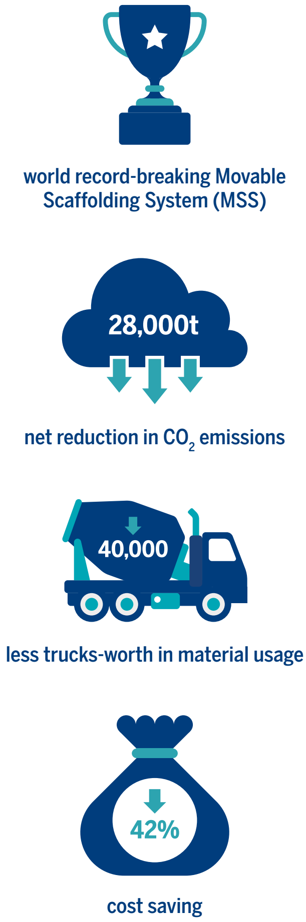


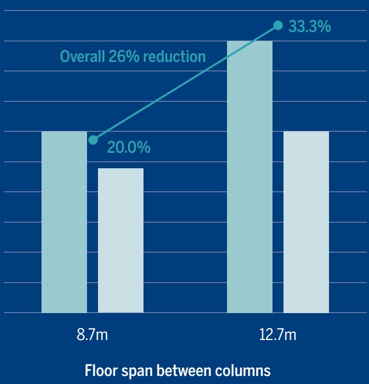
Case Study

Max Stoja Shopping Mall, Croatia

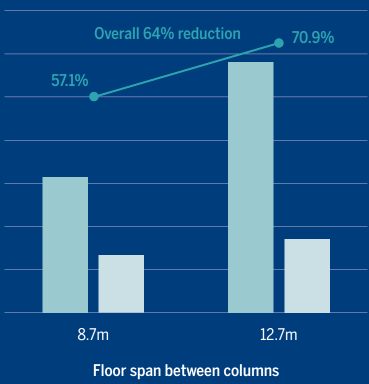
Savings & value added by utilizing a PT solution

1. **Reduced slab thickness** – from 30cm to 24cm & 45cm to 30cm for column spans 8.7m & 12.7m respectively
2. **Reduced concrete material** – overall 26% by volume
3. **Reduced steel reinforcement material** – overall 64% by mass
4. **Reduced embodied CO_2** – by 33.5% from lower material consumption
5. **Reduced construction program** – by 120 days
6. **Reduced construction budget** – EUR1.0mio material savings

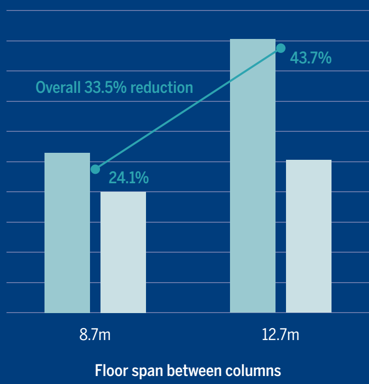
Concrete volume [m³]



Steel mass [tn]



CO_2 equivalent [tn]



RC PT Saving


2


3

Production line techniques

By engaging with factory production line principles and techniques, the construction industry can benefit from greater efficiency and quality. As with a product, the manufacture of construction elements – such as those used in precast segmental construction – can be carefully controlled in the factory throughout the process, so that they embody higher quality, only the quantity of material that is actually needed and, crucially, less waste. The advantages don't stop there – in the design process, ease of on-site handling can be optimized, thus reducing the on-site program and cost of assembly. These techniques have been used for decades by BBR Network Members, in fact you'll have already read (page 25) how BBR engineers pioneered the concept of precast segmental construction for long bridges way back in the 1950s. Since then, BBR has worked to refine and improve both the construction technology and techniques applied, as demonstrated in the many recent projects for light rail systems in Europe, the Middle and Far East.

Modular construction through the technique of PPVC (Prefabricated Prefinished Volumetric Construction) is where prefabricated steel or concrete modules are produced in a factory, after which mechanical and electrical fittings are installed and finally architectural finishes are applied. This technique improves productivity by upwards of 50% and reduces wastage of materials which in turn reduces carbon emissions.

