CONNECT

THE MAGAZINE OF THE GLOBAL BBR NETWORK OF EXPERTS

Edition 12 | 2018

MAXIMIZING PRODUCTIVITY

BBR Network's contribution to greater construction industry productivity

NEW SOLUTIONS FOR EXTERNAL PT

Range of features & applications extended

PT PARTNERS IN POLAND

Three major developments benefit from BBR PT & know-how

VERSATILE OPTIONS FOR BRIDGE CONSTRUCTION

New Malaysian bridge realized with BBR technology & techniques

MOMENTUM AND RHYTHM

Precast segmental construction for new metro viaduct in France

A Global Network of Experts

www.bbrnetwork.com

The BBR Network is recognized as the leading group of specialized engineering contractors in the field of post-tensioning, stay cable and related construction engineering. The innovation and technical excellence, brought together in 1944 by its three Swiss founders – Antonio Brandestini, Max Birkenmaier and Mirko Robin Ros – continues, more than 70 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 70 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).

BREADTH & DEPTH OF EXPERTIZE

When reading this edition of CONNÆCT, you will be able to understand clearly not only the breadth of services provided by the BBR Network around the world, but also the many aspects that are considered when developing BBR technology and techniques.

You will see, for example, that the range of BBR technology is advancing and increasing and that new supply chain arrangements have been implemented. This reflects the need to provide customers with appropriate timely services while maintaining the quality they expect and to allow BBR Network Members the opportunity to extend their offering while benefiting from a single-source of supply.

Meanwhile, the Portfolio section showcases the diverse construction engineering skills of BBR Network engineers who continue to delight their customers. From the Pulau Sekati Bridge in Malaysia where two different construction methodologies were used, to the precast segmental construction of the viaduct for France's Rennes Metro and the launching of Poland's Żmigród Bridge, it is obvious that BBR technology and know-how is contributing to both speed of construction and reduced impact in the realization of new infrastructure. The building projects featured – particularly in Malaysia, the Netherlands, Poland and Singapore – demonstrate how BBR technology supports the creation of architecturally adventurous and high-rise designs.

Elsewhere in this edition, the multitude of practical applications for BBR Network technology and talent is shown through schemes such as the construction of the Ostróda Bridge in Poland where BBR HiAm CONA stay cables were used to support its three arches, the strengthening of another Australian dam with world record-sized ground anchors and a number of projects where new life has been breathed into vital infrastructure by the expert application of MRR techniques.

An insight is also shared into the collaborative work that both BBR Headquarters and BBR Network Members undertake with educational establishments. This points to our overarching philosophy that our work is more than just about developing technology and techniques – it is about encouraging discovery of the most appropriate and latest solutions. By creating and maintaining open dialogues, together we can improve our world – let's start a new conversation today!

Marcel Poser
Chairman, BBR VT International Ltd

José Manuel Illescas
Vice Chairman, BBR VT International Ltd

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SOURCES AND REFERENCES
Front cover image: In today's increasingly fast-paced business environment, demands for the highest level of productivity have never been greater. See page 7 to discover how the BBR Network is responding with vision, innovations and investment in performance-enhancing technology and techniques.

Portfolio section
Versatile options for bridge construction: www.ecerdc.com.my
Thinking outside of the circle: www.paris.fr, www.parisrivegauche.com
Making way for buses: www.pta.wa.gov.au, www.mainroads.wa.gov.au
Momentum and rhythm: www.metro-rennes-metropole.fr, www.metro-rennes-metropole.fr, www.semtcar.fr
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New sports stadium: www.theguardian.com, www.stadiumguide.com, en.wikipedia.org
Major new LNG plant to feature BBR PT: www.hydrocarbons-technology.com, www.kogas-tech.co.kr
Around the clock shifts for silos: www.hanson.com.au, www.illawarramercury.com.au, www.news.com.au, prwire.com.au
Renewed strength for energy: en.wikipedia.org, www.elektroprivreda.ba
PT partners in Poland: www.katowicethecity.com, www.immobelpoland.com, www.garnizon.pl, www.officefinder.pl, en.wikipedia.org, www.tdjestate.pl

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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.

TALKING BBR

BUSINESS REVIEW

Reflections & outlook from BBR VT International's CEO

MAXIMIZING PRODUCTIVITY

The ability to respond to customer needs with the highest quality and most efficient and effective services is increased with vision, innovations and investment in performance-enhancing technology and techniques. Antonio Caballero, CEO of BBR VT International Ltd, shares some insights into how BBR Network Members are being supported in their quest to deliver greater productivity and reviews some business highlights from the past 12 months.

In discussions about almost any construction project, somewhere along the line the word 'productivity' inevitably crops up. In this fast-moving digital environment, there is also much pressure to increase the speed of our performance in the physical world. In the construction industry, this means the challenge is for all parties within professional teams to contribute to delivering schemes as quickly as possible and within defined budgets, while maintaining the highest level of quality. Productivity has continuously increased in other industries while remaining stagnant or even decreasing in the construction sector. We have a responsibility to change this trend and change everything possible to increase the value of our outcomes. This will be achieved with a new and determined vision to evolve the established practice leading to the incorporation of the new technologies now available, migration of knowledge from other industries and/or the replacement of 'old-fashioned' methods by new and disruptive ones.

Improved supply chain

Recognizing that the BBR Network must play its role in this area too, during recent months a major focus at BBR HQ has been the conceptualization, development and introduction of alternative and complementary supply chain arrangements. This was achieved with the support of several BBR Network Members who were already using the new supply chain model during its evolution and have given feedback, allowing us to refine the process prior to launching it globally in January 2018. We have effectively created a one-stop-shop whereby BBR Network Members can now order, from logistics centers in Europe or Asia, the most commonly used ranges of standard BBR technology components – for immediate delivery. In addition, quality control of the items will already have been carried out, so shipments can be delivered directly to project sites, without needing to pass through BBR Network Members' own warehouses. Production and supply chain processes will be audited by the same certification body and subject to the same prescribed test plan as specified in the respective European Technical Assessments – and therefore the systems supplied will also carry the CE mark.

This alternative method of securing BBR technology is fully integrated into our BBR E-Trace trading platform. BBR Network Members will have full transparency in terms of stock availability and will soon be able to interact with the BBR E-Trace App for fast ordering.

Overall the production lead-time has been cut to zero – from a previous average of 8-12 weeks – and 'just-in-time' orders can be fulfilled. In addition, for BBR Network Members the new setup combines competitive advantages in terms of technology with minimized logistics costs and reduced effort of ordering.

Meanwhile, we remain committed to retaining our existing network of suppliers with whom the BBR Network will continue to trade for selected projects and BBR technologies. ➤

> "Time is money and, by adding value through building in some time-saving features to products, not only will productivity be enhanced, but costs will also become highly competitive."

Smarter new technologies

Over recent years, we have even built greater productivity into our technologies. While developing the range of BBR accessories, we took into consideration the on-site installation process and worked to make it easier. Since then, the same principles have been embraced for all new technologies we have produced and are currently working on. For example, the BBR VT CONA CMO onion post-tensioning system offers the advantages of a quick to install clip-on accessory solution, while not needing local reinforcement – and also the BBR VT CONA CMM system will soon be following a similar line.

Time is money and, by adding value through building in some time-saving features to products, not only will productivity be enhanced, but costs will also become highly competitive.

Growth & diversification

BBR VT International's goal, like most companies, is to achieve a solid and continuous growth of the BBR Network and to diversify the business to make it sustainable. This is something that we will continue to work on in the years and months ahead.

We want to grow with new products – perhaps some completely new to the market place, alongside some which complement our existing portfolio.

We have been working on expanding our technology and a broader range is a natural step to helping BBR Network Members to grow their own regional businesses.

We are currently evaluating a range of products with the aim of giving Members a single source for ordering. These will offer the same advantages – of having approval and certification – that come with BBR post-tensioning technology. Elsewhere, we are market testing several other products and expect to launch these in the next 12 months.

World of opportunity

Our quest for diversification is also geographic – we are actively exploring new territories across three continents and are in discussion with several potential new BBR Network Members. The strength of the BBR brand portfolio is such that prospective new partners often make the first move and approach us. The reputation of quality Swiss technology travels well.

This year, the BBR Network has welcomed another new Member – Structural Technology Innovation (STI) who is based in Riyadh, Kingdom of Saudi Arabia. Both STI and PCI in Indonesia, who joined us 18 months ago, have reported a very strong increase in their businesses since becoming BBR Network Members. Part of the service we provide to all BBR Network Members is support as they become familiar with our technology and processes – and, later as they become established, we continue to deliver information updates and training.

Marketing support

Getting our message out to the right audience remains a high priority. As well as keeping our range of technical and promotional literature up-to-date, we have added recently to the range of videos available on our YouTube channel and continue to refine our approach to making postings on other social media channels like LinkedIn and Facebook. This is in direct response to research that people are now learning more readily from video and digital material – we always consider how our audience likes to communicate and present our information in that format and platform. In the coming months, we will be developing and implementing items within our digital marketing portfolio to further extend our reach.

Our main priority is to continue the provision of a top flight service to BBR Network Members. With the launch in the last year of both the BBR VT CONA CMI EIT and Cryogenic systems, the emphasis has been on their introduction and then providing training for teams around the world in the specification and application of the systems. At the same time, personnel from BBR HQ have been supporting promotional tours organized by BBR Network Members to visit their customers. It's all about networking to create market awareness and reinforce our brand values.

Our people

With strong order books into the future, it is clear that BBR Network engineers are going the extra mile to deliver some great solutions for their customers. Many thanks to all BBR Network Members for their efforts, ingenuity and achievements in the last year – and congratulations on securing a great selection of highly impressive projects for 2018 and beyond.

Although it sounds like singing our own praises, before concluding my review, I must also acknowledge the work of the really great team we have at BBR HQ. With several new members joining us over the last couple of years, we have a highly-motivated group of people who are all pulling in the same direction to achieve the very highest results.

Personally, I am very excited about the future of the BBR Network as we approach our 75th Anniversary in 2019 and look forward to many opportunities for forging new links and strengthening existing connections in the months ahead. ●

NEWS HIGHLIGHTS

Events & news from around the BBR Network

AWARDS, ARRIVALS & MORE...

Around the BBR Network, the past year has been exceptionally busy with many events and developments. A few of the especially noteworthy achievements and happenings are summarized in the next few pages.

New BBR Network Member in Saudi Arabia
During 2017, we were delighted to welcome a new BBR Network Member – Structural Technology Innovation (STI). Based in Riyadh, Saudi Arabia, STI is a leading provider of specialist contracting services related to post-tensioning and concrete strengthening. STI has 60+ engineering and technical staff and provides its clients with reliable solutions to their most complex building challenges using post-tensioning technology, as well as exclusive solutions for the repair and refurbishment of concrete using both external post-tensioning and CFRP.

BBR Network Members JV for conference
The BBR Network was represented at the 2017 Austroads Bridge Conference (ABC) in Melbourne, Australia. SRG Limited and BBR Contech joined forces in an exhibition booth at the conference exhibition, with support from BBR HQ. The ABC is the premier bridge conference in Australia and provides a great opportunity for local and international specialists in the field of bridge engineering to share experiences, innovations, achievements and knowledge, as well as showcasing latest technology, products and services. ➤

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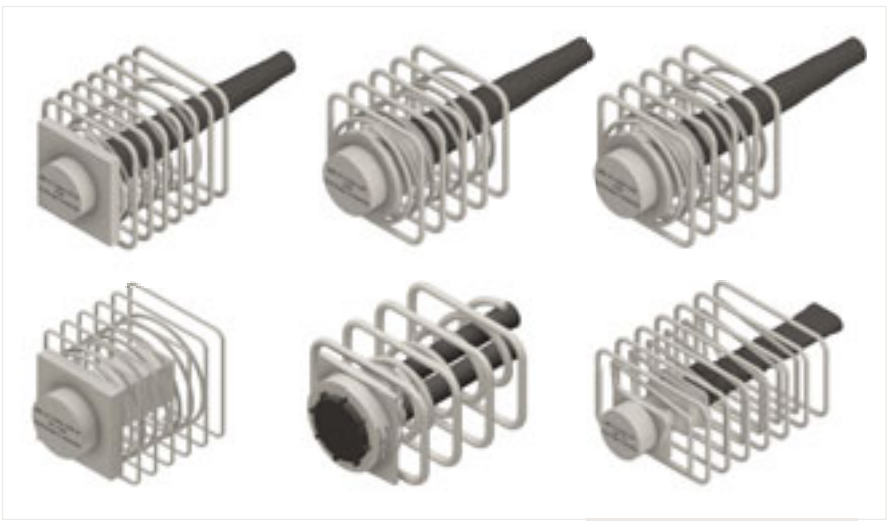

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European Project Managers Workshop
This very productive three-day workshop was held in Valencia, Spain in early October. The program was designed to cover basic, as well as advanced, aspects of the BBR Network and the BBR VT CONA CMX post-tensioning and BBR HiAm CONA stay cable technologies, along with training in BBR's own Factory Production Control system and BBR E-Trace 3.0. On the final day, the 16 delegates – from nine countries – had the unique opportunity of visiting the site of the Fernando Reig Bridge, where a highly complex project was underway to replace 38 old stay cables with the very latest HiAm CONA technology.

Award winners around the BBR Network
In this year's PTI Awards, the James Pascoe Group Distribution Centre at East Tamaki, New Zealand was named the winner in the Slab-on-Ground category (see page 48 for project details). Meanwhile, the International Bridge Conference (IBC) Executive Committee awarded the prestigious Gustav Lindenthal Medal to the owners of Spain's Almonte Viaduct. This award recognizes an outstanding achievement in bridge engineering which demonstrates technical and material innovation, aesthetic merit, harmony with the environment or successful community participation.

In Australia, SRG Limited won awards for their work in two out of the five categories in the 2016 ACRA (Australasian Concrete Repair Association) Awards for Excellence. In the Buildings category, their work at Punt Hill Apartments scooped the top award. SRG's second award was in the Strengthening category where their project for the widening of Princes Highway East Bridge over the Barwon River, Winchelsea (see CONNÆCT 2016) was declared the winner.
Last, but by no means least, SRG was also a finalist in the Civil Contractor's Federation Earth Awards in Western Australia for the fabulous Elizabeth Quay Bridge project. Congratulations to all involved!

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Brochures & flyers updated

The BBR HiAm CONA stay cable brochure and the BBR HiAm CONA Strand Stay Cable Damping Systems brochure, along with the Stay Cable and LNG/LPG Reference Lists have now been updated and are available in the Downloads section of the BBR Network website. Our Stay Cable Damping technology and techniques are both leading edge and have been applied to many projects worldwide. Since 1981, the BBR Network has completed over 60 LNG/LPG structures around the world – a benchmark for cryogenic containment. The range of BBR Network flyers has also been extended to include the BBR VT CONA CMM Single S1 and CONA CMM Single S2 systems.

PT seminar in Poland

A Post-Tensioning Seminar at the Faculty of Civil Engineering, Warsaw University of Technology in Spring 2017 provided delegates with the know-how and tools for the efficient and economical design of post-tensioned structures, focusing mainly on optimizing PT design for buildings. Delegates were familiarized with current PT systems, best practice and latest design codes, before detailed study of specific aspects of PT design. The event was supported by speakers and trainers from Adapt Corporation and the BBR Network.

PT & stay cable models for download

Use of latest digital technology for modeling scenarios is now supported by a complete set of 3D models of the BBR VT CONA CMX post-tensioning and BBR HiAm CONA stay cable ranges which are available for download from the BBR Network website. Downloading these 3D models will enable BBR Network Members and design engineers to perform powerful analyses in a 3D virtual environment.

Technical series & 2017 Highlights videos

The BBR VT CONA CMI internal bonded or unbonded system is the most advanced multi-strand post-tensioning technology on the international market. Now a video has been produced covering its applications and including information about European Approval and testing, as well as details of the anchorage configuration, system accessories and corrosion protection.
A further video about the BBR VT CONA CMX EIT electrically isolated range of systems is also available.
Meanwhile, the BBR Network 2017 Highlights video is the latest in a series showcasing the best projects from around the BBR Network and featuring key moments from the past 12 months, such as the Annual Global Conference, Grouting Seminar and the Training Session carried out in the Asia Pacific Region. ●

1 The newest BBR Network Member – Structural Technology Innovation (STI) – is based in Riyadh, Saudi Arabia.
2 Valencia, Spain – the venue for the BBR Network European Project Managers Workshop held last October.
3 BBR Contech's General Manager Derek Bilby and Conslab Technical Manager Andrew Dallas proudly display the PTI Slab-on-Ground Award, presented for their achievement at the James Pascoe Group Distribution Centre at East Tamaki, New Zealand.
4 A complete set of 3D models of the BBR VT CONA CMX post-tensioning (pictured here) and BBR HiAm CONA stay cable ranges are now available for download from the BBR Network website.
5 The Faculty of Civil Engineering, Warsaw University of Technology, where the BBR Network and Adapt Corporation provided speakers and trainers for a Post-Tensioning Seminar focused on optimizing PT design for buildings. Photograph courtesy of Warsaw University of Technology.
6 Two new videos on the the BBR YouTube channel – BBR VT CONA CMI internal post-tensioning system and BBR Network 2017 Highlights.
7 The Stay Cable Reference brochure front cover. This document, along with the BBR HiAm CONA Strand Stay Cable Damping Systems and LNG/LPG Reference brochures can now be accessed as downloads from the BBR Network website, as can flyers on the BBR VT CONA CMM Single S1 & S2 systems.

SCAN ME
Use your smartphone to scan the code and see the latest videos and news on BBR Network social media channels. Or visit: **http://l.ead.me/baq89k**

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SCAN ME
Use your smartphone to scan the code and download documents from the BBR library.
Or visit: **www.bbrnetwork.com/downloads.html**

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ANNUAL BBR GLOBAL CONFERENCE, **ROME, ITALY**

Business and cultural exchange

CONFERENCE NOTES

Having joined BBR HQ as Business Development Manager for Latin America in December 2016, Daniel Cuerdo presents some impressions of this year's Annual BBR Global Conference after participating for the first time.

Even as a newcomer to this event, I fully realized during my preparation for meetings and workshops that the BBR Global Conference was a super-special occasion for the BBR family – but you just do not realize exactly the magnitude and scope until you experience it yourself. This year was a great combination of formal business meetings and social activities – with a little spare time built into the program. The well-organized yet relaxed agenda was really appreciated by delegates.

Arrival in Rome

Our itinerary began with a superb walking tour in Rome that took us to the old city limits to meet with our guide who revealed more about this unique city. There were also some surprises along the way – the first of which was a bar where we could feast upon an assortment of typical Italian sandwiches. Our second stop was for a classic aperitif on the way to the Pantheon where our venue offered a great view of this monument to the construction expertize of the ancient Romans. The surprises just kept coming – wonderful tourist spots like the Trevi Fountain and Spanish Steps, not forgetting the really amazing ice cream at one of the most famous gelateria in Rome. Our day ended in the well-known Trastevere neighborhood where we each prepared, cooked and ate our own pizzas in one of the coolest restaurants I have ever visited.

Formal conference proceedings

We started with the traditional welcome and vision from BBR VT CEO Antonio Caballero. Juan Maier, Head of Business Development, continued with a marketing and facts-and-figures message and officially welcomed the new BBR Network Member in Indonesia, PCI. Next up was Josef Lamprecht, Head of Supply Chain, who brought delegates up to speed with our exciting supply chain project.

After a short break, Cezary Sternicki, Head of Operations, focused on the geotechnical and structural accessories market and how our franchisees can maximize advantage in these areas. Finally, BBR Head of R&D, Bezhad Manshadi gave a quick overview of the many and new developments completed in recent years – this was extremely impressive.

Special thanks from the whole team must go to Thomas Heubel of KB-VT for his fascinating presentation about the recently inaugurated Tamina Bridge in Switzerland. This was a very challenging project involving an innovative tailor-made stay cable solution for supporting construction of an arch bridge spanning a 200m deep gorge.

2017 BBR AWARD WINNERS

BBR NETWORK PROJECT OF THE YEAR

Hazelmere Dam Strengthening project in South Africa, carried out by BBR Network Member SRG Limited

BEST ARTICLE AWARD

- **Winner:** BBR Philippines (Philippines)
  Title: Signatures on the skyline (high rise developments)
- **Runner up:** BBR Contech (New Zealand)
  Title: Developing region-wide partnerships (MRR projects, Hawkes' Bay area)
- **Highly commended:** Ballast-Nedam Infra-Specialiteiten (Netherlands)
  Title: Europe's widest aqueduct (Aqueduct Vechtzicht)

BEST PHOTOGRAPHY AWARD

- **Winner:** BBR Malaysia (Malaysia)
  Title: Metro Rail Revival & Spanning the Sadong River (LRT & MRT and Sadong Bridge)
- **Runner up:** SRG Limited (Australia)
  Title: BBR sets another anchoring world record (Dam strengthening projects, South Africa & Australia)
- **Highly commended:** ETIC (France)
  Title: Metro Rail Revival (Rennes Metro, Line B)

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Cultural afternoon

In the afternoon, delegates were taken on a tour entitled 'Ancient Rome & the Colosseum'. It seems that, no matter how many times you have been to Rome before, on each visit there's always something new to discover. Our venue for dinner that evening was a delightful typically Italian village, where we could enjoy a wide variety of local food and drinks. Finally, the night ended with many people cheering and celebrating – at this point, I realized that the BBR Global Conference is about more than business issues, it's also about people and shared experiences.

BBR Symposium

The last day of the conference saw the launch of the BBR Symposium, the format for which varies from year-to-year. On this occasion, BBR HQ had invited two experts in the field of digital technology application in the construction sector. Our guest speakers gave presentations about how technology is changing traditional construction methodology and how it will shape the future in terms of improvements in the efficiency and productivity of construction projects. The aims of the BBR Symposium are to encourage delegates to think beyond their current systems and structures – and learn from each other. For my part, I achieved both of these elements and believe participants will find that the messages contained within this session will steer their own business activities in coming months.

Gala Dinner

The venue for the Gala Dinner was the restaurant at the Parco dei Principi hotel. As usual, the BBR Network Awards were presented during the evening and each award was preceded by a high quality video showing highlights of the shortlisted projects. This year, BBR VT International recognized the Project of the Year winners of the last 10 years with a customized trophy and an unforgettable video.

Support for local charity

A huge vote of thanks to our generous BBR Component Manufacturers, the Rupp-Heubel family and two further benefactors who, along with BBR VT International, made a donation to Rome-based charity New Life for Children to help them support Syrian children who are endangered by the ongoing conflict in their homeland.

Successful conclusion

After months spent preparing every single detail for the events, agendas and attendees, you realize this tremendous effort is worthwhile when you see everybody talking and laughing in the bar until very late. Next year's BBR Global Conference will be in Hong Kong, where the whole team at BBR HQ will be trying to raise the level still higher for this important annual gathering. ●

1 BBR Network delegates, from all around the world, line-up for the now traditional group photograph at the 2017 BBR Global Conference in Rome, Italy.
2 The expression "When in Rome, do as the Romans do" took on a whole new meaning for the BBR Network team when they were challenged to construct their own pizzas.
3 BBR Contech's Paul Wymer makes an impromptu speech of thanks after Tectus Group CEO Marcel Poser called team members onto the stage to celebrate their diverse contribution to BBR Network business. Left to right: Paul Wymer, Marcel Poser, Claude Néant, Valentina Mihajlovic, Svein Finstad, Jan Piekarski, Isabella Peier and Christian Roost.
4 Marco Benini, from Rome-based charity New Life for Children, made a presentation about his organization's work during the BBR Gala Dinner. Afterwards, he officially accepted the donation from BBR VT International, the BBR Network and BBR Component Manufacturers.

PERSPECTIVE

Opportunities for value creation with new technology

NAVIGATING THE DIGITAL LANDSCAPE

For this edition of CONNÆCT, we are delighted to welcome as our guest Dr. Dragana Nikolic Ph.D., M.Arch., ASCE. She is a Lecturer in Digital Architecture based within the School of the Built Environment at the UK's University of Reading. Dr. Nikolic offers some thoughts, based on her research, about the adoption of new technologies in the construction industry.

