CONNÆCT

THE MAGAZINE OF THE GLOBAL BBR NETWORK OF EXPERTS

Edition 11 | 2017

SIGNATURES ON THE SKYLINE

Six landmark tower projects in progress

CREATING HOLISTIC VALUE

BBR Network's comprehensive approach

METRO RAIL REVIVAL

BBR technology at heart of six metro rail schemes

EUROPE'S WIDEST AQUEDUCT

Creation of aqueduct allows motorway beneath

NEW GENERATION OF MONOSTRAND PT

Advanced system offers 'world first' benefit

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); KB Spennteknikk AS (Norway), BBR Polska z o.o. (Poland) and KB Vorspann-Technik GmbH (Germany) – all three are members of KB Group (Norway); BBR Pretensados y Tecnicas Especiales PTE, S.L. (Spain), a member of the FCC Group (Spain).

NETWORKING WORLD CLASS SOLUTIONS

When the finest engineers in the world work together, you can be sure the structures and solutions they create are unsurpassable. Teamwork has long been at the core of everything we do and the combination of expertize and technology within the BBR Network is more compelling than ever. In this edition of CONNÆCT, you will read about projects and services which reflect the latest international engineering best practice while offering local customers unbeatable all round value.

Look at urban transit networks, for example, where the BBR Network's skills in precast segmental and allied post-tensioned concrete construction is contributing to major schemes in five countries. The wealth of experience we have accumulated in these techniques has been shared through our Annual Global BBR Conference, at seminars, in our literature – and through personal contact.

After reading the Portfolio section, it will also become clear that the market for post-tensioned buildings is gathering further momentum. Owners and developers continue to embrace the benefits offered by post-tensioning to create uniquely designed landmark structures with large column-free spaces – as well as the revenue enhancing ability to create an extra floor. There are more than six high rise projects, developments involving the creation of five new communities and many commercial buildings currently in progress.

On the stay cable scene, construction work for several new bridges is underway and we can look forward to reading more about these in future editions. Meanwhile, in the Technology section, as well as learning about the new BBR VT CONA CMM Single S2 system there is a feature on the durability – recently proven yet again – of our stay cable technology.

Please also take time to marvel at ambitious projects, such as the Aqueduct Vechtzicht in the Netherlands and strengthening of Hazelmere Dam in South Africa with the world's largest rock anchors – both realized with leading edge BBR technology and know-how.

The BBR Network is continuing to grow in many ways – with new members, new technology, ever increasing capability – and with many new projects. We thank our customers for trusting us with their business and also for the valuable feedback they provide in order that we can continuously improve the technology and services we offer them.

Marcel Poser
Chairman, BBR VT International Ltd

José Manuel Illescas
Vice Chairman, BBR VT International Ltd

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BBR DIRECTORY

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SOURCES AND REFERENCES
Front cover image: The BBR Network is currently working on more than six landmark skyscrapers around the world – each creating their own new 'Signatures on the skyline'. See pages 42-46 for the full story.

Portfolio section
Metro rail revival: www.itdp.org, www.mymrt.com.my, www.spad.gov.my, en.wikipedia.org, www.fastmetroriyadh.com, www.metro-rennes-metropole.fr
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Vegetable based inks have been used and 85% of all waste associated with this product has been recycled.

TALKING BBR

06 BUSINESS REVIEW
BBR VT International CEO Antonio Caballero outlines the BBR Network's approach of holistic value creation while reviewing business and looking to the future

09 PEOPLE, PLACES & THINGS
special extended coverage of BBR Network news & events from around the globe

12 CONFERENCE NOTES
report on the 2016 BBR Annual Global Conference in Cape Town, South Africa, by Cecile Kopp & Thomas Richli

14 PERSPECTIVE
Sturla Rambjør from leading Norwegian consulting engineering practice, Aas-Jakobsen, shares his passion for design, people and PT

BUSINESS REVIEW

Reflections & outlook from BBR VT International's CEO

CREATING HOLISTIC VALUE

One of today's most talked about subjects is value creation, how this might be achieved and, indeed, who this benefits. BBR VT International Ltd's CEO Antonio Caballero explains BBR's approach to creating value and highlights the importance of a holistic approach.

Classically, when 'value creation' is discussed, it usually refers to 'shareholder value' and the financial return on their investment. Within the BBR Network, our ethos is one of creating 'stakeholder' value – and this also embraces all of those who experience our technology or expertize, both now and in the future.

Let me be clear from the start, 'cost' is not the same as 'value'. Cost is usually expressed in hard currency, while value can be expressed, perceived and evaluated in a different way. Value is about achieving goals which extend beyond the budget allocated to a project – and, in the construction arena, could even attach to environmental objectives, buildability issues or, indeed, the building experience as a whole.

We have always been focused on the delivery of more than just construction components or individual services – the true value of our technology and expertize is realized by adopting an approach which is sufficiently flexible and considers all aspects of a project. In this respect, early discussions with owners, developers or main contractors are vital to ensuring that our contribution can help to create the best all round value for the customer – and other stakeholders too.

Personalized service

One of the elements appreciated by customers is the personalized service offered by all BBR Network Members. Each Member takes great care and the time to develop an understanding of each customer and their business, as well as seeking and listening to feedback. This ensures the information and service provided are appropriate, cost-effective and timely. Essentially, we become an integral part of a customer's ecosystem – and, vice versa, they become part of ours.

We can clearly see this in action in the feature, on pages 56-58, about the post-tensioned ground slabs constructed for Westfield and Naylor Love – during relationships which began many years ago – by BBR Network Members SRG in Australia and BBR Contech in New Zealand respectively. Mutually beneficial relationships like this rely on the highest level of understanding and high quality of delivery.

The bottom line is that we want BBR Network customers to be confident that they have produced the best possible solution for their scheme.

Focus on best value

Take the buildings market place, for example. For years, developers have been constructing post-tensioned buildings in the Far East and Australia, while in Europe it is a less commonly used construction technique. The added value of post-tensioning technologies to the building's owner goes way beyond a simple cost reduction. For example, it offers the reward of additional rent from an extra floor – only achievable by building with post-tensioned floor slabs – which will boost their return on investment. Their investment is also future-proofed because of the flexibility – and usability – afforded by the large column-free floor spans made possible with post-tensioning. For example, in the case of a rented property, a new tenant will have more options for arranging the space freely with fewer limitations being imposed by structural columns or walls.

In fact, flexibility is an important aspect of the service we provide – and this is reflected not only in the approach of our people, but also in our range of technology which has been developed to support many different applications.

Recognizing that there is an increasing need for best value, also for BBR Network Members and contractors, new optimized post-tensioning systems tailored to the building sector are being developed. The advantages will accrue not just in terms of pure cost, but also in terms of installation which will also be optimized using e-technologies. See page 82 for further details on our new BBR VT CONA CMM Single S2 system.

Our whole approach within the BBR Network is to remain one step ahead in the creation of technology which improves the performance of structures. At BBR Headquarters, among other developments, we are currently working on a range of structural accessories which will also enhance the scope of the service we are able to provide to customers. ➤

> "Our commitment to ensuring that teams within the BBR Network are able to deliver the highest level of technological support and services stretches back decades. When we came up with the strapline "The Global BBR Network of Experts", we really meant what we said."

Value chain expertize

Our commitment to ensuring that teams within the BBR Network are able to deliver the highest level of technological support and services stretches back decades. When we came up with the strapline "The Global BBR Network of Experts", we really meant what we said.

As well as the Annual Global BBR Conference, the level of training carried out each year is evidence of this continuing commitment – and a contractual requirement for BBR Network Members to have regular formal training ensures maximum attendance. Meanwhile, individual certification at the end of the sessions ensures information has been understood and that standards are maintained.

The BBR Network is essentially one big global family within which experience and expertize is readily shared. BBR Members regularly join forces synergistically to win and to execute projects. For instance, engineers from BBR Polska are currently supporting our newest BBR Network Member, PCI in Indonesia, in the installation of stay cables for the new Sei Dareh Bridge, while FCC and SRG have been working together on the Doha Metro in Qatar and SRG and SSL Africa have collaborated on the project to strengthen the Hazelmere Dam in Durban, South Africa. There is always an open dialogue between Members somewhere in the world and this is something we facilitate and encourage.

Increasing reach

As mentioned, in the last 12 months, we have increased our presence in Asia by welcoming a new BBR Network Member in Indonesia. Over the next year, we are also expecting to announce further new Members in other parts of the globe.

The process of appointing a new BBR Network Member is based on the highest standards of both business practice and technological capability. We then provide training on BBR technology and techniques and opportunities for networking with other Members.

Our plan is to continue to grow geographically, in fact we regard our wide global coverage as part of the value of the service we provide. Often our customers are working with an international team of professional partners – many of whom we have worked with before and who already know the high level of quality input the BBR Network is capable of delivering. In other cases, we find ourselves bringing latest European Approved technology and standards to new local customers and teams.

Outlook

During the past year, we have seen confirmation of the general increase in construction industry activity and expenditure which was initiated in 2014. Markets in Europe remain highly competitive and the Asia Pacific region continues to offer excellent growth potential. Despite some hot competition, BBR Network Members have succeeded in acquiring many landmark projects worldwide – such as for the precast segmental construction of the new Rennes Metro Line B in France and of a 1,200m elevated rail viaduct in Jakarta, Indonesia, as well as several new high rise developments in the Philippines and the Tripla urban redevelopment project in Helsinki, Finland, while continuing to work on other schemes such as the Mersey Gateway Bridge in the UK and the Riyadh Metro in Saudi Arabia.

In the immediate to medium term, our plans include the rollout of the first phase of a new global supply chain configuration which will enhance the competitiveness of BBR technology still further, as well as promoting even greater flexibility of customer service. Of course, we will also be introducing our first range of additional technologies which will raise and diversify future revenue opportunities for BBR Network Members. Alongside these objectives, our efforts to extend our presence around the globe, particularly in new markets, will continue, as will our day-to-day business – and our immense passion for customer support, satisfaction and success.

In the longer term, we see the BBR Network remaining as a key player in the specialized engineering construction field. The emphasis for us will be on implementing strategies and new technologies to enhance competitiveness in products and modernizing services. We will be widening our offering with modern digital tools in the arena of new construction and existing structures while reinforcing our presence in new markets.

The objective of most businesses is to make profits for its shareholders, within the BBR Network we believe that by taking a holistic value creation approach – which includes fulfilling corporate financial targets – you can deliver so very much more. ●

NEWS HIGHLIGHTS

Events & news from around the BBR Network

PEOPLE, PLACES & THINGS

Throughout the BBR Network, the last 12 months have been packed with many newsworthy activities and developments. Presented in an especially extended section this time around, is a brief selection of news items from around the globe.

1

New BBR Network Member in Indonesia

In the last year, we were delighted to welcome a new BBR Network Member – PT. Prestress Construction Indonesia (PCI). PCI, established in 2002, was the first company in Indonesia to specialize in post-tensioned construction. As a pioneer, PCI is committed to providing the best performance and continuous innovation. The company's business is divided into three segments – specialist contracting, import-export services and property development. All segments are integrated, enabling PCI to provide end-to-end services for its customers. For more information, see page 16 or visit www.pcindonesia.net.

BBR marketing material

A range of BBR flyers, covering systems within the BBR VT CONA CMX post-tensioning range and BBR stay cable technologies, have been produced and are downloadable from the BBR website. Developed for easy reference, these can also be obtained from local BBR Network Members who will be able to provide further specific local information too. In addition, we have internationalized our marketing material making the BBR Network website, BBR VT CONA CMX and HiAm CONA brochures available in four global languages – English, French, German and Spanish. ➤

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Asia-Pacific BBR Stay Cable & PT Seminar, Malaysia

As part of BBR VT International's commitment to providing continuous training for BBR Network Members, in June 2016 Behzad Manshadi and Thomas Richli from BBR HQ ran an exciting stay cable and post-tensioning seminar in Kuala Lumpur. The 35 delegates from across the Asian region learnt more about BBR's latest HiAm CONA stay cable technology and applications, as well as having the opportunity to take part in a hands-on session assembling anchorage sets. There were also modules on the European Approved CONA CMX PT range, EN grouting standards and supply chain in Asia, as well as a refresher on the use of BBR E-Trace with all its new features. As is customary, the entire seminar concluded with a workshop and certification ceremony.

Voon Yok Lin, MD, and Chang Chee Cheong, GM, of Malaysia-based **BBR Construction Systems (M) Sdn Bhd**, who kindly hosted the training session, commented: "This was an excellent opportunity for our delegates to learn more and brush up on existing skills, particularly as there are several stay cable projects underway in this region – with still more potentially on the horizon. Knowledge sharing within the BBR Network is always strong – whether during an international site visit or in the class or conference room."

BBR Stay Cable & Bridge Bearings Seminar, Indonesia

In early September, some 130 delegates gathered in Jakarta to attend the Stay Cable & Bridge Bearings Seminar organized by BBR Network Member **PT. Prestress Construction Indonesia** in collaboration with the Ministry of Public Works.

BBR VT International CEO Antonio Caballero presented a history of stay cable technology from its origins, right up to modern stay cable systems – including, of course, BBR's own history and achievements in the stay cable technology field. There then followed a more in depth presentation and technical comparison between existing stay cable recommendations (*fib* and PTI) in terms of system testing and acceptance criteria regarding fatigue, service and ultimate load and corrosion protection levels.

The audience also learnt about technical changes and assessment criteria – relating to stay and extradosed cable systems and saddle systems – which may be introduced in the future, but were currently being discussed within the stay cable technical committees.

BBR Adria TV interview

Last September, **BBR Adria** CEO, Želimir Bodiroga took the opportunity of participating in Bosnia's Naša TV program 'Poslovni Kompas' – Business Compass – which involved an interview with program editor Miljenko Buhač. Viewers of the program which airs at 8pm every Wednesday evening were able to hear about BBR Adria's business, the history of BBR and the importance of quality construction technology. During the 25 minute interview, there were also opportunities to mention BBR Adria's 20th Anniversary, the high quality and standards of Swiss technology and the company's work on major projects such as Zagreb Arena and Zagreb Airport's New Passenger Terminal. This edition of the program can be viewed on YouTube.

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1 A selection from the range of BBR flyers, covering systems within the BBR VT CONA CMX post-tensioning range and BBR stay cable technologies, which can be downloaded from the BBR website or available locally from BBR Network Members.
2 Jakarta, Indonesia – home to the newest BBR Network Member, PT. Prestress Construction Indonesia (PCI).
3 Asia Pacific Stay Cable & PT Seminar, Malaysia – delegates from across the Asian region learnt more about BBR's latest HiAm CONA stay cable technology and applications.
4 BBR Contech MD Paul Wymer presents a commemorative certificate to founding employee Rob Robinson who officially opened their new offices. Rob joined the company in 1963 and served for 47 years before retiring.
5 Želimir Bodiroga being interviewed by Miljenko Buhač for Bosnia's Naša TV program 'Poslovni Kompas' – Business Compass.
6 Delegates conducted hands-on grouting tests during the three day European Project Managers Workshop in Warsaw, Poland.
7 A screen grab from the BBR Project Finder which has been upgraded and optimized.
8 BBR VT International CEO, Antonio Caballero (left) with the PCI team at the Stay Cable & Bridge Bearings Seminar held in Indonesia in collaboration with the Ministry of Public Works.

BBR European Project Managers Workshop

Around 20 delegates attended the very lively and informative session held in October 2016 in the Polish capital, Warsaw. As well as updates on BBR post-tensioning and stay cable technology, delegates were able to conduct hands-on grouting tests during a special grouting seminar. To appreciate the practical application of BBR technologies, three special guests gave technical presentations on recent projects. Concluding proceedings on this three day session was an interactive innovation workshop where those present were challenged to focus on specific aspects of MRR. All-in-all, it was a highly successful event and thanks go to the team at BBR Polska for hosting and providing facilities. Some highlights of the BBR Grouting Seminar can be seen on YouTube.

BBR Project Finder – upgraded & optimized

BBR Project Finder can now be experienced on smaller screen and touch devices like smart phones or tablets. The design and layout adapts to every screen size – from small mobile phones to large desktop computer screens. Meanwhile, further projects have been added – more than doubling the number of projects available in the BBR Project Finder and some smaller design improvements have also been implemented. The Project Finder is an important networking resource and part of an international archive of BBR projects which can be used to support individual marketing and tendering for new work.

BBR PT ground slab for new offices

On 4th November 2016, the new headquarters building of New Zealand-based **BBR Contech** was officially opened. Having completed over 2.5 million square meters of post-tensioned warehouse floor slabs for customers, the BBR team was keen to install one of their own. Their new 1,500m² warehouse with its post-tensioned slab means that they too can enjoy the benefits – and also be able to showcase BBR technology when customers visit. The entire team is loving their new home which meets New Zealand Green Star sustainability standards for building design and functionality. ●

ANNUAL BBR GLOBAL CONFERENCE, **CAPE TOWN, SOUTH AFRICA**

Business and cultural exchange

CONFERENCE NOTES

Some years ago, Cecile Kopp – Administration & Senior Accounting Assistant at BBR HQ – courageously took on the challenge of making the complex arrangements for the BBR Network's premier event of the year. For this edition of CONNÆCT, she offers an insight into conference management and impressions of the 2016 Annual BBR Global Conference, while Thomas Richli provides an overview of the business sessions.

This annual event has become an important networking meeting for the growing BBR Network family and one of the key criteria is that it should be memorable. Thus, the behind-the-scenes planning and organization must be thorough – and include contingency plans in case an element of the agenda suddenly became unavailable due, for example, to adverse weather conditions.

Each year, we carefully examine potential destinations, taking into account such factors as ease of travel for BBR Network Members, the venue's ability to handle groups, quality of catering – especially for our Gala Dinner, local climate and availability of culturally-based activities. The latter are an important part of our agenda to promote cultural understanding.

Arrival in Cape Town

Our first shared experience this year was a trip to Table Mountain. After a short drive, we found ourselves tightly squeezed into a cable car and heading steeply upwards towards the top of the mountain. We were surprised that the windows were open and the cabin turned 360° while moving. On the panoramic terrace at the top, we were welcomed with cool drinks and African snacks – and a truly breathtaking view. What a marvelous place to celebrate our reunion.

Business matters

Antonio Caballero, CEO of BBR VT, launched the formal part of the conference. He mapped out BBR's plan of new initiatives on the technology and supply chain front. Thomas Richli provided an overview about the Network's latest changes and key business statistics. In 2015, the BBR Network increased its sales and strand tonnage volume, as well as related construction engineering revenue.

Details about BBR's future supply chain strategy and moves were presented by Josef Lamprecht. Cezary Sternicki focused on the geotechnical and structural accessories' market and how BBR can tackle them. BBR's marketing team, represented by Juan Maier, emphasized how important the BBR brands are and what paths the Network should strike. He also highlighted the latest promotional tools and BBR's activities in digital marketing.