Digital fabrication

Taking factory production techniques a stage further, automated assembly lines and robots enable digital fabrication. Then, in order to maximize efficiency of material use, the utilization of 3D printed concrete and formwork optimizes concrete placement. Within the scope of this, integration of mechanical, electrical and plumbing (MEP) services can also be achieved in an even thinner structural depth thereby reducing the effective floor-to-floor height in buildings.

BLUEPRINT FOR THE FUTURE

PREEMPTIVE INSPECTION, MONITORING & MAINTENANCE

- Preemptive inspection of existing structures offers early assessment of performance & highlights whether maintenance, repair or retrofitting (MRR) is needed
- Predictive maintenance & early warning signals of impending repair works through real-time digital monitoring & sensor data collection combined with artificial intelligence
- Integrated structural health monitoring & maintenance with digital twin models to understand whole lifecycle of assets supporting facilities management & operations

EXTENDING LIFETIMES

- Use smart, flexible construction methods to adapt or strengthen existing structures & extend their lifetimes
- Repurpose under-utilized buildings rather than demolishing & building anew
- Engage with circular economy & recycle waste materials from existing structures

OPTIMIZE NEW BUILD

- Optimized engineering design to encompass load redistribution, inelastic material behavior, plus non-linear & three-dimensional analysis to reduce material consumption
- Use latest technologies, such as post-tensioning with the option of exchangeable & restressable tendons
- Consider use of low carbon concrete & other advanced low carbon materials

4

1 The Kayas-Yerköy high speed railway viaduct project, Turkey – where Turkish BBR Network Member Kappa used an MSS combined with post-tensioning to deliver an optimized design which brought reductions in materials usage and reduced CO_2 emissions by 28,000t.
2 The LRT Extension Project, Kuala Lumpur, Malaysia – greater efficiency of material usage, speed of installation and quality of finish was achieved through the adoption of factory production techniques.
3 Student Hostel, Nayang Technical University – one of BBR Construction Systems' many projects in Singapore where productivity gains have been achieved through the application of PPVC techniques.
4 DFAB HOUSE project, Zurich, Switzerland – the PT floor segments were produced from 3D printed formwork to optimize the structure and MEP layout. It 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.

Recently, BBR participated in the construction of the DFAB HOUSE – a collaborative demonstrator project of the Swiss National Centre of Competence in Research (NCCR) 'Digital Fabrication'. The project is seeking ways to make building more sustainable and efficient through the use of digital technologies and at the same time create new design possibilities. CONA CMM monostrand post-tensioning tendons were installed into the 'Smart Slab' which was created using 3D printed formwork to optimize the structure and MEP layout. The materials were clearly optimized brilliantly as the slab weighs almost 70% less than a conventional solid concrete slab. In the future, the production of these prefabricated floor slabs will be on an automated production line, similar to the modern automotive assembly line, where customized floor panels will be prefabricated and delivered to construction sites for final assembly.

Embracing change

As on so many occasions in the past, once again our success will be driven by our ability to embrace change. We must approach the challenge of reducing embodied carbon with innovative, cross-cutting construction engineering strategies and technologies which deliver real benefits. The way ahead is clearly signposted as a shared journey between professionals across different disciplines. We must continue to actively explore, combine and apply the learning from other industries to construction in order for our carbon reduction goals to be met. Our customers will now be looking for smarter solutions which can be seamlessly applied to their projects – and this along with the creation of significant value for all stakeholders, must be our focus. Here, BBR Network Members are already one step ahead as they have been using latest construction technologies and techniques for many years and routinely apply value engineered, innovative solutions.