The construction industry is beginning to see the inclusion of new technologies in its toolkit – thanks partly to the adaptation of work pioneered by others, such as the automotive and aviation sectors.
These new digital tools allow our industry to improve the way it approaches a project – from initial design stage through to detailed analysis of building methodology. The benefits come in many forms – enhanced efficiency, less rework, more clarity, better quality, higher profits and, ultimately, greater individual job satisfaction.
Increasingly, governments around the world are demanding that a BIM (Building Information Modeling) approach be taken for construction projects. In the UK this top-down agenda, with a BIM Level 2 mandate for publicly procured projects, has opened up a large playing field for improving processes and technologies and for leveraging and detailing the data accumulated.

Representing information

There has been tremendous growth in digital data and technology development, with ever more powerful portable devices – even mobile phones now have more processing power than early mainframe computers and personal head-mounted displays are lighter weight with better performance than their predecessors.
Some companies are exploring different cases for training, simulation and enhancing productivity.
With the arrival of Virtual Reality we are able to produce, for example, simulations of a construction assembly sequence and with Augmented Reality, we can merge digital and real data to enhance different worksite activities and improve productivity.

Interacting with data

Use of technology – whether this involves BIM, visualization or simulations – is fundamentally a choice to be made based on purpose, information requirements and value offered.
At a basic level, it is about improving the way information is shared to ensure that all team members have the opportunity to understand the project and its goals, as well as to contribute their expertize.
When a project team sees an interactive 3D design visualization, they quickly start to question, confirm or otherwise propose and evaluate the design, even in informal settings.

Building a digital strategy

For the majority of the players in the construction industry, the biggest challenge is not just the financial investment in technology but also the development of an effective strategy for incorporation of digital technologies into their day-to-day businesses. The right resources, capabilities and infrastructure also need to be in place to allow for the new way of working.
The implementation of new technologies requires both a top-down and bottom-up approach at the same time – business leaders need to champion the use of digital technology and engineers need to incorporate the technology into their projects. This is the ideal solution as it blends authority with capability – one without the other will result in the technology being under-used and its value not visible.
This is unlike any other industrial revolution in history – there is a paradigm shift from automating to 'informating' processes. We are seeing roles being redefined, rather than being replaced, by automation.

On the horizon

While this will take a little time to filter through to the construction industry, data from new initiatives currently underway elsewhere, like the driverless car, will also provide a lot of potential for the built environment.
Here, it will be about protecting assets, collecting data about their use and performance and planning updates for future operations. Then we can start leveraging that data to make informed decisions about predicting and planning accordingly for long-term maintenance and for 'rush hours' when resources will be stretched.
Technology alone will not improve things, there has to be understanding of what the value is that everyone wants to obtain. Tailor the technology to that use and this will yield benefits further down the line. ●

PORTFOLIO

1

IN THE SPOTLIGHT

Benefits of membership of the BBR Network

GROWING WITH THE BBR FRANCHISE

The BBR Network is now well-established and growing – both in terms of business and membership. Juan Maier, Head of Business Development at BBR VT International, takes a look at some of the drivers of this successful global enterprise and offers some reasons why equally talented organizations should be interested in taking up a BBR franchise.

The BBR Network is essentially a worldwide group of independent businesses which have strong local roots in their geographic region and, most importantly, proven skills and knowledge in the field of post-tensioning, stay cables, ground anchoring and other related construction engineering. They all have access to the latest Swiss BBR technology and are regularly trained and updated in its application and international best practice by franchisor BBR VT International.

Growth through brand strength

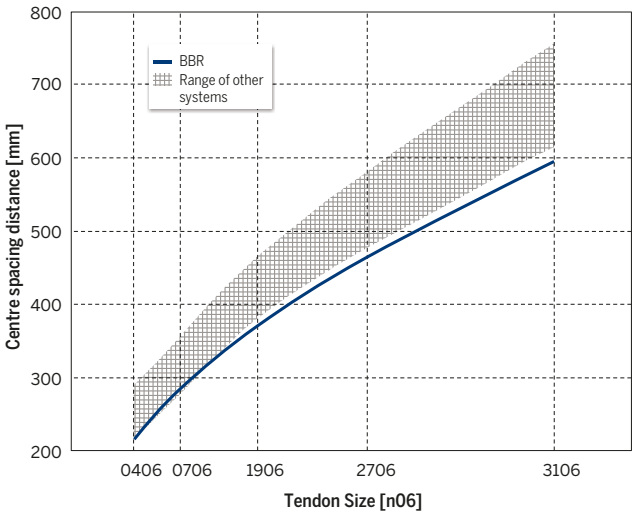
Many qualities are associated with a brand – technical excellence, highest quality control, ease of use, durability and flexibility are just a few that people associate with BBR brands. It is these and other attributes that attract customers and make the BBR proposition compelling.

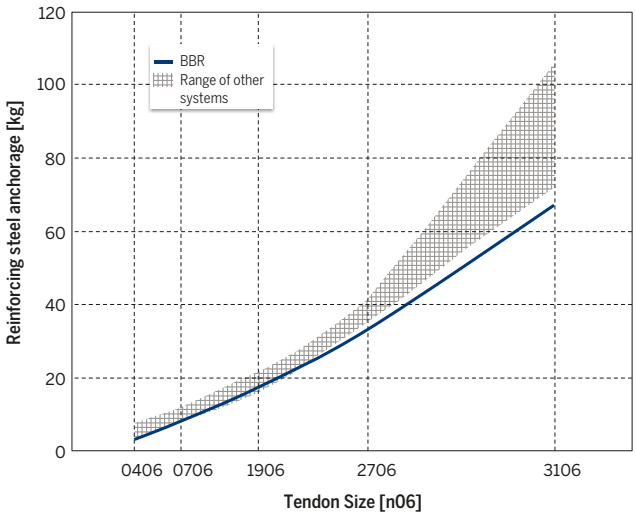
Recently, two new companies have joined this highly successful and supremely talented network of professionals providing well-engineered solutions to construction industry customers. In South East Asia, PT. Prestress Construction Indonesia (PCI) has built a strong local reputation and wanted to improve their business by offering BBR technology. A few months later, Structural Technology Innovation (BBR STI), based in Saudi Arabia, became a BBR Network Member based on similar objectives. Since joining, both organizations have experienced a strong surge in business which, in many cases, has resulted from direct customer approaches rather than marketing alone. This is proof positive that the reputation of the BBR brands of technology and BBR Network expertise are widely respected on the international scene.

> "...we have essentially doubled our annual revenues compared to the year before joining BBR."
>
> Hotman Sianipar, PT Prestress Construction, BBR Network Member for Indonesia

Influencing the future of construction

BBR Network Members, by communicating feedback from their local markets, can influence the development and direction of BBR technology and systems. Most recently, the introduction of the BBR VT CONA CMM S2 post-tensioning anchorage, the BBR H Bar System and BBR's new fully integrated global supply chain are the results of such feedback.





These graphs show a few of the competitive advantages gained from using BBR technologies. For instance, the BBR VT CONA CMI BT multi-strand post-tensioning system has been optimized to achieve the smallest tendon center spacing and concrete edge distance on the international marketplace (left) while at the same time using the least amount of local anti-bursting reinforcement (right) – promoting project time and cost savings.

Promoting people power

One of our greatest brand assets is our people. Down the years, we have nurtured some of the world's most talented engineers who have become bold innovators, ready to solve even the toughest challenges for their customers. In turn, this innovation has been shared with their worldwide colleagues and thus expertize has grown around the globe. BBR Headquarters provides regular updates, training and workshop sessions where BBR Network engineers have the opportunity to meet with each other. The Annual Global BBR Conference draws together senior delegates from around the BBR Network to review progress and future plans. BBR VT International sets the scene by bringing people together and providing forums for learning or discussion – BBR Network Members then shape their own roles within their markets and the BBR family itself.

Collaborative working

While initial introductions are made at the global or regional BBR conferences and seminars, relationships between BBR Network Members evolve and develop outside of these gatherings. As Members get better acquainted, collaborative working begins – from simple exchanges of information to working together on projects – or indeed, whole market segments.

> "... it was important that our business should be built on quality European approved technology. Already, we are setting new benchmarks in our local market."
>
> Adam Farouk, STI, BBR Network Member for Kingdom of Saudi Arabia

Greater than the sum of its parts

The BBR Network is about so much more than just the supply and installation of construction technology. It is also about supporting individuals and businesses in their efforts to promote and deliver the very best of construction engineering services. Although in the next edition of CONNÆCT we expect to be introducing some further new BBR Network Members, we are always interested in hearing from like-minded organizations who are committed to growing their business locally, with internationally approved technology – and within the environment of a major international group, such as the BBR Network. ●

1 Artist's impression of the 56-storey Pacifica Tower which will feature expertize from the JV formed between Australian and New Zealand BBR Network Members, SRG Limited and BBR Contech (see also page 45 for more details). The scheme is being constructed for developer Hengyi Pacific in Auckland, New Zealand by main contractor Icon Co Pty (NZ) Limited. Image courtesy of Hengyi Pacific.

SCAN ME

Use your smartphone to scan the code and learn more about becoming a BBR Franchisee. Or visit: **www.bbrnetwork.com/aboutus/bbr-franchise**

Key benefits of a BBR franchise

- Access to best-in-class internationally approved PT and stay cable systems offering technical and commercial competitive advantages to help win project tenders.
- Members benefit from a very competitive commercial offering, material components and services, allowing higher margins than subcontracting or operating a stand-alone business.
- Usage of recognized global brands and trademarks carrying the highest international reputation.
- Instant brand name recognition and association with belonging to a much larger global entity.
- Leading edge global supply chain with fully integrated quality management system.
- Certified suppliers manufacturing components to highest quality standards.
- Technical, commercial and project-specific support.
- Knowledge transfer and sharing of resources, equipment, skills, expertise and business contacts.
- International collaborations, joint ventures and alliances for large or special projects.
- Professional marketing and communication tools.
- Continuous R&D to maintain the finest Swiss BBR technologies.
- Regular regional and local training seminars.

PULAU SEKATI BRIDGE, **KUALA TERENGGANU, MALAYSIA**

Balanced cantilever & T-beam girder construction

VERSATILE OPTIONS FOR BRIDGE CONSTRUCTION

1

Over recent years, increased economic activity has brought with it higher traffic levels and two of Kuala Terengganu's bridges have become heavily congested. Hiang Miang Goh of BBR Construction Systems (M) Sdn Bhd, the BBR Network Member for Malaysia, describes the project to build a new bridge.

Kuala Terengganu – on the east coast of Malaysia, about 440km north-east of Kuala Lumpur – is the administrative and royal capital and the main economic center of the State of Terengganu.
Since the implementation, in 2008, of the Government's East Coast Economic Region (ECER) Master Plan to improve the socio-economic status of the area, there has been an increase in developments and activities. One of the consequences has been serious traffic congestion on two of the city's bridges – Sultan Mahmud Bridge and Manir Bridge. Thus the project – estimated to be valued at RM245 million – to build an alternative route to cross the Terengganu River, connecting Terengganu City Center and Nerus district, was created. It was a proud moment when BBR CS Malaysia was chosen to be the specialist bridge contractor for completion of this important project. ➤

2

1 View of the T-beam girder bridge from the Kuala Terengganu side of the river.
2 The new bridge spans across the Terengganu River, via the island of Pulau Sekati, providing a link from Kuala Terengganu to Telok Pasu and Jeram.
3 View from beneath of the two main carriageways as they approach the River Terengganu. Approach viaducts can be seen on either side.
4 Construction in progress of the two approach T-beam girder bridges.

TEAM & TECHNOLOGY

Owner – Jabatan Kerja Raya Negeri Terengganu (Public Works Department of Terengganu State)
Main contractor – Zainal & Shariff Ibrahim Sdn Bhd
Technology – BBR CONA internal, balanced cantilever in situ
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

Bridge design overview

The new bridge spans Terengganu River, via the island of Pulau Sekati, linking Kuala Terengganu to Telok Pasu and Jeram. Comprising two bridges side-by-side, each bridge consists of a 280m box girder bridge and two approach T-beam girder bridges, with bridge lengths of 174m on the Teluk Pasu side and 600m on the Kuala Terengganu side. The 11.9m wide box girder bridge carries two three-lane carriageways, while the T-shaped girder bridges carry four traffic lanes – two in each direction. In total, 2.02km of new highway was constructed for this project – 1.58km of which involved an elevated concrete viaduct structure.

The elevated superstructure was comprised of 27 piers. Three spans were designed as monolithic balanced cantilever box girder construction, while the remaining sections were designed as a T-beam girder bridge.

T-beam girder bridge

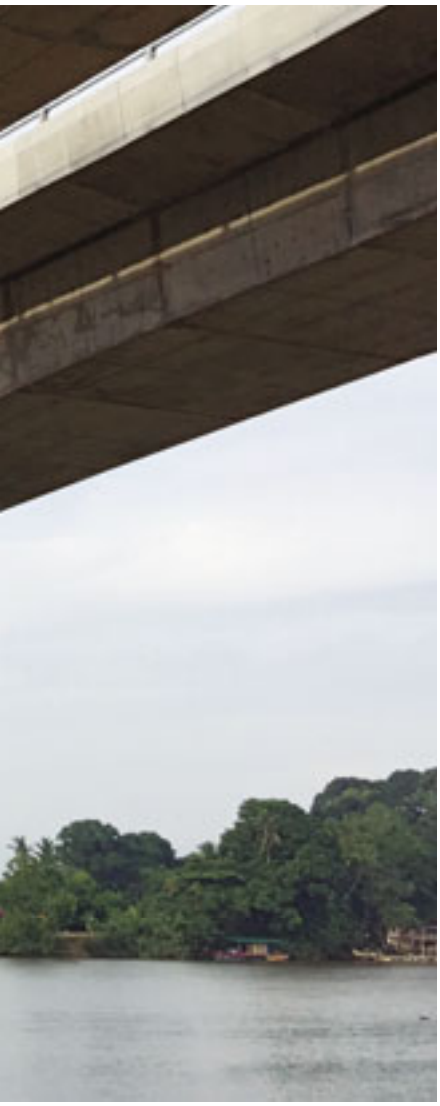
The post-tensioning used for the T-beams was the BBR CONA internal system.

The T-beams range from 28 to 40m in length, with the majority of them being 40m long. The overall height of the T-beams is just over 2.4m.

The configuration of the post-tensioning tendons was as follows:

- 28m T-beams – three tendons each with 7 x 15.2mm diameter strands
- 36m T-beams – three tendons each with 12 x 15.2mm diameter strands
- 40m T-beams – one tendon with 7 x 15.2mm diameter strands, plus three tendons each with 12 x 15.2mm diameter strands.

In total, we constructed 314 post-tensioned concrete T-beams for this greatly anticipated project.



Balanced cantilever spans

Two balanced cantilever cast in situ box girder bridges were designed for Piers 8, 9, 10 and 11 – which would carry two three-lane carriageways, one in each direction, over the main navigable channel of the river. Each of the twin bridges was configured in spans of 80m-120m-80m and construction was of single cell box section. The deeper bridge segments measured up to 7.5m, while the shallowest was 2.8m. We used form travelers to construct the balanced cantilever spans. The BBR CONA internal anchorage sizes used for these two box girder bridges were 1506 and 1906. We stressed all the tendons to 75% of their Ultimate Tensile Strength (UTS).

The whole bridge was opened to traffic on 29 May 2017 and has now become an important landmark in the region. The completion of this project has delivered a great benefit to the local communities who now have a more direct access and can significantly reduce their traveling time.

3

4

PORTE D'IVRY INTERCHANGE, **PARIS, FRANCE**

PT for access ramps to major ring road

THINKING OUTSIDE OF THE CIRCLE

A team from French BBR Network Member ETIC is working on the installation of post-tensioning for access ramps as part of a major interchange reconfiguration project on the Boulevard Périphérique ring road which encircles Paris.

The Porte d'Ivry interchange is undergoing alteration as part of the Bruneseau Nord urban redevelopment scheme which effectively aims to extend the famous 'Paris Rive Gauche' – left bank of the River Seine – to beyond the boundary created by the ring road. Following the remodeling of the interchange, land will be freed up for commercial, residential and leisure developments – and the creation of the Paris-Ivry walkway will also be able to go ahead.

The post-tensioning operations here include the installation of 100 BBR VT CONA CMI 1906 internal tendons consisting of 150mm^2 diameter 1,860MPa steel strand. The quantity of steel being used by ETIC for the post-tensioning on the project is estimated at 130t. The location of the site means that the team is working close to the live traffic of the busy Boulevard Périphérique. ETIC is also supplying and installing expansion joints with a toothed installing expansion joints with a toothed solution, as required by the consultant in order to reduce the noise generated by the traffic load in the city setting of this access ramp.

While the ETIC team complete their tasks here in stressing and grouting the CONA CMI tendons with a special cement grout, finishing works will continue. The new interchange will be commissioned at the beginning of 2020. ●

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1 The project to provide access ramps for the new Porte d'Ivry interchange on the major Paris ring road – the Boulevard Périphérique – means that the construction team is working close to live traffic flows.
2 After the ETIC team has completed their specialist tasks on the project, finishing work will continue and the new interchange is scheduled for to open in early 2020.
3 Engineers from French BBR Network Member, ETIC, are installing and stressing 100 BBR VT CONA CMI internal post-tensioning tendons and then grouting them with a special cement grout.

TEAM & TECHNOLOGY

Owner – City of Paris
Main contractor – Eiffage Group with Artelia
Technology – BBR VT CONA CMI internal
BBR Network Member – ETIC (France)

SUNGAI RIMBAS BRIDGE, **SARAWAK, MALAYSIA**

Construction across a river using self-advancing launcher

LAUNCHING IN PICTURES

The Sungai Rimbas Bridge in Sarawak, Malaysia is now open to traffic thanks to the technology and techniques applied to the construction project by Malaysian BBR Network Member BBR Construction Systems (M) Sdn Bhd. Project Manager for the project, Moi Chun Chok, presents a view of the launching operations in photographs.

1 The River Rimbas Bridge is a simply supported bridge located in Pusa Town, Sarawak, Malaysia.

2 The bridge consists of eight spans, each of which is 40.75m long.

3 Each span consists of six 40m T-girders, each weighing 120t.

4 The most challenging part for the team was the 6.5% gradient for launching the first span on each side.

5 The launching cycle is one span per month – including launching of girders, casting diaphragm and deck slab.

6 The beam launcher was comprised of double trusses and each truss is divided into six equal modules, connected with high tensile bars. It has two main support legs and three auxiliary support legs, attached with hydraulic jacks and a motorized trolley system for level adjustment and transverse shifting of the beam launcher.

TEAM & TECHNOLOGY

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

Main contractor – Jaya Mutu Sdn Bhd

Technology – BBR CONA internal, Span-by-span construction

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

1

The Charles Street Bus Bridge and Busway opened in June 2017 – passengers and motorists alike will now be reaping the benefits of the A$31m Public Transport Authority's investment in the scheme. Australian BBR Network Member, SRG Limited, provided both technology and expertise to the project.

CHARLES STREET BUS BRIDGE, **PERTH, WESTERN AUSTRALIA**

Incremental launching of bridge

MAKING WAY FOR BUSES

2

The scheme, a smart transport initiative, involved the construction of a 120m bridge over the Graham Farmer Freeway which runs through the Perth CBD in an east-west direction, the creation of a new freeway off-ramp into Northbridge and 500m of bus lanes on Charles Street.

SRG were awarded the contract by main contractor York Civil for the incremental launching and post-tensioning of the bus-only bridge taking Charles Street over the freeway.

The many objectives for this project included reducing traffic congestion on key routes, improving or reducing travel time for passengers and road users, as well as reducing bus operating costs and at the same time increasing the on-time reliability of the bus services. In addition, the scheme allows the city to maximize the benefits of earlier investments, such as the nearby new underground Perth Busport – where SRG also delivered post-tensioning services (see CONNÆCT 2016, page 45) for this top-down construction project. ●

1 Australian BBR Network Member SRG carried out the incremental launching and post-tensioning of the bus-only bridge taking Charles Street over the freeway in downtown Perth.

2 This new bus bridge runs from the existing James Street bus bridge, behind Perth Arena pictured here to the left, over the Graham Farmer Freeway.

TEAM & TECHNOLOGY

Owner – Public Transport Authority (PTA)

Client – Main Roads Western Australia

Main contractor – York Civil

Technology – BBR VT CONA CMI internal, Incremental launching

BBR Network Member – SRG Limited (Australia)

1

RENNES METRO LIGNE B, **RENNES, FRANCE**

Precast segmental viaduct construction

MOMENTUM AND RHYTHM

Since reporting on the early stages of the project in CONNÆCT 2017, construction of the viaduct for the overhead section of the Rennes Metro Line B has passed the halfway stage. Claude Néant from French BBR Network Member ETIC presents an overview of the project.

As with any scheme of this nature, the precast segmental construction of the 2.4km viaduct has developed a momentum and rhythm of its own now that the project is well underway. By the time this edition of the BBR Network magazine is published, the team from ETIC will be preparing to install the final viaduct segments.

Site organization

Base camp for viaduct construction operations is at the easternmost end of the viaduct's route, in the suburb of Cesson-Sévigné. This 4.2ha site provides not only project management offices and facilities, but also the reinforcement yard used for viaduct piers and segments, plus a concrete plant, segment prefabrication and storage area. It was also here that the launching girder was assembled and was then 'launched' on its journey westwards.

The launching girder, powered by a generator, is a self-propelled machine, supported only by the viaduct deck and the piers. It comprises two 110m long lattice beams mounted on three 8m cross beams which sit on the piers. ➤

2

> "The rate of installation is running at one span every 10 days, while PT strand insertion and stressing per span is a one day operation."

3

Segment manufacture & placement

Major benefits of precast segmental construction include the speed with which the project is able to progress due to the repetition of tasks, plus the ability to quickly produce a quality controlled product.

For the project here in Rennes, the team has on average been producing four segments per day – a total of 973 are required to complete the viaduct. The segments are match-cast to ensure a good fit with the adjacent segments when in their final positions.

First, a reinforcement cage is constructed and transferred to the concreting area by crane. The reinforcement cage is placed in a mould into which concrete is then poured. A 24-hour manufacturing cycle is being followed – installation and concreting start in the morning and finish in the evening.

The new segments spend the night under a mobile shelter to allow the concrete to cure. After this, the segments are moved to the storage area where they remain for about a month. Each segment is numbered and placed in a well-planned order.

From here, the sequence of segment handling is as follows:

- The loader – a motorized vehicle on tires – transports segments, one-by-one, from the storage area to the launching girder. There, a gantry crane – moving between the two lattice girders – delivers them to the place of installation.
- The segments are pre-positioned and suspended using hangers – two spans at a time.
- The segments are placed in their final positions and assembled. Distribution beams and hangers are removed.
- The launching girder is moved along to the next three piers, ready to begin the placement cycle again.

Post-tensioning operations

After the segments have been installed in their final positions, they are first bolted together with steel rods and then post-tensioned with BBR VT CONA CMI internal tendons to form a monolithic deck structure. The team from ETIC is installing 12 longitudinal post-tensioning tendons into the segments. Strand insertion and stressing is carried out on a span-by-span basis. The rate of installation is running at one span every 10 days, while PT strand insertion and stressing per span is a one day operation. When the project is complete, a total of 788 tendons, requiring some 600t of steel post-tensioning strand, will have been installed, grouted and stressed.

The viaduct – and our involvement in the project – is programmed for completion in April 2018 while further work on constructing stations and the tunnel sections will continue. The whole 14km-long Metro Line B, with its 15 stations, is scheduled to enter passenger service in 2020. ●

4

5

1 Precast segmental construction of the Rennes Metro viaduct is well underway and has developed a momentum and rhythm of its own.
2 The launching girder turns a corner as the viaduct grows westwards.
3 The segments are first bolted together with steel rods, before being post-tensioned with BBR VT CONA VT CMI internal tendons to form a monolithic deck structure.
4 The segments are pre-positioned and suspended from the launching girder using hangers – two spans at a time.
5 Each segment is precast with 12 ducts which will contain longitudinal post-tensioning tendons after each span is erected.