1 Delegates at the 2016 Annual Global BBR Conference pose for a photograph at the Cape of Good Hope.
2 Conference breakout sessions – where BBR Network Member teams discussed topical business issues and future initiatives.
3 Thomas Heubel celebrates the 2016 BBR Network Project of the Year Award won by KB VT (Austria) for their highly innovative work in providing temporary stay cables for Tamina Bridge, Switzerland. LtoR: Herma & Hans Veerman (Ballast Nedam, Netherlands), Thomas Heubel (KB VT, Austria), Margret Rupp and Paul Wymer (BBR Contech, New Zealand).
4 This year, a Special Lifetime Achievement Award was presented to a well-known personality within the BBR Network – Bob Freedman, pictured here with conference hostess, Giselle and Thomas Richli on the left. Over the last 50-or-so years, Bob has been responsible for the introduction – as well as much of the subsequent continued growth – of the BBR business in Australia.
5 The BBR Network team was challenged to a wine blending competition at the Backsberg Estate.

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Jürg Däniker from Swiss-based Stahlton and Behzad Manshadi provided an insight into the benefits of Electrically Isolated Tendons (EIT) and the market. The Swiss, with their 27,000 bridges, have a long track record of using EIT which offers not only increased corrosion protection but also constant monitoring to the client. Behzad also showcased BBR's new developments in the slab and external post-tensioning arenas – both growing areas.

The afternoon session started with a look at South East Europe when Želimir Bodiroga from BBR Adria presented the company's impressive track record over the last two decades. Also, he outlined BBR Adria's key role in convincing the client to transform Zagreb's new airport terminal into a post-tensioned design.

Another highlight was the talk from Mark Sinclair, SRG Limited, about Australia's largest building project since the year 2000 – Barangaroo Development, Sydney. More than 2,500t of post-tensioning strand is being installed using a wide range of technologies. He illustrated the benefits of SRG's strategic alliance with a leading developer, as well as SRG's value engineering drive including its new temporary movement joint product.

The conference closed with a case study about the Rzeszow Stay Cable Bridge presented by Jan Piekarski and Tomasz Jendernal, both from BBR Polska. The stay cable work for Poland's new landmark structure was executed in record time and with the highest efficiency which could only be achieved because of BBR Polska's enduring expertise and experience in the stay cable field.

Getting the right blend

South Africa is well-known for its wine culture, so it was fitting to accept an invitation from the Backsberg Estate – with its lovely gardens and vineyards – for a special wine blending experience. In a traditional cellar with big old oak barrels, we were challenged to replicate a well-balanced red wine cuvée of the house. Of course, there was much laughter at the expressions on the faces of the judges as they assessed our best blending efforts. Congratulations go to Maria Thunberg and the Scandinavian team who came up with a challenge-winning blend.

Gala dinner

Our restaurant for the Gala night was just a few steps from the hotel. The DJ played cool songs and we were served 'BBR blue' cocktail drinks. The Annual BBR Network Awards were presented during the evening – accompanied, for the first time, by videos showing the shortlisted projects.

This year, thanks to our kind sponsors – BBR Component Manufacturers and BBR VT International – we raised funds for local charity, iThemba Labantu which means hope for the people. The organization focuses on creating a safe space for children and adults to learn, develop and receive free health care as well as psychological support.

There is something very special about working with the BBR team to create the annual conference package. As organizer, it's the most satisfying feeling in the world when, on the last night, you see that everyone is still talking animatedly in the bar until very late – then you know you have facilitated something of value. With many exciting plans in place, I am now looking forward to making our 2017 Annual BBR Global Conference even more memorable. ●

2016 BBR AWARD WINNERS

BBR NETWORK PROJECT OF THE YEAR

Temporary stay cables for Tamina Bridge, Switzerland executed by KB VT, Austria

BEST ARTICLE AWARD

- **Winner:** BBR Polska (Poland)
  Title: Voyage of discovery (Rzeszow Bridge)
- **Runner up:** BBR Malaysia (Malaysia)
- **Title:** Longest multiple span balanced cantilever bridge (Sadong River Bridge)
- **Highly commended:** SRG (Australia)
  Title: Innovative water tank solution (Onslow Tanks)

BEST PHOTOGRAPHY AWARD

- **Joint winners:** KB Spennteknikk (Norway) & BBR Contech (New Zealand)
  Titles: Optimized bridge construction (Gulli Bridge) & Going with the flow (Otaio Rail Bridge)
- **Highly commended:** BBR Adria (Croatia)
  Title: Gateway to South Eastern Europe (New Passenger Terminal Zagreb International Airport)

PERSPECTIVE

Insight into design engineering

TEAMWORK & TECHNOLOGY

Our guest interview for this edition of CONNÆCT is with Sturla Rambjør who is a Project Manager within the Oslo-based international consulting engineering practice Aas-Jakobsen. Since specializing in dynamic loading, wind engineering and then bridge engineering at the Norwegian University of Science & Technology (NTNU), Sturla has acquired over 25 years of bridge design experience. He shares an insight into the working life of a design engineer, along with great personal enthusiasm for his work and the people he works with.

Most of my work is for the Norwegian Public Roads Administration (Statens Vegvesen) and consists of road and railway bridge design, oversight and inspection. The practice of post-tensioning bridges is well-established in Norway and we definitely feel that we use more post-tensioning than many other countries. The biggest factor for us is the materials – with a post-tensioned solution, less concrete is required and often more elegant and cost-effective structures result from this.

People power

Engineering design is always interesting but, for me, the greatest thing about the construction industry is its people. In-house, we have highly skilled people in every position and we are always confident that together we can deliver a good project. This makes the job easier – if I don't know the answers, I can explore solutions in a relaxed way with colleagues.
Equally, I get a lot of satisfaction from working with other members of the professional team. Talking with clients and contractors, I enjoy hearing about how they would like to build a structure and helping them overcome what they see as challenges.

Construction technology

When it comes to construction technology suppliers, I think many design engineers would say that most of all they appreciate timely support and good technical information. In my case, I have been fortunate to have strong connections and access to good professional advice from the various technology suppliers and experts anytime that I have needed it. Specifically, I am a great fan of post-tensioning and the flexibility it affords a designer. Obviously, detailed European Assessments are helpful in the first instance, but beyond this I really like to work with the smallest anchorages possible. This permits us to keep bridge cross-sections as thin as possible – in fact, the anchorage size dictates how thin this can be. Again, this saves precious materials.
Very early in my career, I worked on the Raftsundet Bridge in Lofoten, Norway. This was a free cantilever project and with a then world record concrete cantilevered span of 298m. It was here that I first encountered BBR technology in the shape of bonded post-tensioning tendons – some of which were 273m long, pretty spectacular. We also 'future proofed' the bridge by constructing the precast box beams of the bridge in such a way that they could accommodate the installation of eight external tendons. This was a precaution in case – at some later stage – a greater load capacity is needed due to increased traffic, or any unexpected long-term deflections occur and need to be reduced. It was a great project and it's not every day that you can say that you designed a world record bridge.

Shared history

There has long been a certain synergy between the Aas-Jakobsen and BBR organizations in that their forefathers were early pioneers in the field of concrete construction. Our founder, Andreas Aas-Jakobsen, was a leading light in Norwegian concrete design – particularly of shells and columns – from 1937. A few years later, in 1944, the three BBR founders were working in Switzerland on their first small post-tensioned beam.
With similar aims of structural strength and economy of materials, it is quite likely that they would have at least known each other or perhaps even collaborated. It was without doubt an exciting time within the construction industry during which talented and far-sighted engineers shaped the way we design and build structures today.

Future ambitions

My main experience has been of concrete bridge design and now my ambition is to design other bridge types. For example, I would love to work on a stay cable bridge project. There is a real beauty in the way the design transfers loads from girders, pylons and stays to the ground. Also, it's visually easy to understand where the forces are traveling through the bridge. From a design perspective, the joy is in defining good details – the spacing of the stay cables and their connections, as well as choosing the right type of pylon and bridge deck.
In the immediate future, I shall be exploring the advantages offered by electrically isolated post-tensioning tendons, especially for railway bridge schemes, and am confident that any support needed will be forthcoming from the BBR Network. ●

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IN THE SPOTLIGHT

New BBR Network Member in Indonesia

FIRST TO FOCUS ON PT

During the past year, the BBR Network has been delighted to welcome a new Member – Prestress Construction Indonesia (PCI). By way of further introduction, Ir. Hotman Sianipar MTSi, President Director of PCI presents an insight into the local market and activities of PCI.

Indonesia is one of Asia's largest construction markets – and it is growing fast. It has a still rising population of 260 million people and predicted shortfall of 20 million homes. Heavy government investment in infrastructure projects is targeted at driving economic growth and this in turn is fueling activity in the construction sector. Some 30 major schemes, together worth more than US$68 billion, have been identified and prioritized for development by 2019.

When it was founded in 2002, PCI was the first local company to focus on the provision of post-tensioning services in Indonesia. The company's business is organized into three segments – Specialist Contracting, Export-Import and Property – with Specialist Contracting as the main business stream. PCI is a full service contractor specializing in post-tensioning applications, construction engineering, repair and strengthening, bridge accessories and conveyor belt systems for a variety of projects in Indonesia. For other projects, we have installed ground anchors and also seismic protection systems. We offer excellent and well-managed engineering services, provided by a staff of experienced professionals. Our clients recognize that we are a reliable project partner who adds value to projects from conception to completion. In the decade and a half since its inception, PCI has contributed technology, services and expertize to a number of major schemes.

1 The Kanci-Pejagan toll road, part of Indonesian National Route 1 and the Trans-Java toll road.
2 PCI supplied post-tensioning services for Lippo Mall – the shopping mall within Jakarta's first mixed-used scheme.
3 Bajul Mati Bridge is the first bow string arch bridge in Indonesia.
4 The Kelok Sembilan Overpass – a 2.5km long viaduct has increased highway capacity in a geologically constrained area.
5 The prestigious Aula Jing Si facility where PCI provided, installed, grouted and stressed post-tensioned beams.
6 PCI provided post-tensioning services – supply, installation, stressing and grouting – for the Plaza Oleos I 18-storey office building in South Jakarta.

4

5

6

Major highway bridge

One of our major highway bridge projects was for the challenging Kelok Sembilan Overpass. The Kelok Sembilan Road, 30km east of Payakumbuh in West Sumatra has a sharp bend and is only five meters wide. It is in a ravine, flanked by two hills, and sits between two nature reserves. The road was completed in 1914, during the time that Indonesia was known as the Dutch East Indies. Since those days, it is no surprise that traffic has grown massively – however, no major widening of the road was possible due to the geological constraints. Work on the 2.5km Kelok Sembilan Overpass began in November 2003. The spans of the overpass snake down a steep hill supported by tall concrete columns of varying height up to 58m. The overpass crosses from side-to-side of the ravine no less than six times. The team from PCI supplied and installed bearings and expansion joints for a major bridge on this new route.

During the long construction period of the above, we were also called upon to provide bearings and expansion joints for the Bajul Mati Bridge – a bow string arch bridge. Bajul Mati is a popular and dramatically beautiful beach on the south coast of East Java, south of the city of Malang. The decision to build a bridge here was part of the central government's plan to open isolated areas by providing new infrastructure and support the promotion of the natural resource sector and tourism in the south of East Java. Aesthetic considerations for the design of the bridge included the need to create harmony with the environment in this tourist area and resulted in construction of a bow string arch bridge – the first in Indonesia. The 90m bridge consists of three 15m wide spans – the central span has a reinforced concrete bridge deck suspended from steel cables anchored to an arch.

Another of our dramatic highways projects has included the supply and installation of bearings on the Kanci-Pejagan toll road which opened in 2010. The road is part of Indonesian National Route 1 and the Trans-Java toll road.

Prestigious buildings

On the buildings front, we have worked on some of the most prestigious schemes in Jakarta – including the 18-storey Plaza Oleos I high rise office tower. With typical floor sizes around 2,500m^2, this was the first office block to offer such a large floorplate in TB Simatupan, South Jakarta. Future development here will include the construction of the Plaza Oleos II tower and apartments.

Another landmark building project for us was the Aula Jing Si – or Jing Si Hall – in Pantai Indah Kapuk, North Jakarta for Tzu Chi, the world's largest Buddhist charitable organization. Here, we supplied, installed, stressed and grouted post-tensioning for beams.

Our vision is to be the Number One local company in Indonesia with the best and certified quality in the world. We will achieve this by taking the lead in the provision of superior designs, solutions and products and the highest level of customer service. Thus, we are delighted to have become part of the international BBR Network and, as well as sharing our knowledge and expertize, look forward to advancing our business with the help of BBR technology and other BBR Network Members. ●

URBAN METRO SCHEMES, **AUSTRALIA, FRANCE, INDONESIA, MALAYSIA & SAUDI ARABIA**

BBR technology provides optimum performance for rail networks

METRO RAIL REVIVAL

1

During the past year, the LRT Kelana-Jaya Line light rail project and new MRT network – both in Kuala Lumpur, Malaysia and both featuring BBR technology and expertize – have opened for passenger service. Meanwhile, construction of a further four metro schemes – in Australia, France, Indonesia and Saudi Arabia – is underway.

The benefits offered by BBR construction systems and techniques are attractive to the developers of metro rail networks and their chosen contractors who, amongst other things, are looking for a fast delivery time and smooth on-site and operational performance, combined with low future maintenance requirements.
We take a look at the schemes and review how specialist technology and knowledge from BBR Network Members is contributing to their realization.

Overview & current challenges

The world's first underground railway opened in London in 1863 and during the following decades it was electrified and, with massive expansion, grew into the London Underground urban transit network we recognize today. At the end of the 19th century and early 20th, many major cities followed suit and underground networks were created in other European countries, Scandinavia, the Far East, North and South America. Today, it is estimated that 111.5 million passengers travel daily on metro networks in 187 cities around the world.
While most cities have continued to expand and update their networks, there has recently been a revival in the development of new urban rail transit systems. With massive growth predicted in the world's urban population between now and 2050, according to recent reports from the Institute for Transportation and Development Policy, it is vital that urban mass transit developments reflect this trend to ensure "sustainable, economically healthy and livable cities". ➤

1 LRT Extension, Kuala Lumpur, Malaysia

Rapid growth in Kuala Lumpur and the Klang Valley meant that two existing Light Rail Transit (LRT) lines required extension to allow easy access from the satellite towns and suburbs to the city.

The newly extended Kelana Jaya and Ampang LRT lines in Kuala Lumpur were opened to the public in mid-2016.

The lines pass through some of the most developed and highly populated areas in the Klang Valley. They connect at Putra Heights, where an integrated station provides an interchange between the two lines.

2

> "Segment launching was carried out using overhead launching gantries and there were a total of 583 spans".

BBR Construction Systems Malaysia won the contract for launching and prestressing works on Packages A and B of the LRT Kelana Jaya Line Extension Project. The total length of the two packages is 17.3km, almost all of which runs on elevated viaducts. Segment launching was carried out using overhead launching gantries and there were a total of 583 spans. Meanwhile, there were a number of intersections with major highways where curved long span elevated bridges – known as 'special crossing bridges' – were constructed. These required both temporary and permanent post-tensioning to withstand the stresses of construction and normal daily usage. The BBR Malaysia team used the BBR CONA internal bonded post-tensioning system for the permanent tendons and a 50mm diameter bar system for temporary prestressing. Full technical reports on the project can be found in CONNÆCT 2013 and CONNÆCT 2015.

3

2 New MRT network, Kuala Lumpur, Malaysia

At the same time, another major project was also underway in Kuala Lumpur for a new MRT system comprising three lines. Opened on 16th December 2016, MRT Line 1 starts at Sungai Buloh and runs through the city center, ending in Kajang – a distance of 51km. There are 31 stations along its route and for the elevated part of the route, the BBR team created post-tensioned precast segmental crossheads for three stations. See also CONNÆCT 2015. ➤

1 The total length of Kuala Lumpur's two new LRT extensions is 17.3km, almost all of which runs on elevated viaducts constructed by BBR Construction Systems Malaysia.
2 Viaduct leading to Semantan Station on Kuala Lumpur's new MRT network which opened in December 2016.
3 LRT Extension project, Kuala Lumpur, Malaysia – segment erection in progress.

CONSTRUCTION METHODS & TECHNOLOGY

Two main construction methods are being used by BBR Network Members to construct the overhead viaducts which carry tracks for the new metro systems. These are:

Balanced cantilever – precast construction

Balanced cantilever is one of the most popular bridge construction methods used by BBR Network Members on all continents. The economical range of span lengths for cast in situ cantilever construction begins at roughly 70m and extends to beyond 250m. Considerable savings can be achieved by using this method rather than conventional bridge construction.
Free cantilevering is a method of construction where a structure is built outward from a fixed point to form a cantilever structure, without temporary support, using staged cast in situ construction. When two opposing free cantilever structures are attached as a single structure and erected in the same step, it is known as 'balanced cantilever'. In basic terms, cast in situ construction describes a process whereby segments are progressively cast on site in their final positions within the structure.

Precast span-by-span

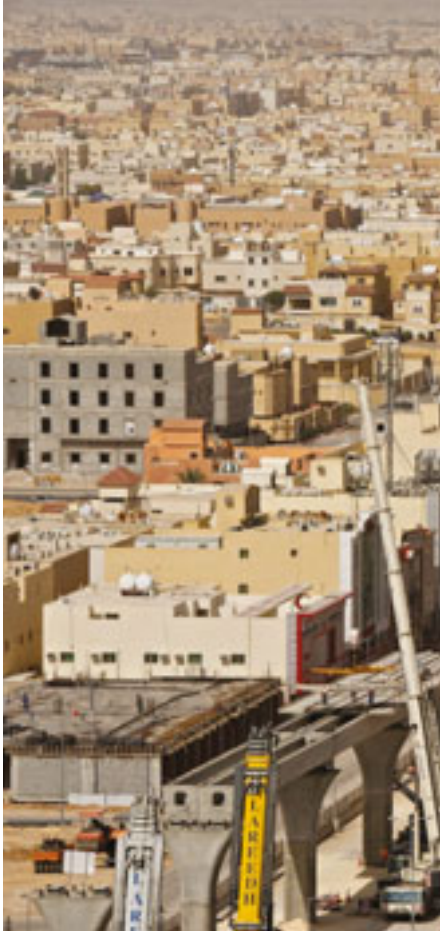
The precast span-by-span bridge construction method offers a very high speed of construction. It is most often used for spans ranging from 25m to 45m and in conjunction with an erection truss under the bridge segments or an overhead erection gantry to guide the precast elements into position. The precast segments are prefabricated at a casting plant – either on site or at a remote facility – then transported to the project site.
The span-by-span construction technique consists of the following primary steps:

- Erecting segments for the entire span onto a temporary erection girder spanning between a pair of adjacent permanent piers
- Installing and stressing longitudinal post-tensioning tendons enabling the segments to span on their own
- Advancing the erection girder into place to erect the adjacent span

Since there is only one cycle of stressing and grouting of tendons per span, the method can be significantly faster than precast and cast in situ balanced cantilever construction, which requires one such cycle per pair of segments.
See also CONNÆCT 2015 for an in depth illustrated description of precast segmental construction.
Alternatively, full-span precast beams can be delivered from the production site to the erection front by the launching gantry – allowing a fast rate of erection.