OFF-SITE PREFABRICATION & MODULAR CONSTRUCTION

- Industrialization enabling off-site assembly-line production using lighter, easier-to-handle materials to improve productivity & reduce material wastage
- Complete submodules of a larger building are prefabricated in a factory or nearby yard permitting higher quality control before final assembly at the construction site
- Reduced labor requirements on-site & shortened construction time program

DIGITAL FABRICATION

- 3D printed concrete structures or formwork to optimize the placement of concrete before final on-site assembly could transform the industry with respect to design, cost & time as well as reduce material wastage
- 3D printing which is undertaken on site can significantly reduce transportation costs, the need for labor & the risk dimension is reduced tenfold
- Integration of mechanical, electrical and plumbing (MEP) services with 3D printed structures offers an efficient mechanism to minimize the floor-to-floor height in buildings

ROBOT-ASSEMBLED CONSTRUCTION

- Automation of processes with robotic technologies enables industrialization & off-site manufacturing
- Robots are now also selectively being used on-site for repetitive & predictable activities, such as tiling, bricklaying, welding& spool fabrication, demolition & concrete recycling
- Workers will need to learn to work side-by-side or in a hybrid role with robots

Our global presence

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

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

HEADQUARTERS

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

EUROPE

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

BOSNIA & HERZEGOVINA
see Croatia

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

DENMARK
see Norway

FINLAND
see Norway

FRANCE
ÆVIA – Etablissement Câbles et Manutention
3-7 Place de l'Europe
78140 Vélizy-Villacoublay
Tel +33 1 71 59 51 30
www.eiffage-aevia.com
etic.aevia@eiffage.com

GERMANY
see Austria

KOSOVO
see Croatia

LIECHTENSTEIN
see Switzerland

LUXEMBOURG
See France

MONTENEGRO
see Croatia

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

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

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

BBR Polska Sp. z o.o.
ul. Tarnogórska 214a
44-105 Gliwice
Tel +48 32 331 47 98
www.bbr.pl
bbrpolska.gliwice@bbr.pl

PORTUGAL
see Spain

SERBIA
see Croatia

SLOVENIA
see Croatia

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

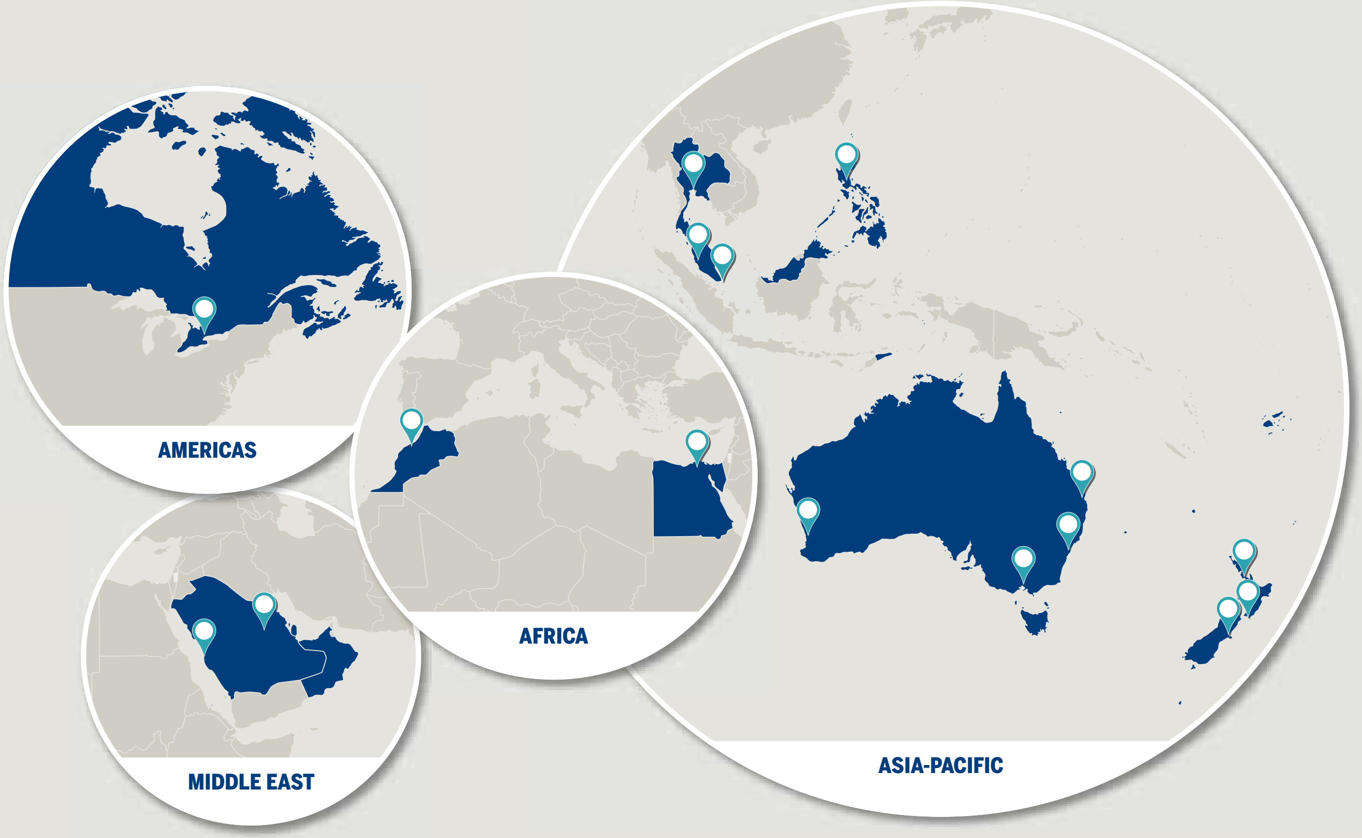
SWEDEN
Spännteknik SLF AB
Koppsängsvägen 13
671 93 Arvika
Tel +46 8 510 678 10
Fax +46 8 510 678 19
www.spannteknik.se
info@spannteknik.se