TEAM & TECHNOLOGY

Owner – SEMTCAR (Société d'Economie Mixte des Transports Collectifs de l'Agglomération Rennaise)

Architect – L'Heude & L'Heude (Metro Line B), Lavigne-Cheron (Viaduct)

Designer – EGIS Rail – Arcadis

Main contractor – JV Eiffage Génie Civil & Razel-Bec

Technology – BBR VT CONA CMI internal, Span-by-span precast

BBR Network Member – ETIC (France)

METRO RAIL VIADUCTS, **QATAR & KINGDOM OF SAUDI ARABIA**

BBR Network precast segmental construction solutions for elevated metro viaducts

PROMOTING WELL-INTEGRATED SOLUTIONS

The construction of elevated bridge structures for mass transit rail systems has less impact in city center or urban areas and offers potential cost savings when compared to surface railway lines. Juan Linero of BBR Network Member **FCC Construcción**, part of the FCC Group, reviews how the precast segmental construction method results in a well-integrated solution – even when tunneling is a valid option too, or indeed when the scheme is for suburban or more rural locations.

1

2

> "Of course, the best known advantages of precast segmental construction will always be the cost and time savings offered by this methodology."

3

Of course, the best known advantages of precast segmental construction will always be the cost and time savings offered by this methodology. However, one of the most significant of the many potential advantages is that this structural approach is sufficiently flexible that it can be combined with any other construction technique or design solution.

Flexibility for Doha & Riyadh

The recently finished Red Line Metro in Doha, Qatar and the Line 5 (Green Line) of the Riyadh Metro in the Kingdom of Saudi Arabia are both good examples of this flexibility. Along the 40km length of Doha's Red Line Metro most of the design and construction solutions currently available have been implemented. These include simply supported span and continuous span construction linked with underground sections, where we find full precast beam single span, precast segmental viaducts – constructed by both the balanced cantilever and span-by-span methods – along with cast in situ full-span viaducts and cast in situ pier caps.

Most of the wide range of construction techniques mentioned above can also be found in the Green Line of the Riyadh Metro which is some 13km long. The most noteworthy difference in this case is that the full precast beams for the single span structures were divided into two longitudinal halves to reduce their weight, mainly to facilitate transportation and erection. Once placed in their final positions, both halves were connected to each other with PT bars and the top slab was concreted.

Harnessing benefits globally

If we examined the many similar projects carried out recently by the BBR Network – such as the Rennes Metro Line B in France, the elevated rail viaduct in Jakarta, Indonesia, the New MRT network in Kuala Lumpur, Malaysia, or the Sydney Metro Northwest, Australia – we would also find that these projects have taken full advantage of the flexibility of adopting a precast segmental approach to the construction of elevated metro viaducts. Customers worldwide are also discovering the advantages of the global experience and superior technology and techniques offered by the BBR Network. As my colleague Claude Néant said in his earlier article about the Rennes Metro, we certainly have 'momentum and rhythm' – I would like to add that we also have style, in the form of the best technology and techniques! ●

1 Junction of two elevated tracks for Doha Metro's Red Line North which stretches for 40km, taking full advantage of the flexibility of precast segmental construction, as well as the time and cost savings it offers.
2 Line 5 (Green Line) of the Riyadh Metro: Segment placement operations in progress.
3 Line 5 (Green Line) of the Riyadh Metro: The viaduct turns the corner towards downtown Riyadh.

TEAM & TECHNOLOGY

DOHA METRO, QATAR

Owner – Qatar Rail

Design & build contractor – RLR Joint Venture (Rizzani De Eccher S.p.A, Lotte Engineering and Construction Co., Ltd., Redco International Trading and Contracting WLL)

Technology – BBR VT CONA CMI internal, Span-by-span precast

BBR Network Member – NASA Structural Systems LLC (UAE) & FCC Construcción (Spain)

RIYADH METRO, KINGDOM OF SAUDI ARABIA

Owner – Arriyadh Development Authority

Main contractor – FAST Consortium

Technology – BBR VT CONA CMI internal, Span-by-span precast

BBR Network Member – FCC Construcción (Spain)

BRIDGE MS-06, **S5 EXPRESSWAY, KORZEŃSKO – WROCŁAW, POLAND**

Incrementally launched bridge

LAUNCHING ADVENTURES IN POLAND

After a flurry of motorway construction projects connected with the 2012 UEFA European Football Championship, Poland has now received another tranche of EU funds for setting up an expressway network. Paweł Surman from BBR Polska, who specializes in longitudinal launching, describes one of the projects recently carried out using the incremental launching method.

1

Over the last few years, this method of bridge construction has become increasingly popular in Poland. The BBR Polska adventure with incrementally launched concrete bridges started in 1995, but after we built the expressway viaduct in Międzyrzecz (see CONNÆCT 2013) seven years ago, this journey has been continuous. Today, we have experience of building bridges using all possible types of launching equipment – jacks and strands (the most popular among PT companies), double-action hollow plunger cylinders with bars and also push-and-lift systems.

In 2015, we launched two concrete structures on the A1 motorway, near Łódź, where each of the structures had two independent decks. Shortly after this, we were awarded a further similar project near the village Żmigród. The following article is a step-by-step account of the process we followed to complete the project – with, of course, a special emphasis on launching technology.

Project overview

The bridge structure, known as MS-06, is under construction as part of the S5 Expressway project, between Korzeńsko and Wrocław. This project is a part of a larger scheme which will link the A2 and A4 motorways.

This scheme aims at developing a network of modern expressway connections in Poland which will also contribute to greater efficiency for international road safety and reducing environmental impact of the infrastructure.

On the north western outskirts of the small town of Żmigród, famed for its ruined Baroque palace and park, the new bridge crosses the Barycz and Młynówka rivers, a local road and a railway line.

The bridge consists of two independent carriageways, each with a 3.6m high single-cell box cross-section. The horizontal radius of the route is 2,620m and the vertical curvature radius is 14,500m – reaching the highest point over the railway lines. The maximum upward gradient was 3.17% and this progressively decreased to 0.75%. Each of the two decks consist of 29 segments with an overall length of approximately 746m. The total weight launched in the last phase was 25,000t.

Generally, the bridge was launched without temporary piers – a typical span is 56m. It was only in the area of the railway tracks that two additional temporary supports were used for each carriageway deck because here we were presented with a longer span of 61m to 81m. We began launching over the railway tracks in a four hour night-time closure of the line. This was necessary as we were using a steel launching nose. However, it was safe for train services to continue while we launched the concrete sections. ➤

2

Launching system & method

We used the lift-and-push method. The incremental launching system consisted of two lifting jacks – the maximum lifting load was 2,200kN – each of them was accompanied by three shifting jacks with a maximum shifting force of 9,120kN.
The system was secured on a pier that had been additionally strengthened for transfer of the traction forces. Securing the system in this way guaranteed the appropriate vertical reaction in the final phase of launching.
When the lift-and-push system is secured outside of the abutment, additional measures must be taken. During the first stages of launching, lifting cylinders need to be prevented from moving and becoming detached. We used very long traction bars and to counteract the piston retraction force of the shifting jacks, we applied steel restraints to prevent the bars from loosening.

Friction coefficients

The relatively high weight of the viaduct, combined with the uphill launching, meant that we needed to achieve minimal friction coefficients to be able to move the sections. The static friction coefficient occurs at the beginning of each segment launch. When we launched the first segment, we reached 15% of the static friction coefficient and when we launched the last segments we were at about 2.5%. After about 300m of launching, we achieved a dynamic friction coefficient of about 3%, which finally reduced to below 1.3% for the last segments. The temporary neoprene-teflon sliding bearings were working under compressive stresses of nearly 15MPa.

Bearing replacement

When we finished launching, our last task in this project was to replace the temporary sliding bearings with the final bearings that the bridge will rest on during its service life. We used two independent hydraulic bearing sets, each consisting of eight cylinders with a capacity of 400t. Each cylinder was equipped with a locking nut and integrated tilt saddle. Temporary sliding elements were used during bearing installation to protect the cylinders against damage. These allow the bridge to shorten or lengthen, depending on temperature changes.

Post-tensioning system

The bridge has 610t of prestressing steel for the BBR VT CONA CMI 1906 tendons, eight tons for the BBR VT CONA CMF 406 tendons and 256t for the BBR VT CONA CME 2206 tendons.
BBR VT CONA CMI internal tendons were installed in the top and bottom slab to take the loads generated by launching operations. Meanwhile, CONA CMF flat tendons were used as transverse post-tensioning in the top slab only for the bridge section above the railway lines. To speed up this part of the work, transverse tendons were prefabricated to be ready for placement by the team working on the deck.
BBR VT CONA CME external tendons were installed in the box girder sections during the final stages of launching. The tendons were of varying lengths – the longest being some 247m.
For the first time, we used a mini crane to stress the CONA CME external cables.
This was a decision that greatly accelerated the pace of work inside the box girder. In addition, we also carried out various tactical technological stressing operations, such as for the launching nose or pier traction.

> "For the first time, we used a mini crane to stress the CONA CME external tendons. This was a decision that greatly accelerated the pace of work inside the box girder."

1 The twin launching noses of BBR Polska's incremental launching system on their journey, which took them over main Poznan to Wrocław railway lines and two rivers, to build the two carriageways of the MS-06 bridge on the S5 Expressway project between Korzeńsko and Wrocław.
2 Bridge MS-6 progresses towards the railway tracks, after having crossed the Barycz river.
3 For the first time, a mini crane was used in the operation to stress the CONA CME external tendons. This greatly accelerated the pace of work inside the box girder.

Photographs 1 & 2 from www.s5korzensko-wroclaw.pl, courtesy of GDDKiA.

"The relatively high weight of the viaduct, combined with the uphill launching, meant that we needed to achieve minimal friction coefficients to be able to move the sections."

3

Always looking ahead

We offer our customers the widest possible range of incremental launching services and the reason we can do this is that we have amassed a vast specialist experience in this field over many years. In addition, we have been systematically investing in new equipment that makes our work all the more efficient.

Currently, we are working on another launching project which is a part of the Wałcz ring road – and you will probably be able to read about it in the next edition of CONNÆCT. ●

TEAM & TECHNOLOGY

Owner – General Directorate for National Roads & Motorways

Main contractor – Consortium Budimex (lead) and Strabag (partner)

Designer – Transprojekt Warszawa Sp. z o.o. and Stähler + Knoppik

Technology – BBR VT CONA CMI internal, BBR VT CONA CME external, BBR VT CONA CMF flat, PT bar, incremental launching

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

COMMERCIAL BUILDINGS, **GDANSK, KATOWICE & WARSAW, POLAND**

BBR post-tensioning solutions for office & retail developments

PT PARTNERS IN POLAND

As the team at **BBR Polska** begins to prepare for their 25th Anniversary celebrations next year, the award of three recent contracts has given them cause to reflect. Bartosz Łukijaniuk describes how these projects all feature post-tensioned concrete slabs – a construction method that the team worked hard to introduce into Poland and which has since become the system of choice for many developers and main contractors.

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"Quite often, as a result of previous successful co-operation, a contractor or a designer working on a new project seeks our help to develop a PT solution."

The transition to a highly successful free market economy has seen an increase in smart new office buildings in all of Poland's major cities. In the early days, we had carried out some slab or girder strengthening with post-tensioning – usually during building conversion projects – but it was still proving difficult to convince professional teams to adopt a post-tensioned approach for their new buildings.

Fashion was changing and this was on our side – a desire to create expansive, light and airy open plan offices brought a need for large column-free spaces and opened the market and minds to the possibilities that post-tensioned floor slabs could offer.

Today, flat PT slabs in buildings are no longer a novelty in Poland. We are successful in providing post-tensioning as an alternative solution for reinforced concrete or precast concrete slabs. Quite often, as a result of previous successful co-operation, a contractor or a designer working on a new project seeks our help to develop a PT solution.

1 .KTW, Katowice

In recent years, the city of Katowice has been growing – based on its GDP, it is recognized as one of the most powerful cities within the European Union. Historically, the city's economy was founded on heavy industry – steel and coal mines – and now it has become an attractive area for inward investment from around the world.

As part of Katowice's ongoing transformation, the 72m tall former DOKP building built in the early 1970s – as the HQ of the Regional Directorate of State Railways – was demolished to make way for new development. The site has distinguished neighbors – on one side is the very distinctive UFO-shaped Spodek Arena and International Convention Centre, on the other is the Polish National Radio Symphony Orchestra complex, which opened in 2014, and the Silesian Museum.

The new scheme, consisting of two high-rise buildings connected by an underground garage, is being constructed in two phases, the first of which is the shorter of the two office buildings.

BBR Polska has provided post-tensioning services for the project and has used BBR VT CONA CMF flat tendons to construct an 11m span banded slab on all of the 13 above-ground levels. The key to the project's success here has been the excellent level of collaboration with a skillful structural designer and an experienced contractor who executed the whole concrete frame structure in a highly efficient manner.

2 HIRO, Garnizon, Gdansk

The HIRO office building at 11 Chrzanowskiego Street in Gdansk lies in the heart of a new district in the city. The Garnizon district covers almost 30 hectares and dates back to the creation of the 'Black Hussars' regiment, the Privy Guard of Emperor William II in the 19th century.

Down the years, the garrison has had a variety of uses – some secretive and dark with the changing political tides in the region – until most recently the land was acquired in 2005 by the Hossa Investment Group SA. Recognizing the historical and traditional importance of the area, they are developing the new Garnizon multi-functional district and their massive investment will see the blending of modern architecture with old fine brick construction to deliver revitalized buildings. The HIRO offices will complement a range of other structures – residential blocks, other offices and public and cultural service buildings.

We have provided around 9,900m^2 of post-tensioned slabs on five levels – starting with a slab above ground level and finishing with a roof. Typical spans are 12.5 + 10.9m by 5.5 to 7m and, due to these long spans designed by the architects, a post-tensioned approach was the perfect choice.

There was great co-operation with the main structural designer, who originally proposed a PT solution, and excellent collaboration with the concrete frame contractor. As a result, the project execution was a fantastic journey for the whole team. ➤

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3 CEDET, Warsaw

The CEDET development lies in the center of Warsaw, at the junction of Krucza and Bracka streets. Due to open in spring 2018, the scheme has seen the restoration of the original façade of the Smyk Shopping Center – an architectural icon from the post-war period, featuring the first modern style glass façade in Poland – and the construction of a completely new office block. The modern glass office building rises from the back of the shopping center. Its lower floors were designed with around 7,100m² of lettable retail and service space, while the floors above will contain some 15,300m² of modern office space. Parking for 138 vehicles is provided in the underground car park.

The project consists of two parts – two adjacent, connected buildings – the old one that was restored and a completely new one. Executing the new structure for the old building was a little challenging. The original concrete structure is on a national heritage list, but its condition did not satisfactorily meet new regulations. The main issue for this part was to preserve and strengthen the existing concrete structure, creating completely new office space. Every second column was strengthened – this resulted in structural spans of 12.4 x 8m, with some old columns piercing the slabs. The new building was created on irregular column grids, resulting in spans of between 6 and 12m. The structural layout was flat slabs with drop panels, without edge beams – at the edges under the façade load the slabs were also flat.

This project's challenges included slab deflection limits, load transferring structural elements and prefabricated concrete edge beams. For the old building, due to the façade structure being based on the original design, the slab deferential incremental deflection was limited to 15mm. This figure relates to after the façade load had been imposed between neighboring façade columns which were spaced evenly at 6.2m intervals – and was also applicable for the 12.4m long spans.

For the new building, the corresponding deflection was limited to 3mm – the average distance between neighboring façade columns here was 1.35m, even on spans of 10.6m. On some levels while transferring load from floors above, we faced challenges with very low deflection limits. Restoration and architectural guidelines demanded extremely low deflections and no cracking of edge beams.

The main contractor decided to use prefabricated edge beams connected to the slab with an insulation layer, so that the beams were non-structural elements giving only load, not stiffening the slab. Due to the expectation that there should be no cracked beams, we designed a special post-tensioning solution involving the stressing of a few individual elements together.

We approached the architectural requirement for no edge beam deflections by evaluating a very special solution for connecting the beam and the slab. The connection allowed beam movement on the horizontal and vertical planes – making the beams independent from the slab deflection which was the critical issue. So the beams were able to shorten due to stressing forces and were not affected by slab deflection. In other words, the edge beams stay straight even when the slabs deflect at their edges. The longest beam was 31m long and it consists of five prefabricated elements.
These three major projects have all presented challenges that we have helped the professional teams to overcome by using our wealth of post-tensioning experience and the latest BBR technology. We look forward to many more such challenges and to working again alongside such great colleagues. ●

1 Visualization of the .KTW development in Katowice, Poland where BBR Polska has contributed BBR post-tensioning technology and techniques towards the realization of this stunning building. Image courtesy of KTW sp. z o.o.
2 Artist's impression of the HIRO office building in Gdansk. Image courtesy of Hossa Investment Group SA.
3 Artist's impression of the CEDET development in Warsaw. Image courtesy of CeDeT.

TEAM & TECHNOLOGY

1 **Developer** – KTW sp. z o.o. (TDJ Estate)
Architect – medusagroup sp. z o.o. sp. k.
Main contractor – Strabag Sp. z o.o.
Structural engineer – FI Statyk
Technology – BBR VT CONA CMF flat
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

2 **Developer, architect & main contractor** – Grupa Inwestycyjna HOSSA S.A.
Structural engineer – Primes Sp. z o.o.
Concrete frame contractor – PB Granit Sp. z o.o.
PT design – gp projekt sp. z o.o. / BBR Polska
Technology – BBR VT CONA CMF flat
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

3 **Developer** – CEDET Development Sp. z o.o. (Immobel Poland)
Architect – AMC- Andrzej M. Chołdzyński Sp. z o.o.
Main contractor – Korporacja Budowlana Doraco Sp. z o.o.
Structural engineer – BWL- Projekt Sp. z o.o.
PT designer – gp projekt sp. z o.o. / BBR Polska
Technology – BBR VT CONA CMF flat, BBR VT CONA CMM monostrand
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

HIGH RISE PROJECTS, **MANILA, PHILIPPINES**

Nine skyscrapers for repeat customer

CHANGING THE MANILA SKYLINE

Three major high rise developments featuring BBR technology and expertise, in the Metro Manila area, were presented in CONNÆCT 2017 – now, Rey Singh, General Manager of BBR Philippines reports on a customer relationship that, by the end of 2019 will have achieved NINE high rise schemes, as well as many other projects.

1

We have developed a close working relationship with developer Ayala Land Inc and their construction arm Makati Development Corporation (MDC). Established in 1974, MDC is the largest multi-disciplinary engineering, procurement, construction and construction management (EPC/CM) company in the Philippines. Their portfolio includes estates, hotels, offices, residential schemes, resorts and shopping malls.

Our first project, back in 2009, with MDC was for the post-tensioning of the roof beam and slab tendons of the Eastridge Water Reservoir in Binangonan, Rizal Province. Since then, and particularly due to the resurgence of the Philippine economy in the last seven years, we have partnered with MDC for their bridge, commercial center and building projects.
It is this robust partnership that has – so far – brought MDC and BBR Philippines together for the post-tensioning of nine high-rise buildings. Our recent joint portfolio is shown in the adjacent table. All of these projects have been designed with post-tensioned slabs, except the ATG Diamond Building where only the ground level will have PT slabs and other levels will have post-tensioned beams. The latter also feature in the podium level of Two Roxas Triangle and West Super Block buildings.
Together, these nine skyscrapers account for around 2,000t of post-tensioning strand – and a great deal of specialist expertize from all parties involved in the schemes. ●

PROJECTS	PT LEVELS	COMPLETION DATE
Park Terraces – Point Tower	59	2015
Park Terraces – Twin Tower	46	2016
Two Roxas Triangle – Tower 2	50	2017
Garden Towers – Tower 1	48	2018
West Super Block – The Suites	61	2018
East Gallery Place, Vader 1	41	2018
Garden Towers – Tower 2	52	2019
West Gallery Place, Vader 2	40	2019
Ayala Triangle Garden (ATG) Diamond	39	2019

1 Garden Towers, Manila – one of nine prestigious high-rise developments currently underway for customer Makati Development Corporation in the Philippines. Image courtesy of Ayala Land Inc.

TEAM & TECHNOLOGY

Owner – Ayala Land Inc
Main contractor – Makati Development Corporation (MDC)
Technology – BBR CONA flat, BBR CONA internal
BBR Network Member – BBR Philippines Corporation (Philippines)

DATUM JELATEK, **KUALA LUMPUR, MALAYSIA**

Four high rise towers linked by ring bridge

STRUCTURALLY SOUND SOLUTION

When the owner of an exciting new development in Kuala Lumpur's Klang Valley region decided to adopt a post-tensioned approach for part of the scheme, **BBR Construction Systems (M) Sdn Bhd** was delighted to provide an effective construction method and technical support.

Located just off the prestigious Embassy Row of Jalan Ampang, Datum Jelatek is a mixed development consisting of four residential towers with 23 to 29 floors and exclusive retail space. With a connecting link bridge to the existing Jelatek LRT Station, Datum Jelatek, covering an area of around 23,500m^2, will offer its residents seamless integration with the city's recreational landmarks and iconic retail hubs. Also, Datum Jelatek features the first ring bridge in Malaysia – this connects all four towers and is set to become a recreational wonder at a refreshing altitude of about 100m above street level.

The decision was made to use post-tensioning for the retail and car park area, as well as for the transfer floor supporting the residential towers.

1

Typical flat slab design – retail & car park

Flat slabs are commonly used in building floors because they provide structural integrity without the need for beams which results in flat and thinner slabs, as well as enhancing the aesthetics of slab soffits. Alongside these considerations and with slabs spanning 8.7m, the owner was keen to reap the benefits of a post-tensioned approach.

For the retail area at Levels 2 and 3, 210mm thick flat slabs and 2,900 x 2,900 x 440mm drop panels are designed to support a floor loading of SDL=2.7kN/m^2 and LL=5.0kN/m^2. While for the car park area from Levels 4 to 10, 180mm flat slabs and drop panels sized 2,900 x 2,900 x 340mm are designed to withstand floor loadings of SDL=0.5kN/m^2 and LL=2.5kN/m^2. The BBR CONA flat 306 and 406 systems are being used for the slabs.

Each floor is divided into 17-20 construction zones and connected by either using pour strips or construction joints. In the construction joint method, tendons are anchored inside the completed zone and lapped with existing tendons, performing in a similar manner to continuity tendons. While for the pour strip method, tendons are spaced and lapped with reinforcement. These connections are important in ensuring that the slab provides a continuous prestressing force.

Transfer beam – 50m long

On Level 5, there are six post-tensioned transfer beams of 2,000mm width by 1,800mm depth which are designed to take loads from Levels 6 to 11 of the car park, as well as the hanging Level 4 slab. Since the soffit of the Level 4 slab is reserved for particular architectural finishes, columns at the center of the building are not allowed to continue as supports beyond Level 3. Therefore, the Level 5 transfer beams are designed to hang beneath the Level 4 slab by using special columns, as well as supporting Levels 6 to Level 11 with normal reinforced concrete columns on beams. Special columns for this area have been designed using steel sections to resist tension instead of compression. BBR CONA internal 1206 tendons, arranged in a harped profile, are being used for these transfer beams.

Foundation of typical upper floors – transfer plate

The four residential towers lie on a structure which acts as a foundation – a transfer plate. The towers, which are supported by series of continuous shear walls, transfer the load down to the post-tensioned transfer plate at Level 12.

The transfer plate thickness is designed according to the number of upper floors it supports. For Blocks A and D, they are designed to be 1,500mm thick, while for Blocks B and C, the thickness is 1,300mm. As the plates are so thick, two layers of concrete casting are being provided – a 600mm concrete pour for the first layer and 700-900mm for the second. By this method, the first layer of the transfer plate will act as temporary support for the second casting. BBR CONA flat 406 and CONA internal 706 post-tensioning systems are being used for these transfer plates.

Timely completion

The project started in early 2016 and is expected to be completed by mid-2018. The BBR CONA internal post-tensioning system has successfully accomplished the project objectives of providing a thinner slab, longer span, lighter floor, time saving – and, of course, a structurally sound solution for the client for this masterpiece in Malaysia. ●

> "The decision was made to use post-tensioning for the retail and car park area, as well as for the transfer floor supporting the residential towers."

TEAM & TECHNOLOGY

Owner – Datumcorp International Sdn Bhd
Main contractor – Conlay Construction Sdn Bhd
Technology – BBR CONA internal, BBR CONA flat
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

2

1 Visualization of the completed Datum Jelatek development, where BBR Malaysia is providing BBR technology, as well as effective construction methodology and technical support.
2 The team is using BBR CONA flat and BBR CONA internal tendons for flat slabs, transfer beams and transfer floors.