4 Balanced cantilever construction in progress on Grudziadz Bridge in Poland.
5 Construction of the viaducts for the new LRT lines in Kuala Lumpur, Malaysia was carried out using the precast span-by-span bridge construction method.

6



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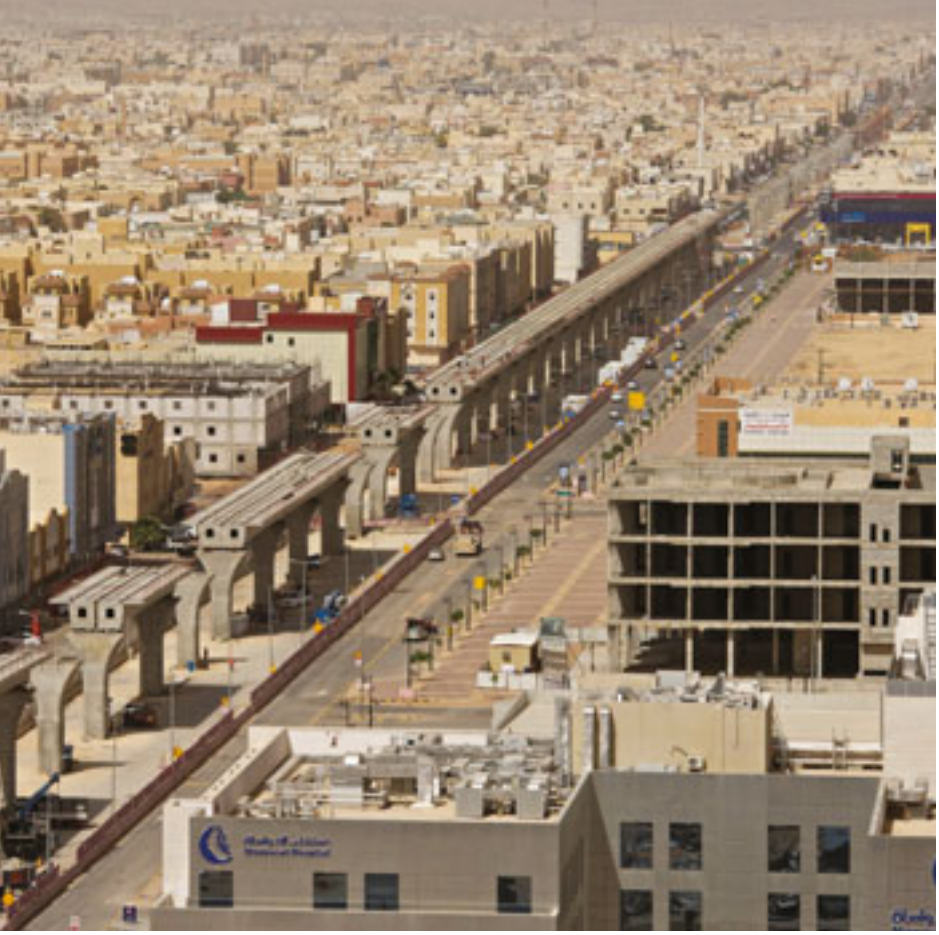
"This project uses a pair of overhead trusses, each 180m long and weighing approximately 600t."

6 Sydney Metro Northwest – in a typical erection scenario, an overhead truss lifts two 39m spans, each comprising 10 segments.
7 Riyadh Metro – the BBR PTE team is installing BBR VT CONA CMI internal post-tensioning tendons to beams which are being placed in 22km of elevated structures.
8 Sydney Metro Northwest – before the overhead truss is disconnected from the newly erected spans, up to 12 post-tensioning tendons are installed, stressed and grouted.

3 Sydney Metro Northwest, Australia

In Australia, a blend of precast span-by-span and balanced cantilever construction is being used to build the Skytrain viaduct for the Sydney Metro Northwest project. SRG, the BBR Network Member for Australia, has been working on the scheme since October 2015 to provide external post-tensioning services to the Impregilo Salini JV (ISJV) on behalf of Transport for New South Wales. Sydney Metro Northwest, formerly known as the North West Rail Link, is Australia's largest public transport infrastructure project currently under construction. Part of the project involves the construction of the Skytrain which takes the Sydney Metro Northwest above ground for 4km between Bella Vista and Cudgegong Road stations via Rouse Hill in North Western Sydney. SRG's scope includes the supply, installation, stressing and grouting of 1,600t+ of 15.7mm strand using the BBR VT CONA CME external post-tensioning system. The viaduct is constructed between 10-15m above the ground, using the span-by-span method and balanced cantilever construction over existing roadways. This project uses a pair of overhead trusses, each 180m long and weighing approximately 600t. In a typical erection scenario, the truss lifts two 39m spans, each comprising 10 segments with a combined weight of 710t. Once in position, SRG installs, stresses and grouts up to twelve 31- and 22-strand CONA CME tendons. Once the stressing is complete, the truss is free to disconnect from the newly erected spans and launch onto the next span set.

This fast paced project is scheduled to open in 2019. Meanwhile, the team is working around the clock to maintain program and ensure minimal disruption to the surrounding infrastructure.



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4 Riyadh Metro, Kingdom of Saudi Arabia

At 176km long, the Riyadh Metro has created a world record for having the longest stretch of metro lines under construction at the same time.

In 2013, the Arriyadh Development Authority awarded a contract to the FAST Consortium for the design and construction of three of the six metro lines covering a distance of approximately 63km of track, 25 stations and two train depots. The lines are as follows:

- Line 4 (Yellow Line) – connects King Khalid International Airport to the King Abdullah Financial District, all above ground. The length of the line is around 29km and it features eight stations.
- Line 5 (Green Line) – runs underground in a bored tunnel along King Abdulaziz Street, between King Abdul Aziz Historical Centre and the Riyadh Airbase, before connecting with King Abdullah Road. The length of the line is almost 13km and it features 11 stations, in addition to two transfer stations with Lines 1 and 2.
- Line 6 (Purple Line) – starts at King Abdullah Financial District, passing by Imam Mohamed Bin Saud University and ending at Prince Saad Ibn Abdulrahman Al Awal Road. It is mostly above ground, with a short underground section at Sheikh Hasan Bin Husein Bin Ali Street. The length of the line is approximately 21km and it features six stations.

These lines involve different construction methodologies – including a tunnel executed by TBM, precast segment launching, cast in situ structures and precast beams installed by cranes.

The BBR Network is represented here by the BBR PTE team within FCC, a key player within the FAST Consortium. For 11km of elevated structures, the team is installing BBR VT CONA CMI internal post-tensioning tendons – made of 12 and 19 strands – in precast beams of varying lengths (40, 36, 32 and 26m) and covering a total of 315 spans. The beams are manufactured in a precast factory where daily operations, including threading, stressing and grouting, have been arranged to achieve a weekly production cycle of nine beams, with more than two castings from each formwork per week. ➤

9

10

5 Rennes Metro, France

One of the most recent metro projects on the BBR Network's books can be found in the Brittany region of France where Line B of the Rennes Metro is under construction. With the opening of the 9.4km long Line A and its 15 stations, back in 2002, Rennes – over 350km from Paris – acquired the distinction of being the smallest city to boast a metro system. According to INSEE, France's National Institute of Statistics and Economic Studies, Rennes – the capital of Brittany – is one of the fastest growing metropolitan areas in France and has become an important hub for high technology industry and digital firms.
Construction of the 14km-long Line B, with a further 15 stations, is now underway and expected to enter service in 2020. The scheme features multi-modal transport interchanges and three park-and-ride facilities. In addition, a new green corridor will be created along the length of the viaduct, connecting existing landscape features and containing paths and cycle tracks leading towards the stations.
The route includes a 2.4km viaduct, at the extreme north of the new metro line, serving three elevated stations. The viaduct is a complex 8.6m wide structure and, again, use of the precast segmental construction method will minimize impact on urban traffic and the environment.

After the casting in situ of the viaduct piers, work began in September 2016 on installing the deck. In a casting yard adjacent to the eastern end of the site, 970 precast concrete segments will be prefabricated, then placed – two spans at a time – using a launching girder and post-tensioned with 600t of BBR VT CONA VT CMI internal tendons to form a monolithic deck structure. The contract for the viaduct was awarded to the Eiffage Génie Civil and Razel-Bec joint venture. ETIC, the BBR Network Member for France, will be carrying out the post-tensioned precast concrete segmental construction. The viaduct superstructure is targeted for completion in early 2018.

6 Elevated rail viaduct, Jakarta, Indonesia

As CONNÆCT 2017 goes to print, our newest BBR Network Member – PT. Prestress Construction Indonesia (PCI) – is mobilizing for post-tensioning work for a massive double track railway project from Manggarai to Jatinegara stations in Jakarta. The 1,200m long elevated precast segmental viaduct will be constructed by the span-by-span method using two launching gantries. PCI will be using the latest CONA CMI internal and the CONA flat post-tensioning systems. Construction work is programmed to run for 24 months, so look out for further details in future editions of CONNÆCT. ●

TEAM & TECHNOLOGY

1 **Owner** – Prasarana, Government of Malaysia
Main contractor – Trans Resources Corporation Sdn Bhd – Package A Sunway Construction Sdn Bhd – Package B
Prestressing and launching contractor – BBR Construction Systems
Technology – BBR CONA external, Span-by-span precast
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

2 **Owner** – MRT Corporation
Main contractor – Naim Engineering Sdn Bhd
Designer – AECOM Perunding Sdn Bhd
Bridge contractor – BBR Construction Systems (M) Sdn Bhd
Technology – BBR CONA internal, PT bar
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

3 **Owner** – Transport for NSW
Main contractor – Impregilo Salini JV (ISJV)
Technology – BBR VT CONA CME external
BBR Network Member – SRG Ltd (Australia)

4 **Owner** – Arriyadh Development Authority
Main contractor – FAST Consortium
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR PTE (Spain)

5 **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
BBR Network Member – ETIC (France)

6 **Owner** – PT. Kereta Api Indonesia (KAI), Public Works
Architect – PT. Dardela Yasa Guna
Main contractor – PT. Wijaya Karya – PT. Hutama Karya – PT. Adhi Karya KSO
Technology – BBR VT CONA CMI internal, BBR CONA flat
BBR Network Member – PCI (Indonesia)

9 Rennes Metro – viaduct segments for the Rennes Metro Line B are being installed two spans at a time and post-tensioned using CONA CMI internal tendons.
10 Rennes Metro – artist's impression of a section of the viaduct for the Rennes Metro which will be constructed using 970 precast concrete segments, post-tensioned together with BBR VT CONA CMI internal tendons.

TAMINA BRIDGE, **SWITZERLAND**

Arch bridge nears completion

NEW SWISS LANDMARK

The Tamina Bridge in the Swiss Canton of St Gallen is nearing completion and the official opening date has been set for 22nd June 2017. Pictured here is the bridge while deck surfacing was underway.

As reported in CONNÆCT 2015 and 2016, the project has featured the skill and expertize of Austrian BBR Network Member KB Vorspann-Technik who devised a method of supporting arch construction with the application of stay cables and manufactured to an innovative specification in their own workshops. After the arch had been completed Stahlton, the BBR Network Member for Switzerland, also contributed to the project with BBR VT CONA CMI internal post-tensioning for the bridge deck. With the opening of the bridge, the two communities of Pfäfers and Valens – either side of a 200m deep gorge – will be united for the first time. The excitement and anticipation is such that the community of Pfäfers has organized a three-day Bridge Festival from 9th to 11th June. As well as improved road connections, they will no doubt also be celebrating the engineering skill and innovation that made this landmark structure possible. ●

TEAM & TECHNOLOGY

Owner – Tiefbauamt Kanton St. Gallen
Main contractor – STRABAG – Erni – Meisterbau JV
Structural design – Leonhard, Andrä und Partner
Alternative design – Höltschi & Schurter (now Meichtry & Widmer Dipl. Ing ETH/SIA AG) (arch alternative for JV)
Technology – BBR VT CONA CMI internal, BBR VT Plastic Duct
BBR Network Member – Temporary stay cables: KB Vorspann-Technik GmbH (Austria), Post-tensioning: Stahlton AG (Switzerland)

AQUEDUCT VECHTZICHT, **SCHIPHOL-AMSTERDAM-ALMERE HIGHWAY LINK (A1/A6), NETHERLANDS**

Massive installation of post-tensioning for aqueduct

EUROPE'S WIDEST AQUEDUCT

Another ambitious infrastructure scheme has been completed in the Netherlands and this time it has involved creating an aqueduct to carry a river over a major highway route. Ron van Dijk from Dutch BBR Network Member Ballast-Nedam Infra-Specialiteiten describes the project and his company's role in its realization.

1

The Schiphol, Amsterdam and Almere (SAA) scheme involves five projects for Rijkswaterstaat – the agency responsible for execution of infrastructure and public works in the Netherlands – which will improve some 63km of road network. This massive scheme is being undertaken to reduce traffic congestion in the region and encourage economic growth in Almere, to the east of Amsterdam. Estimated to cost €5 billion, the scheme involves improvements to four motorways – the A1, A6, A9 and A10 – construction of one tunnel, two major bridges, realignment of five interchanges, adjustment of around 100 structures and, last but not least, the creation of Europe's widest aqueduct.

Aqueduct at Muiden

Just 12km from Amsterdam, the town of Muiden lies on the shores of the IJmeer at the mouth of the River Vecht and is mostly known for its yacht harbor and historic castle. Recently, it became a focal point for the civil engineering industry, as the construction site for the aqueduct – to carry the River Vecht over the A1 motorway – was a hive of activity.

Work on site began in October 2013 and was carried out in two phases. The first phase involved creating two cofferdams with sheet piling reaching halfway across the river to create construction 'pits'. Foundations were created by piling, installation of ground anchors, groundworks and pouring concrete. However, the eastern pit had filled with water and sand, probably as a result of an underground connection with the River Vecht. So the decision was taken to use underwater concrete and flood both pits with water to ensure stability – and, thus ensure that the pits could be pumped out later. This also allowed the project to continue on schedule.

After the water had been pumped out of the pits, work started on concreting the floors, water cellar, walls, pillar and post-tensioned deck. ➤

FACTS & FIGURES

- Widest aqueduct in Europe – 65m wide
- Total length 620m
- Deck – around 194m long
- 12 lanes total – 2 x 5 lanes + 2 flexible lanes at peak times
- 5,300 piles below aqueduct – piles measured 90km end-to-end
- 57,000m^3 concrete
- 8,000t reinforcement steel
- 120,000m^3 groundworks

1 Boats travel over the new Aqueduct Vechtzicht while road traffic passes beneath on the A1 motorway.
2 Installation of post-tensioning.
3 The team used short stroke jacks because of the limited space – and, working under extreme time pressure, they needed to carry out stressing both day and night over several shifts.
4 Aerial view of the new A1 motorway passing beneath the River Vecht.

Images 1, 2 & 4 courtesy of Rijkswaterstaat.

2

PT WITH BBR VT CONA CMI

Section 7	19 strands, 42 tendons
Section 8	19 strands, 50 tendons
Section 9	19 strands, 62 tendons
Section 10	19 strands, 50 tendons
	22 strands, 33 tendons
Section 11	19 strands, 72 tendons
Total PT strand – 500t	
Total PT tendons – 276	

TEAM & TECHNOLOGY

Owner – Rijkswaterstaat
Main contractor – SAAone EPCM Bouwcombinatie v.o.f.
Technology – BBR VT CONA CMI internal
BBR Network Member – Ballast Nedam Infra-Specialiteiten (Netherlands)

PT installation

Our role in this challenging project has been to provide advice on post-tensioning to the engineering design team and, acting as a subcontractor, carry out the installation of the post-tensioning on site.

In total, five sections of the aqueduct required post-tensioning. The most complex was Section 11 which has 72 BBR VT CONA CMI tendons. Concreting began bright and early on a Thursday morning – at 0600hrs – and continued for 30 hours. During this time, we installed the anchors and wedges after removing formwork during the concreting.

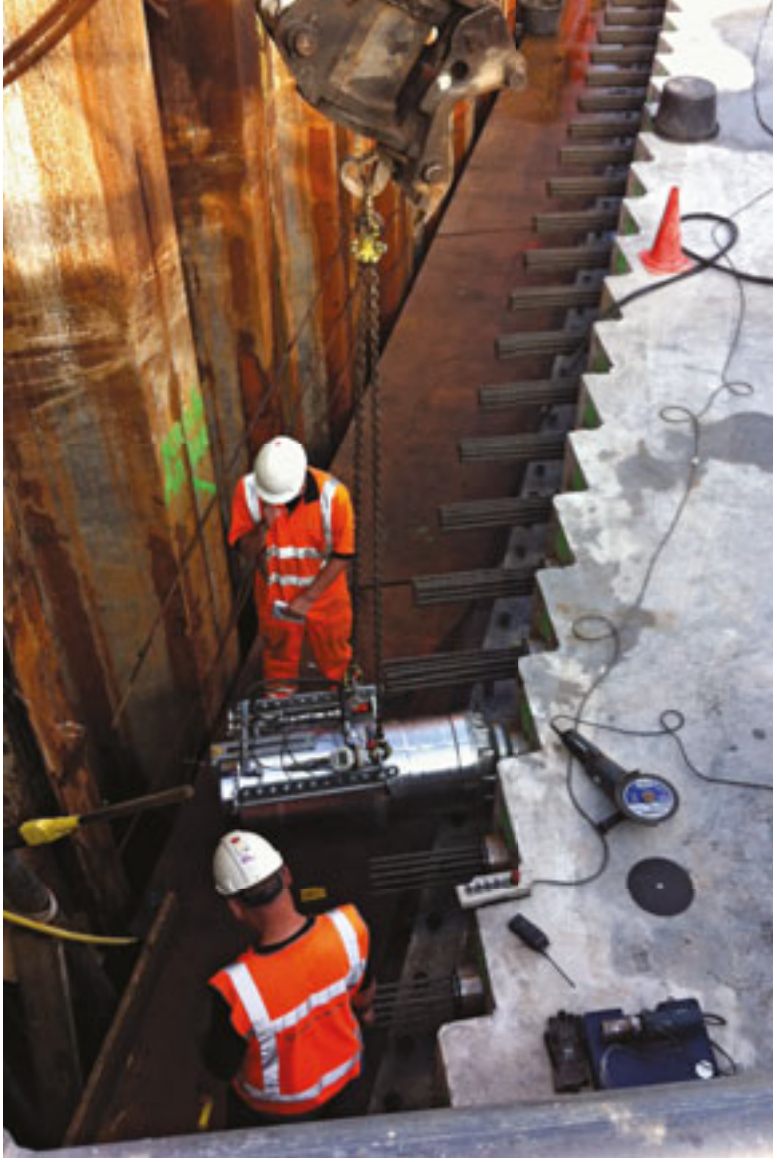
We carried out first stage stressing on the north-south side of the tendons to 23Nmm^2 immediately after concreting – beginning around midnight on the Friday. Second stage stressing to 100% was applied to both sides at the same time after around 10 days. Finally, we grouted the tendons.