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

TURKEY
Kappa Kalip Insaat Ve Taahhut A.S.
Beytepe Mah. 5387. cad,
Mira Ofis A Blok No: 15/49
06800 Çankaya/Ankara
Tel +90 312 963 00 33
www.kappa.gen.tr
info@kappa.gen.tr

AMERICAS

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



AFRICA

EGYPT
ESPT
43 Moez Al Dawla Street
Nasr city, Cairo
Tel +20 106 094 1272
+20 100 450 5820
Fax +20 2 267 102 51
www.bbrnetwork.com

MOROCCO
Becomar
Rue Al Adarissa
Berrechid
Casablanca 26100
Tel +212 522 324 024 / 26
www.becomar.net
contact@Becomar.net

MIDDLE EAST

BAHRAIN
BBR Bahrain
see Kingdom of Saudi Arabia

QATAR
BBR Qatar
see Kingdom of Saudi Arabia

KINGDOM OF SAUDI ARABIA
BBR Saudi Arabia
Ahmad Bin Hanbal Street
Gloria Center Block 3, Office 313
Riyadh
Mailing address: PO Box 5005,
11371 Riyadh
Tel +966 12 236 7880
M +966 50 799 3533
Fax +966 12 236 7880
www.bbrnetwork.com
afateh@bbrsti.com

BBR Saudi Arabia
Prince Sultan Street
Al Humaidy Building, 1st Floor
Jeddah
Tel +966 12 236 7880
M +966 50 799 3533
Fax +966 12 236 7880

ASIA-PACIFIC

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

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

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

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

FIJI
see New Zealand

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

NEW ZEALAND
BBR Contech
15 Kerwyn Ave, East Tamaki
Auckland 2013
Mailing address: PO Box 51-391,
Pakuranga, Auckland
Tel +64 9 274 9259
www.contech.co.nz
akl@contech.co.nz

BBR Contech
27 Port Road, Seaview
Lower Hutt 5010
Wellington
Mailing address: PO Box 30-854,
Lower Hutt, Wellington
Tel +64 4 569 1167
Fax +64 4 569 4269
www.contech.co.nz
wgn@contech.co.nz

BBR Contech
40 Depot Street
Hornby South
Christchurch 8042
Mailing address: PO Box 8939,
Riccarton, Christchurch
Tel +64 3 339 0426
Fax +64 3 339 0526
www.contech.co.nz
chc@contech.co.nz

PHILIPPINES
BBR Philippines Corporation
Suite 502, 7 East Capitol Building
No.7 East Capitol Drive
Barangay Kapitolyo
Pasig City
Metro Manila 1603
Te +632 8638 7261
Fax +632 8638 7260
info@bbr.com.ph

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

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

A Global Network of Experts
www.bbrnetwork.com