1

PT SLABS, **GLENAVY & PORT NELSON, NEW ZEALAND**

Long and rewarding post-tensioning relationship

PRODUCTIVE PARTNERSHIP

It's been 15 years since New Zealand's BBR Contech first installed a post-tensioned slab for South Island construction specialist Calder Stewart – and 36 projects later, the relationship is as strong as ever.

Established by Bruce Stewart and Lance Calder in 1955, Calder Stewart is still family owned and headquartered in the small South Island town of Milton. However, the company's size and capabilities have grown exponentially – it has opened offices in Christchurch and Auckland, grown its team to around 400 and established an enviable reputation as an innovative leader in industrial, commercial and agribusiness construction nationwide.

Partnership in action

Calder Stewart and BBR Contech have worked together on construction projects in both the North and South Islands, with all of them involving high-performance post-tensioned flooring systems. Two recent projects stand out for their scale – a 27,000m² floor for Oceania Dairy and warehouse floors for Port Nelson with a total area of more than 22,000m².

1 Oceania Dairy

Oceania is a relative newcomer to New Zealand's dairy industry. A subsidiary of China's largest dairy company, the Inner Mongolia Yili Industrial Group (Yili), it was established in 2013 and occupies a 38-hectare block of land at Glenavy, near the South Island's Waitaki River. Soon after arriving, the company embarked on a two-stage, NZ$600 million project to build a new, state-of-the-art dairy processing plant. BBR Contech and Calder Stewart – together with project manager Babbage Consultants – were involved in stage 2 of the project, a 27,000m² extension to a 5,500m² slab in the plant's drying area. The extension allows for a new UHT plant, an infant formula canning line, a whole-milk-powder drier and facilities to manufacture UHT milk products and lactoferrin.

Requiring three months' work, the project saw BBR Contech design, supply and install six 165mm slabs of 40MPa concrete, poured in approximately 12 pours and strengthened using 528 BBR CONA flat 405 anchors and 113t of post-tensioning strand. When fully operational – a third stage has yet to be completed – the plant will have the capacity to process 16t of functional protein dairy product and 80,000t of UHT per year, produce 56,000t of whole-milk powder and make 30,000t of infant formula – in turn generating more than NZ$700 million in annual export revenue.

1 The 27,000m² extension to an existing slab in the dry store at the Oceania Dairy site required the installation of 528 BBR CONA flat 405 anchors and 113t of post-tensioning strand.
2 BBR Contech and Calder Stewart worked together on stage 1, shown here, of the first warehouse at Port Nelson.

2 Port Nelson

The Port Nelson warehouse was the first major building project of a NZ$32 million, multifaceted redevelopment of the port to meet the burgeoning demands of the Nelson-Marlborough region's fishing, apple, wine, forestry and shipping industries.

Stage 1 was completed in January 2017 and a second building – separated from the first by a truck drive-through area – was completed 10 months later. Together, the facilities provide a warehousing, distribution and logistics hub for wine industry bottles and bottled wine destined for export, increasing the port's storage capacity to 22,000m^2 and enabling a significant increase in line-haul truck movements.

Calder Stewart was appointed as main contractor for both stages of the project, with BBR Contech being given the task of designing and installing a 13,000m^2 post-tensioned floor for the first and a 9,400m^2 floor for the second.

The larger floor comprised three 165mm thick slabs of 40MPa concrete poured in six pours, using the BBR CONA flat 405 and proprietary coupler system to eliminate saw joints and internal armor edging. Around 47t of post-tensioning strand was installed into 318 anchors in a little over two months.

Praise from the client

According to Peter Stewart, Joint Managing Director of Calder Stewart, the success of this business partnership is based on a combination of factors.

"The BBR Contech team is very good at what they do, but just as importantly we have a good working relationship. The team is easy to deal with, they do what they say they'll do, they meet all our requirements at a fair price and, when issues arise, they take a collaborative and constructive approach to resolving them.

"We work with Contech's Peter Higgins and his crew for all our South Island projects and, since opening an Auckland office, have involved Paul Wymer's Auckland team in projects there. It helps that some of their key people have been with them for many years – we all understand each other and the ways we prefer to work."

A strong foundation for the future

BBR Contech's 15-year relationship with Calder Stewart has enabled the team to work on a wide variety of interesting and challenging post-tensioned-flooring projects. While many have focused on the dairy sector, for clients including Fonterra (New Zealand's biggest company and the world's largest dairy product processor), Westland Milk Products and Synlait, others have spanned the realms of plant breeding and research, hardware, paper and packaging, air travel, foodstuffs, freight and more.

The success of these projects can be put down to the essence of this long-standing partnership: a mutual commitment to performance excellence, a clear respect for each other's professional capabilities – and a flexible approach to defining projects, devising solutions and delivering to clients' specifications. ●

TEAM & TECHNOLOGY

1 **Owner** – Oceania Dairy
Main contractor – Calder Stewart
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

2 **Owner** – Port Nelson
Main contractor – Calder Stewart
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

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PAVILION SHOPPING MALL, **BUKIT JALIL CITY, MALAYSIA**

Post-tensioned flat slab and banded beam construction

ULTIMATE FLEXIBILITY

The Pavilion Bukit Jalil shopping mall is situated in Bukit Jalil City, an integrated development township under development by Malton Bhd and the Pavilion Group. Scheduled to be completed by 2020, the mall with two million square feet of retail and entertainment space, is poised to be a regional 'retail-tainment' hub. BBR Construction Systems Malaysia has been given the task of installing BBR CONA flat internal bonded post-tensioning tendons for the flat slab and banded beam structure of the building.

A complication arose within the project due to architectural changes, such as the requirement for an additional escalator, in a slab which had already been cast. Therefore, tendon locking was carried out to secure the existing PT tendons in place so that a new opening could be safely made in part of the slab. The tendons were locked at approximately 375 locations in Basement 1 of the building.

Tendon locking is achieved by first creating an opening in the slab to expose the existing PT strands. Pourable non-shrink high strength epoxy grout is then used to grout the exposed PT strands. Finally, the remaining space in the locking pocket area is cast with flowable non-shrink high strength grout to create an even and smooth surface, level with the rest of the slab. Pull out tests were conducted to verify that the bond strength of the epoxy was sufficient to anchor the tendon in place.

It is well-known within the BBR Network that post-tensioning allows freedom of design – and that it is also sufficiently flexible to allow customers or designers to change their plans at a later stage. ●

1 Artist's impression of the completed development, showing Bukit Jalil Pavilion shopping mall on the left.

TEAM & TECHNOLOGY

Owner – Pioneer haven Sdn Bhd
Main contractor – Domain Resources Sdn Bhd
Designer – SNA Consult Sdn. Bhd.
BBR Technology – BBR CONA internal
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

BUNNINGS WESTGATE, **NEW ZEALAND**

Collaboration for innovative high-rise

COLLABORATING FOR GROWTH

A formal partnership forged between two members of the BBR Network is already designing a significant floor construction project – with the promise of many more to come. The joint venture, between New Zealand's BBR Contech and Australia's SRG Limited, will see the two firms work together to deliver world-class elevated post-tensioned flooring for multi-storey buildings in New Zealand.

Detailed design is underway on the first project – a 15,000m^2 single level elevated floor for a Bunnings Warehouse store in Auckland's Westgate Shopping Centre. This retail hub is part of the new, purpose-built, 56-hectare Westgate town – 'a complete destination to shop, work and play' that includes street-based retail and community services, parks, office blocks, specialty shops and large-format and yard-based retail stores such as Bunnings. Main contractor for the project, H Troon Pty Ltd and the client Bunnings have a long relationship spanning many projects with SRG in Australia.

"SRG has decades of experience in designing, installing and maintaining post-tensioned floors for clients in Australia, including about 35 for Bunnings," says Marc Stewart, a BBR Contech manager assigned responsibility for business development of the new venture.

"This joint venture is a natural development, as we have a 20-year record of working together on projects like these."

"The value of this relationship comes from the fact that, while we both offer extensive capabilities in post-tensioned flooring, SRG's in-house design expertise and depth of experience in a much larger marketplace, combined with our local knowledge, mean we can take on bigger and more complex projects in New Zealand."

The joint venture also provides access to a wider range of business relationships in Australia and New Zealand and allows fast interaction with developers, architects, contractors and designers – on both sides of the Tasman Sea. The team can respond quickly and effectively to outline the benefits of post-tensioned floors in these applications and assist with optimizing design layouts.

Marc says that, as a side effect of the joint venture, BBR Contech will be able to raise the profile of post-tensioned flooring in New Zealand and accelerate its use.

"The commercial advantages of post-tensioning over precast are well accepted in Australia and now the post-tensioned approach is gaining some traction in New Zealand also." he says. "By demonstrating its advantages – thinner slabs, fewer or no joints, longer spans, better durability – and meeting clients' expectations, we'll have more opportunities to grow our respective businesses." ●

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The SRG/BBR Contech JV offers:

- Full in-house design and construction service
- Extensive experience in elevated post-tensioned flooring
- Decades of performance in New Zealand and Australia
- Access to leading-edge technology and support via the global BBR Network
- Local knowledge supplemented with Australasia-wide expertise
- Reassurance of a best-practice, high-performing, ultra-resilient and proven flooring system
- Ability to exploit the power of two to maximize project development and delivery.

1 Two BBR Network members are collaborating to deliver innovative multi-storey construction to the NZ Market. Pictured here are Marc Stewart, BBR Contech's Building PT Business Development lead (left) with Adam O'Dea, SRG's Divisional Manager – Building (right).

TEAM & TECHNOLOGY

Owner – Bunnings
Structural engineer – Stiffe Hooker Ltd
Main contractor – H Troon Pty Ltd
Technology – BBR CONA flat
BBR Network Member – SRG Limited (Australia) & BBR Contech (New Zealand)

1

EUNOIA JUNIOR COLLEGE, **SINGAPORE**

Progressive design presents PT challenges

INNOVATION FOR NEW TECHNOLOGY

The first high-rise junior college is being constructed in Singapore and it will feature some wonderful facilities for students. Keith Lim and Dickson Liew from local BBR Network Member BBR Construction Systems Pte Ltd present a full overview of the project.

The new Eunoia Junior College (EJC) is located at the junction of Sin Ming Avenue and Marymount Road, overlooking Bishan-Ang Mo Kio Park and both Bishan and Ang Mo Kio estates. It consists of two academic tower blocks (Block A) with 10 and 12 floors and comes equipped with a multitude of amenities such as a 900-seat auditorium, a range of seminar rooms, learning rooms, science laboratories and other special use rooms. Sitting on the top of the 10-storey block there will also be a duplex library with a panoramic view of Bishan Park.

EJC will also be the first college built with an elevated track and field stadium (Block B) as part of its infrastructure. This five storey structure will be built beside the academic blocks, with a link bridge connecting them. There will be a wide variety of student interaction areas for group activities – such as music rooms, Co-Curricular Activities (CCA) rooms, a dance studio and a multi-purpose hall, which are sheltered by an elevated field. As part of the government's planning for a seamless integration of the college with the community, Block B will also house communal facilities such as a neighborhood police post and a karaoke room. These recreational rooms and sports facilities will be made available for public use outside of the curricular periods, to fulfill the need for a community center for the residents of the estate.

The execution of the project began in early 2017 and it will be ready for the start of school term in 2020. BBR CS Singapore won a supply and installation contract for this scheme and is tasked with providing BBR technology and our expertise in design to the main contractor for both academic blocks and the elevated field.

1 Visualization of the completed Eunoia Junior College in Singapore where BBR Construction Systems Pte Limited is providing design support, as well as installation services, for a post-tensioned approach.
2 Considerations for the structural frame of Block B roof level had to include loadings from the soil, running track material and waterproofing, as this would form the base of the football field and athletics track.
3 The EJC project is the first high rise project to feature a hybrid system of Cross Laminated Timber (CLT) and concrete. This presented the BBR CS team with greater challenges upon award of contract.

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3

> "As this would eventually be the football field and running track, the structural design would have to consider loading from the soil, running track material, waterproofing and transfer structure of the spectator grandstand."

TEAM & TECHNOLOGY

Owner / Developer – Ministry of Education People's Association
Architect – CPG Consultants Pte Ltd
Structural consultant – CPG Consultants Pte Ltd
Main contractor – Kimly-Lian Ho Lee JV
Technology – BBR CONA flat, BBR CONA internal
BBR Network Member – BBR Construction Systems Pte Ltd (Singapore)

Pre-tender design support

It was a prolonged design stage – starting from mid-2015 – which saw BBR CS Singapore supporting the structural consultant and providing post-tensioned design solutions throughout the pre-tender stage, detail design stage and lastly the authority submission stage.

Block A was framed using post-tensioned beams supporting precast hollow core slabs, while Block B was designed with post-tensioned beams and post-tensioned slabs. They are designed to uncracked section properties, with two hour fire rating, based on EN 1992 as the governing code of practice.

The crucial challenge of the design process was encountered on firming up the structural frame of Block B roof level. To accommodate architectural features and authorities' requirements, the design was based on 12m long span continuous slabs of 425mm thick and multiple spans of beams – with 36m being the longest span length – designed to 2m depth. As this would eventually be the football field and running track, the structural design would have to consider loading from the soil, running track material, waterproofing and transfer structure of the spectator grandstand. Coupled with the requirement to maintain an uncracked section and code of practice recommendations on the serviceability limit state, this thus translated to the large member sizes that were adopted.

First high rise CLT project

Championed by the Singapore authorities, the local construction industry is looking at aspects of high buildability and sustainability, low cost and fast construction methodology, while contractors are encouraged to adopt new technology or innovative products in their construction projects. The EJC project was earmarked to be the first high rise project (more than 10 stories) for a hybrid system of Cross Laminated Timber (CLT) and concrete. Greater challenges awaited us upon award of contract, as the integration of the CLT and concrete hybrid system by substituting the intended precast hollow core slabs was implemented by the main contractor upon authority approval. This hybrid system is relatively low in weight which reduces total loading of the building and thus leads to overall cost effectiveness by allowing for shallower and fewer reinforced supporting horizontal frame members, less reinforcement in vertical frame members and also shallower foundations.

Redesign of PT beams

With this substitution at Block A, BBR CS responded by providing re-designs for shallower post-tensioned beams and worked closely with the main contractor's design and operations teams and structural consultant's team in order to achieve the main contractor's goal of an optimum and constructible solution.

Concurrently, in order to reduce excessive formwork and staging, the main contractor proposed replacing post-tensioned slabs by precast double Tee slabs for Block B.

A top-down construction method was also proposed to be implemented, so as to expedite architectural feature works on the elevated field. As a result of these proposed changes, BBR CS expects to face more challenges in terms of the installation and stressing operation during the construction phase for Block B.

BBR CS is proud to have participated actively in the design process of this project from the early stages and to have witnessed the evolution and development process in the adaptation of such an innovative construction product. We look forward to the challenges of the construction phase which is expected to be completed by the end of 2018. ●

1

DISTRIBUTION CENTER, **AUCKLAND, NEW ZEALAND**

Award winning PT performance

WORLD LEADING PT FLOOR

BBR Contech's involvement in the James Pascoe Group project has seen the delivery of floor flatness that is at the highest level in the world – and the award of the Post-Tensioning Institute's (PTI) Award of Excellence in the Slab-on-Ground category.

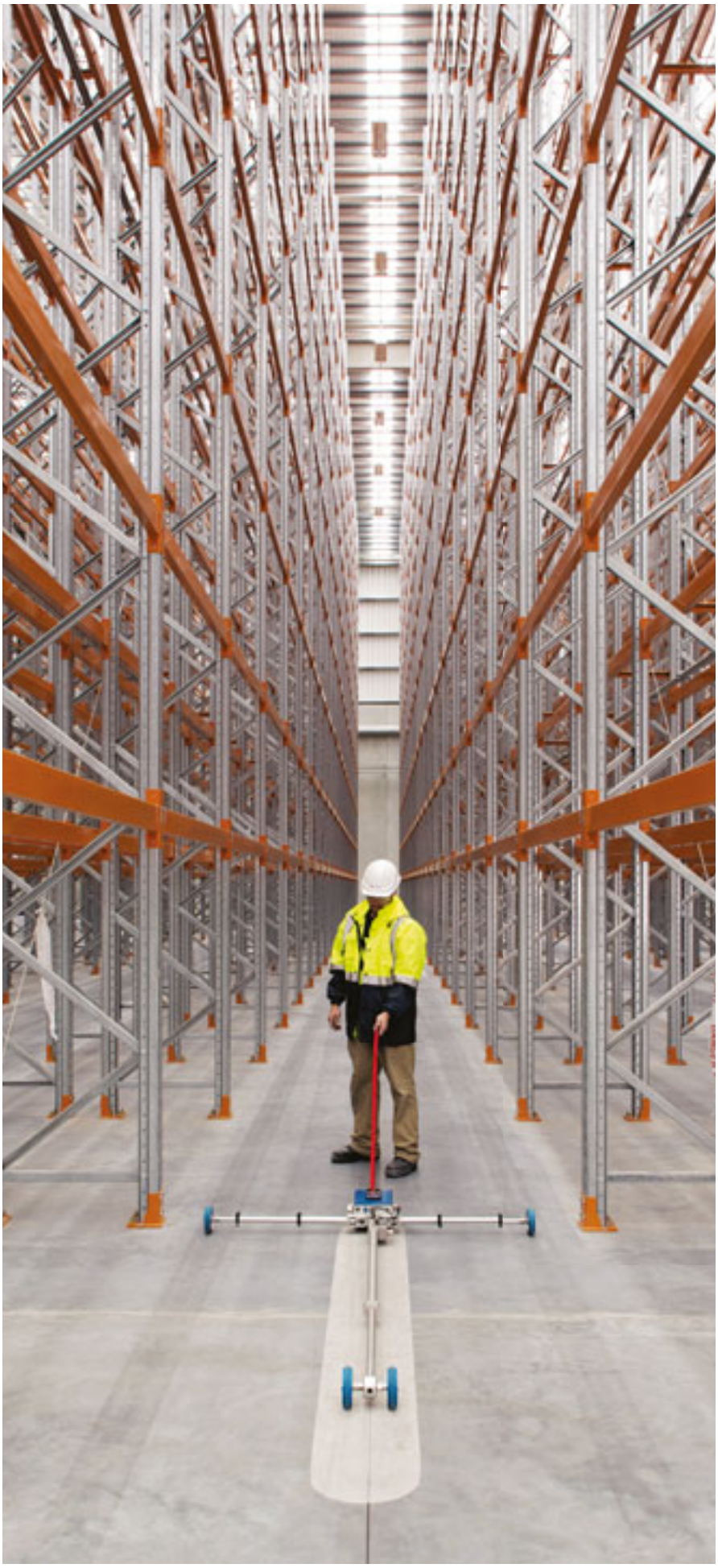
The Project Awards, presented every two years, were announced during the 2017 PTI Convention Awards Dinner in Atlanta, USA. They recognize excellence in post-tensioning applications and the jury of industry professionals judge the projects on seven different traits – creativity, innovation, ingenuity, cost-effectiveness, functionality, constructability and aesthetics.

State-of-the-art distribution center

James Pascoe Group required a state-of-the-art national distribution center to consolidate, warehousing for all of the group's retail brands, which include Farmers, Whitcoulls, Stevens and Pascoes. They set out with a long-term goal to minimize costs and maximize value for customers. This was supported by introducing the absolute latest warehousing systems and technology, including 16m high very narrow aisle (VNA) racking – the highest level installed to date in the southern hemisphere.

The cutting-edge VNA racking and material handling equipment (MHE) required a level of floor flatness that is considered the highest in the world, existing on the margins of what had been achieved globally. The floor was constructed as a series of large bay post-tensioned floors, coupled together so that there were only two opening joints located within the 25,000m^2 ground floor. Combined with the use of a new system for concrete floor jointing, this creates a surface that would require little-to-no maintenance during the life of the structure.

The use of post-tensioning allowed for an efficient and relatively thin 240mm thick floor to cater to the 120kN back-to-back rack loading, thereby reducing the volume of concrete compared to a traditional floor system. As the key working surface in the facility, the 25,000m^2 post-tensioned concrete high-performance ground floor played a pivotal role in the success of the project.



2

Hybrid solution

Traditionally, a VNA floor would be constructed in narrow strips one aisle at a time to ensure the exacting flatness standards were achieved. Traditional construction processes would slow down program, thicken the floor, and make it weaker and more prone to maintenance. A hybrid, large-bay post-tensioned solution was developed, which minimized joints, allowed fast construction – and provided a more sustainable solution by reducing concrete volumes. Conslab Limited was responsible for designing and delivering the completed floor and worked closely with client James Pascoe Group and BBR Contech as PT supplier to address all of the challenges. The expertize in constructing large PT slabs to tight tolerances meant that the rigorous flatness standards were met, giving the client the operational surface they needed without having to compromise on the durability of a large joint-free PT slab.

Cost reduction

The combination of faster construction time and a more efficient use of materials resulted in an approximate 25% reduction in cost.

The PTI jury declared that the project was a worthy award winner because the use of post-tensioning significantly minimized the number of construction and expansion joints and allowed for precise control of floor flatness. They endorsed what every BBR Network customer for slab-on-ground projects already knows – that a facility such as this one really benefits from the advantages of post-tensioning. ●

1 The combination of faster construction time and a more efficient use of materials resulted in an approximate 25% reduction in cost.

2 Thanks to BBR Contech's PT services and Conslab's concrete construction expertize, the award-winning national distribution center for James Pascoe Group features 16m high very narrow aisle (VNA) racking – the highest level installed to date in the southern hemisphere.

TEAM & TECHNOLOGY

Owner – James Pascoe Group
Architect – TSE Architects
Main contractor – James Pascoe Group
Flooring contractor – Conslab Ltd
Engineer – BGT Structures
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

MAJOR MIXED DEVELOPMENTS, **SINGAPORE**

Value & flexibility offered by post-tensioning

NEW & REVITALIZED COMMUNITIES

Dickson Liew of Singapore-based **BBR Construction Systems Pte Ltd** (BBR CS) reports on three major schemes which are currently underway and for which he and his colleagues are providing BBR technology and specialist technical skills.

1

1 Downtown East

Downtown East is a major lifestyle, recreational and entertainment destination in Singapore's Pasir Ris area. The resort was originally founded over 40 years ago with the objective of providing affordable leisure amenities. Today, it offers a hotel and water park, as well as an entertainment and leisure center.

BBR CS has been working on several schemes within the complex, including a hotel development, redevelopment of a three storey podium for recreational and food & beverage outlets, plus a project to provide an additional floor for an existing multi-storey car park.

2 Our Tampines Hub

Led by People's Association and located on the site of the former Tampines Stadium and Tampines Sports Hall, Our Tampines Hub is Singapore's first-ever integrated community and lifestyle hub.

Residents and people working within the vicinity can now enjoy a variety of sports facilities, a brand new regional library, countless community club programs and amenities, arts programs and facilities, a hawker center, retail shops and many more user-friendly features. Conceptualized with input from 15,000 Tampines residents, Our Tampines Hub is a project designed by residents, for residents.

2

3

> "...BBR CS is the sole PT specialist for the entire PLQ project which is estimated to require 700t of prestressing steel."

3 Paya Lebar Quarter

The Paya Lebar Quarter (PLQ) – a scheme estimated to be worth SGD3.2 billion – aims to forefront the government's redevelopment plans for the precinct. Its goal is to offer a commercial hub and residences that are pedestrian friendly and lushly adorned by greenery – and achieve a green plot ratio (GPR) of 6.

Situated on 3.9 hectares of land and the closest commercial hub to the central business district of Singapore, PLQ is a mixed development project offering more than 800,000ft² of Grade A office space, 310,000ft² of retail space and more than 400 residential units. With half of the development (Plots A & B) located right next to the Mass Rapid Transport (MRT) station, PLQ offers a wide plaza area between the two towers so as to provide seamless transition between the office tower, retail mall and the MRT station which is the interchange station for two lines. Boasting a direct link to the green park connector highway route leading to East Coast Park, PLQ will incorporate 300 bicycle lots with dedicated pathways for wheeled or foot transport and sky walkways between the four plots to whole-heartedly reflect the government's campaign for a 'car-lite' Singapore by providing a safe and beautiful path between work, play and home.