Challenges

During installation of the post-tensioning, we met with a number of challenges. Firstly, we found it tricky to make the connection between the anchors and ducts as there was so much reinforcement. Next, we were pushing strands for 72m long tendons in a very small area, confined by the sheet piling and boards of the cofferdam – we had space of only between 1.3m and 1.5m in which to work.

Also, for the stressing we were using short stroke jacks because of the limited space – and, working under extreme time pressure, we needed to carry out stressing both day and night over several shifts.

These challenges certainly served to make Phase 1 of this project very interesting for us and ensured we were well prepared for Phase 2 – on the other side of the river – when our part in this started in late spring 2016.



3

Phase 2

We worked on the post-tensioning for Sections 8, 9 and 10 to an even tighter program. In the period between mid-May and mid-July 2016 – exactly two months – we completed the three remaining sections. We installed 14,000m of ducts, 310t of prestressing strand, 39 anchors and 113t of cement. The post-tensioning tendons were stressed one week after concrete had been poured.

The A1 running beneath the Aqueduct was fully opened to traffic by the end of September 2016. Already many thousands of motorists have passed beneath the River Vecht, including many who have just made the journey to admire the very best in 21st century engineering. ●

4

HIGHWAY DRAŽENCI – MMP GRUŠKOVJE 1, **SLOVENIA**

Five structures post-tensioned with BBR VT CONA CMI

IMPROVING INTERNATIONAL CONNECTIONS

1

A 13km highway scheme is underway to replace the existing road between Draženci and Gruškovlje in north eastern Slovenia, south of the city of Maribor. Tomislav Lozančić reports that BBR Adria, the BBR Network Member for Slovenia, has provided post-tensioning for four viaducts and one bridge in the past 12 months.

The overall project is the final section of a wider 33.7km long scheme begun in 2007 to improve the north-south international border crossing, between Šentilj and Gruškovje, with Austria and Croatia respectively.

The new road will also connect the two principal cities of this region of Slovenia – Maribor and Ptuj – and eliminate the congestion that builds up in the area, particularly over the summer months and before major holidays. The scheme is also expected to enhance road safety and generally improve the quality of life of those who live in the region.

BBR Adria has installed BBR VT CONA CMI internal post-tensioning for five structures – four overbridges and a bridge, 90m, 75m, 60m, 265m and 32m long respectively – using over 100t of prestressing steel.

The highway is scheduled to open fully in 2018, giving easier congestion-free access for local and international traffic across this part of Slovenia. ●

2

1 The BBR Adria team at work installing CONA CMI post-tensioning for the 32m long Bridge (5.4) of the Draženci and MMP Gruškovlje 1 project in Slovenia.
2 Viaduct (0093-1, 4.3) is 60m long and was post-tensioned using 15 strand CONA CMI tendons.

TEAM & TECHNOLOGY

Owner – DARS d.d.
Main contractor – SGP Pomgrad d.d.
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR Adria d o.o. (Slovenia)

BRIDGE OVER ROSENBACH, **ST. JAKOB I.R, CARINTHIA, AUSTRIA**

Challenging post-tensioning installation supports unusual bridge design

AUSTRIA'S MOST MODERN BRIDGE

In the very south of Austria, close to the Slovenian border, an unusual bridge has been built so that pedestrians and cyclists no longer have to cross the small Rosenbach creek by going through a ford. The bridge is capable of carrying up to 26t, so it can also accommodate local farm vehicles. Norbert Bogensperger of Austrian BBR Network Member KB Vorspann-Technik provides an overview of the project.

The Paulifurt Bridge is probably one of the most modern bridges in Austria.
The main construction elements are four prefabricated open web girders made from ultra high performance concrete (UHPC).
There were a number of challenges for the project as a whole. Firstly, such slim concrete web girders – sometimes less than 10cm thick – had never previously been used. Then, a method had to be found of connecting these outward leaning girders in the middle, longitudinally with screws, supported by a brace in the middle of the creek.
Another challenge was finding a way to connect the transversal beams with temporary beams such that they retained their position and allowed the placing of steel beams for the deck. On the post-tensioning side, we had to devise a method for connecting the ducts which were at the joints between abutments and precast girders and between precast elements in the middle of the bridge. The connection needed to be tight, as grouting was carried out over a pure and crystal clear creek and within a protected landscape.
It took a lot of brainwork from all participants to achieve a successful solution – although for us, our physical contribution to the project involved just eight bonded post-tensioning tendons with four strands each. This goes to prove that, as well as the use of world-class technology, it is a blend of good teamwork and innovation based on sound experience that ultimately delivers customer satisfaction. ●

TEAM & TECHNOLOGY

Owner – Community of St. Jakob i. R.
Main contractor – TEERAG ASDAG AG
PT designer – SDO ZT GmbH
Technology – BBR VT CONA CMI internal
BBR Network Member – KB Vorspann-Technik Austria GmbH (Austria)

1

BATINAH EXPRESSWAY PACKAGE-1, **OMAN**

Post-tensioned structures for major highway

PT FOR EIGHT LANE EXPRESSWAY

The Batinah Expressway is a 266km long road which will link Muscat to the new Sohar Port and industrial area and to the border of the United Arab Emirates. The Oman branch of **Structural Systems Ltd**, part of the SRG Group, has been working on Package-1 of the project since December 2012 and Ravindra Chauhan, Manager – Civil Projects, provides an overview.

2

The Expressway, will have eight lanes – four in each direction – and is expected to ease the traffic exiting the existing four lane Dubai-Muscat Highway which runs parallel to the new road. The overall project has been divided into 11 separate construction packages. Prior to our appointment for Package-1, we carried out extensive testing, comprising both static load and load transfer tests, in accordance with project specifications to demonstrate compliance of BBR VT CONA CMI internal systems to the requirements of AASHTO LRFD Bridge Construction specification for highly aggressive environments.

Package-1 is 45.5km long and has featured a number of cast in situ structures post-tensioned with the CONA CMI system. These include 17 structures between 90m and 160m long at four major interchanges, a vehicular overpass involving five structures of 60m-70m in length, plus two Wadi Bridges requiring a total of 360 x 28.5m long precast girders.
Among the structures we post-tensioned was the Barka Interchange which is situated at Barka near to Muscat. It has two structures – the East Bridge and the West Bridge. The length of each bridge is 160m over three continuous spans. The center span is 70m and both end spans are 45m each. Each bridge is a three cell post-tensioned box girder structure, with depths varying from 2m to 4m. Here, we used the CONA CMI 4206 system and almost 260t of prestressing steel. The interchange is believed to feature the longest single bridge tendons – around 162m long – in Oman.
The scope of our work, completed in May 2016, on Package-1 comprised shop detailing, supply of specialist post-tensioning materials, supervision of installation, stressing and grouting.
We used eight different sizes from the CONA CMI range – 1306, 1506, 1906, 2206, 3106, 3706, 4206 and 4806, the latter being used for the first time in Oman – which were all selected to suit the specific application.
For the precast girders, we used 15.2mm diameter strand compliant with ASTM A416 and for the cast in situ structures, we used 15.7mm diameter strand. In all, this massive project required 1,432t of prestressing steel. ●

1 The Barka Interchange was one of four interchanges within Package-1 of the Batinah Expressway and features what are thought to be the longest single bridge tendons in Oman.
2 The completed Interchange 03 (IC03 – BEW) of the Batinah Expressway.

TEAM & TECHNOLOGY

Owner – Ministry of Transport & Communications
Design & supervision consultant – Parsons International & Company LLC
Main contractor – Galfar Engineering & Contracting SAOG
Technology – BBR VT CONA CMI internal
BBR Network Member – Structural Systems Limited (Oman branch)

1

RAS AL KHAIMAH RING ROAD, **UNITED ARAB EMIRATES**

Post-tensioned cast in situ highway structures

CITY RING ROAD

Construction of the Ras Al Khaimah Ring Road is well underway. When completed, this 32km ring road will connect all internal and external road networks in Ras Al Khaimah and is expected to accelerate development in the Emirate. NASA Structural Systems LLC , part of the SRG Group, began post-tensioning work at the end of 2013 and expect to finish in May this year.

This is a six lane highway, with three lanes in each direction, on the periphery of Ras Al Khaimah city. The project involves construction of the road itself and nine interchanges which are post-tensioned cast in situ bridge structures. The team has chosen to use the BBR VT CONA CMI internal 1206 and 1906 systems made up of 15.2mm steel strand.
Structural Systems' contract includes shop detailing, supply of specialist post-tensioning materials, supervision of installation, stressing and grouting.
When completed in 2018, the new road is expected to reduce travel time by as much as 50% between Sharjah and Ras Al Khaimah. ●

1 The new 32km long Ras Al Khaimah Ring Road is under construction and features BBR VT CONA CMI internal post-tensioning.

TEAM & TECHNOLOGY

Owner – Ministry of Infrastructure Development
Design & supervision consultant – Core Engineering Consultancy
Main contractor – Al Rajhi Construction LLC
Technology – BBR VT CONA CMI internal
BBR Network Member – NASA Structural Systems LLC (Dubai, UAE)

BATANG SADONG BRIDGE, **SARAWAK, MALAYSIA**

Specialist construction services & techniques

SPANNING THE SADONG RIVER

The longest bridge crossing in Borneo, the 1.48km long Batang Sadong Bridge in Sarawak, opened to traffic in October 2016. **BBR Construction Systems Malaysia** provided BBR Network technology and expertize – not only for the balanced cantilever construction of its 10 spans, as reported in CONNÆCT 2016, but also for several further important technical aspects of this major bridge.

1

Pilecaps, piers & hammerheads

Construction of the pilecaps was a major challenge in the deep river water while working around the limited tidal times. Thian Jut-Wei, BBR Malaysia's Project Engineer, explains the construction methodology used for the construction of pilecaps, piers and hammerheads.

Floating pilecaps

The bridge designer had wisely chosen pilecaps 'floating' at water level – rather than 'embedded' pilecaps resting on the river bed – to simplify the construction and obviate the need to use expensive cofferdams. The top portion of each pilecap is exposed and visible, even at the highest water level, so that vessels steer to avoid them. Precast skirting panels were built around the pilecaps to prevent small vessels accidentally being swept under a pilecap base.

After piling, the 1.5m diameter steel tube piles were exposed above the water. The 4m deep pilecaps were concreted in two pours. Permanent precast soffit panels were installed onto the steel tube piles to serve as formwork to support the weight of the wet concrete after the first casting. The gaps between the precast panels were stitched by interlocking the protruding rebar from each panel and concreted. Precast walls served as permanent formwork for the sides of the pilecap and they were raised to prevent high tide water ingress into the work area. Pier rebar was fixed and secured in position and verticality maintained with a temporary rebar guide template. Five sets of thermocouplers were installed at height intervals of 0.325m to measure and monitor temperature rise during concrete pouring. Next, 38 precast skirting panels were mounted around the pilecap, followed by installation of fender strips. Five sets of thermocouplers were placed at height intervals of 0.575m. Then, after 56 sets of prestress bar dead end anchorages had been installed for the temporary pier fixity, the second casting was carried out. After concreting, a curing compound was sprayed onto the top surface. ➤

2

Pier construction

The piers were constructed using steel formwork to meet the dimensional tolerances required and to provide a fair-faced concrete finish. After removal of the temporary rebar guide templates, the construction joint was roughened to remove any loose concrete. Rebar was lapped up and, for congested areas or for large diameter T40 rebar, bar couplers were installed. Next, the steel formwork was closed and secured with form tie bars.
To eliminate concrete segregation during concreting, a concreting funnel fitted with a rubber hose was used to channel the concrete to the bottom of the pier.
Maximum height per cast was three meters. The next day, the formwork was removed and 'jumped' to the next level by lifting with a crane. Thus, a high pier could be completed in several castings with this jumpform.

Hammerhead construction

The hammerheads – so named because the pier resembles a handle and the initial deck section looks like a hammer head – are monolithically connected to the taller piers. On shorter piers, the hammerheads are not rigidly connected and the bridge deck loads are transferred onto them by pot bearings. For this project, longitudinally and transversely guided pot bearings of up to 4,100t capacity were used. Upon completion of installation and adjustment to the correct level and alignment, the bottom socket recesses were filled with high strength non-shrink grout to secure the bearing dowels.
The hammerhead castings for Piers 2 and 8, plus Piers 3 and 7, were approximately 8.5m and 10m high respectively and were divided into four casting stages.
The first stage was construction of the bottom slab and part of the web walls up to three meters high. As the weight of the hammerhead was considerable, structural steel columns and beams were erected on top of the pilecap to support the weight of the concrete. By a cantilevering arrangement of structural steel, all the supports were able to rest on top of the pilecap without any additional temporary piles. Timber and plywood was used for the hammerhead soffit.

In the second stage, the web walls were cast up to the level of the transverse tendons. Steel and timber form finishes were carried out for the web walls. Scaffolding was erected for working platforms and temporary supports for deck slab casting. This was followed by fixing of transverse tendons across the box girder through the diaphragm. After the third stage casting to the deck slab soffit, the cantilever tendons and top continuity tendon ducts were installed in the deck slab. The duct positions were secured with templates. All other embedded items and temporary openings for the form traveler installation and temporary fixity bars were installed and confirmed before concreting the deck slab. Four transverse internal tendons were installed below the deck slab through the diaphragm. This induced a precompression force in a perpendicular direction to the cantilever tendons, thus providing confining pressure to the concrete. A 480t multistrand jack was used to stress the 2206 tendons.

1 Construction of Borneo's longest bridge crossing called for the BBR Network's finest technology and technical expertize – as well as balanced cantilever construction, BBR Construction Systems Malaysia carried out floating pilecap, pier and hammerhead construction and ensured temporary fixity of the deck to piers.
2 Balanced cantilever construction progressed safely with the use of form travelers after temporary fixity of the deck to the tallest piers had been achieved.
3 Falsework support for one of the hammerheads which were constructed in several phases, with casting divided into four stages.
4 Precast skirting panels in position around a pilecap – these are designed to prevent small vessels accidentally being swept under the base of the floating pilecaps.

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Temporary fixity of deck to piers

The Batang Sadong Bridge was constructed using the balanced cantilever construction method whereby a pair of form travelers was installed on each pier to cast a pair of segments for each construction cycle. During the various stages of construction, when there is unbalanced load on one cantilever, it tends to rotate the deck about the top of pier – like a see-saw action. Lee Yu Chan, also a BBR Malaysia Project Engineer, outlines the solution involving the temporary fixing of the deck to the top of piers during the various stages of construction.

Unbalanced situation

The word 'balanced' in the expression balanced cantilever construction is actually a misnomer, because the cantilevers cannot practically be balanced due to construction activities. Although the casting of a segment can be divided into several steps – such as bottom slab, web walls and finally deck slab – the left and right-hand side segments cannot be concreted at exactly the same time, hence one side will be slightly heavier than the other side. The top of the deck is subject to transfer and shifting of materials, equipment and workmen. Also the form travelers, mounted at cantilever ends, may be launched or advanced forward at different times. Safety code requirements call for a stability check of the deck which assumes an entire form traveler and segment are missing from one side – a worst case scenario. ➤

5

Temporary fixity set-up

Basically, deck weight increases during segmental deck construction. For this project, the deck weight was supported by temporary steel struts either on top of the piers or pilecaps. Four sets of 450mm high steel stools were fabricated from steel plates and mounted on the four corners of each pier. The steel stools were designed to withstand high compression forces being transferred from the deck.

A total of 56 vertical 36mm diameter prestress bars were used to tie down the deck, on both sides of the pier, to the pilecap. The bars were Grade 835/1030 with an Ultimate Breaking Load of 1050kN. When there was a tendency for the deck to rotate about the top of pier – for example, say the left-hand side of the deck tried to move up, this potential upwards movement was halted by the post-tensioned tie-down bars on the left side. If the rotation was in the other direction, the tie-down prestress bars on other side would do the same. This strut-and-tie action forms the basis of the temporary fixity system – the strut formed by the steel chairs and the tie formed by the prestress bars.

Temporary fixity installation

The prestress bar anchorages were cast into the pilecap, each comprising bearing plate, hex nut and bursting reinforcement. It was important to keep the bars upright by using a template before casting the pilecap. If the starter bars were inclined, there would be a higher risk of bars breaking during stressing. Galvanized iron ducts were cast in the hammerhead as hole formers. Then, the 36mm diameter bars were coupled up to the top of the deck. One-by-one, the bars were stressed with a 100t jack to 620kN = 59%UTS.

After completion of the temporary fixity, the form travelers were installed and balanced cantilever construction began. After the ends of the adjoining cantilever spans were stitched together and all top and bottom continuity tendons stressed, the temporary fixities were removed and deck loads were transferred to the pot bearings.

Key benefits

A number of benefits accrued from our approach to this major project.

Floating pilecap construction, through use of permanent precast soffit panels and wall panels, simplified the construction operation and also reduced cost and program. By dividing concreting of the pilecaps into two casts, the structure produced by the first casting became a temporary support for the construction load of the second casting, resulting in an economical design of precast soffit panels.

Repetitive use of steel jumpform enabled efficient and economic construction of the piers in similar stages.

Temporary fixity forms a crucial temporary work in the construction engineering to enable safe construction of balanced cantilever bridges sitting on pot bearings.

By combining BBR post-tensioning technology with our construction experience, we have delivered excellent and competitively engineered solutions to our client. ●

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5 Four steel stools were installed on the top of each pier and, together with prestress bars for tying, formed the temporary fixity system to bear the deck weight and prevent deformation during balanced cantilever construction.

6 A pier with temporary fixity bars installed to tie-down the deck to the pilecap, preventing deflection of the bridge deck during construction.

N31 BRIDGES, **HARLINGEN, NETHERLANDS**

Post-tensioning of structures

FIVE BRIDGES & AN AQUEDUCT

In the north of the Netherlands and following the coastline near Harlingen, six post-tensioned structures, to form part of the upgraded N31 highway, are currently being constructed by BBR Network Member Ballast Nedam Infra-Specialiteiten.