BBR Construction Systems Pte Ltd was awarded separate contracts by two main contractors for the design support, supply and installation of the PT works. This means that BBR CS is the sole PT specialist for the entire PLQ project which is estimated to require 700t of prestressing steel. ●

OVERVIEW – PAYA LEBAR QUARTER

Plot	Usage	Structural system	Details
A	Retail	Post-tensioned beam & RC slab	Single block of 8 floors. Estimated retail space of 310,000ft²
B	Office	Post-tensioned beam & slab	Two towers of 15 floors. Estimated Grade A office space of 550,000ft²
C	Residential	Conventional RC	Three towers with 429 units of 1 to 3 bedroom condominiums
D	Office	Post-tensioned beam & slab	Single tower of 14 floors. Estimated Grade A office space of 340,000ft²

1 Downtown East – BBR CS is providing PT services for three main schemes to improve and extend facilities for this leisure destination.
2 Our Tampines Hub – BBR CS has executed post-tensioning for this community facility which was designed by residents, for residents.
3 Paya Lebar Quarter – perspective of Plaza Area. Plot A (left), Plot B (right) & MRT Station (background).

TEAM & TECHNOLOGY

1
Developer – NTUC Club
Architect – DP Architects Pte Ltd
Structural consultant – Beca Carter Hollings & Ferner (SE Asia) Pte. Ltd
Main contractor – Vigcon Construction Pte. Ltd
Technology – BBR CONA internal, BBR CONA flat
BBR Network Member – BBR Construction Systems Pte Ltd (Singapore)

2
Developer – People's Association
Architect – DP Architects Pte Ltd
Structural consultant – T. Y. Lin International Pte. Ltd
Main contractor – Hexacon Construction Pte Ltd
Technology – BBR CONA internal, BBR CONA flat
BBR Network Member – BBR Construction Systems Pte Ltd (Singapore)

3
Developer – Lendlease & Abu Dhabi Investment Authority
Architect – DP Architects Pte Ltd
Structural consultant – Arup Singapore Pte Ltd
Main contractor – JDC Corporation (Plot A)
Hexacon Construction Pte Ltd (Plots B & D)
Kim Seng Heng Engineering Construction Pte Ltd (Plot C)
Technology – BBR CONA internal, BBR CONA flat
BBR Network Member – BBR Construction Systems Pte Ltd (Singapore)

8KIA PENG RESIDENCE, **KUALA LUMPUR, MALAYSIA**

Post-tensioned flat plate transfer floor

LUXURY RESIDENCE BENEFITS FROM PT

The latest luxurious residence to grace a neighborhood within Kuala Lumpur City Center is 8Kia Peng, King of the Hill @ KLCC. This prestigious development consists of 41-storey residential tower blocks on top of a common podium car park floor. The original transfer floor was designed with 4m deep reinforced concrete transfer beams to carry the load-bearing wall from above – this solution required a large amount of temporary falsework to support it during casting. Thus, BBR Construction Systems Malaysia undertook the challenge to redesign the transfer floor with a thick post-tensioned plate.

1

1 BBR Construction Systems Malaysia provided an alternative design, using post-tensioning, for the transfer floor at the luxury 8Kia Peng, King of the Hill @ KLCC residential development and thus reduced the requirement for temporary falseworks – thereby also reducing program and saving costs.

> "As well as enhancing the building aesthetics, taking a post-tensioned approach also delivers the key benefits of reducing the cost of formwork, props and backprops for the main contractor."

BBR Malaysia's Yan Mung Chung designed the 2.7m thick post-tensioned flat plate using the latest software program which enables the tendons to be modeled accurately and precisely at the location where required to avoid all the M&E openings.

A two stage concrete casting procedure has been adopted. In the first stage, a 1.0m thick Grade 45 concrete is cast on the temporary props. Upon achieving a concrete transfer strength of 35MPa, the first group of BBR CONA internal 705 tendons are stressed to support the weight of casting of the 1.7m thick wet concrete for the second stage.

The tendons for the second stage, also from the BBR CONA internal 1905 system, are stressed with a 300t multi-strand jack. Stresses are checked at transfer to ensure they are within allowable limits because the stressing is carried out before constructing the floor above. For columns with shear loads, up to 800mm deep drop caps are used to increase the punching shear capacity.

As well as enhancing the building aesthetics, taking a post-tensioned approach also delivers the key benefits of reducing the cost of formwork, props and backprops for the main contractor. In addition, the client benefits from a shorter construction period with less formwork and reinforcement to install. It is no wonder that post-tensioned flat plate structures are becoming increasingly common in this region. ●

TEAM & TECHNOLOGY

Owner – i-City Properties Sdn Bhd
Main contractor – Setiakon Sdn Bhd
Technology – BBR CONA internal
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

1

THE STAR GOLD COAST, **BROADBEACH ISLAND, AUSTRALIA**

PT for prestigious new luxury hotel tower

ICONIC GOLD COAST PROJECT

A new luxury suite hotel is in the advanced stages of construction on Queensland's famous Gold Coast. Australian BBR Network Member SRG Limited was selected to assist Probuild Constructions, through the provision of post-tensioning installation services for this prestigious project.

Comprised exclusively of luxury suites, the 17-storey tower forms the centerpiece of The Star's landmark transformation and is scheduled to be completed before the Gold Coast 2018 Commonwealth Games.

SRG was responsible for the supply, installation, stressing and grouting of approximately 160t of post-tensioning covering an area of 30,000m^2. ●

1 Australian BBR Network Member SRG Limited supplied, installed, stressed and grouted approximately 160t of post-tensioning for the new luxury suite hotel at The Star Gold Coast. Concept image for illustration purposes only, courtesy of The Star Gold Coast.

TEAM & TECHNOLOGY

Owner – The Star Entertainment Group
Main contractor – Probuild Constructions
Technology – BBR CONA flat
BBR Network Member– SRG Limited (Australia)

1

2

CONVENTION CENTER, **SOLARIS RESORT, ŠIBENIK, CROATIA**

Column-free space for conferences

CREATING FLEXIBLE EVENT SPACE

With its new 1,500-seat hall, Amadria Park's Convention Center in Šibenik, Croatia will offer the largest single room capacity conference facilities in the Adriatic region. Local BBR Network Member, BBR Adria, delivered post-tensioning services which have ensured that it had column-free, uninterrupted space. Predrag Presečki gives an overview of the project.

The Convention Center is set within the Solaris Beach Resort – south of Šibenik and less than one hour's drive from Split or Zadar airports – on Croatia's stunning Adriatic coastline.

The original design for the 24m wide building had two rows of columns, however, by adopting an alternative design based on post-tensioned construction of the ceiling, the need for columns was avoided. Thus, an uninterrupted and open character for the hall was achieved – to the great satisfaction of the developer.

The total plot requiring our post-tensioning services measured 46x41m – within which was the 40x24m conference hall space.

The solution we delivered is a load-bearing concept based on shallow beams running in the 24m direction. Beam dimensions are 2,000mm wide by 600mm deep, between which the flat slab is 220mm thick. We have installed 40 BBR VT CONA CMM 0406 unbonded tendons for the shallow beams while, in the transverse direction, we used BBR VT CONA CMM 106 unbonded tendons.

The stepped post-tensioned ceiling plate that we constructed was designed with a record range of shallow-wide beams for the given ratio of plate thickness and its size. The layout of the beams has been integrated as an attractive design feature of the finished ceiling.

The team has created a high quality structure which is in keeping with the client's aim to provide the finest facilities at their state-of-the-art convention and leisure resort at Šibenik. ●

1 The total plot requiring BBR Adria's post-tensioning services measured 46x41m – within which was the 40x24m conference hall space.

2 Thanks to BBR Network technology and expertise, the new Convention Center at the Solaris Beach Resort, south of Šibenik, is not only spacious and column-free, but also offers the largest single room capacity conference facilities in the Adriatic region.

TEAM & TECHNOLOGY

Owner – UGO GRUPA, Zagreb

Architect – SANGRAD Architects & AVP Arhitekti

Main designers – Vedran Pedišič d.i.a. and Eric Valasco d.i.a.

Main contractor – A3 d.o.o.

Structural engineers – Prof. Boris Baljkas d.i.g. and Predrag Presečki d.i.g.

Technology – BBR VT CONA CMM monostrand

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

DE STELTLOPER TOWER, **AMSTERDAM, NETHERLANDS**

BBR post-tensioned transfer floor plate

ROOMS WITH A VIEW

In Amsterdam's highly fashionable Eastern Docklands precinct, a new residential tower – De Steltloper – is under construction. Ruud Steeman of BBR Network Member Ballast-Nedam Infra Specialiteiten reports on this imaginative project which will sit partly on land and partly in the water.

Over the last few decades, this former docklands area has been transformed into a new neighborhood which has attracted both families and young professionals to come and live here. On the Ertskade, a quayside location where in bygone days coal and iron ore were transloaded, the slender 62m high De Steltloper tower is now rising from the ground – and water.
De Steltloper is no ordinary tower – its name literally means 'stilt walker' and on the land side, it is supported on 12m high columns or 'stilts'. A post-tensioned concrete transfer plate rests on these stilts and forms the foundation for one 14-storey wing of the residential tower.
The transfer plate is 1,400mm thick and we installed 96 unbonded BBR VT CONA CMM 0406 tendons for the post-tensioning.

The transfer plate was poured with a C50/60 high strength concrete. Only three days after pouring, this mixture had sufficient strength for the first stage stressing to take place.
After the first stressing stage, temporary supports could already be disassembled and the floor – weighing around one thousand tonnes – stood independently on its 'stilts'. As construction progresses, the tendons will be stressed in further phases so that the building load is transferred to the columns in three stages.
Construction of De Steltloper began in September 2016 and, soon after completion in December 2018, its new residents will be enjoying waterside living – and panoramic views across the River IJ and the Markermeer lake. ●

1 Visualization of Amsterdam's 'De Steltloper' tower which is rising – from land and sea – in the city's Eastern Docklands area.

TEAM & TECHNOLOGY

Owner – Wonam
Architect – Dam en Partners Architecten
Main contractor – Bouwbedrijf M.J. de Nijs en Zonen
Structural engineer – Van Rossum
Technology – BBR VT CONA CMM monostrand
BBR Network Member – Ballast Nedam Infra Specialiteiten (Netherlands)

1

WANDA METROPOLITANO STADIUM, **MADRID, SPAIN**

First use of BBR VT CONA CMF flat in Spain

NEW SPORTS STADIUM

Madrid's former La Peineta stadium has been transformed from a venue with a single-sided grandstand into a major world-class venue with spectator seating all around the pitch. Juan Linero of FCC Construcción, part of the FCC Group and BBR Network Member for Spain, provides some details of this exciting project.

Atlético Madrid's new home stadium occupies a total area of 88,150m² and has a capacity to seat more than 68,000 spectators within its general public and VIP areas. Also, the new venue offers more than 1,000 parking spaces for spectators within the stadium and a further 3,000 parking spaces outside. The leading design of the sports complex carries the stamp of the architects Cruz and Ortiz. Design highlights include the concrete finishes and the wide interior spaces that facilitate the movement of fans throughout the complex.

1

2

Design layout

The layout of the new grandstands makes it possible for spectators to be close to the field of play. The new stadium has three new T-shaped grandstands – a lower seating area formed by 28 tiers, a 13-tier middle section intended for VIPs which has direct access to the outside, plus an upper section of 32 tiers supported on a perimeter building which is where the general public entrance, VIP boxes and complementary services are located. In addition, main contractor FCC Construcción built 94 boxes in the lower area of the upper grandstands.

Roof structure

A noteworthy feature is the roof which differentiates this stadium from other recently designed European sporting venues. It consists of an approximately 6,300t steel structure, tensioned with radial cables and joined with a membrane which covers a surface area of over 83,000m^2. The membrane is made up of 720 PTFE panels weighing some 92t. The roof provides cover for the grandstands, right down to the lower seating areas, and will protect 96% of the arena from rain.

1 The inaugural event in the new Wanda Metropolitano Stadium was a grand occasion.
2 The BBR VT CONA CMF flat post-tensioning system was used for the first time in Spain and proved ideal for constructing the different grandstand levels.

TEAM & TECHNOLOGY

Owner – Atlético Madrid FC
Architects – Cruz y Ortiz
Main contractor – FCC Construcción SA
Technology – BBR VT CONA CMF flat
BBR Network Member – FCC Construcción (Spain)

Latest post-tensioning

The role of FCC Construcción on the project was to fully install all the post-tensioning for the different levels of the new grandstand. For this purpose, we selected BBR VT CONA CMF flat tendons for the task – this system is ideal for internally post-tensioned applications where the anchoring has to be carried out in very thin concrete cross-sections. Also, this system allows for very small center and edge distances at the anchorages, as well as full stressing at very low concrete strengths. It was the first time that the CONA CMF flat system had been used for a project in Spain – and it was ideal for this new high profile stadium.

Inaugural match

Atlético Madrid FC's opening match against Malaga FC, on 16th September 2017, was a grand event attended by His Majesty King Felipe VI of Spain. The occasion saw the match ball being delivered by parachute, followed by an Atlético flag and then a Spanish flag. It was hard for players and spectators alike not to be distracted by their imposing new surroundings – despite this, the home team secured a victory over their opponents.

This is a project which has resulted in the realization of a stadium that is modern and functional – but one that is also in the premier league of European and world sporting venues. Having been selected to host the 2019 UEFA Champions League final, it appears that the new Wanda Metropolitano Stadium has already established its place on the international scene. ●

OSTRÓDA BRIDGE, **POLAND**

Installation of BBR HiAm CONA stay cables

BRIDGE FOR PATRIOTIC PONDERING

This huge new red bridge with its triple arches is an icon on the outskirts of Ostróda and stands astride the inland waterway as if to welcome mariners arriving in the town. As the project nears completion, Project Manager Jacek Sowa from **BBR Polska**, the BBR Network Member for Poland, describes the creative ideas, construction technology and the challenges successfully overcome by the site team which have contributed to the realization of this impressive new bridge with its 84 BBR HiAm CONA stay cables.

This large public sector project – the upgrading and modernization of the road linking the capital city of Poland, Warsaw with the coastal city of Gdańsk – has been in progress for several years. The Expressway S7 is the shortest route connecting these two major cities. After completing the scheme, the whole 220km long road will become an efficient and convenient two-lane expressway.
One of the most important sections is the construction of a highway through Masuria – the land of a thousand lakes, the jewel in the crown of the Polish tourist industry. This is where BBR Polska has been providing expertize in the supply and installation of BBR stay cable technology for a new landmark bridge.

Creative vision

As they leave Ostróda heading in a northerly direction – and just before taking a major bend to the left – motorists will have a perfect view of this majestic red arch bridge with its alternating red and white stay cables. They might even notice that there is an empty space in the center, as if one of the white stay cables were missing. The designer's vision was to represent Polish society which has been divided and subjected to boundary changes for centuries. At the same time, the red and white stay cables reflect the colors of the Polish flag. The intention is to interrupt the monotony of driving on the expressway and to cause motorists perhaps to ponder, at least momentarily, on the significance and message of this structure. ➤

1

1 Ostróda Bridge – before stay cable installation began – showing the three arches above the bridge deck.
2 The BBR Polska workforce was organized into teams for stay cable prefabrication, installation and stressing, while support and lifting equipment from the main contractor helped to avoid downtime.
3 For the first time in Poland, the team used the latest HiAm CONA Uni Head Short Socket for the upper stay cable anchorages.
4 Jacek Sowa, BBR Polska's Project Manager for the Ostróda Bridge project. Photograph courtesy of Mikołaj Miśkiewicz.
5 Lower stay cable anchorages are on the outside of the bridge deck and for these, the team used BBR HiAm CONA Nut Heads.
6 Working platforms were installed to allow efficient access to the upper anchorage zones on all three arches.
7 Looking upwards from the bridge deck while the BBR Polska team completes stay cable stressing operations.

Bridge design

The bridge spans the Pauzeński Channel which connects two lakes in the vicinity of Ostróda. Difficult soil conditions – such as boggy areas at the edges of the lake – forced the designer to specify a 340m long bridge. Thus, a three span superstructure – with a 200m long center span and 70m side spans – was designed.

The composite steel beam structure with a concrete deck slab is suspended from three arches – two either side of the highway, with one central arch between the two carriageways. The bridge is suspended by a total of 84 BBR HiAm CONA stay cables – 28 stay cables on each arch.

Suspension works

For execution of the suspension works, the main contractor chose BBR Polska with our offering of the BBR HiAm CONA stay cable system.

For the outer arches, 12-strand stays were used and for the center arch we used 19-strand stay cables.

The upper anchorages are passive and there, for the first time in Poland, we used the latest technology – the HiAm CONA Uni Head Short Socket anchorage. For bottom anchorages, we used HiAm CONA Nut Heads. HDPE pipes with spiral rib and unified lengths of telescopic pipes allow optimization of costs and labor.

2

3

"The bridge is suspended by a total of 84 BBR HiAm CONA stay cables – 28 stay cables on each arch."

Need for time saving

While a number of unforeseen challenges were overcome, the contractor was facing the fact that the entire project could be delayed, especially since the winter – which can be especially harsh in Poland – was fast approaching. So now all the attention was focused on BBR Polska as, at this point, every day that could be saved would be worth its weight in gold.

Thanks to the earlier co-operation between the designer, contractor and ourselves, construction details had been agreed and optimized for the use of the BBR HiAm CONA system. BBR Polska's long and in depth experience gained during earlier projects – not least among which was the most recent one in Rzeszów with over 200m long stay cables – was now to deliver some real advantages for the Ostróda Bridge project. ➤

Construction sequence

This complex project required constant co-operation between the contractor and the designer on construction technology and methodology.

The incremental launching method – using three temporary supports in a main span – was chosen. With a complicated steel superstructure, stay-cables and a relatively thin 260mm deck slab, detailed analysis of each load case was required. Finally, the main stages of the construction project were agreed as follows:

- execution of the complete steel structure for the arches and deck
- lifting the main span deck by 500mm
- concreting the deck slab
- lowering the main span back down by 500mm (to achieve passive concrete compression)
- post-tensioning of the deck slab with internal tendons
- installation of stay-cables
- finishing works.

4

> "With a complicated steel superstructure, stay cables and a relatively thin 260mm deck slab, detailed analysis of each load case was required."

5

6

Stay cable installation

To allow efficient access to the upper anchorage zones on all three arches, working platforms were installed along on the whole length of the bridge. Access to the bottom anchorages was gained using four movable working platforms, plus stationary platforms on the outer ones.
Partly before and partly after deck slab concreting, we installed 168 HiAm CONA anchorages. The lower HiAm CONA Nut Heads were inserted from the top and the nut was screwed from the bottom.
An important factor in reducing the time needed for the installation of stays was to avoid having to make force adjustments. As a result, the design was prepared in such a way that, after installation of all strands and deactivation of temporary supports, the whole deck slab would reach the assumed final alignment. This required a stressing sequence to be applied totally symmetrically and evenly. There was only one solution – simultaneous stressing with six multi-strand jacks, symmetrically in both the longitudinal and transverse axes of the structure. In addition, stressing with multi-strand jacks guaranteed the application of force which would precisely meet the designer's calculations.

Contractor support & teamwork

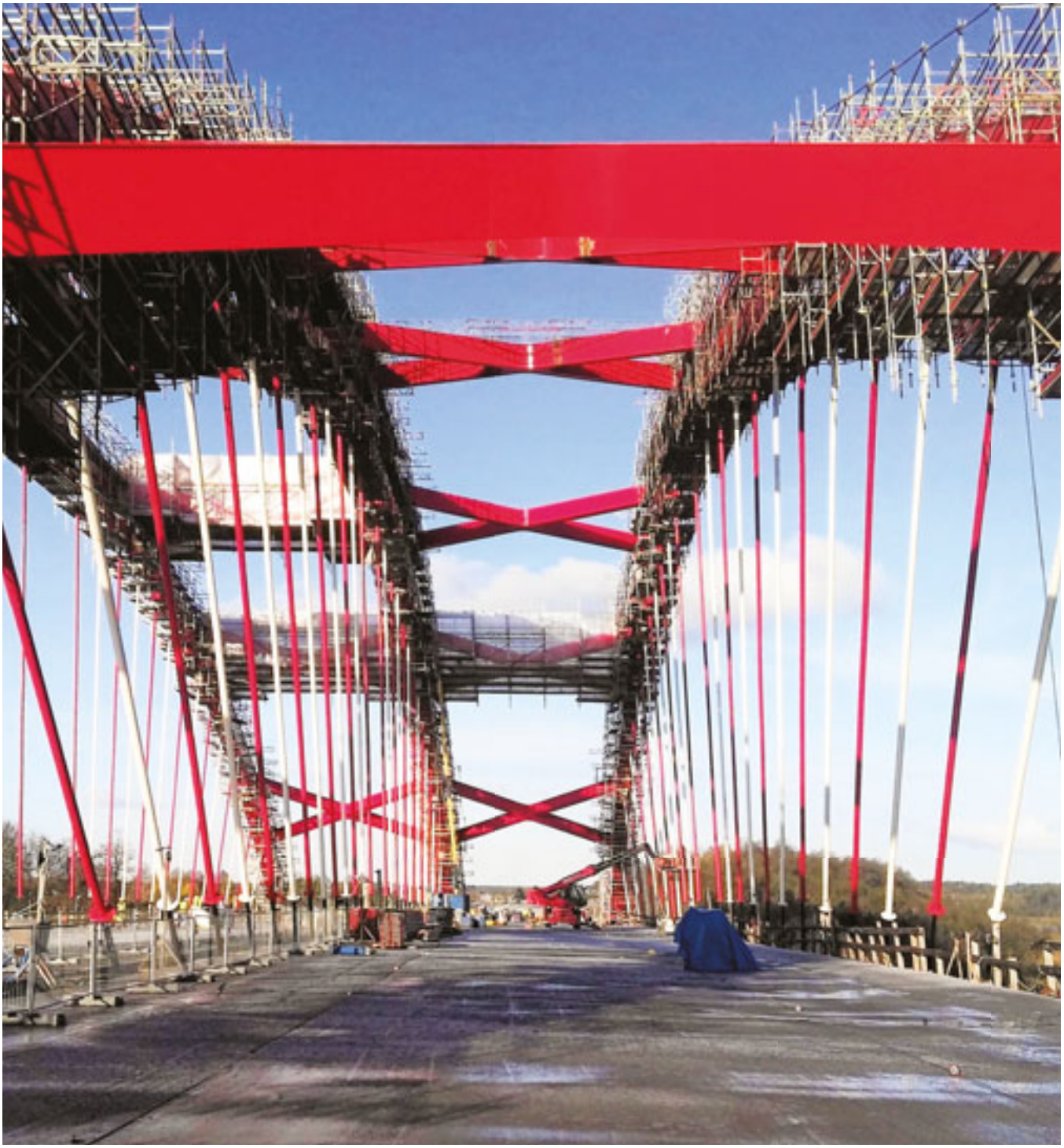
Before starting work, we sat around the table with the contractor and, after brainstorming, we set up a detailed work schedule.
Installation of stay pipes and strands was carried out by three independent teams, each of four people working on three stays at the same time. Then we installed the next three on the opposite side. When strands had been installed for six stay cables, the workers were divided into six teams for the simultaneous stressing operation. Radio communication and continuous supervision facilitated the application of uniform force in all stay cables.
At the same time, a further independent four person team was prefabricating strands, in preparation for the next group of six stay cables to be installed. The large displacement of the structure during stressing operations meant that it was impossible to fabricate the strands in advance with the required precision.
A great deal of help from the main contractor – who provided us with constant access and the use of two lifters and six telescopic handlers for manipulation of stressing jacks – allowed us to work without any downtime.
Of course, even on this one occasion, the weather refused to be our ally – thus much of our work was carried out in rainy and windy conditions which is not very comfortable, but, for sure, did not stop us!

Excellent results

The final result was more than satisfactory – from an agreed three week program for stay cable installation and stressing, we managed to complete these works in only two weeks. Moreover, the measurements of deck slab displacements and applied forces in the stay cables confirmed that the superstructure response conformed with the design assumptions which meant that there was no need for any force adjustments to be made. The finishing works at the anchorage zones were carried out in parallel with the execution of pavements and deck surfacing works. Time-and-time again, we see that the choice of an experienced company – such as BBR Polska who offer complementary and well-proven technology – together with good co-operation with the main contractor, is a guarantee of success. We look forward to our next challenge – and perhaps more favorable weather conditions will also help us on that occasion too! ●

TEAM & TECHNOLOGY

Owner – General Directorate for National Roads & Motorways, Olsztyn District
Designer – Transprojekt Gdański Sp. z o.o.
Main contractor – Budimex S.A.
Technology – BBR HiAm CONA stay
BBR Network Member – BBR Polska Sp. z o.o. (Poland)



7

AQUATIC CENTER, **SAINT-NAZAIRE, FRANCE**

BBR post-tensioning strengthens architectural pillars

FINE ART MEETS CONSTRUCTION

A massive new aquatic center will soon be ready to open in Saint-Nazaire, western France and the exterior of the new pool halls will feature the work of BBR Network Member, ETIC. The team is tasked with prefabricating the 40 elegantly designed pillars and lamellas which will rise from ground level to the sloping roofs of the three pool halls, lining the panoramic glass windows.

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In the realization of its new aquatic center, the town of Saint-Nazaire has taken care to retain the lightness, transparency and luminosity of the original design produced by Coste Architecture. The elevations of the pool halls feature large windows which bathe the interiors with light while offering expansive views of the landscaped grounds.

The pillars

The desire of the architects to purify the space led to a solution featuring a number of slender columns to support the roof structure. The roofs of the three pools are carried by 40 structural pillars. These are made of BSI® high-performance fiber-reinforced concrete (HPFRC) developed by Eiffage Group in collaboration with ETIC for this application and using the BBR VT CONA CMI internal post-tensioning system – and require no additional reinforcement. The pillar design has also been verified by modeling for seismic performance. This particular brand of HPFRC was selected for its mechanical and durability properties in order to meet the technical and architectural requirements dictated by this project in an aquatic environment. The 3m to 10m pillars all have the same structural diameter of 350mm and the architectural style, inspired by algae, is shaped around this structural core. From the 3D architectural drawing, a 10m high 1:1 scale model is machined by means of a 5-axis machine, in a resin type material. The lines of the model can be retouched by the architect when inspecting the full size component.

Prefabrication

The pillars are made of fair-faced HPFRC with metallic fibers – either white, gray or black according to the architectural plans. The height of the pillars depends on their position under the sloping roof. Pillars taller than 6.5m are prestressed using one BBR VT CONA CMI 0706 tendon. Before concreting, guides are placed precisely at the center of the pillars to assist the exact positioning of the CONA CMI tendon. Each piece of shuttering for the formwork is precision manufactured to match with the pillar design. The mould incorporates the spaces necessary for the post-tensioning tendon, tubes and injection vents, as well as inserts for framework fixings at the top end and steel components at the foot for installation.

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Passive anchorage
Demoulding takes place on a daily basis when the concrete has aged 20 hours and has reached a compressive strength of about 70 to 80MPa, without the application of heat treatment. The newly produced pillars are moved by straps, placed at 3m intervals, to the stockyard. The PT tendons in the pillars will be stressed when their strength exceeds 110MPa, at around seven to ten days old.
Finally, the active anchors are sealed by a non-shrinking grout to ensure they are protected against corrosion.

The lamellas
Non-structural pillars, known as lamellas, with their advanced design and extreme elegance, give rhythm to the large bay windows along the side of the pool halls. They are also made of HPFRC with synthetic fibers.

Moulding

The lamellas range in height between 3m and 10m and they are formed by two wings that twist around a slender core. As for the pillars, a full-scale resin model is machined in a similar way.
In parallel with this work, preparation takes place of the metal shell which will stiffen the polyester moulding of the model.
The formwork shuttering is machined for concreting stops and includes placement positions for the fixing plate at the tops and the connecting steels at the bases.
The concrete is introduced into the mould through a narrow 30mm opening. Like the pillars, unmoulding takes place daily.
Studies made during the early stages of the project indicated that these elements must be lifted with a lifting beam with the lifting points balanced at 2m intervals.

Load testing

Load tests simulating wind loading were carried out to confirm the modeling results obtained for synthetic fiber HPFRC laminates, over-and-above those required by the design brief.
The production of moulds is a major phase in the production program, both in terms of its meticulousness and in terms of the amount of time this activity requires.
Finally, a prefabrication cycle of one piece per mould per day is delivering elements in time to meet the installation program.
The completed structure, with its HPFRC pillars and lamellas, will stand as a testament to the blending of architectural creativity with latest construction technology and engineering skill. ●

1 Visualization of the completed Aquatic Center in Saint-Nazaire, France.
2 The full height windows allow the pool halls to be bathed with light, while offering expansive views of the landscaped grounds.
3 Following prescribed lifting procedures, pillars and lamellas are placed in the stockyard after manufacture, ready for installation.

Images 1&2 copyright of Agence Coste Architectures.

TEAM & TECHNOLOGY

Owner – Communauté d'Agglomération de la Région Nazairienne et de l'Estuaire
Architect – Agence Coste Architecture
Main contractor – SONADEV
Technology – BBR VT CONA CMI internal
BBR Network Member – ETIC (France)

LNG TANKS, **AL ZOUR LNG IMPORT PROJECT, KUWAIT**

BBR post-tensioning for eight new cryogenic storage tanks

MAJOR NEW LNG PLANT

BBR Network Member **SRG Limited** has secured a A$26.5 million contract with Hyundai Engineering and Construction Co., Ltd to provide specialist contracting services for eight new cryogenic LNG storage tanks for Kuwait's Al Zour LNG Import Project.

The Al-Zour LNG Import Terminal Project will include the construction of a large-scale liquefied natural gas plant, including eight LNG storage tanks, located 90km south of Kuwait City.
Under the contract, SRG will be responsible for post-tensioning eight LNG storage tanks which are a core part of the Al Zour LNG Import Project in Kuwait.
Once fully operational, the facility is expected to produce approximately 22 million metric tonnes (MMT) of natural gas per year and will have a storage capacity of 1.8 million cubic meters of LNG. ●

TEAM & TECHNOLOGY

Owner – Kuwait National Petroleum Company (KNPC)
Main contractor – Hyundai Engineering and Construction Co., Ltd.
Technology – BBR VT CONA CMI internal
BBR Network Member – SRG Limited (Australia)

1 BBR Network Member SRG Limited is to provide specialist contracting services for eight new cryogenic LNG storage tanks for Kuwait's Al Zour LNG Import Project.

1

BBR TECHNOLOGY FOR CRYOGENIC APPLICATIONS

The total system resilience of the BBR VT CONA CMI internal post-tensioning system has been proven through tensile testing of single and multi-strand BBR VT CONA CMI internal post-tensioning tendons.
BBR VT International carried out testing in which the entire tendon length – including both anchorages – was completely submerged into a liquid nitrogen bath.

Test results verified the performance of the CONA CMI PT system and prove, not only that it is in full compliance with the ETAG 013 testing regime under cryogenic conditions, but also that the structural resilience of the system would remain at its highest level during the occurrence of an accident. See full report in CONNÆCT 2017. ●

KEEPIT DAM, **NEW SOUTH WALES, AUSTRALIA**

Ground anchoring for mass concrete gravity dam

WORLD RECORD ANCHORS FOR FIFTH DAM

After setting another anchoring world record at Hazelmere Dam in Durban, BBR Network Member for Australia, SRG Limited has secured a further specialist contract for the installation of high capacity ground anchors at Keepit Dam in Gunnedah, New South Wales.

Just over a year after winning the contract for strengthening works to the Hazelmere Dam in Durban, KwaZulu Natal, South Africa, SRG was awarded a A$24.4m contract by WaterNSW for specialist dam anchoring works on the Keepit Dam upgrade project in New South Wales.

Keepit Dam

Keepit Dam is situated on the Namoi River, 30km upstream of Gunnedah on the north west slopes of the New South Wales Northern Tablelands. The dam has a capacity of 425,000Ml, making it nearly as large as Sydney Harbour.

Record capacity ground anchors

SRG is the lead contractor on the project and will complete all the works required for the installation of 67 permanent ground anchors in the concrete section of the existing dam, as well as significant civil works associated with the project. Each of the anchors is made up of 15.7mm strand cables of varying lengths, the largest anchors will have 91 strands and be approximately 88m in length. This will be the fifth dam project to use these world record capacity 91 strand anchors supplied and installed by SRG.

Transporting anchors of 88m in length requires a great deal of planning. The anchors are being manufactured on site but are required to be transported 1.5km to the dam wall. A transport management plan was developed and the anchors are transported on a purpose-built set of trolleys – nearly 100m long for the longest anchors.

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Innovations

Innovation, one of SRG's core values, also played a major role with a number of new developments for the Keepit Dam Upgrade project.

Grouting is an integral part of the anchoring process. In order to grout the anchors once they are installed, a grout mixer/pump is located on the dam wall which typically utilizes 20kg bags of cement to be lifted manually and loaded into the grout mixing bowls one at a time. This process is labor intensive and requires significant manual handling.

A solution was developed and engineered internally to provide a purpose-built grout machine and bulk handling system including a hopper, capable of holding up to one ton of bulk cement which is loaded into the hopper using a forklift to then deliver a pre-set measured amount of cement into the mixing bowls via the highly automated system.

This new piece of specialist equipment not only saves a significant amount of time, but it is also more accurate and increases safety by removing all forms of manual handling from this operation.

Another innovation which has been adopted on site at the Keepit Dam Upgrade project is a remote controlled stop switch for the three large air compressors which supply high volume compressed air to the drill rig. The drill rig can be up to 300m away from the compressors during drilling operations. To ensure safety in the event of an emergency, a remote stop switch (e-stop) has been developed and installed on the drill rig to enable the compressors to be shut down at the press of a button. ●

1 BBR Network Member SRG will install 67 high capacity ground anchors at Keepit Dam in Gunnedah, New South Wales – the largest anchors will be around 88m long and have 91 strands. This is the fifth dam project to use these world record capacity anchors.

TEAM & TECHNOLOGY

Owner – WaterNSW
Main contractor – SRG Limited
Structural engineer – SMEC
Technology – BBR CONA ground
BBR Network Member – SRG Limited (Australia)

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SILO SLIPFORMING, **SHELLHARBOUR, NEW SOUTH WALES, AUSTRALIA**

Six concrete silos slipformed at aggregates quarry

AROUND THE CLOCK SHIFTS FOR SILOS

BBR Network Member SRG Limited has completed the slipform construction of six concrete silos, each with a post-tensioned base, for a working quarry at Shellharbour near Wollongong in New South Wales, around two hours' drive to the south of Sydney.

The Bass Point Quarry is operated by Hanson, part of the international Heidelberg Cement Group. The site has been used for extractive operations since as far back as 1880, although the more modern use of the site began in the 1960s. Today, the quarry supplies a range of products primarily for the Sydney and Illawarra construction and civil engineering markets.

Each of the silos are 15.6m high and will hold quarry aggregates and manufactured sand. SRG's site team worked around the clock during six back-to-back shifts on each slipform operation until the full height of the silos was reached.

The slipform process involves the continuous upward movement of formwork by means of jack rods and hydraulic jacks. The slipform technique is a rapid and economical construction method which can achieve considerable cost savings when compared with the cost of conventional formwork.

Other services delivered by SRG included a 2,053m^2 post-tensioned slab, silo recovery culvert, scalps stockpile tunnel, primary stockpile reclaim tunnel and a primary crusher station. SRG's expertise with slipform construction and detailed reinforced concrete works was integral to securing this now completed project. ●

1 Bass Point Quarry – the SRG team slipformed six concrete silos, each with a post-tensioned base.

TEAM & TECHNOLOGY

Owner – Hanson
Main contractor – Brolton Group
Technology – BBR CONA flat
BBR Network Member – SRG Limited (Australia)

HOBSON & TE WERO WHARVES, **AUCKLAND, NEW ZEALAND**

Mid-city wharf repairs

GETTING THE FOUNDATIONS RIGHT

If you've heard about or followed the ups-and-downs, literally, of the America's Cup yachting regatta, you probably know that New Zealand teams have had considerable success in wresting the 'Auld Mug' from other, richer, better-resourced competitors.

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> "We appreciate that working in the wharf and marine environment isn't easy, and were pleased with BBR Contech's positive, practical and genuinely collaborative approach. They did a great job."
>
> Phil Wardale, Project Manager, Panuku Development Auckland

Since the first shock win in 1995 – more than 140 years after the regatta was established – Kiwi boats have won the Cup twice, most recently in 2017 with an emphatic victory over the United States' defender, Oracle Team USA.

As a result of this success, New Zealand will host the next America's Cup competition. Although at the time of writing the location had not been finalized, Auckland's waterfront is again the preferred contender. In each of the past regattas, its Viaduct Marina has served as the event's racing and social headquarters, hosting tens of thousands of local and international visitors and generating a financial boom for the local and national economies.

The prospect of the regatta returning to the Viaduct Harbour has the city buzzing and it provided the BBR Contech team with an extra incentive to do a great job on a recent project – repairing the structures of two wharves that are key to the Viaduct Marina's current and future operations.

Rehabilitating a piece of history

The wharf repair project actually began before the latest America's Cup win – in September 2016 at Hobson Wharf, a 155m long structure built in the 1930s to provide berthing for ships.

In 2013, a condition assessment of the 80-year-old wharf revealed that, while it was performing well above minimum requirements, the concrete beams and piles underneath it required significant repairs and rebuilding. This would be no easy task, as sitting on top of the wharf is the New Zealand Maritime Museum, a popular tourism destination for locals and visitors alike. What's more, the wharf is an integral part of the Viaduct Marina precinct – a vibrant hub of the city that now includes world-class marina facilities, more than 30 restaurants and bars, superior hotel and apartment accommodation, as well as sought-after venues for events and art installations.

The wharf project would have to consider everyone in the area – residents, businesses, boat owners and visitors – and provide an assurance of minimal disruption to their everyday lives and livelihoods.

The project's manager, Phil Wardale of Panuku, the development arm of Auckland Council, knew he had to get two things right. The first was to ensure that all affected stakeholders understood, accepted and were kept up to date on what was happening. Secondly, he had to engage a contractor who understood the demands of the project and would work with Panuku to manage stakeholder expectations and address potential issues and complaints promptly and effectively. Where concerns have been raised by neighbors, especially about noise, BBR Contech made great efforts to minimize impact.

"There was no doubt that the project would be noisy and everyone in the area would be affected," he said, "so we were determined to be as helpful and as upfront as possible every step of the way."

"We developed a strategy that included, for example, public meetings before the work started, email newsletter updates and hoardings on the site that explained what was happening and why and included diagrams of the repair process. I also made myself available for calls and emails – so anyone with questions could be confident they were speaking directly to the project manager." ➤

Securing the right contractor

BBR Contech is no stranger to harborside work in Auckland – they have been responsible for assessing, repairing, protecting and strengthening wharves, jetties, ferry terminals, walkways and seawalls there for almost 25 years. It's not surprising that this record was one of the key reasons for the company being awarded the Panuku contract – but Phil is quick to comment that other factors came into play.

"They also had a reputation for being more 'partners' than 'suppliers', which was the quality we were looking for," he said.

"We made the right choice, as they had a great ability to work within the formality of the contract while also taking a more informal approach to our working relationship. They were attuned to the way we worked and added a lot of value to our fortnightly project meetings."

BBR Contech's Oliver Smith and Mark Kurtovich were both involved in leading the project – Oliver in the early stages and Mark subsequently as the full-time, on-site contact. They both pinpoint Panuku's proactive 'community engagement' as one of the keys to the project's success.

"Due in large part to Panuku's investment in consultation and regular communication, the people who had to put up with the noise and inconvenience were supportive and understanding," says Mark. "It enabled us to focus on getting the job done as quickly and efficiently as possible."

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1 The team from BBR Contech carried out repairs to Hobson Wharf at Auckland's Viaduct Harbour – beneath the New Zealand Maritime Museum.
2 A comprehensive suspended scaffold is erected and covered with a layer of fabric to catch broken out material and prevent it from falling into the harbor.
3 A cross-brace with deteriorated concrete removed and reinforcing steel prepared ready for installation of the new marine-grade concrete. Fully repaired braces can be seen in the background.
4 Corroded reinforcing steel is removed and new reinforcing steel is lapped and welded where needed.

TEAM & TECHNOLOGY

Owner – Panuku Development Auckland
Main contractor – BBR Contech
Structural engineer – Beca
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

Getting it done

Scheduled to be completed in early 2018, the Hobson Wharf project sees the team working around the ebbs and flows of the tides to:

- break out damaged and deteriorated concrete in identified areas, using hydro-demolition
- remove corrosion on exposed reinforcing steel
- install new reinforcing steel, where required
- apply new, marine-grade concrete using either box-and-pour techniques or dry spray gunite techniques to create a structure with a long-life expectancy.

As part of its construction noise-management plan, Panuku and BBR Contech implemented mitigation measures that included:

- limiting the hours of noisy work to 7.30am-6.30pm Monday to Saturday
- scheduling the noisiest work in the quieter months – and stopping work completely in the Viaduct Marina's busy summer period
- employing trained personnel to monitor noise levels
- installing sound curtains and other equipment to minimize the noise of compressors and generators wherever possible.

The team also implemented an environmental management plan that included capturing debris with filter cloths and disposing of it responsibly off-site. An innovative capture and filtering system was developed to ensure that dust created during the dry spray process was captured.

Extending the work

BBR Contech's work at the Viaduct Harbour was extended in March 2017 to include repair and rebuilding work at Te Wero Wharf, a smaller island structure which is central to the Viaduct Marina and surrounded by some very expensive boats. While the working conditions and work requirements were similar to those of Hobson Wharf, mitigation measures also included relocating some of these precious vessels to temporary berths.

"It's an indication of how well the Hobson Wharf project was going that BBR Contech was awarded this contract," said Phil. "We appreciate that working in the wharf and marine environment isn't easy, and were pleased with BBR Contech's positive, practical and genuinely collaborative approach. They did a great job." ●

BRIDGES & ROADS, **SOUTH ISLAND, NEW ZEALAND**

Post-earthquake infrastructure repairs

RESTORING POST-QUAKE ORDER

A 7.8-magnitude earthquake struck the north-eastern corner of New Zealand's South Island in November 2016. It lifted the seabed in Kaikōura Harbour by up to two meters and destroyed parts of the State Highway 1 road, as well as bridge and rail networks along the coastline. So, it was all hands to the rescue for the BBR Contech team.

Contracted in the immediate aftermath by national rail provider KiwiRail, the team was directed to undertake remedial repairs to two rail bridges. This involved epoxy injection for cracks in the concrete and, elsewhere, breaking out damaged concrete, installing starter bars and reinforcing cages, and forming and pouring micro-concrete.

Shortly afterwards, the New Zealand Government established the North Canterbury Transport Infrastructure Recovery (NCTIR) alliance to manage all repair work and get the state highway and rail (especially freight) networks reopened as quickly as possible. The pressure was on, as all traffic was diverted to a temporary inland route that, while usable, was longer than the direct route and often narrow and windy.

Under the NCTIR contract, BBR Contech is undertaking further bridge repairs and, together with SRG Australia, helping to stabilize a slip-affected site to the south of the Kaikōura township. The work involves installing self-drilling anchors, undertaking grouting and load testing, and positioning foundation pads and a rock-fall netting system. Through this collaborative approach, BBR Contech is benefiting from SRG's knowledge and expertise in drilling and grouting and accessing resources vital to completing the work quickly and efficiently.

With a constant focus on health and safety in this inherently dangerous environment, the team are confronting some unusual challenges. Wild goats are running amok and causing rocks to cascade down the slopes (helicopters are trying to scare them away), flocks of sheep have been known to wander where they shouldn't – and curious seals from a nearby coastal colony have occasionally invaded the site's shipping containers! ●

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1 A rockfall protection fence installed by the BBR Contech SRG JV on one of the slip-affected sites south of Kaikoura.

TEAM & TECHNOLOGY

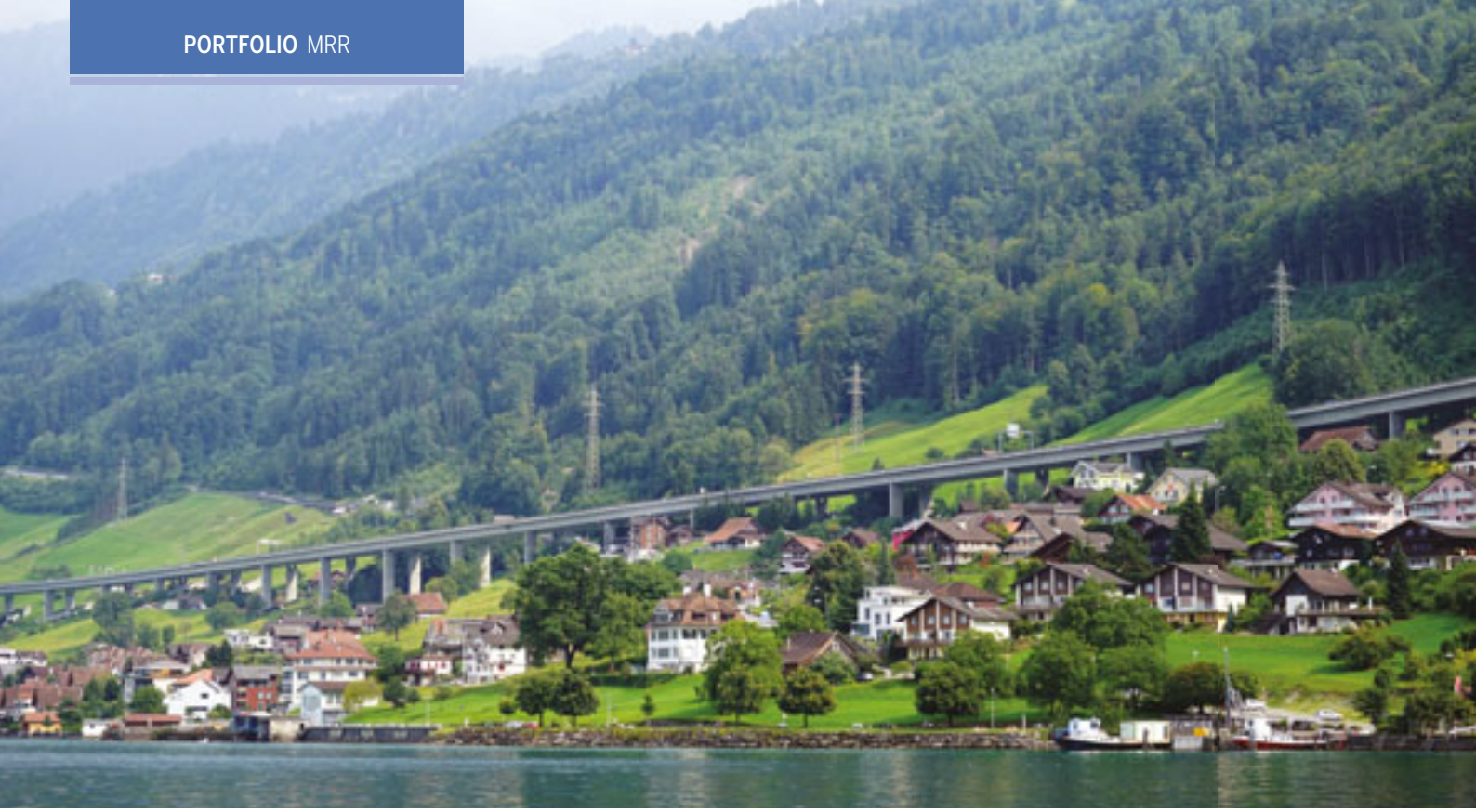
Owner – The New Zealand Government

Main contractor – North Canterbury Transport Infrastructure Recovery Alliance (comprising the NZ Transport Agency, KiwiRail, Fulton Hogan, Downer, HEB Construction and Higgins)

Structural engineer – North Canterbury Transport Infrastructure Recovery Alliance

Technology – MRR range

BBR Network Member – Bridges & remedial work : BBR Contech (New Zealand) Ground retention : BBR Contech SRG JV (New Zealand & Australia)



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LEHNEN VIADUCT, **LUCERNE, SWITZERLAND**

Post-tensioned lamellas for bridge strengthening

INNOVATIVE SOLUTION FOR VIADUCT

The BBR Network Member for Switzerland, Stahlton, has recently provided an innovative solution for the Lehnen Viaduct – once the country's longest motorway bridge – which forms part of the A2 motorway, near Lucerne.