The N31 directly connects Amsterdam and Leeuwarden, via the Afsluitdijk – the 32km causeway connecting Den Oever in North Holland to Zurich in Friesland – and passing through Harlingen. This upgrade project – to construct a dual carriageway – is designed to improve the accessibility of Friesland province, as well as enhancing safety and improving traffic flow in-and-around Harlingen. The new road is expected to be open to traffic at the end of 2017.

Already, the BBR Network team has completed post-tensioning work on the overpass and is currently working on the Aqueduct, as well as bridges at Oosterparkweg and for the Centrale Aansluiting (central connection). Work will shortly begin on the Kimswerderweg and Grensweg bridges. In total some 234.4t of prestressing steel will be used in 224 BBR VT CONA CMI internal post-tensioning tendons, varying in length between 27.46m and 60m. ●

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1 Artist's impression of the Aqueduct, currently under construction, to carry the N31 highway beneath the Harinxma Canal.
2 Working beside live railway tracks, the BBR Network team has already installed, stressed and grouted the CONA CMI post-tensioning tendons and is protecting the anchorages with concrete.

TEAM & TECHNOLOGY

Owner – Rijkswaterstaat, Provincie Fryslân en de Gemeente Harlingen
Main contractor – Ballast Nedam Infra B.V.
Technology – BBR VT CONA CMI internal
BBR Network Member – Ballast Nedam Infra-Specialiteiten (Netherlands)

TEAM & TECHNOLOGY

Owner – Government of Malaysia
Main contractor – Perkerjaan Piasau Konkrit Sdn Bhd
Designer – J.H.L Konsult Sdn. Bhd.
PT & balanced cantilever construction – BBR Construction Systems
Technology – BBR CONA internal, PT bar
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

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NORMANBY REALIGNMENT PROJECT, **SOUTH TARANAKI, NEW ZEALAND**

BBR technology & service specified for bridge

SUPPORTING SAFER ROADS

A major highway and rail realignment project in South Taranaki, New Zealand, has seen the demolition of one bridge and the building of another – both with the aims of improving safety and travel times on a busy and important route for the region. BBR Contech has contributed to its success, applying post-tensioning expertise to a key road and rail intersection.

TEAM & TECHNOLOGY

Owner – NZ Transport Agency & KiwiRail
Main contractor – Downer
Structural engineer – Novare Design
Project manager – MWH
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR Contech (New Zealand)

The NZ Transport Agency's two-year 'Normanby Realignment Project' was launched in January 2015. Valued at NZ$11 million, it was developed to eliminate the risks posed by a poorly aligned 4.2km stretch of state highway that had a long history of incidents and serious accidents. The project involved building a new road with fewer and less sharp curves that better met modern engineering and safety standards. It included replacing a 75-year old railway overbridge on a dangerous corner with a new arrangement on the newly aligned highway, where the rail line was converted to a bridge and a new 'road under rail' underpass was created about seven meters beneath it.

Designed by engineering specialist Novare Design and managed by main contractor Downer and MWH for the Transport Agency, this rail-road connection required careful planning to ensure a safe and robust construction process that still enabled the trains to get through. With speed and efficiency essential, BBR Contech's post-tensioning expertise featured early in the project.

"We specified BBR Contech's PT system in the bridge design as we were familiar with it from previous projects and have always found BBR Contech's documentation and support helpful for the design process," said Novare Design Director Richard Keenan. "We'd also worked with BBR Contech on a number of other projects before and always found them great to deal with."

1 The new 'road under rail' underpass was created about seven meters beneath the new Normanby Bridge.
2 The railway line now runs over the new post-tensioned bridge, replacing the previous 75-year old structure.

RAILWAY OVERPASS, **MICHAELERBERG, STYRIA/AUSTRIA**

Longitudinal post-tensioning with BBR VT CONA CMM monostrand

CURVED RAILWAY OVERPASS CONSTRUCTION

Permission to construct this overpass was first sought during building of the railway line in 1874 – but construction only began around 140 years later.

This curved bridge with an overall length of about 98m is a simple carriageway slab with four spans – two of 27.5m and two of 21m in length.
Austrian BBR Network Member, KB Vorspann-Technik, was called on to carry out the post-tensioning of the structure. The unusual part of the project was that the team carried out longitudinal prestressing with unbonded bands of monostrands, comprising four coextruded strands, connected with webs. Post-tensioning tendons near the bridge axes were placed in an upright position, while the outer and inner tendons were placed normally. The length of the tendons varies from 93.8m to 100.8m because of the curvature of the overpass. ●

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1 The curved railway overpass is around 98m long and has four spans.
2 The project is unusual because longitudinal post-tensioning was carried out using unbonded BBR VT CONA CMM bands.

BBR Contech was involved in both the rail and road aspects of the project. In the first stage – building the rail bridge while the track was temporarily rerouted – the team installed, stressed and grouted the post-tensioned multi-strand tendons, each with a capacity of over 400t. Approximately 15t of stressing strand was used to construct the 22 16-strand tendons. Once the rail overbridge span had been completed, the excavation for the underpass vehicle roadway began. The BBR Contech team post-tensioned and grouted 'dead-man' type stress bars between the pile cap, wing wall retaining panels and buried dead-man walls that were required for the underpass.
Having campaigned long and hard for the highway realignment, community members and local police, fire and ambulance officers will breathe a huge sigh of relief when the Normanby Overbridge is in full operation. It is fervently hoped that accidents and fatalities on that stretch of road will become a thing of the past. ●

TEAM & TECHNOLOGY

Owner – ÖBB Infastruktur (Austrian Railway Authority)
Main contractor – Gebr. Haider & Co
PT designer – KMP ZT GmbH
Technology – BBR VT CONA CMM monostrand
BBR Network Member – KB Vorspann-Technik GmbH (Austria)

HIGH-RISE DEVELOPMENTS, **PHILIPPINES, SINGAPORE, AUSTRALIA & DUBAI**

Maximizing value by choosing a post-tensioned approach to construction

SIGNATURES ON THE SKYLINE

Cities around the world are increasingly building high-rise accommodation or offices to maximize precious space at ground level. The inherent flexibility and advanced technical characteristics of BBR post-tensioning systems offer architects more freedom of expression as they create new 'signatures' for urban skylines. Developers and main contractors benefit too from use of BBR technology as there are also advantages in terms of budget and program. In this feature, we examine six high-rise projects currently underway in the Philippines, Singapore, Australia and Dubai.

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> "...flat slabs were employed to eliminate the use of beams, thus optimizing floor-to-ceiling heights, maximizing the number of floor levels..."

Property development in the Philippines

In the Philippines, the population has already exceeded 100 million and it is said that at least 10% are working overseas. With the resurgence of the Philippine economy since 2010, brought about by renewed confidence in the Government and aided by the steady income from overseas foreign workers, the surge in business process outsourcing hirings and a growing industrial sector, Ortigas & Company Limited Partnership (OCLP) foresaw the demand for residential condominium units. One of the local pioneers in real estate development, OCLP started with The Viridian in Greenhills located in San Juan City's Greenhills Commercial Center – the latter is also an OCLP development. The commercial success of this venture enabled the subsequent launch of The Royalton and also The Imperium at Capitol Commons, in Pasig City.

Creating value with PT

The post-tensioned floors start at the fifth level of The Viridian and at the sixth level of both The Royalton and The Imperium. Rey Singh of BBR Philippines Corporation reports that flat slabs were employed to eliminate the use of beams, thus optimizing floor-to-ceiling heights, maximizing the number of floor levels, facilitating mechanical, electrical, plumbing and fire protection installations and reducing the total weight of the building which, in effect, lessens the seismic mitigation requirements. D. M. Consunji, Inc. (DMCI), a leader in the Philippine construction industry, took on the task of constructing the three high-rise buildings based on the construction plans prepared by the owner's design team. DMCI has entrusted all of the post-tensioning works to BBR Philippines Corporation as part of the structural works package.

1 The Viridian in Greenhills, Philippines

For The Viridian, performance-based design was used and a buckling restraint brace (BRB) system was adopted to ensure lateral stability. There are 49 levels of two-way post-tensioned flat slabs with a typical thickness of 25cm and these are supported by inner shear walls and perimeter columns. The compressive strength of the concrete used was up to 55MPa and this allowed earlier tendon stressing. The slabs here are thicker compared to the other two buildings because of the longer spans and cantilevers of The Viridian's floors. We successfully completed post-tensioning here in August 2015 and the building is due for completion by August 2017.

2 The Royalton at Capital Commons, Philippines

The Royalton used a performance-based design as well, but adopted an outrigger structural system for lateral stability. There are a total of 61 floors of two-way post-tensioned flat slabs in the building with a standard thickness of 22.5cm. They are supported by shear walls and perimeter columns. The compressive strength of the concrete is 41MPa which allowed the general contractor to achieve a one week floor cycle, with two concrete pours per floor. Banded post-tensioning tendons are employed at the supports and run in the opposite direction to the distributed tendons. In addition, catenary tendons are deployed for the cantilever areas. The post-tensioning work for The Royalton was completed in early 2017 and the overall project is due to complete in December 2018. ➤

3 The Imperium at Capital Commons, Philippines

A performance-based design was also used for The Imperium, where an outrigger system supported by a BRB system was chosen for the project's circular layout and due to its slenderness. Two-way post-tensioned flat slabs with a typical thickness of 20cm will be used for 58 floors and supported by a central shear wall and perimeter columns. Post-tensioning tendons will radiate from the central shear wall and banded tendons will ring the floor perimeters. Post-tensioning work began on site in September 2016.

All of the flat slabs constructed in the above three projects are post-tensioned with 205 and 405 BBR CONA flat tendons. The team used a total of around 730t of prestressing steel for the three towers. Elsewhere in the Philippines, a further six high-rise developments are benefiting from the BBR post-tensioning approach, as well as BBR Philippines' expertize and experience.

4 Fraser Tower, Cecil Street, Singapore

Meanwhile in Singapore, construction is underway on a 38-storey premium grade A office tower located at the gateway to the island nation's central business district (CBD). Projected for completion in 2018, Fraser Tower reaches 235m into the skyline, while lower down offers a direct connection from the lobby, via an underground walkway, to the Tanjong Pagar MRT station.

The development offers column-free floor plates ranging from 1,900m^2 to 2,100m^2 and, with these column-free spaces, it is no surprise that construction is based on one-way post-tensioned slabs and post-tensioned beams. BBR Construction Systems, the BBR Network Member for Singapore, is providing design and installation services.

The development has been uniquely designed as an office space within a park with open terraces on the fourth storey of the tower and a roof garden and, most importantly, adjacent to the tower will be a park with lush greenery and eye-catching water features.

Coupled with a cascading three storey retail podium with open air roof garden and featuring both retail and food and beverage options, Fraser Tower aims to be more than just an office space – creating a shopping and garden paradise within the concrete jungle.

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"Two-way post-tensioned flat slabs with a typical thickness of 20cm will be used for 58 floors and supported by a central shear wall and perimeter columns."

1 The Viridian in Greenhills, Philippines.
2 The Royalton at Capitol Commons, Philippines.
3 Fraser Tower, Cecil Street, Singapore.
4 The Imperium at Capital Commons, Philippines.
5 Whitehorse Towers, Melbourne, Victoria, Australia.
6 One at Palm Jumeirah, Dubai, UAE.

5 Whitehorse Towers, Melbourne, Victoria, Australia

The Australian State of Victoria's largest development – outside of Melbourne's CBD – is Whitehorse Towers. Set to become Box Hill's most prestigious address and a landmark for the future, Whitehorse Towers is a mix of one, two and three bedroom residential apartments, boutique hotel, retail outlets and eateries.

Located 14km east of Melbourne's CBD, Whitehorse Towers will be an impressive sight. Two soaring towers will rise from a podium and terrace where commercial tenancies, specialty shops, cafés and restaurants will provide linkages with the vibrant culture of the surrounding area. Within the towers will be 511 residential apartments and the latest of the successful Art Series Hotels.

Australian BBR Network Member SRG is providing post-tensioning design and installation services for I&D Group on this prestigious scheme. SRG's scope on this project includes the supply, installation, stressing and grouting of 280t of post-tensioning to all levels of both towers plus basement and podium levels. Whitehorse Towers is scheduled for completion in 2017. ➤

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TEAM & TECHNOLOGY

1 2 3

Owner – Ortigas & Company Limited Partnership (OCLP)
Main contractor – D. M. Consunji, Inc. (DMCI)
Technology – BBR CONA flat
BBR Network Member – BBR Philippines Corporation (Philippines)

4 **Developer** – Frasers Centrepoint Limited
Architect – DP Architects Pte Ltd
Structural Consultant – Meinhardt (Singapore) Pte Ltd
Main contractor – Hyundai Engineering & Construction Co Ltd
Technology – BBR CONA internal, BBR CONA flat
BBR Network Member – Systems Pte. Ltd. (Singapore)

5 **Developer** – Asia Pacific Group
Architect – Peddle Thorp Architects
Frame contractor – I&D Group
Technology – BBR CONA flat
BBR Network Member – SRG Limited (Australia)

6 **Developer** – Luxury Developments LLC
Main consultant – AREX
Main contractor – Brookfield Multiplex Constructions LLC
Technology – BBR CONA flat
BBR Network Member – NASA Structural Systems LLC (Dubai)

6 One at Palm Jumeirah, Dubai, UAE

Moving now to Dubai, BBR Network Member NASA Structural Systems LLC (part of the SRG Group) has been appointed by Brookfield Multiplex for the design, supply, installation, stressing and grouting of post-tensioning for the One at Palm Jumeirah project.

Situated on Dubai's world-renowned Palm Jumeirah island, One at Palm Jumeirah will offer 90 ultra-exclusive residences, ranging in size from 270 to 2,000m².

The company's scope of works on this project includes the design, supply, installation, stressing and grouting of post-tensioning which includes around 300t of prestressing steel strand and covers approximately 51,500m² over levels 1 through 24.

As is evident from the image, the geometry of every tower floor is unique and there are significant perimeter cantilevers of varying lengths. Post-tensioning was an ideal solution for dealing with the large spans and significant cantilevers.

The team includes up to three supervisors, as well as a project engineer, engaged in the site post-tensioning work which is programmed to finish by the middle of 2017. ●

ABLOK 67A, **NEW BELGRADE, SERBIA**

BBR post-tensioning for residential & commercial project

QUALITY FOCUS

A major project is underway in New Belgrade, Serbia and the focus is on quality of materials and finishing. It is therefore no surprise to learn that BBR Adria is on site installing the latest BBR technology.

TEAM & TECHNOLOGY

Owner – Deka inženjering
Architect – ZAPP
Main contractor – Exing B&P d.o.o.
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o.

New Belgrade is the central business district – and fastest developing area – of the city of Belgrade. The area has evolved since 1948 and was planned and constructed in 'blocks' – currently there are 72 blocks in the municipality.

ABlok 67a is part of a major new residential and commercial complex which features a 50,000m² building with two underground levels for garaging and 14 above ground floors.

Working alongside main contractor Exing B&P d.o.o., BBR Adria has installed slab post-tensioned slabs using the BBR VT CONA CMM unbonded system and placed some 135t of prestressing steel. ●

PT SLABS FOR TENNIS COURTS, **POLAND**

BBR Network technology & service quality wins contracts

GAME, SET AND MATCH!

Outdoor playing surfaces need to be of extraordinary high quality in Poland because of the local climate conditions – the country has the largest number of annual freezes and thaws in Europe. Now, BBR slab-on-ground post-tensioning is also delivering the sports industry a joint-free, low maintenance surface. Dariusz Masłowski of BBR Polska describes the company's recent projects.

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Following some promotional activities for post-tensioned slabs-on-ground targeted at the sporting community, we were awarded three tennis court projects. Lack of joints and greater safety against cracking during their service life were the customers' key reasons for choosing the post-tensioned ground slab approach.

In the southern Polish town of Pszczyna, we are constructing a 2,500m^2 post-tensioned ground slab for four tennis courts.

Meanwhile further north, near Swarzędz, a private tennis court owner accepted our post-tensioned slab solution because it could overcome the challenges of the locally very porous natural soil conditions and guarantee a stable playing surface overall. Here, we have constructed a 648m^2 post-tensioned slab.

In Poznań, our team has post-tensioned a 1,780m^2 ground slab for three tennis courts which will be covered by a tented roof.

The slab serves both as an excellent sub base for the professional tennis surface and as a solid foundation for the steel structure supporting the tented roof frame which spans over all three tennis courts.

For each of the tennis court projects, we used the BBR VT CONA CMM monostrand system to provide two-way post-tensioned ground slabs of exceptionally high quality.

It is worth mentioning that, for all of the projects, the BBR Polska team delivered the post-tensioned slabs for the customers as a complete package. Our contract included performing the necessary calculations, execution of drawings, delivery and installation of all construction materials – including the concrete. As a part of the service, we also made recommendations about the minimum soil preparation requirements. It seems that a comprehensive one-stop shop approach was the key to our success in winning these projects. ●

1 For a private customer near Swarzędz, BBR Polska delivered a post-tensioned tennis court ground slab solution which guaranteed a stable playing surface despite difficult soil conditions.

2 Part of the concrete pour completed for a private tennis court project. BBR Polska's winning formula has been to offer their post-tensioned sports industry solution as a complete package comprising calculations, design, delivery and installation – and even including concrete.

TEAM & TECHNOLOGY

Owner – PB Molbud Sp. z o.o. Sp. K. (Pszczyna)/Private Owner (nr Swarzędz)/ POSiR (Poznań)

Design & installation – BBR Polska z o.o.

Technology – BBR VT CONA CMM monostrand

BBR Network Member – BBR Polska z o.o.

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JTC FOOD HUB, **SINGAPORE**

Post-tensioning for precast building construction

IMPROVING PRODUCTIVITY

Combining BBR post-tensioning technology with a precast modular approach to the construction of a new facility in Singapore has improved productivity on site. Yeo Swee Choo of BBR Construction Systems, the BBR Network Member in Singapore, provides a report on this novel approach for an innovative project.

The JTC Food Hub at Senoko is being developed by JTC Corporation in collaboration with the Singapore Manufacturing Federation and Singapore Food Manufacturers' Association. The seven storey food hub is Singapore's first multi-tenanted development with shared integrated cold room and warehouse facilities.

Built on a 3,300m^2 plot, the JTC Food Hub comprises 50 modular factory units of 1,100m^2 each, spread over five floors with an access ramp catering for 40ft container trucks. The 15,300m^2, double volume cold room/warehouse is located on the first floor.

The structural system adopted for the superstructure is post-tensioned beams with precast hollow core slabs supported on precast columns and walls. The factory units are laid out on a grid of 12.5m x 13m. The post-tensioned beams for the factory range in width from 2,400mm to 2,600mm and are 950mm deep, spanning 13m and for the driveway, 2,800mm or 3,200mm wide by 1,250mm deep, spanning 13 or 19m. Both the factory and driveway will have a 400mm thick hollow core slab with a 100mm thick concrete topping. The ramp consists of a 300mm thick reinforced concrete slab which will have 2,500mm wide x 750 or 1,000mm deep post-tensioned beams.