Completed in the 1980s, the bridge is situated in a geologically problematic area, thus the piers were driven into healthy rock – sometimes up to 75m deep – and protected by shafts.
In the recent project, seven prestressed CFRP lamellas were placed on top of the concrete in order to compensate for a damaged BBRV post-tensioning tendon. However, the risk of drilling existing post-tensioning and dense reinforcement meant that an alternative method of anchorage was required.
Stahlton devised a solution based on anchoring the lamellas to a large steel base plate, whereby the plate allowed adaptation of the anchorages and dowels to avoid clashes with existing post-tensioning tendons. ●

Methodology

1 Unprotect the upper reinforcement layer up to ducting of post-tensioning tendon using high pressure water.
2 Determine the position of the anchoring holes and the position of the CFRP lamellas.
3 Reprofile the concrete structure.
4 Position and glue the steel base plate using epoxy adhesive.
5 Drill and move the anchoring dowel.
6 Position and bond the CFRP lamellas, stressing each to 140kN.
7 Cover the entire structure with vandal and UV-resistant reprofiling mortar.

1 The Lehnen Viaduct – a bridge forming part of a major motorway near Lucerne, Switzerland – has been repaired using an innovative solution.

TEAM & TECHNOLOGY

Owner – Baudirektion Kanton Uri
Main contractor – Stahlton AG
Technology – MRR range
BBR Network Member – Stahlton AG (Switzerland)

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1 Installation of steel base plate.
2 Application of protective reprofiling mortar.
3 Stressing in progress.
4 Completed project, after application of protective profiling mortar.

TUI BREWERY, **MANGATAINOKA, NEW ZEALAND**

Strengthening a heritage-listed brewery

PROTECTING A KIWI ICON

It's a rare New Zealander who hasn't heard of the tiny settlement of Mangatainoka, with its population of around 1,500. For most, it means three things – Tui beer, a favorite ale for Kiwis for the past 125 years; the Tui Brewery, established in 1889; and the distinctive, seven storey Tui Brewery Tower, built in 1931 where, until recently, the beer was made.

While the BBR Contech team would no doubt have welcomed a project focused on the beer, it was the tower that saw project manager Matt Mumford and his crew take the first of what were to be many 2.5-hour trips to Mangatainoka in May 2016. Located in a geographically isolated part of the North Island's Manawatū-Wanganui region – with no ready access to supplies or labor – the project was to be a challenge in many more ways than one.

The team were tasked with strengthening the iconic, heritage-listed tower before its decommissioning as a large-scale production factory and redevelopment as a small, boutique brewery and tourism destination. The tower was in a state of disrepair, requiring a multi-phase strengthening approach that, for the BBR Contech team, included:

- clamping together interior and exterior pairs of sandwich beams around the existing foundations, before the beams were post-tensioned with tendons comprising 12 and 19 strands of 12.9mm diameter
- post-tensioning the sandwich beams longitudinally
- using vertical stress bars to post-tension the structure's two towers vertically, with bars running from the sandwich beams at the bottom to purpose-built reaction blocks at roof level
- using flat-jacking to prove six new foundation pads and engage new seismic isolator bearings at the six corner locations of the two towers.

Matt sums up the experience of this long and complex project: "We were pleased to have the opportunity to secure the future of this well-known and historically important building," he said, "it was a challenging project with many working constraints and it is very rewarding to now see it completed." ●

1 The heritage listed Tui Brewery tower was strengthened before decommissioning as a production facility and being redeveloped as both a boutique brewery and tourism destination.

TEAM & TECHNOLOGY

Owner – DB Brewery
Main contractor – Fletcher Building
Structural engineer – Dunning Thornton
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR Contech (New Zealand)

POWER PLANT, **TUZLA, BOSNIA AND HERZEGOVINA**

Renovation of cooling tower

RENEWED STRENGTH FOR ENERGY

The renovation of one of the cooling towers at the Tuzla Thermal Power Plant in Bosnia and Herzegovina required specialist services from local BBR Network Member, BBR Adria. Project Manager Darko Kašica provides some background and outlines the work undertaken.

1

Tuzla Thermal Power Plant is the largest power plant in Bosnia and Herzegovina. The original construction of the plant took place between 1959 and 1978, while power generation began in 1963. It is a coal-fired plant which draws on the significant geological reserves of lignite and brown coal at the Kreka – Banovići coal basin which enable a reliable and long-term quality supply of coal for the thermal power plant. Although two of the plant's generating units have now been permanently decommissioned, rehabilitation and modernization of the remaining four units has ensured their continued operation – and the supply of energy to customers. We were awarded the contract to provide post-tensioning services for the renovation of the RT-1 cooling tower.

Replacing PT rings

Our work involved the replacement of the 16 sloping horizontal rings to the outside of the tower, each consisting of four post-tensioning tendons. We started from the top and operated from a platform which was moved downwards as work progressed. We installed BBR VT CONA CMM 0106 tendons with 150mm^2 diameter steel strands of very low relaxation grade steel and a minimum breaking strength of 1860N/mm^2. All strands were individually sheathed and each tendon was fitted within an outer UV-resistant HDPE pipe for further protection.

2

Temporary restraints

Before removing the existing rings, temporary ties made of steel wire were installed – two directly above and two immediately below each ring and stressed to 18.75kN. The system of temporary restraints consisted of 7mm diameter steel wire, wire guides and steel blocks for the 7mm diameter wire.

3

PROJECT STATISTICS	
62.40m	cooling tower height
77-98m	diameter of PT rings
128	number of anchorages
78.64m	maximum tendon length

1 The Tuzla Thermal Power Plant, Bosnia and Herzegovina where a cooling tower has been strengthened using the BBR VT CONA CMM post-tensioning system. Photograph released into the public domain by MoserB at German Wikipedia.
2 The team from BBR Adria operated from a platform – starting from the highest level and moving progressively downwards.
3 Pictured here is a concrete block onto which tendons were anchored for stressing. These were fitted to each ring of the tower and enable the transfer of forces into the structure. The blocks were fabricated off-site using moulds and a vibratory concrete slab.

Tendon removal & renewal

The next step was to remove the existing tendons in each ring. This was carried out by terminating the wires in each tendon by using an electric welding machine. Then, the existing permanent anchorages were removed and new ones installed. Each ring has four anchorages for permanent tendons – one tendon covers half the circumference of each ring. In each ring, one of the four tendons was anchored in both horizontal and longitudinal planes. After securing the anchorages in place, the new CONA CMM post-tensioning tendons were installed and stressed to 72kN. Finally, the excess PT strand was cut and protective grease-filled caps were installed over the anchorages. ●

TEAM & TECHNOLOGY

Owner – UGO GRUPA, Zagreb
Architect – SANGRAD Architects & AVP Arhitekti
Main designers – Vedran Pedišić d.i.a. and Eric Valasco d.i.a.
Structural engineers – Prof. Boris Baljkas d.i.g. and Predrag Presečki d.i.g.
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o. (Croatia)

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THE GLEN SHOPPING CENTER, **VICTORIA, AUSTRALIA**

Carbon fiber strengthening

EXCEEDING OWN RECORD

Australian BBR Network Member, **SRG Limited** has carried out its largest yet carbon fiber strengthening project as part of a massive upgrade scheme at The Glen Shopping Centre, in Glen Waverley, a suburb of Melbourne in the state of Victoria.

The A$1.8m contract for the carbon fiber strengthening design and construction works at The Glen was awarded to SRG by main contractor, Probuild.
The project involved carbon fiber reinforcement of the lower ground slab, shear strengthening of the beams using 1,800 x 650mm long M24 threaded rods and the carbon fiber wrapping of over 100 columns.
The strengthening works are part of a A$500 million upgrade of the shopping complex and are required to accommodate the new Aldi, Woolworths and Level 1 car park deck over the existing structure.

As well as SRG's vast experience in applying FRP – both fabric and plate – to a host of different structures, they also have an in-house design capability which assists engineers and owners alike. ●

1 The SRG team at work applying carbon fiber laminates overhead as part of SRG's strengthening project at the Glen Shopping Center.

PROJECT STATISTICS

6.1km	length of carbon fiber laminate/wrap used to strengthen concrete slabs
1.3km	length of carbon fiber rods used to strengthen beams
6.3km	length of carbon fiber wrap used to strengthen columns

TEAM & TECHNOLOGY

Owner – Vicinity Centres and Perron Group
Main contractor – Probuild
Strengthening design – SRG Limited
Technology – MRR range
BBR Network Member – SRG Limited (Australia)

SHELL GULLY BRIDGE, **WELLINGTON, NEW ZEALAND**

Critical CBD bridge repair

PROVIDING STRUCTURAL SUPPORT

A bridge that **BBR Contech** helped to build more than 40 years ago faced its biggest test in November 2016, when a 7.8-magnitude earthquake rocked New Zealand's capital city in the middle of the night.

The Shell Gully Bridge, part of Wellington's urban motorway and used by some 40,000 vehicles daily, provides a vital link to the central business district, hospital and airport. Beneath the bridge is a small car park, often used by commuters as it is close to the city center.

Engineers assessed the structure immediately after the quake and, while deeming both the bridge and its piers structurally sound, found that repairs were needed to address loosened concrete from the piers and superficial damage around their bases.

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TEAM & TECHNOLOGY

Owner – NZ Transport Agency
Structural engineer – Opus International Consultants
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

1 The team from BBR Contech wrapped the repaired columns with FRP to ensure a smooth, future-proofed surface.
2 The columns supporting Shell Gully Bridge, after repairs to address loosened concrete and superficial damage.

Assisting trials

The BBR Contech team was called in to assist Opus International Consultants and the NZ Transport Agency in undertaking trial repairs to four of the 21 piers under the bridge. This involved removing the loose concrete, forming and pouring new concrete, and wrapping the repaired columns in FRP to ensure a smooth, future-proofed surface and protect both the cars and the people in the car park area.

Major challenges

The major challenges of the work related to the terrain, with the narrow space and low headroom preventing access for large vehicles and equipment. Traffic management was also required to allow commuters to use as much of the car park as possible.

With the trial complete, the team completed remedial work to the remaining 17 piers which required attention – ensuring a structure that should service the busy thoroughfare for many years to come. ●

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PALAIS THEATRE, **MELBOURNE, AUSTRALIA**

Restoration of historic building

RESTORED TO FORMER GLORY

Australian BBR Network Member **SRG Limited** has completed the façade refurbishment work on one of Melbourne's most iconic and best-loved entertainment venues, the Palais Theatre.

Located in St Kilda, this 90-year-old building is the largest seated theatre in Australia. The former cinema, which retains many of its original features, is considered to be one of the finest examples of Art Deco architecture in the country and is included on the Victorian Heritage Register.

SRG commenced the façade refurbishment work in August 2016, following months of investigation and project development with the managing contractor, Built Pty Ltd. Works were completed in March 2017. ●

TEAM & TECHNOLOGY

Owner – Port Phillip City Council
Main contractor – Built Pty Ltd
Technology – MRR range
BBR Network Member – SRG Limited (Australia)

1 Façade refurbishment work by Australian BBR Network Member SRG Limited has helped to restore the exterior of Melbourne's 90-year old Palais Theatre to its former glory.

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MOA POINT WWT PLANT, **WELLINGTON, NEW ZEALAND**

Addressing corrosion in wastewater treatment plant

DOING THE DIRTY WORK

The Moa Point Wastewater Treatment Plant takes its name from its location – Moa Point, the smallest suburb in New Zealand's capital city with a street of just 21 homes. Situated adjacent to Wellington Airport on the city's rugged south coast, it is notoriously exposed to icy winds driven all the way from Antarctica.

BBR Contech is familiar with this environment, having already undertaken a number of remedial projects for the operator, Veolia. Its strong relationship, competitive tender and innovative, more environmentally friendly approach led to the company being commissioned in March 2016 to work at the plant again – this time to undertake a substantial rehabilitation program. Routine inspections had revealed evidence of severe concrete deterioration in certain chambers within the plant, largely the result of the aggressive wastewater environment, where the effluent breakdown process produces acids that are particularly tough on materials such as steel and concrete.

Two stage approach

The work was completed in two separate stages, using a common approach that involved applying high-pressure water jetting to remove the degraded concrete, and next identifying and repairing any defects in exposed reinforcement.

The team then dry-sprayed the latest calcium aluminate mortar, specifically designed for use in the wastewater industry, to thicknesses of 25-45mm. This achieved corrosion-resistance levels more than eight times that of standard concrete. In total, the team repaired three 10m deep tanks and one seven meter deep 'wet well', on time and with minimal interruption to Veolia's operations.

Preparatory planning

This kind of work is particularly challenging and hazardous for the BBR Contech team. A risk and emergency management plan was put in place, with everyone specifically trained and inducted for working in confined spaces. All site personnel were required to be appropriately inoculated for working in a wastewater treatment plant environment. It's something to think about next time you pass a wastewater treatment plant – guys like these are the unsung heroes of our households! ●

1 By dry-spraying the latest calcium aluminate mortar, specifically designed for use in the wastewater industry, to thicknesses of 25-45mm, the team achieved corrosion-resistance levels more than eight times that of standard concrete.
2 The BBR Contech team faced extreme weather and hazardous working conditions to carry out repairs to concrete at the Moa Point Wastewater Treatment Plant.

TEAM & TECHNOLOGY

Owner – Wellington City Council
Operator/client – Veolia
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

TECHNOLOGY

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RESEARCH & DEVELOPMENT

Extending use & applications for BBR VT CONA CME BT post-tensioning technology

NEW SOLUTIONS WITH CONA CME BT

The R&D team at the BBR Headquarters in Zurich has been developing new advanced solutions based on the BBR VT CONA CME BT post-tensioning system. BBR VT International's Head of Technology, Dr Behzad Manshadi describes the technology and the advantages it offers.

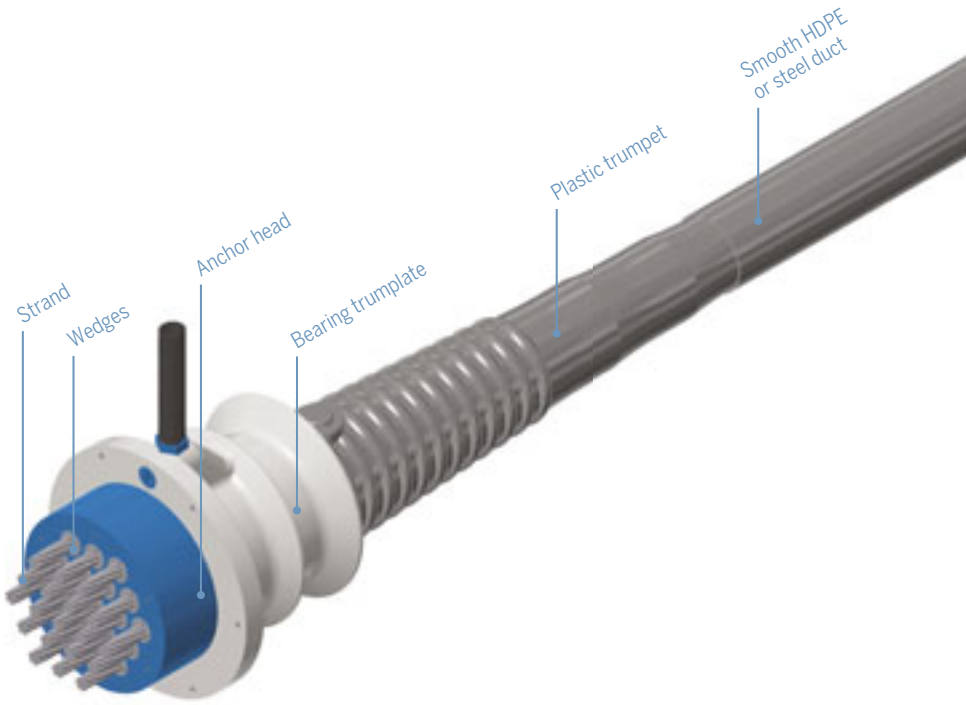
Most compact and light-weight system on the market

The European approved BBR VT CONA® CME BT external post-tensioning system is the most advanced multi-strand technology for all types of externally post-tensioned applications. The CONA CME BT (bearing trumplate) system can be applied for the prestressing of bridges, precast segmental construction and repair and strengthening works for all kinds of structures. CONA CME BT tendons are installed outside the cross-section of a structure and can be designed as restressable and exchangeable for concrete and composite structures (steel, masonry and timber).

The standard CONA CME BT tendon sizes range from 4 to 61 strands. Most commonly 0.62" (15.7mm) strands with a cross-sectional area of 150mm^2 and a characteristic tensile strength of 1,860MPa are used.

The main components in the anchor zone of the CONA CME BT system are the wedges, anchor head, bearing trumplate – as the load transfer element – and trumpet. CONA CME BT is the most compact and light-weight system available. It makes use of an advanced and proprietary three-plane load transfer, allowing for very small center and edge distances at the anchorages, as well as application of the full post-tensioning load at very low concrete strengths, $f_{cm,0}$=19/23MPa.

1 Construction of the world's longest incrementally launched bridge – the Seaford Rail Bridge, Adelaide, Australia – featured use of the BBR VT CONA CME external post-tensioning system.
2 CONA CME BT with smooth HDPE duct.
3 BBR VT CONA CME BT with monostrands – with temporary sealing plate and an activation plate.
4 BBR VT CONA CME BT with monostrands – after grouting and stressing.
5 BBR VT CONA CME BT – Exchangeable Tendon with Electrical Isolation.
6 Protection caps are being fitted to anchorages of the BBR VT CONA CME Electrically Isolated Tendon system which is being installed for the MRT project in Malaysia.
7 BBR Construction Systems Malaysia is installing BBR VT CONA CME Electrically Isolated Tendons for their MRT project currently underway in Kuala Lumpur. Pictured here are precast segments of viaduct being delivered to the launching girder for erection.



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Other prestressing strands approved at the place of use – such as strands having a cross-sectional area of 140mm² and/or a characteristic tensile strength lower than 1,860MPa – can be used with the same anchorage components.

Other key features of the system include:

- Fixed and stressable couplers – although less common for external tendons, CONA CME BT tendons can be coupled using the proprietary Type K overlap coupler for tendons ranging from 4 to 31 strands (larger sizes on request) or Type H sleeve coupler for 4 to 61 strands.
- Deviator/saddle – an element that is specific to external prestressing is the deviator/saddle. The deviator transfers the transversal forces generated by the tendon to the structure and provides a smooth surface for the tendons. The deviator can be made of concrete, steel, HDPE or equivalent.
- Corrosion protection – the strand bundle is enclosed in a smooth round plastic or steel duct with the most optimum duct size and minimum possible curvature radius. The filling of the tendons is carried out using a high performance BBR grout or grease/wax.

Maintaining our commitment to deliver constant improvement, the R&D department team has recently completed the development of new advanced solutions and features for the external restressable and exchangeable BBR VT CONA CME BT post-tensioning system.

Smallest radius of curvature & multi-layer corrosion protection

For the new BBR VT CONA CME BT with monostrands solution, monostrands are placed in a common duct that is grouted prior to stressing. During grouting, a temporary sealing plate together with an activation plate is installed at the anchorage to arrange the monostrands and resist the grouting pressure. After grouting, the monostrand ends are de-sheathed. For stressing, the anchor head A is placed on the grouted tendon. Stressing can begin once the compressive strength of the grout is sufficiently developed. This solution is applicable to anchorage A, as well as K and H coupling anchorages.

The key advantages and features of this solution are:

- Provides the smallest radius of curvature – 2.5m
- Offers multiple layers of corrosion protection – duct, grout and finally monostrand (which incorporates PE sheathing/grease)
- Cost-efficient as cement grout used, instead of grease/wax
- Restressable & replaceable strands.

Exchange of tendons with monostrands is generally performed by the strand-by-strand procedure, individually for each monostrand. After exchanging the prestressing steel strands, the monostrands are then well refilled with corrosion protection material.


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Highest possible level of corrosion protection

The European approved BBR VT CONA CME Electrically Isolated Tendon (EIT) is the most advanced multi-strand post-tensioning system for external applications with the highest possible level of corrosion protection – fulfilling the PL3 criteria as described in *fib* recommendations.

Typical external applications for the CONA CME EIT system include situations where enhanced safety, corrosion protection, quality control, durability and long-term monitoring of post-tensioning tendons are required.

The main components in the anchor zone of the CONA CME EIT system are the protection cap, wedges, anchor head, steel ring, isolation ring, load transfer element (bearing trumplate) and trumpet. In the anchorage zone, the plastic duct is connected to the trumpet and the strand bundle is spread out towards the anchor head, where each strand is individually locked with special BBR wedges. The protection cap, with the help of the isolation ring, encapsulates the whole anchor head with the wedges and locked strand. CONA CME EIT tendons can also be coupled with fixed coupler Type H.

Thick corrugated plastic duct eliminates the ingress of chlorides and anchor head encapsulation prevents stray currents from causing electro-chemical corrosion of the steel. When combined with a simple, continuous and non-destructive method of measuring the impedance of the tendons, this is the ultimate post-tensioning system for achieving the highest level of protection with an early detection warning system – conforming to *fib* recommendation PL3.

But there's even more – the system has been independently verified in accordance with testing procedures specified by the latest *fib* recommendations (Bulletin 75). Thus, the BBR VT CONA CME EIT range has been confirmed as meeting the criteria for the optional use category 'electrically isolated tendon', in accordance with the latest European Assessment document EAD 160004-00-301 (which replaced ETAG 013) and in accordance with Swiss guidelines *"Leitfaden für die technische Zulassung von Spannsystemen in der Schweiz"*.

Exchangeability for all configurations

Exchanging BBR VT CONA CME BT Exchangeable Tendons with/without Electrical Isolation in general is an option available for:

- Bare strands with grease, wax, or an equivalent soft material in a common duct
- Monostrands, grouted in a common duct, as for BBR VT CONA CME BT with monostrands (described above)
- Bare strands, grouted in a common duct.

Even where bare strand grouted in the duct has been used, a BBR VT CONA CME BT tendon can be completely removed and subsequently replaced by a new tendon.

The main components in the anchor zone of the CONA CME BT Exchangeable Tendon with bare strand grouted in the duct are the protection cap, wedges, anchor head, steel ring (for EIT), isolation ring (for EIT), load transfer element (bearing trumplate), outer trumpet and inner trumpet.

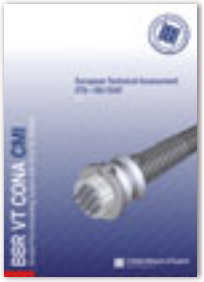
In the anchorage zone, the duct (plastic duct for EIT) is connected to the inner trumpet and the strand bundle is spread out towards the anchor head, where each strand is individually locked with special BBR wedges. The inner trumpet is placed in the bearing trumplate and the trumpet extends up to the anchor head (or steel ring for EIT) and provides a separating layer between structure and tendon. In the case of a tendon with electrical isolation, the protection cap – with the help of the isolation ring – encapsulates the whole anchor head with the wedges and locked strand.

For exchanging the tendon, the prestressing force should first be fully released, then the complete tendon with inner trumpet can be pulled out from the structure and replaced with a new tendon. This innovative solution can also be coupled with fixed couplers Type H & K. ●

TECHNICAL UPDATE

Recent European Technical Assessments

NEW & EXTENDED TECHNICAL ASSESSMENTS



Over recent months, three new assessments have been secured for technologies within the BBR VT CONA CMX post-tensioning range. European Technical Assessment for the CONA CME external system has been secured, along with new assessments for the CONA CMI internal and CONA CMF flat systems.

BBR VT CONA CME – external

The European Technical Assessment ETA-07/0168 has been issued for BBR VT CONA CME, the most up-to-date and advanced multi-strand post-tensioning technology for external post-tensioning applications.

Compared to the previous CONA CME European Technical Approval, this assessment incorporates the following new key features:

- Widest range of external tendons available from 4 strands up to the largest tendon size of 61 strands
- Introducing the new BBR VT CONA CME grouted tendon with monostrand (see page 82)
- Introducing the new BBR VT CONA CME fixed and stressing replaceable tendon with bare strand grout in common duct (see page 82)
- Extending the optional uses of the system to electrically isolated tendon (see page 82)
- Introduction of new BBR VT CONA CME grouted tendon with monostrand (see page 82)
- Introduction of new BBR system grouting accessories:
  - Grouting & protection caps
  - Accessories for inlets and outlets
- New 2-segment CONA CMX 06 wedge Type Z and extending material possibilities for global supply of all CONA CMX 06 wedges Type H, F and Z
- The most optimum duct sizes as well as deflection radius of the tendon.