The main contractor adopted a precast shell scheme for the post-tensioned beams in the factory and driveway to improve productivity. This is in line with the Singapore Government's constant push for the construction industry to re-think the construction process and lessen the demand for on-site labor – and precasting is one such methodology by which construction productivity can be improved.

The U-shaped reinforced concrete precast shells are fabricated in the factory with post-tensioning ducts and reinforcement in place. As well as acting as support for the hollow core slab, the 11.8m and 17.2m long shells are strengthened to span between temporary supports which are needed because of the long spans between columns. Once the shells are lifted in place, the ducts over the columns are connected and the strands are threaded through. The beams are then cast and stressed. ●

1 One of the precast shells being lifted in place.
2 A precast shell on site ready prior to lifting onto temporary supports between the columns.

TEAM & TECHNOLOGY

Developer – JTC Corporation, in collaboration with Singapore Manufacturing Federation & Singapore Food Manufacturers' Association

Main contractor – Yongnam – Jian Huang JV

Architect – Surbana International Consultant Pte Ltd

Technology – BBR CONA internal

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

RAMP-UP MULTIPLE USER WAREHOUSE, **SINGAPORE**

High specification structural system with post-tensioning

MEETING DESIGN & CONSTRUCTION CHALLENGES

The team from BBR Construction Systems in Singapore has met the challenges of producing an economic engineering design and also of their customer's demanding schedule. Dickson Liew describes his company's work on this ramp-up multiple user warehouse project.

1

1 The completed Mapletree Logistics Hub where structural design requirements were met with BBR post-tensioning – and the skill of the local BBR team.

TEAM & TECHNOLOGY

Developer – HSBC Institutional Trust Services (Singapore) Ltd, as trustee of Mapletree Logistics Trust

Main contractor – Lum Chang Building Contractors Pte Ltd

Architect – 3HPArchitects Pte Ltd

Technology – BBR CONA flat, BBR CONA internal

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

The Mapletree Logistics Hub at 5B Toh Guan Road East occupies a land area of 25,400m^2 with a gross floor area of 63,432m^2. It is a brand new high quality warehouse in a prime logistics location with excellent connectivity to the city center, Jurong Port and Iskandar region in Johor. The six storey ramp-up warehouse was built to high specifications to enable users to achieve greater efficiency in managing their warehousing and logistics operations. The warehouse has a high floor loading of up to 20kN/m^2 and ceiling height of up to 10m. The ramp-up design offers direct access to warehouses on every level. Other key features of the site include open space container parking lots, dedicated loading bays and large floor plates to cater for business scalability.

The structural system for the superstructure of the project is summarized in the adjacent table. It was designed to the British Standard, BS8110 and Code of Practice of Singapore, CP65 which has since been superseded by Eurocode 2. In the design, service stresses are limited to Class 3 0.2mm crack with a four hour fire rating requirement.

We were involved extensively in the superstructure design and construction of the post-tensioned structural elements of the project. Challenges in both design and construction were encountered.

The key challenges for the design were to provide an economical design based on a thinner concrete section in order to reduce loading on the vertical members. This had to be achieved while still meeting the stringent deflection requirements, compliant with final floor levelness and flatness, FM2, as stipulated in the Concrete Society's Technical Report 34, 4th Edition.

The challenges faced by the construction team were largely around meeting the main contractor's schedule based on a three day stressing cycle and laying of the closely spaced tendons with a relatively small radius at the corner of the ramp. The site layout, swept path requirement for truck trailers and constraints regarding adding more columns, meant that it was inevitable for the architectural layout of the ramp to be skewed. Thus a structural layout emerged with long spanning beams and slabs – the design requirements were met by using post-tensioning.

The new facility was completed on time, in early 2016, after a construction program of some 16 months. We are pleased to have been involved in this project and looking forward to building on our capabilities with more such challenging projects. ●

PROJECT SUPERSTRUCTURE

Zone	Structural System
Warehouse Area	• 315mm thick post-tensioned flat slab with 715mm drop panel or band beam
Driveway, Loading & Unloading Area Ramp	• 400mm thick one-way post-tensioned slab system • 3,800mm x 1,200mm & 800mm depth post-tensioned beam at driveway • 3,000mm x 700mm, 900mm & 1,200mm post-tensioned beam at ramp

NEW NEIGHBORHOODS, **AUSTRALIA, CROATIA, FINLAND & NEW ZEALAND**

Harnessing the advantages of BBR technology & expertize to shape new communities

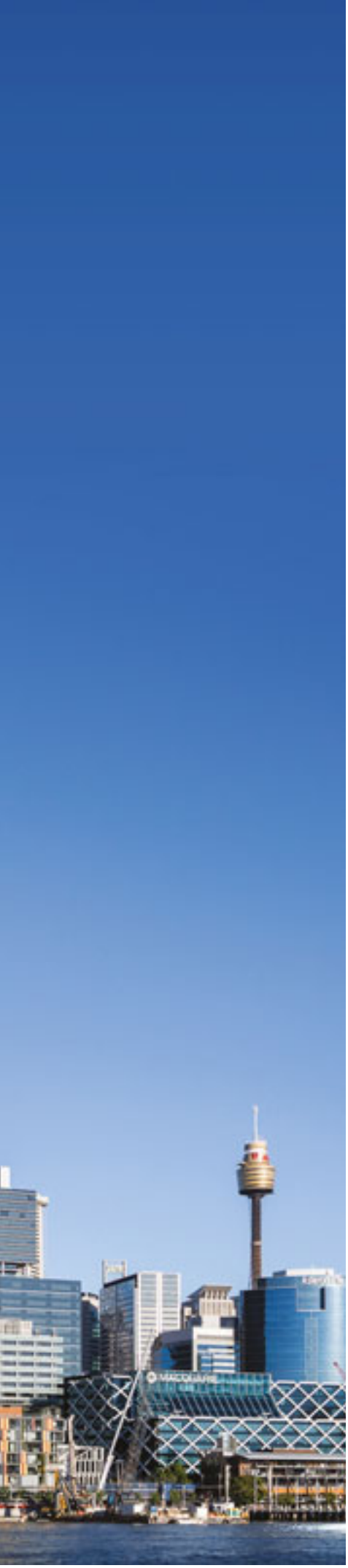
SHAPING NEW COMMUNITIES

As world populations expand and develop, economic and social priorities shift – as does the need for supportive infrastructure. Here, we present the background to the schemes and construction challenges being undertaken to shape five exciting new communities. Although the communities under construction have differing roots, scales and purposes, they all have sustainability at their hearts and the BBR Network is contributing green technology to their realization.

BBR technologies are inherently environmentally friendly from a number of perspectives. Their design only uses the amount of material necessary and in turn they promote the use of less other materials such as reinforcement bar and concrete.

The use of BBR post-tensioning systems leads to a low maintenance structure that is also sufficiently flexible for later repurposing or reconfiguring. However, as the projects described below will show, architects also benefit from flexibility of design when using BBR post-tensioning and can thus produce more efficient – as well as more exciting – structures.

1



1 Barangaroo Update (SRG)

Sydney's largest construction project – the 22 hectare Barangaroo harbor-front urban renewal scheme – continues to transform the western edge of the city's Central Business District (CBD). On completion Barangaroo will be home to more than 2,000 people and a place of work for 24,000 people. In addition, 33,000 people are expected to visit each day – a total of 12 million every year.

The creation of Barangaroo is a long term project and completion of the buildings and infrastructure will take around 20 years. The scheme has been divided into three main areas:

- Barangaroo South – a 7.6 hectare mixed-use commercial hub. Stage 1 completed in 2016, with the opening of all three commercial office towers (International Towers Sydney), two residential apartment buildings and over 40 shops, cafés and restaurants. A further 40 retail outlets will open in 2017, followed by an international hotel and three further residential buildings.
- Barangaroo Reserve – opened in 2015 and is a six hectare harbor foreshore park for the enjoyment of local people and visitors alike. Its creation involved turning a former concrete container terminal into a naturalistic rocky outcrop and sensitively landscaping the site with over 75,000 native trees and shrubs.
- Central Barangaroo – located between Barangaroo Point and Barangaroo South, this 5.2 hectare site will combine civic and cultural attractions with recreational, residential, retail and commercial facilities.

Australian BBR Network Member, SRG has had a long association with this massive development. Back in the mid 2000s, when the concept was first launched, the project's developer and main contractor, Lendlease, formed a number of alliances with selected subcontractors to enable economies. SRG has worked alongside Lendlease on Barangaroo, reviewing designs and constructability since the tender stage.

The developer's aim for the PT Alliance was to reduce tendering, administrative and legal costs, as well as enabling corporate assessment to ensure that safety, quality and value were delivered on all projects.

Lendlease wanted to foster trust with key suppliers, to ensure technical innovations were shared to the benefit of both parties and to encourage value engineering, delivering financial and time savings.

Aside from these aspirations, Lendlease recognized the benefit of having a regular team of specialists on repeat projects.

SRG began work at Barangaroo in 2013 and has carried out a number of projects including post-tensioning works for the Napoleon Street Bridge and installation of 22 BBR VT CONA CMI tendons for the 80t beams for the Barangaroo Cultural Space. Further reports on these projects can be found in CONNÆCT 2015 and 2016.

SRG has recently completed work at Barangaroo South on the three commercial office towers – containing 38, 41 and 48 floors – that make up International Towers Sydney. The SRG flat slab system and BBR VT CONA CMF post-tensioning systems were used for the floor slabs and a cycle time of one floor per week on each of the buildings was achieved. Some 3,000t of prestressing steel is going into the project.

SRG is also working on some smaller buildings in this part of the development.

Among the advantages offered by choosing a bonded slab post-tensioning system, compared to an unbonded system, are that quantities of conventional reinforcement are reduced, failure risk – if tendons need to be cut after installation – is minimal and late design or geometry changes can easily be adjusted for.

Future work on this site includes a 275m tall, 75-storey six star hotel resort – which is due to open in 2020, three large residential towers, plus low rise residential and services structures.

The challenges for SRG, on this busy inner city and high profile construction site, have included programming and scheduling material procurement to suit the actual construction program.

Meanwhile SRG's value engineering on numerous projects has reduced quantities and facilitated construction. They have even developed their own product, Surelok – a unique engineered solution for temporary movement joints – and had this introduced into a number of Lendlease projects. ➤

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2 Tripla, Helsinki, Finland

A massive redevelopment project is underway in Pasila to transform this important metropolitan public transport intersection into a second center for Helsinki. The suburb of Pasila is divided into East and West Pasila by a central railway marshaling yard which is now being redeveloped as 'Central Pasila' and will unite the two communities.

Following a design competition, the €1 billion Tripla project is the first development within this 59.3 hectare urban renewal scheme to get underway. It involves a three block complex comprising a shopping center, housing units, hotel, executive offices and a public transport terminal.

In the summer of 2015, concrete frame specialist Naulankanta presented a solution using the BBR VT CONA CMM monostrand system, where the monostrands are arranged in a band, with CONA CMM 0406 active and passive anchors, instead of mono anchors, to their client. With a very tight program, main contractor YIT became interested in this special solution and ultimately awarded the contract to Naulankanta.

Now, several months into the project, both YIT and Naulankanta are very satisfied with the advantages offered by using post-tensioning tendons comprised of CONA CMM bands which allow installation of five slabs of up to 1,500m^2 per week.

The installation team's challenge is to stress a total of 200 slabs, completing a minimum of three slabs per week. In total, there are 200,000m^2 of post tensioned slabs which will require some 1,400t of prestressing steel.

Although the pre-assembled tendons are produced on a just-in-time basis according to the latest construction drawings and transported from KB-Vorspann Technik's workshop in Austria to the building site in Helsinki, the solution provides major advantages compared to standard on site installation. Especially during the coming winter, where temperatures may drop below -20°C, easier installation of the pre-assembled CONA CMM monostrand system will be more than welcome to Naulankanta's project manager at Tripla, Harri Hänninen, who is leading a team of 13 installation workers on site.

Shell construction for this part of the project is planned for completion in early 2018, while the final handover of the project is currently programmed for 2025.

3 University campus, Varazdin, Croatia

The new student dormitory at the University of Zagreb's Varaždin campus is a tall structure which cascades down to the level of the existing dormitory roof. The building has a basement, five upper floors and a common ground floor where most of the dormitory and administration facilities will be housed. The common areas of the floors – dining rooms, kitchens, classrooms and roof terraces – will be connected by a corridor, or a kind of 'street', to encourage student interaction.

Goran Tomišić from local BBR Network Member, BBR Adria, reports that they began work on site in October 2016. The team will be installing a post-tensioned slab for the underground car park and floors of the dormitory building. The car park sits beneath the central courtyard, surrounded by other buildings, and has spans of up to 16m for which the team is installing wide, shallow beams running in the longer direction with a constant slab thickness between beams. In the dormitory building, the spans are smaller and BBR Adria has managed to achieve an engineering design for post-tensioned slabs of a constant thickness without the need for beams.

The design of the Varaždin campus includes use of solar collectors, ecological local materials, as well as rain and waste treatment. It will also use a green energy power plant to fuel the whole campus, resulting in the complex operating on a low-energy consumption basis – one of the first of its kind in Eastern Europe.

Thus, the choice of a post-tensioned approach from the BBR Network for the construction of the new building further reinforces the University's sustainable approach – lower materials consumption, less excavation, low maintenance structure and a building that is sufficiently flexible to be reconfigured or repurposed in the longer term. ●

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1 International Towers Sydney, Barangaroo South – where SRG has completed post-tensioning work for the three high rise towers of 38, 41 and 48 floors.
2 Artist's impression of Finland's new Tripla development at night. Image courtesy of YIT Group.
3 Artist's impression of the new campus for the University of Zagreb in Varaždin. Image courtesy of SANGRAD-AVP Arhitekti.
4 Artist's impression of the Parklands Project in Queensland, Australia.
5 Artist's impression of Ryman Healthcare's new resort style retirement village near Auckland, where post-tensioning by BBR Contech has delivered major savings for their customer.

4 Parklands Project, Queensland, Australia

The Parklands Project is a A$550 million mixed-use master planned development which features 1,252 dwellings with a mix of apartments and townhouses, a retail precinct and green landscaped space built around a 'Village Heart'. Since works commenced on site in November 2015, SRG has installed over 700t of post-tensioning as well as approximately 3,500 units of SRG's product SureLok™.

5 Ryman Healthcare, Greenlane, New Zealand

A new 'resort style' retirement village in New Zealand will go a long way to meeting the increasing demand for high-quality homes and healthcare for those over 70 years of age. BBR Contech has, quite literally, been in at the ground level of this NZ$100 million project.

Ryman designed the village to maximize the land area available, with four multi-storey blocks and, beneath them, 6,500m² of car parking space at basement level. However, investigations revealed that the ground to be excavated for the car park was pure basalt rock – bringing with it the risks of skyrocketing costs and the inconvenience of noise, dust and disruption for the neighboring residents.

The Ryman team began the hunt for smart, cost-effective ways to reduce these risks and, through word-of-mouth and personal recommendations, found a solution that has delivered major budgetary savings – BBR Contech and a post-tensioned suspended ground-floor slab.

Despite having never installed a PT slab before, the Ryman design team were quick to understand its advantages.

"A conventional precast slab is usually about a meter thick, while a PT slab is just 500mm," says David Gibson, Ryman's Regional Construction Manager. "The PT option made logical sense; the less rock we had to excavate, the cheaper the excavation costs."

Ryman also appreciated the other comparable benefits of PT slabs – a lighter weight that could allow for smaller columns in the car park, a longer span that could reduce the actual number of columns and better long-term performance that could reduce the costs of maintenance and repair.

With a feasibility study complete and the 'go-ahead' decision made, BBR Contech is working closely with Ryman's preferred engineering partner, Mitchell Vranjes – and benefiting from the specialist advice of Australian BBR Network colleague SRG – to ensure that the supply and installation of the post-tensioning goes well.

TEAM & TECHNOLOGY

1
Developer – Lend Lease (Barangaroo South), Barangaroo Delivery Authority (Headland Park), Transport for NSW (Wynard Walk)
Main contractor – Lend Lease (Barangaroo South & Headland Park), Thiess Contractors (Wynard Walk)
Subcontractor – Ward Civil (Wynard Walk), Baulderstone (Headland Park)
Technology – BBR VT CONA CMF flat, BBR VT CONA CMI internal, BBR CONA flat, MRR range, PT bar
BBR Network Member – SRG Limited (Australia)

2
Developer – State of Finland & City of Helsinki
Main contractor – YIT
Concrete frame contractor – Naulankanta
Technology – BBR VT CONA CMM monostrand
BBR Network Member – KB Vorspann-Technik GmbH (Germany)

3
Owner – University of Zagreb
Architect – SANGRAD Architects & AVP Arhitekti
Main designer – Vedran Pedišić d.i.a.
Structural engineer – 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)

4
Developer – Grocon
Main contractor – Grocon
Subcontractor – SRG Limited
Technology – BBR CONA flat
BBR Network Member – SRG Limited (Australia)

5
Owner – Ryman Healthcare
Developer/Builder – Ryman Healthcare
Designer – Adams Engineering (Sydney)
Structural engineer – Mitchell Vranjes
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

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REDQ, **KLIA 2, SEPANG, MALAYSIA**

Optimizing construction with BBR technology & know-how

SIMPLE, EFFICIENT & FAST TRACK

In the competitive airline business world, the 'company in red', AirAsia Berhad, has taken another stride towards an even greater success by building their new HQ offices right next to Kuala Lumpur International Airport 2 (KLIA 2).

1 The new six storey AirAsia Berhad HQ, next to Kuala Lumpur Airport 2, has a large full height central atrium featuring link bridges running side-to-side. This large central opening created a long span in places and floor-to-floor height restrictions ruled out use of deep conventional beams, BBR Malaysia overcame this by installing shallow 800mm deep post-tensioned beams.

TEAM & TECHNOLOGY

Owner – AirAsia Berhad
Main contractor – Maxprom Bina Sdn Bhd
Technology – BBR CONA internal
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

The main contractor, Maxprom Bina Sdn Bhd, set out to optimize every single factor during the construction stage. They chose an alternative post-tensioned design, thus removing the complexities and inefficiencies of traditional reinforced concrete design. Zuhair Rawi, Design Engineer from BBR Construction Systems Malaysia was up for the challenge. Equipped with an optimum post-tensioning design, proper planning, effective construction methodology and great teamwork, BBR won and successfully completed the project.

The new headquarters consists of six storeys, comprising over 22,000m^2 of programmed work areas with another 10,000m^2 of ancillary general offices. Named 'RedQ' in short for RedQuarters, the new complex is expected to house over 2,000 workers from both AirAsia and AirAsia X.

Cost effective structure

With the introduction of post-tensioning to the structure, we managed not only to reduce the cost, but also to create a simpler construction methodology and improved the efficiency of construction work. The structural schemes chosen are post-tensioned flat slabs with drop panels which are typically applied to most of the structure and a number of post-tensioned beams to cater for long span areas.

MALL OF SWITZERLAND, **EBIKON, SWITZERLAND**

BBR post-tensioning for massive shopping center

RETAIL THERAPY

On a site the size of around 10 football pitches in Ebikon – in the suburbs of Lucerne, Switzerland – a new shopping center is taking shape. Stahlton AG, the BBR Network Member for Switzerland is currently working on the post-tensioning for the project.

The Mall of Switzerland will be a multi-storey retail center and 1,600 space car park, with a neighboring leisure complex including cinemas and sporting facilities. The core of the project is a 200m long three level Mall building which will offer 46,000m² of retail space. It is estimated that the Mall will attract around four million visitors to its 140 shops and restaurants.

Stahlton is tasked with installing 250 BBR VT CONA CMI internal bonded post-tensioning tendons, using approaching 37,000m of prestressing steel and round corrugated steel ducts. The new shopping and leisure center is due to open its doors to the general public in autumn 2017. ●

TEAM & TECHNOLOGY

Developer – FREO Switzerland
Main contractor – Halter AG
Architect – Burckhardt + Partner AG
Technology – BBR VT CONA CMI internal
BBR Network Member – Stahlton AG (Switzerland)

1 The Mall of Switzerland will offer 46,000m² of retail space when it opens in autumn 2017.
2 Stahlton is installing a total of 250 BBR VT CONA CMI internal bonded post-tensioning tendons for the project.

1

2

Simple & efficient structure with PT

The column grid layout of 8.4m by 8.4m enabled design of slabs for the car park area which were only 170mm thick and similarly, just 180mm thick slabs were sufficient for the office area. The post-tensioned slabs were thickened to 300mm at the column locations, forming drop panels which is structurally efficient for handling hogging moments and punching shear. To simplify post-tensioning installation, banded tendons of four or five strands were laid close to columns and distributed tendons of three or four strands at equal spacing in the other direction. Completion of one zone took about eight hours. The shallow flat structure saves formwork and material – and is faster to install. Without deep beams, the flat structure enables less upturns and downturns of M&E services trunking.

Architectural freedom

The concept was not only focused on the effective application of post-tensioning, but also on being able to realize every architectural requirement that had been set for the project. The concept of an open plan office was raised by the client and led the architect to introduce an atrium garden at the very center of the building. Thus, each floor has a large opening at the center with link bridges running side-to-side and creating an aesthetically pleasing environment around the office spaces. The large central opening created some long spans and floor-to-floor height restrictions ruled out use of deep conventional beams. The optimum solution to the architectural dilemma was found in shallow 800mm deep beams, post-tensioned with BBR CONA 1205 tendons, which were introduced for 25m long spans. These beams have the ability to control deflections, due to the uplift force of the tendons.

Boosting efficiency

Each floor was divided into several zones with a controlled concrete volume of 200 to 250m³ per zone. At first, each zone was separated by pour strips but, after in-depth discussions with the main contractor about the speed achievable if pour strips were eliminated, we then agreed to use construction joints with a pan-stressing method for each floor. We were able to complete around four to five zones a week – the increase in speed was simply amazing. In addition to that, the simplistic layout allowed the main contractor to fully exploit the use of modular formwork on the project, thereby realizing cost and time savings. ●

LONG-TERM CUSTOMER RELATIONSHIPS, **AUSTRALIA & NEW ZEALAND**

Post-tensioned floor slabs for malls & warehousing

STRENGTHENING STRUCTURES AND RELATIONSHIPS

It appears that BBR post-tensioning not only strengthens structures, but also relationships. Within the global BBR Network, there are many examples of customers returning for post-tensioning services time-and-time again. In this edition of CONNÆCT, we look at how post-tensioned floor slabs have grown in popularity and formed a foundation for long and productive working relationships. We examine the long term associations between three clients and their BBR Network partners, while reviewing projects past and present.

Both the technology and the expertize offered by the BBR Network is delighting customers. Firstly, the advantages of using BBR technology – low maintenance, lower costs and shorter construction program – are helping customers' businesses and, secondly, the know-how and high quality of service provided by BBR Network Members contributes to each customer's project and overall construction experience.

1 Westfield – 40+ years of commitment & service

Australian BBR Network Member, SRG is again providing post-tensioning installation services to Scentre – having maintained a strong relationship for over 40 years and completing more than 20 Westfield shopping center projects together throughout Australia. The relationship began in the 1970s, with the construction of the world famous Sydney Tower (Centrepoint). It is Sydney's tallest free standing structure and is owned by Westfield, now Scentre Group. With its innovative approach to construction, SRG provided the unique supporting net structure in what was one of the first applications of stay cables of this magnitude in Australia.

Back to the present day, SRG is installing post-tensioning at Westfield Warringah Mall in New South Wales.

The A$310 million redevelopment will include more than 70 new stores within a new two-storey parallel mall, a new refurbished Myer and a new multi-deck car park.

The contract was awarded to SRG in October 2015 and site works commenced shortly after, in mid-November. Post-tensioning work was completed by October of 2016 and the SRG labor force for the project peaked at around 15 employees on site.

SRG's work included the production of shop drawings and supply and installation of post-tensioning to three different zones. Again, SRG's own product, SureLok, was introduced into the project as a superior alternative to the documented lockable dowels in one of the zones.

In addition to the supply and installation of post-tensioning for the new floor slabs, SRG worked with Scentre Group Design and Construction in truncating the post-tensioning in the existing floor slabs.

The Warringah Mall redevelopment project was completed on schedule in late 2016.

SRG'S WESTFIELD PORTFOLIO – PAST & PRESENT

New South Wales/Australian Capital Territory

- Westfield Sydney
- Westfield Hornsby
- Westfield Kotara
- Westfield Belconnen
- Westfield Macquaire
- Westfield Miranda
- Westfield Warringah
- Westfield Chatswood
- Sydney Tower

Queensland

- Westfield Garden City
- Westfield North Lakes

Victoria/Tasmania

- Westfield Doncaster
- Westfield Plenty Valley
- Westfield Fountain Gate

Western Australia

- Westfield Galleria
- Westfield Whitford City
- Westfield Innaloo
- Westfield Carousel

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2 Naylor Love – PT in harmony

In the past 16 years, New Zealand's BBR Contech and commercial construction company Naylor Love have worked together on 24 building projects, producing in total more than 250,000m² of post-tensioned flooring. Along the way they have forged a strong, productive relationship based on professionalism, trust and respect.

Shared history

The two companies first worked together in 2000 on a flooring project for The Warehouse – a nationwide chain of stores well-known for its catchy advertising jingle and slogan 'Where everyone gets a bargain'. In those days, post-tensioning was still in its infancy in New Zealand and BBR Contech was one of very few companies promoting it. Scott Watson, Naylor Love's Business Development Director, had heard good things about the technique and was keen to give it a try. The Warehouse job, in the South Island town of Rangiora, was the perfect candidate.

While the floor was relatively modest at 3,500m², the Rangiora project quickly proved the benefits of using PT technology. The biggest Warehouse retail store floor to date is 14,000m², while its South Island Distribution Centre, constructed in 2002, covers a massive 32,000m².

"As a low-maintenance, high-performing solution it's ideal for stores with large floor areas and traffic that can damage conventional jointed floors," said Scott. "Yes, it may require slightly more effort and cost more, but it pays off in the long term." Since that first project, BBR Contech and Naylor Love have worked together on many more post-tensioned floor projects – including a further 14 for The Warehouse. BBR Contech remains Naylor Love's preferred post-tensioning provider wherever possible. "They do what they do well, and they do what they say they're going to do," added Scott. "They're reliable and professional, and we regularly recommend them to our clients."

In 2016, BBR Contech and Naylor Love united once again, this time on two Warehouse projects. The first, now complete, was an extension to the first Warehouse retail store post-tensioned floor they worked on, in Rangiora, and the other is an extension to the largest installed so far, at the Warehouse South Island Distribution Centre in the Christchurch suburb of Rolleston.

Retail store extension

The Rangiora project reflected recent growth and therefore consumer demand in the area. Completed in 12 days while the store remained fully operational, it involved cutting away a 660mm wide section of the original 3,500m² floor – including the PT anchorages – installing new armor edging and pouring a new 1,900m², 150mm thick post-tensioned slab so that it aligned neatly with the cut. In total, 6.2t of prestressing steel was installed and then the tendons were stressed and grouted, enabling the slab to accommodate 15kN in racking post loads and forklift loads of up to two tonnes.

Extending Distribution Centre

The extension to the South Island Distribution Centre floor is currently underway. A much larger proposition than the Rangiora project, it involves supplying an additional 14,200m² of 175mm thick floor to the 32,000m² warehouse, and 2,000m² of 150mm thick slab to a 2,800m² adjoining canopy.

This project will require 65t of prestressing steel and produce a floor slab to support 79kN in racking post loads and forklifts with a rated capacity of up to six tonnes. The existing slabs are still in excellent condition, so BBR Contech, Naylor Love and engineer Holmes Consulting Group are maintaining a strong focus on ensuring that the extensions meet the same high standards.

As with the Rangiora slab, the floors will be resilient to heavy traffic both inside the warehouse – with its high-tech, automated racking system – and in the canopy area, from where trucks unload products for the warehouse and distribute products to Warehouse stores throughout the South Island. The work is due to be completed early in 2017. ➤

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1 Westfield Warringah Mall under construction – one of SRG's latest projects to result from a 40-year customer relationship.
2 A mutually successful long-term relationship with main contractor Naylor Love has resulted in the installation of many post-tensioned floors, such as this recently completed project for retail store The Warehouse in Rangiora, New Zealand.
3 BBR Contech installed post-tensioned slabs for this 28,500m² dry storage warehouse, as well as a 4,850m² load-out facility, at Fonterra's Lichfield South Waikato milk processing plant in New Zealand.

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3 Supporting the dairy industry

BBR Contech's connection with New Zealand dairy giant Fonterra strengthened even further in 2016, with projects that included installing post-tensioned slabs at its Lichfield, South Waikato milk-processing plant.

Built in 1995, the plant produces a wide range of cheeses and transforms whey into ingredients for use in nutritional and energy drinks. It has recently undergone a NZ$360 million upgrade with the installation of a new whole-milk powder dryer – a move that will enable the company to more than double Lichfield's milk processing capacity, from 3.2 million to 7.6 million liters of milk per day – and produce 160,000t of milk powder per year.

Engaged by the project's main contractor Ebert Construction, BBR Contech's role was to install post-tensioned slabs in a dry storage warehouse and load-out facility located next to the new dryer tower – the former spanning an area of 28,500m² and the latter 4,850m². Both projects were undertaken once the roofing and walls had been installed, which meant the team and their equipment were protected from the elements throughout.

In installing the larger floor, the team took the time-efficient approach of setting it up as one floor, with two way tendons with a joint in the middle. With this in place they poured five slabs in two days, saving time and therefore money while also delivering the high-quality, incredibly strong floor the client required. The resulting surface is capable of holding 40,000t of whole milk powder and withstanding the weight and movements of multiple automated forklifts transporting pallets 24 hours-a-day.

The smaller load-out facility slab is even more robust, with the capacity to handle extremely heavy loads. It includes a built-in rail siding, where product is loaded into containers for direct transport to the appropriate export shipping ports.

As this issue of CONNÆCT went to print, the 121t dryer chamber had been lifted into position inside the 55m high dryer tower, and the final installation and other works were almost complete. In this massive two year project, more than 300 companies were employed and around 3,000 people worked on site. Together, they have provided Fonterra with an asset that will boost not only the company's output but also the economic prosperity of New Zealand as a whole. ●

TEAM & TECHNOLOGY

1 **Owner** – Scentre Group
Main contractor – various
Technology – BBR CONA flat
BBR Network Member – SRG Ltd (Australia)

2 **Owner** – The Warehouse
Main contractor – Naylor Love
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

3 **Owner** – Fonterra
Main contractor – Ebert Construction
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

HOTEL & SHOPPING CENTER PROJECTS, **POLAND**

Post-tensioned transfer beams overcome load & deflection challenges

CREATING COLUMN FREE SPACE

The weight of two new prestigious buildings in Poland is literally being carried by post-tensioned beams. Bartosz Łukijaniuk of BBR Polska describes the construction of the Five Star Hotel Radisson Blu Resort, Świnoujście and the Galeria Północna shopping center in Warsaw.

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TEAM & TECHNOLOGY

1 **Developer** – Zdrojowa Invest
Main contractor – Erbud S.A.
Architect – PPA
Structural design – Pracownia Konstrukcji Budowlano-Inżynieryjnych Pikus Adamski Sp. p.
PT design – Hemleccy sp. z o.o., BBR Polska Sp. z o.o.
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

2 **Developer** – Globe Trade Centre S.A.
Main contractor – Unibep S.A.
Design architect – Moshe Zur Architects
Project architect – APA Wojciechowski Sp. z o.o.
Structural design – Ove Arup & Partners, ARBO Projekt Sp. z o.o.
PT design – gp-projekt sp. z o.o, Structural Design Services sp. z o.o., BBR Polska Sp. z o.o.
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

1 Visualization of the Galeria Północna shopping center project which involved the construction of a set of beams supporting the whole building – to allow column-free space beneath for large delivery trucks to enter.
2 Artist's impression of the new Five Star Hotel Radisson Blu Resort, Świnoujście where BBR Polska installed 11 post-tensioned beams above the ground floor conference hall to deliver a large column-free area – and support the 13 storeys above.

1 Five Star Hotel Radisson Blu Resort, Świnoujście – PT beams for column-free conference hall

In 2015, BBR Polska won a project for the design and execution of a set of heavily loaded, post-tensioned transfer beams supporting almost the whole of the Radisson Blu Resort hotel building. The nearly 31m long and 3.3m high beams are located above the ground level conference hall.
A grid of 11 post-tensioned beams now support the hotel's 13 storeys.
Stressing operations were divided into two stages to accommodate the progressively increasing load factors during construction. First stage stressing was carried out after all the beams had been completed – and after total self-weight had been applied. At this point, the structure was able to take a considerable loading – the dead load from a few levels – and all formwork was removed. The second stage stressing took place after nine levels of the superstructure had been concreted and six levels of brickwork walls had been completed.
In the first stage stressing, 58% of tendons were stressed to the final force and the remaining 42% were stressed in the second stage. After each stressing stage, all tendons that had been stressed were then grouted. In total, 50 BBR VT CONA CMI internal post-tensioning tendons were installed and 38t of prestressing steel was used in the creation of Poland's first Five Star hotel with LEED certification.

2 Galeria Północna shopping center, Warsaw – PT beams in 'difficult' locations

In 2016, we completed a contract covering design and post-tensioning services for 31 heavily loaded transfer beams for one of the new shopping centers in Warsaw – the Galeria Północna. A post-tensioned solution was used in many locations – in fact, every time we faced difficult conditions involving either heavy loadings or where only small deflections were admissible.
The most challenging part of the project was execution of the set of beams supporting the whole building. They needed to take the load from columns and transfer this over a supply zone where large trucks enter an underground parking area. Thus, the column grid changes and two rows of columns are supported only on post-tensioned beams. A column-free space under the post-tensioned beams was crucial as large vehicles would need to access the loading bays to deliver new stock for the various retail stores. ●

SPRM HQ BUILDING, **PUTRAJAYA, MALAYSIA**

Post-tensioning supports 'floating' office towers

MASTERPIECE IN MALAYSIA

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1 The transfer floor structure sits on 30m high slanting columns inclined at 4.5 degrees and carries up to 22 floors for offices.
2 SPRM's headquarters building is a three-tower office complex with a striking sloping perspective – the challenging design was realized with effective construction methodology and BBR technology.

This three-tower office complex was designed to have a futuristic architectural form with a striking sloping perspective which will fascinate anyone who passes by the center of the Government City of Putrajaya. Shukree Saidi, Design Engineer at BBR Construction Systems (M) Sdn Bhd rose to the challenge of providing an effective construction method and technical support by introducing the BBR CONA internal post-tensioning system.

TEAM & TECHNOLOGY

Owner – Putrajaya Holdings Sdn Bhd
Main contractor – Pembinaan Mitrajaya Sdn Bhd
Prestressing contractor – BBR Construction Systems (M) Sdn Bhd
Technology – BBR CONA internal, BBR CONA flat
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

The high-rise towers with 15 to 23 floors start at a height of 30m above the ground and are founded on top of a transfer floor which is supported by a series of inclined mega-columns. The owner decided to adopt a post-tensioning approach for the transfer floor due to its structural ability to withstand heavy loadings from upper floors onto the long and slender inclined columns with spans up to 20m apart.

Transfer floor – key structure of high-rise towers

Transfer floors are widely used in Malaysia to transfer high loads from tall tower columns to lower columns which have a different orientation to the foundation. In this project, the transfer floor structure sits on 30m high slanting columns inclined at 4.5 degrees and carries up to 22 floors for offices. The transfer floors are designed as post-tensioned flat plates which vary in thickness for each tower – for example, 1.2m for Tower A, 1.5m for Tower B, and 1.8m for Tower C. Grade 40 concrete was used and two stages of casting were required for concreting the slab to full depth.

A modular formwork system supported by heavy duty shoring from the ground level is being used to support the slab weight of the first layer of casting. Once all the tendons within the first casting have been stressed to the required jacking force, the slab then acts as a permanent formwork for the second layer of casting – without requiring any more propping support from below.

Each transfer floor is divided into four construction zones by construction joints. At the joints, overlapping tendons for the next zone are anchored in the zone being concreted. The tendons are BBR CONA internal 705, 1205 and 1905 for the transfer floor, while BBR CONA flat 205, 305, 405 and 505 are being used for the typical floors above.

Typical upper floors – flat plate design

Flat plates are commonly used in building floors because of the advantages compared to traditionally reinforced concrete beams with flat slabs, as well as enhancing the aesthetics of the soffits. From the ninth floor upwards, post-tensioned flat plates are being implemented which are mainly designed for offices and have a 250mm thickness. Each floor is divided into three construction zones and each zone can be concreted in just two to three days with the usage of stressing pans which allow the tendons within the slab to be stressed later. In addition, the modular formwork system used by the main contractor has been more economical as formwork costs and cycle times were lower.