BBR VT CONA CMF – flat

The European Technical Assessment ETA-12/0076 for the BBR VT CONA CMF BT internal post-tensioning system with flat anchorage and 02, 03 and 04 bonded or unbonded strands has been issued. The new assessment is based on the previous CONA CMF European Technical Approval and has the following key features:

- For internal bonded & unbonded post-tensioned applications
- Compact light-weight and flat system for thin concrete cross-sections
- Available in either 2, 3 or 4 strand configurations
- Optimized for 140mm² & 150mm², 1,860MPa strands while also usable with 93mm² & 100 mm², 1,860MPa strands
- Advanced proprietary load transfer element for very small center spacings and edge distances at the anchorages
- Application of full PT force at very low concrete strengths ($f_{cm,0}$=17/21MPa)
- Fixed and movable H couplers for joining tendons
- Corrugated round or flat tendon duct utilizing either galvanized steel or plastic material
- For bonded applications the ducts are filled with high performance grout
- For unbonded applications the ducts can be injected with grease/wax or circulating dry air
- Restressable & exchangeable tendons perfectly suited for long-term inspection and maintenance.

BBR VT CONA CMI – internal

The European Technical Assessment ETA-06/0147 has been issued for BBR VT CONA CMI, the most up-to-date and advanced multi-strand post-tensioning technology for internal bonded post-tensioning applications. The new assessment is based on the following key features:

- Standard tendon sizes from 4 to 31 strands
- Optimized for 140mm² & 150mm², 1,860MPa strands
- The most compact & light-weight system available utilizing an advanced proprietary load transfer element for very small center spacings and edge distances at the anchorages
- Application of full post-tensioning force at very low concrete strengths ($f_{cm,0}$=19/23MPa)
- Fixed and movable H & K couplers for joining tendons
- Corrugated or smooth round tendon duct utilizing either galvanized steel or plastic material
- Extending the optional uses of the system:
  - Tendon for cryogenic applications: superior cryogenic performance ideal for LNG tank applications
  - Encapsulated tendon
  - Electrically isolated tendon
- Including all required BBR system grouting accessories (i.e. grouting, plus protection caps, inlets and outlets)
- Including various material possibilities for global supply of all CONA CMX 06 wedges Type H, F and Z. ●

RESEARCH & DEVELOPMENT

BBR H Bar System

INTRODUCING THE BBR H BAR SYSTEM

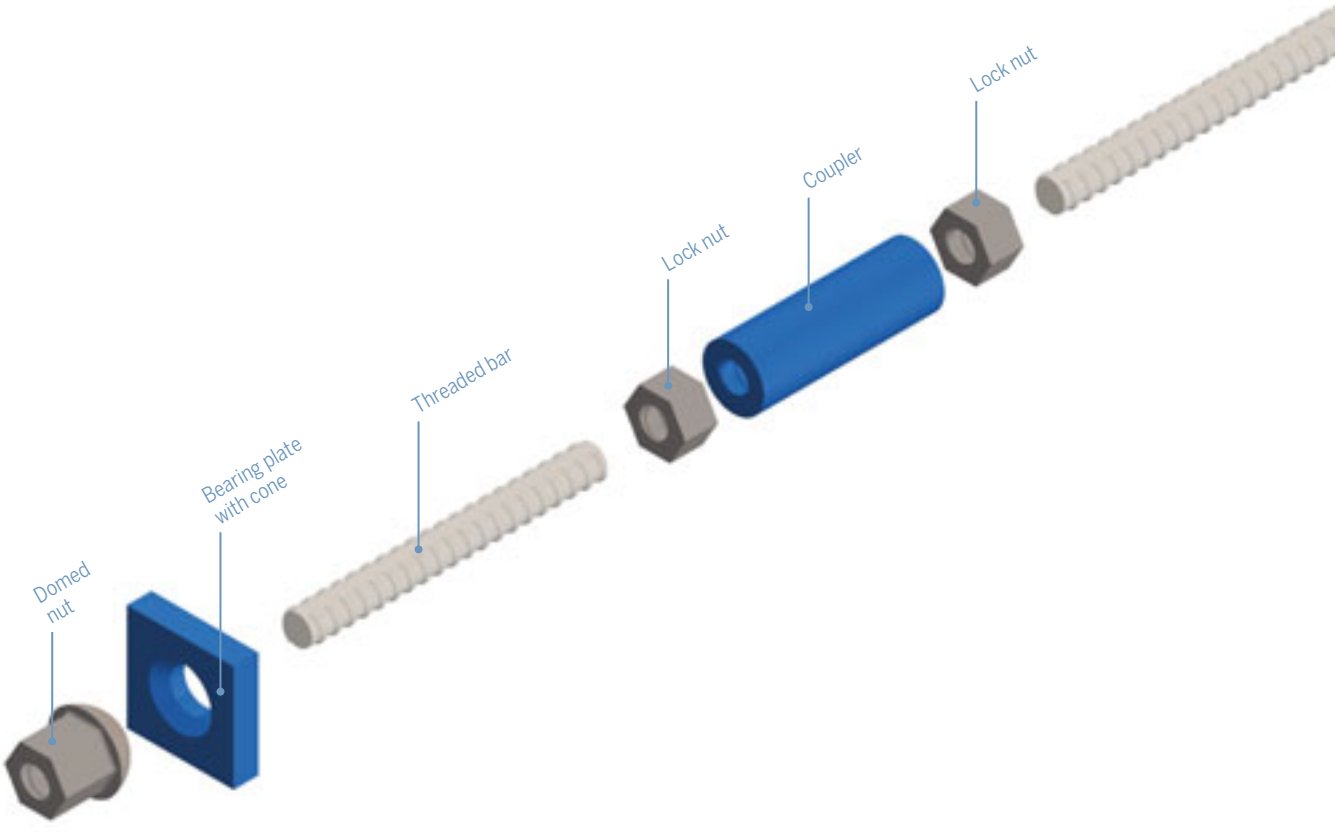
BBR Network Members will now be able to use the new BBR H Bar System for their general construction, civil engineering and underground projects. Cezary Sternicki, Head of Operations at BBR VT International, describes the new addition to the BBR technology portfolio and highlights its unique selling points.

The new BBR H Bar is a high quality threaded bar solution which is available in four different yield strengths – 500, 670, 830 and 930MPa. The introduction of this new product complements our existing portfolio of post-tensioning, geotechnical and stay cable construction technologies.

Technology overview

BBR H Bar is a high carbon, hot rolled bar – which means the bar and thread are shaped using the hot-rolling process – and subsequently stress relieved.

A unique characteristic of the BBR H Bar System is the very coarse and continuous thread, which allows the bars to be cut at any desirable place and to be connected together by using system couplers. The robust design of the BBR H Bar also reduces the risk of thread damage during handling. The flat-sided thread geometry, contributes to the self-cleaning process of the bar – any dirt does not bond to the bar and simply falls off during handling. This is a significant characteristic which distinguishes the BBR H Bar range from other solutions available on the market, where the thread might become damaged in harsh construction site conditions, thus making threading impossible.



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Project experience

BBR VT International supplied 32mm diameter H930 Bars and related accessories for the Light Rail Transit project from Jakarta to Bekasi, Bogor and Depok in Indonesia. This project is of significant value for commuters traveling to-and-from Jakarta and will contribute to better development of surrounding cities, as well improving the quality of life for millions of citizens by reducing congestion in the Indonesian capital city.

The 108.7km long elevated double-decked U-girder structure is divided into seven sections and is being constructed under supervision of the Provincial Government of Jakarta. The main contractor is PT. Adhi Karya (Persero) Tbk and the structure has been designed by Systra. The main contractor has chosen precast segmental construction methodology and BBR H Bars are being used to fix the superstructure to the bridge pier heads.

Prestress Construction Indonesia (PCI), the BBR Network Member in Indonesia, was responsible for bar installation, supply of stressing equipment and stressing the bars.

Tambok Lamhot David, ST, MM, who is in charge of the project from the PCI side said: "We are pleased to be able to use the newly introduced BBR H Bars and believe this extension to the product range will help us to strengthen the local BBR presence and enable us to offer more complex solutions for our clients. We have especially valued the support of BBR VT International during the very demanding and thorough quality control procedures."

Testing & quality control

As a part of the service provided, BBR VT International carried out project-specific tensile tests of the BBR H Bar system, as well as stringent quality control according to the project specification. The entire quality process was in line with our own internal BBR E-Trace procedures and full traceability has been assured. ●

1 Visualization of the BBR H Bar and related accessories.
2 BBR Network Member PCI is using BBR H Bars for fixing the superstructure to the pier heads.
3 Pallets of H930 BBR Bars ready for dispatch and awaiting collection.
4 The newly introduced BBR H Bar is being used in the construction of the elevated sections of the new LRT system in Indonesia.
5 Final quality control of the BBR H Bar consignment at the BBR logistics center.

TECHNIQUES

Evolution & application of external post-tensioning systems

STRENGTH FROM EXTERNAL FORCES

Today, external post-tensioning is mostly applied for the prestressing of bridges, wind towers, precast segmental construction and repair and strengthening works of all kind of structures. It is easy to imagine that this is a new concept when, in fact, the practice was first introduced in the 1920s. Dr Behzad Manshadi, BBR VT International's Head of Technology, presents a historical overview of the technology and its more recent applications.

German engineer Karl Dischinger pioneered the use of external post-tensioning for bridge construction. The earliest application of external prestressing was carried out in 1928 on a bridge over the River Saale. There were lessons to be learnt – after this and two subsequent projects – about plastic deformation of concrete due to creep and shrinkage, as well as the need for adequate corrosion protection to be applied to the tendons.

The concept of external prestressing was further developed following World War 2 – the devastation of which necessitated reconstruction of many bridges, particularly in Belgium, France and Germany. Distinguished Belgian engineer Gustave Magnel is believed to have been the first to test the concept of using deviators to deflect the external tendons. He reported in 1954 on the use of external prestressing for a number of bridges in Belgium, indicating that the technique was gaining in acceptance. Since then, other eminent names – such as Fritz Leonhardt, Philippe Lecoq and, most recently, Michel Virlogeux – have been associated with the development of techniques for the external post-tensioning of bridges.

Definition of external post-tensioning

For absolute clarity, it should be explained that external post-tensioning consists of tendons placed on the outer surface of structures – as opposed to internal post-tensioning tendons which are installed in formwork prior to pouring concrete. External post-tensioning allows access for maintenance and replacement and is therefore the solution of choice for bridge enhancements and refurbishments, but can also be applied to many other types of structure. For example, external post-tensioning can be applied to buildings or architecturally innovative structures, both old and new, to increase structural strength.

Benefits of external unbonded PT

- Can be combined with broad range of construction materials including concrete, steel, masonry and timber.
- Monitoring, inspection and maintenance can be easily carried out.
- Option for restressing, destressing and replacing external tendons.
- Improved concrete placing and tendon installation.

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How is external PT applied?

External post-tensioning tendons are placed outside of the cross-section of the structure and transfer the forces to the structure only at the anchorages and deviators. They are not bonded to the structure.

While the anchorages are mounted on or within the structure at either end of a tendon and permit stressing, deviators – made of concrete, steel, HDPE or equivalent materials – are installed at points along the length of the structure. They provide the hold-down points necessary to achieve the tendon profile required to resist the flexural and shear forces, as well as deformations induced by external loading onto the structure.

Benefits of external PT

There are many advantages to the application of external post-tensioning not least of which is its instant 'active' strengthening effect. As a solution, it can be applied to a range of materials including concrete, steel, masonry and timber.

Subsequent monitoring, inspection and maintenance – including restressing, destressing and tendon replacement – are all possible with external PT. Meanwhile, on site concrete placement and tendon installation is improved because the two operations are carried out independently of each other.

Additional benefits in the case of bridge strengthening and rehabilitation include the low weight of the additional components, speed and short duration of construction, low costs involved – and minimal disruption to traffic.

Latest BBR Network technology

Thanks to the enterprising engineers of yesteryear, we have had the opportunity to improve and refine both the technology and techniques we offer.

The BBR Network offers a range of post-tensioning technology to suit all external applications. Our latest European approved BBR VT CONA CME external, CONA CMM monostrand and CONA CMB band unbonded post-tensioning systems have been tested to criteria in excess of the requirements of national and international codes.

Corrosion protection is also a priority and our external systems can be grouted, greased or waxed in continuously extruded HDPE ducts and can also be double sheathed and greased or waxed.

BBR VT CONA CMX post-tensioning systems promote a hugely versatile range of uses which, when combined with the technical skills of the BBR Network, can play a significant role in even the most challenging of construction projects. ●

1 The roof for the Orlen Arena in Płock, Poland was created by using the BBR VT CONA CME external post-tensioning system which permitted the 85m span to be achieved. Other advantages of taking the external post-tensioning approach were that it created a light structure for the long span roof and no temporary supports or scaffolding were needed.

2 Typical layout of an externally post-tensioned box girder bridge – seen here is the project, carried out by BBR Network Member Spanstaal-Ballast Nedam to strengthen Deventer Bridge at Overijssel in the Netherlands.

3 The 'new' bridge over the River Meuse in Belgium, one of the first post-WW2 bridges to be constructed using external post-tensioning. Distinguished Belgian engineer Gustave Magnel was a consultant engineer for the project. Photograph: Viarja, CC BY-SA 4.0, via Wikimedia Commons.

4 External post-tensioning is also applied for realization of architecturally innovative structures, such as the Bergisel Ski Jump in Innsbrück, Austria. Here, external PT tendons were installed to fasten the tower head steel structure to the concrete shaft and for the in-run bridge.

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INSIGHT

Developing new material combinations & techniques

MATERIAL INNOVATIONS

Innovations in the field of construction materials technology and techniques – like, in fact, the development of BBR post-tensioning systems – are often driven by compelling events or situations. Meanwhile, as BBR VT International's Head of Technology, Dr Behzad Manshadi recounts, their realization and application ultimately results from a highly collaborative approach.

The situation that BBR's three founders were presented with, back in 1944, was wartime materials shortages. They were all qualified engineers and first met during their studies in the 1930s at ETH, the Swiss Federal Institute of Technology in Zürich. Their partnership was formed to develop products which would minimize the materials needed for concrete construction. Financial support came from an employer who encouraged the development of their initiatives with investment.
This combination of innovation and investment resulted in the small post-tensioned beam – and later grew into the versatile range of BBR technology which today is applied to a wide variety of projects around the world.

Researching structural glass

So where could the future lead us? One of the research projects recently supported by BBR VT International was at the EPFL (École Polytechnique Fédérale de Lausanne) in Switzerland and involves post-tensioned glass.
The 'Atlas' project has resulted in the production of an aesthetically attractive glass bench which has proved that glass can be transformed into an ultra-resistant material. The bench was created using three meter long glass beams, post-tensioned with steel tendons which are anchored in the beam ends and bonded along the glass edges. The bending resistance of the beams is increased by prestressing. This means that, in the case of failure of the glass, the PT tendons take up the tensile forces making the glass more ductile and able to sustain significant deformations. If this system were to be used for a glass roof, for example, it would prevent the structure from collapsing immediately without warning – ensuring the safety of people in or around the building.

Setting new records in NZ

Other innovations on the global construction scene have included the PRESSS (PREcast Seismic Structural System) concept which involves post-tensioning and is suited to precast concrete structures. Originating in California, this concept combines unbonded post-tensioning and specially designed ductile joints to allow a controlled rocking mechanism that returns the building to upright without significant structural damage, even after a major seismic event.
Having assisted with materials, equipment and construction advice to the teams planning the research, BBR Contech understood the technology and construction detailing – offering clients confidence in the company's ability to deliver such a project.
In fact, BBR Contech participated in the pioneering use in New Zealand of the PRESSS system – for the award-winning Alan MacDiarmid Building, as reported in CONNÆCT 2010.
Subsequently, the Pres-Lam system was developed – a prestressed laminated timber building system – to offer a cost-effective and sustainable alternative to heavier, non-renewable, concrete and steel framing.
BBR Contech also provided post-tensioning services for the first Pres-Lam building to be constructed after the 2010-11 earthquakes in Christchurch and has participated in the construction of the world's largest Pres-Lam building – Trimble Navigation's new Christchurch office. By the time CONNÆCT 2018 is published, BBR Contech will have started work on their 18th structure using PRESSS or Pres-Lam type systems.

Extending material lifecycle

Meanwhile, in Switzerland a pilot project based on the use of wood from deciduous trees is also underway. The aim of this project is to use this wood – normally sold as heating pellets – more economically and sustainably by first incorporating it into structures.
BBR Network Member Stahlton worked with the Institute of Structural Engineering at the ETH in Zurich on the creation of a four storey building which features laminated beams connected to columns by a single monostrand post-tensioning tendon, along with composite beech wood panels and concrete slabs. The building will be monitored over its lifetime for forces, deformations, vibrations, temperature and humidity. Meanwhile, the structure is serving as offices, as well as a pilot installation.

Quest for the best

Tomorrow's construction engineering technology and techniques may have their roots in compelling events – or in sheer engineering curiosity. However, one thing is certain – the BBR Network will always be receptive to new ideas and mobilizing to offer its customers increasingly smarter solutions. With our Swiss heritage and as engineers, it's part of our DNA to constantly strive for improvement in every aspect of our work. ●

1 By combining her know-how with that of EPFL architect Alexander Wolhoff, Jagoda Cupać, doctor in civil engineering – pictured here sitting on the Atlas bench – has proven that glass can be transformed into an ultra-resistant material. Photograph courtesy of Alexander Wolhoff.
2 Assembly of one of the three post-tensioned glass beams for the Atlas project in the workshop of Félix Constructions which specializes in the construction of glass façades. Photographs courtesy of Jagoda Cupać.
3 BBR Contech participated in the construction of the world's largest building to use the Pres-Lam system – PRESSS technology, in conjunction with LVL (laminated veneer lumber) – for Trimble Navigation's new Christchurch office. Photograph Conor Boyd, courtesy of PTL Structural Consultants.
4 In Switzerland, the Institute of Structural Engineering at the ETH in Zurich now contains The House of Natural Resources, a four storey building constructed with laminated beams connected to columns only by one monostrand post-tensioning tendon, along with composite beech wood panels and concrete slabs.

3


4

Jan Piekarski, Chairman of the Supervisory Board at BBR Polska, the BBR Network Member for Poland, shares his roadmap for success

PASSION & PERSISTENCE

Thinking back to the very beginning of BBR Polska, almost 25 years ago, the tireless pioneering spirit of those early days still amazes me. The success of our efforts today goes to prove that, when you know you have the best solution, you can change minds and the marketplace through your own passion, along with sheer persistence and determination, combined with some well-applied mentorship.

Back then in the early 1990s, Poland was just hitting the road to transformation and everything around us was changing, including our professional environment, that of the civil engineering industry.

My focus had always been steel structures which traditionally were the strength of Polish construction companies. Yes, concrete structures were popular too – but strangely enough, not post-tensioned ones. While there were several reasons for this, the fact remained that, despite some remarkable achievements with post-tensioning in the past, the market for PT structures was practically non-existent.

You might say that this was an ideal situation for the introduction of new technologies, but at that time the mental resistance was immense and even the leading personalities in our field displayed a deep-rooted disbelief that post-tensioned bridge structures could ever be constructed on a large scale in Poland.

Early in my engineering career, solving technical problems was my sole interest rather than looking for opportunities to promote and sell them to clients. I did not have the relevant education in marketing or any natural talent for it – and had never felt attracted to working in that area.

However, my passion for bringing and implementing modern PT technologies and innovative construction methods within the Polish market was very strong indeed. After putting my misgivings about performing marketing tasks aside and equipping myself with all the usual promotional materials, I set off on a nationwide tour visiting clients, designers and contractors to convince them of the technical and economic advantages of BBR solutions. The hardest experience to bear was being confronted with skepticism, lack of understanding or even reluctance of the people with whom I met. Some people repeatedly postponed our meeting and eventually just declined it altogether, while others overtly began to consult their watches after only a few minutes of conversation. It will be no surprise to hear that I frequently felt discouraged during this period, had thoughts about giving up the whole innovation – and even considered returning to a 'normal' job.

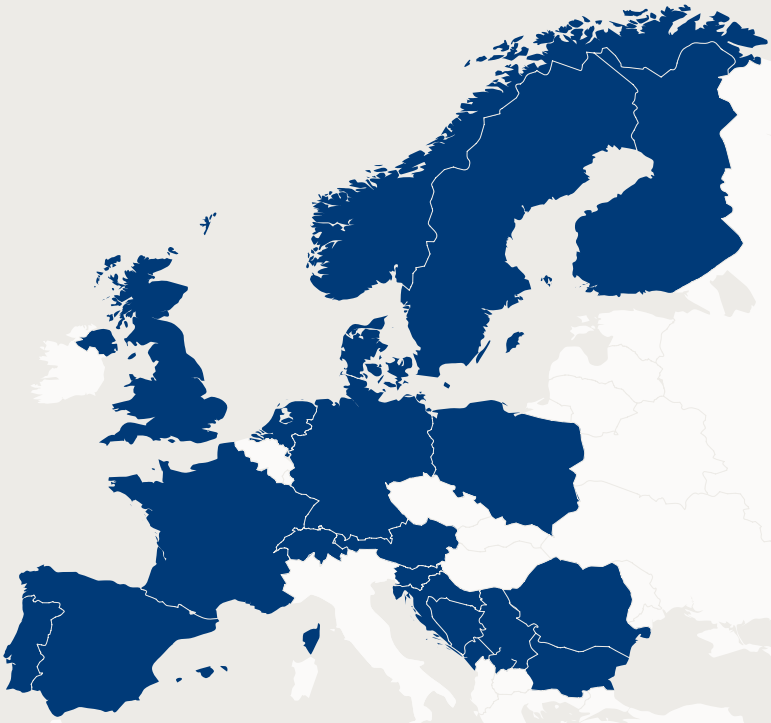
Meanwhile, the young company had to somehow make its living and – despite my Swiss bosses, headed by Bruno Valsangiacomo, not urging me or putting me under financial pressure – my ambition was badly hurt. So, rather than hiring further employees, I kept trying to do the job myself – working more intensely than ever.

Make no mistake, this could not have happened without the help of external and internal influences. Externally, strength and encouragement came from Bruno's positive attitude – which was not just based on the optimism of a visionary, but also founded on careful professional evaluation. On the technical side, Fritz Speck was the best support anyone could wish for.

Internally, it was my fundamental belief that the direction we were taking was correct and my strong conviction, with the Polish system undergoing such intense transformation, that contemporary construction engineering would be greatly enhanced by our modern post-tensioning technology.

From time-to-time, pioneering projects came along – like the arch bridge in Ostrołęka, suspended with BBR DINA stay cables – but real success still lay far ahead. The significant turning point came only four years after BBR Polska had been established, when we were entrusted with the design of the superstructure, balanced free cantilever construction and post-tensioning works for a modern bridge over the Odra river in Opole. Today, at 400m long, we would describe this structure as a rather small bridge – but then, it was a milestone in Polish bridge construction history. Its inauguration opened the Polish market for post-tensioned structures – now they dominate the market.

With the benefit of hindsight, I can honestly say that when you passionately believe something is right – and this is reinforced by experienced professionals who perhaps have the advantage of distance too – do not give up. Persistence and determination, backed by sound mentorship, is a recipe that works every time – and the personal satisfaction is incalculable! ●



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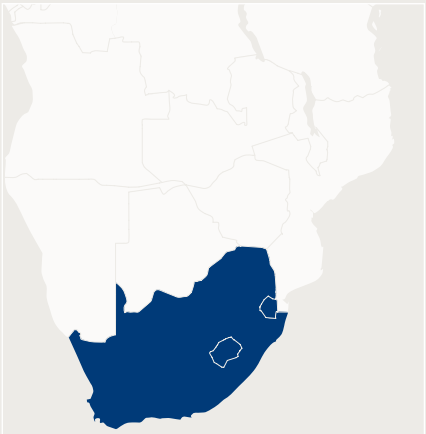

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