PT accomplishes many aims

Our installation of the BBR CONA internal post-tensioning system has successfully accomplished the aims of providing a thinner slab, longer span, lighter floor, time saving and, of course, structurally sound solution for the client for this architectural masterpiece in Malaysia. ●

PRÊCHEUR BRIDGE, **MARTINIQUE**

Stay cable installation for bow string arch bridge

FIRST IN THE CARIBBEAN

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A new €8.5 million bow string arch bridge – believed to be the first of its kind in the Caribbean – is under construction on the island of Martinique, one of France's overseas territories. Claude Néant of French BBR Network Member ETIC tells the story.

The bridge spans the Prêcheur River which flows through the north of the island in the shadow of the brooding Mount Pelée volcano. In June 2010, the bridge was damaged by two high discharge 'lahars' – a type of mud or debris flow comprised of a slurry of pyroclastic material, rocky debris and water. Road traffic was severely disrupted as this road connects the north and south of the island and only single file traffic has been permitted since the damage occurred. Monitoring is now carried out of the smaller landslips, which often go unnoticed by the local people, because these can often give an early warning of a larger event.

The new bridge has been designed to resist damage from flooding, seismic activity – and even 250km per hour winds. The 65m long bridge sits seven meters above the river bed and is founded on abutments constructed with 24 concrete columns, each 20m long and one meter in diameter. The project will require more than 800m^3 of concrete. The team from ETIC has been focused on the installation of the four BBR HiAm CONA 2706 stay cables which suspend the bridge deck from a 45t steel arch structure.

When the new bridge is declared open in mid-2017, the two parts of the town of Le Prêcheur will again be reunited, bringing the community back together. ●

1 The new €8.5m bow string arch bridge features four BBR HiAm CONA stay cables. When completed, the new bridge will reunite the two parts of the town of Prêcheur.

TEAM & TECHNOLOGY

Owner – Collectivité Territoriale de la Martinique
Main contractor – Entreprise Comabat and Berthold JV
Technology – BBR HiAm CONA stay
BBR Network Member – ETIC (France)

REGENTS BRIDGE, **JOHANNESBURG, SOUTH AFRICA**

Cable stays for pedestrian bridge

BRIDGE WITH A DIFFERENCE

Regents Park Bridge is a new pedestrian bridge in Johannesburg which crosses the N17 motorway at Regents Park. The bridge is an initiative aimed at preventing people from trying to run across the major highway.

The bridge was designed by SMEC in South Africa and is being built for SANRAL. The main cables of the bridge run from HiAm CONA anchorages in the first pylon to the same anchorages in the second pylon. Due to the tight spaces at the top of the pylons, Structural Systems (Africa) utilized nut head anchorages which allowed installation from both sides of the bearing plate. The back stays run from the pylon to a thickening in the deck over the abutments. The deck is then anchored to the abutment using vertical tendons which run down into the abutments. All of the stay pipes on the bridge are steel, and all strand utilized is cable stay strand which will be grouted into the pipes upon completion of the stressing.

The HiAm CONA system was chosen for its excellent fatigue characteristics. The system was also used on the vertical tendons due to the amount of longitudinal movement expected on the bridge. The vertical tendons utilized a short socket on one end and the standard long socket on the other. They were prefabricated off site and dropped into position. Stressing of the vertical tendons was carried out from an opening which was cast into the abutment.
The project created several challenges for Structural Systems Africa, but offered an innovative use of the BBR HiAm CONA system. ●

1 Artist's impression of the completed Regents Bridge.

TEAM & TECHNOLOGY

Owner – SANRAL
Designer – SMEC
Technology – BBR HiAm CONA stay
BBR Network Member – Structural Systems Africa

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ELIZABETH QUAY PEDESTRIAN BRIDGE, **PERTH, AUSTRALIA**

BBR Network expertize helps realize iconic design

NEW ICON ON THE FORESHORE

The team at SRG, the BBR Network Member for Australia, can now stand back and admire their work in the realization of Perth's newest landmark structure – the Elizabeth Quay Bridge.

The bridge, which opened last year, is on the north shore of the Swan River, on the Perth City foreshore. It is part of the Elizabeth Quay development – a project delivered by the State Government of Western Australia and designed to revitalize Perth while embracing one of the city's best natural assets. Part of the development included the construction of this spectacular pedestrian and cyclist bridge.

The A$20m contract to build the unique curving bridge was awarded to the Decmil, SRG Limited and Hawkins Civil joint venture, operating as DASSH JV (DASSH). DASSH was responsible for the construction of the 110m long, 20m high double arch, cable stay suspension bridge – the first of its kind in Perth. The bridge provides a link from Williams Landing to a new island, reinstating the pedestrian and cyclist access from the Narrows Bridge to the Causeway.

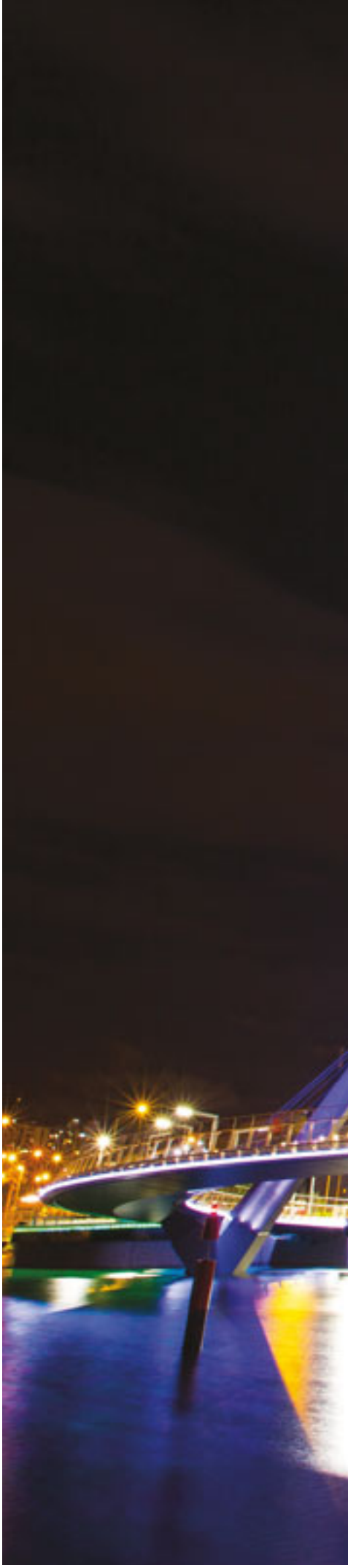
Innovative structural engineering and detailed civil infrastructure works were integral to bringing this ambitious architectural design to reality.

The project consisted of four partially immersed concrete piers supporting the pair of inclined arches, in-turn suspending the torsion box bridge deck with 16 cable stays. The arches and bridge deck were fabricated and modulised off site to enable a safer and more efficient installation. Upon delivery to site, the modules were butt welded and painted onsite then lifted into position.

The architecturally driven design called for stainless steel cladding, jarrah timber decking, data controlled light installations and seamless sweeping curves to create an iconic landmark to the Elizabeth Quay development. (See also CONNÆCT 2016 for more details.)

TEAM & TECHNOLOGY

Owner – Metropolitan Redevelopment Authority
Main contractor – Leighton Broad
Architect & designer – ARUP
Technology – Heavy lifting, hangers
BBR Network Member – SRG Ltd (Australia)



1 The Elizabeth Quay Bridge, Perth, Australia.

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PULAU POH BRIDGE, **LAKE KENYIR, MALAYSIA**

BBR HiAm CONA stay cables for new bridge

LANDMARK FOR ECO-TOURISM

The team from BBR Construction Systems Malaysia has begun construction of the new landmark bridge on the island of Pulau Poh.

The new bridge will connect Pulau Poh island with the new Pengkalan Gawi marina center development on Lake Kenyir. Following the damming of the Kenyir river, South East Asia's largest artificial lake was created and the vision is to develop it for eco-tourism.
When completed, the Pulau Poh Bridge will carry two lanes of traffic in each direction and there will be a 2.5m wide pedestrian walkway on both sides of the deck. Its striking 60m high inclined curved A-pylon will become a landmark for the area.
The project features a steel bridge deck which will span the channel between the marina center and Pulau Poh island. Also included in the project is construction of a floating jetty which has been designed to move with the changes in the lake's water level.
A temporary steel bridge has been installed to give access for the construction of the new bridge, along with a temporary steel substructure to support the steel bridge decks before stay cable installation has been concluded.
The iconic pylon will provide upper anchorages for the 20 pairs of HiAm CONA stay cables supporting the deck and seven pairs of massive 12706 HiAm CONA back stays will be provided to counter-balance them. ●

1 Artist's impression of the completed bridge which features a striking 60m high inclined pylon.

TEAM & TECHNOLOGY

Owner – Public Works Dept Malaysia
Main contractor – Casa Hartamas Sdn Bhd
Designer – Roadnet Solutions Sdn Bhd
Technology – BBR HiAm CONA stay
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

SEI DAREH BRIDGE, **SUMATRA, INDONESIA**

Installation of BBR HiAm CONA stay cables for new bridge

SPEEDIEST SOLUTION

Trade and travel have increased substantially in Sumatra since the building of the existing Sei Dareh Bridge some 30 years ago. Tambok Lamhot David ST MBA, Marketing Manager of Indonesian BBR Network Member PT. Prestress Construction Indonesia (PCI), explains that an urgent increase in the bridge's capacity was needed to alleviate pressure on the existing bridge and ensure smooth traffic flows.

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The bridge forms part of an important highway connection between North Sumatra and the southern province of Lampung. It crosses the Sungai Batanghari River which, running around 500 miles from its source until it flows into the Java Sea, is the longest river in Sumatra. It is important for transporting people and goods, as well as for quarries, fisheries, fishing and other industries.

The speediest and least disruptive solution was to build a second bridge alongside the existing one. The new Sei Dareh Bridge will be 180m long overall and feature a 120m main span supported by BBR HiAm CONA stay cables. The two side spans of 30m each will be of post-tensioned 'I' girders. When completed, the bridge will have two 3.8m wide traffic lanes, plus a pedestrian lane of 1.2m on each side.

PCI is contracted to install the 30 HiAm CONA stays, an operation expected to take eight weeks. To harness the know-how within the BBR Network and advantages of international best practice, BBR Polska will be collaborating with PCI in the execution of this project.

The vision for the new bridge is that, with its distinctive 'A' shaped pylons, it should become an icon for the Dharmasraya District. Local people will greet the new bridge with great pleasure when it is opened in mid-2017. ●

1 Artist's impression of the completed Sei Dareh Bridge.
2 Work in progress on the piers for the new Sei Dareh Bridge while the existing bridge continues to operate close by.

TEAM & TECHNOLOGY

Owner – Indonesia Ministry of Public Works
Main contractor – PT. Cahaya Tunggal Abadi
Designer – PT. Beutari Nusakreasi
Technology – BBR HiAm CONA stay
BBR Network Member – PT. Prestress Construction Indonesia Ltd (Indonesia)

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DAM IMPROVEMENTS, **SOUTH AFRICA & AUSTRALIA**

World's largest full-scale proving test anchors & four more projects

BBR SETS ANOTHER ANCHORING WORLD RECORD

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The team from SRG, the BBR Network Member for Australia, has recently completed the largest full-scale proving test anchors ever undertaken in the world at the Hazelmere Dam project in Durban, KwaZulu Natal, South Africa. In addition, SRG has also been working on a further four dam improvement projects in Australia. Mark Sinclair, SRG's General Manager – Engineering & Technical, reports on how the BBR VT CONA CMG test anchors destined for South Africa were months in the making and provides an overview of the company's additional dam projects.

1 Hazelmere Dam

Initial test anchor designs were completed some eight weeks ahead of mobilizing the crew to site for drilling and installation, followed by completion of testing four months later in early 2016.

The tests were required in order to finalize design of the anchors – prior to starting production of the 84 anchors to be used on the project. Of these 84 anchors, 12 will be produced using 91 strands, the first time this size has been used outside of Australia – and only the fourth time these have been used in the world. The other three projects which used anchors of this size were all completed by SRG – Catagunya Dam in Tasmania and Western Australia's Wellington and Canning Dams.

> "Of these 84 anchors, 12 will be produced using 91 strands, the first time this size has been used outside of Australia"

Anchor testing

The four test anchors were tested in accordance with the very rigorous British Standard. The test anchors were each made of 61 strands using 15.7mm (279kN) steel strand. These were tested up to 80% of breaking load, and achieved a maximum load of 13,615kN using our 1,500t stressing jack with a 300mm stroke. The entire load was transferred over a 3m length of the 355mm drill hole into the dam's sandstone foundation.

Project background

In October 2015, SRG was awarded the contract with Group Five Coastal for strengthening and heightening works to the Hazelmere Dam in Durban, KwaZulu Natal, South Africa. Hazelmere Dam is a concrete gravity arch-type structure which is 478m long with a center line radius of 725m. It incorporates a 103m long ogee spillway, situated 60m from the right back end. The dam was originally completed in 1976 and was designed and built to accommodate a proposed 7m increase in dam height through the installation of steel gates.

The project includes repair to the grout curtain to reduce leakage under the dam wall, the construction of piano key weirs to increase the stored water height and ground anchors to strengthen the wall to take the increased loads due to the higher water level. When complete, the Hazelmere Dam will hold close to double the current 18,000Ml.

Currently the work at Hazelmere Dam is progressing well, with considerable waterproof grouting being undertaken as a result of the highly fractured nature of the sandstone. Anchor fabrication is on target and the first of the 49 and 61 strand production anchors have been installed and were stressed last July using our new 7.5t jack which has a 1m stroke and 1500t capacity. Its 10t big brother – also with 1m stroke, but capacity of 2200t – has been stressing the 80- and 91-strand anchors which arrived in September. Work began on site in November 2015 and is scheduled for completion in 2017. ➤

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1 Hazelmere Dam, Durban, South Africa where SRG has carried out the largest full-scale proving test anchors ever undertaken in the world.
2 Anchor crew during manufacture of one of the massive anchors for the Hazelmere Dam project.
3 Mark Sinclair and Jeff Babbage next to SRG's 1,500t stressing jack during testing of the 61-strand test anchors at Hazelmere Dam.
4 Fairbairn Dam, Queensland, Australia.
5 Paradise Dam, Queensland, Australia.

5

Two SunWater contracts

In April 2016, SRG was awarded two contracts with SunWater for work at Paradise and Fairbairn Dams in Queensland valued at over A$20 million. The award of these two contracts supports SRG's civil strategy of securing specialized projects of scale in the water sector and extends SRG's strong existing working relationship with SunWater. Work is currently underway on both projects with SRG undertaking the role of principal contractor utilizing both our civil and mining businesses.

The civil business is managing the core construction components and SRG's mining business is responsible for the drilling and geotechnical works on each project.

2 Paradise Dam

Paradise Dam lies on the Burnett River and is situated near Childers, 80km south west of Bundaberg in Queensland. The Paradise Dam Safety Improvement Project involves strengthening of the downstream structure. Work commenced in May 2016 and will be completed in early 2017 following an increased scope of works.

3 Fairbairn Dam

Fairbairn Dam is Queensland's third largest water storage facility and meets demand for industrial, mining and urban sectors. It is an embankment dam across the Nogoa River, located south west of Emerald and 270km west of Rockhampton in Central Queensland. The Fairbairn Dam Improvement Project involves the construction of improvements to the dam's chute slab, including upgrading the under-drainage system, installing ground anchors and constructing a reinforced concrete overlay slab. ➤

> "...SRG was awarded two contracts with SunWater for work at Paradise and Fairbairn Dams in Queensland valued at over $20M."

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7

Two contracts for Water Corporation of Western Australia

SRG was awarded two dam improvement contracts with the Water Corporation of Western Australia during FY16. Work at Lefroy Brook Weir and Samson Brook Dam in the south west of Western Australia has now been completed.

4 Samson Brook Dam

Our project at Samson Brook Dam was completed in August 2016, despite bushfires putting a stop to work for more than two weeks. The dam is situated approximately 110km south-east of Perth and our contract involved remedial work including a spillway upgrade.

Samson Brook Dam is a 32.65m high zoned earthfill/rockfill embankment located on Samson Brook. Initially constructed between 1938 and 1941, the embankment was raised in 2013. The dam has a storage capacity of eight billion liters and is currently used by Water Corporation as a public drinking water supply source.

As part of the 2015/2016 upgrade, SRG was engaged by Water Corporation to complete work on the dam. Around 250 people worked on the project, including several different subcontractors. The upgrade included the construction of a temporary cofferdam and bulk excavation, stream diversion, cutting through the existing dam and the construction of a new spillway which involved around 4,000m^3 of concrete and a design capacity of 280 cumecs (cubic meters per second) on the right abutment.

We also re-constructed part of the dam adjacent to the spillway, undertook the rehabilitation of the existing quarry and decommissioned the existing spillway bell-mouth and spillway tunnel.

Just over three months into the project, in early January 2016, the Samson Brook Dam site narrowly escaped the bushfires in the south west of Western Australia. The site was safely evacuated, with work suspended for approximately 15 days as a precaution. Fortunately, the dam itself and the partially completed upgrade were not damaged by the bushfire and there was no impact to the dam's water supplies.

5 Lefroy Brook Weir

Lefroy Brook Weir is located in Pemberton, Western Australia. Remediation work on this project included detailed excavation, abutment repairs, filter layer construction and weighting the embankment.

As the reservoir supplies the water treatment plant in Pemberton and the Department of Fisheries hatchery, a bypass system was designed and installed to provide uninterrupted water supply to the end users. This also required the provision of emergency back up, remote monitoring and 24/7 call out attendance.

Our site team mobilized on site in March 2016 and completed the work in May 2016. This project involved a high level of environmental management to ensure the hatchery was supplied with water and protected for the project duration.

A letter from the Pemberton Freshwater Research Centre within the Department of Fisheries was received acknowledging and congratulating the team on the successful delivery of the project. ●

> "...The manner and standard of professionalism that was shown throughout and the way the contract was conducted and completed was second to none. ...I cannot speak highly enough of the management team and would confidently recommended SRG and all involved with this project."
>
> Terry Cabassi, Senior Technical Officer, Freshwater Ecosystems, Department of Fisheries WA, Pemberton Freshwater Research Centre

6 Lefroy Brook Weir, Western Australia.
7 Samson Brook Dam, Western Australia.

NEW TANK, SEWAGE TREATMENT WORKS, **REINACH, SWITZERLAND**

Application of circular post-tensioning tendons

STRENGTH FOR CONTAINMENT

The BBR Network has much experience of post-tensioning wastewater treatment tanks – and this has proved to be a fast, efficient and economical way of constructing new facilities. Recently, the BBR Network Member for Switzerland, Stahlton AG, was called upon to provide circular tendons for a new tank at a sewage treatment works.

The sewage treatment works at Reinach, near Lucerne, Switzerland first became operational in 1962. Since then, there have been many improvements in the way wastewater is treated. The facility at Reinach has kept pace with these, as well as population growth and additions to the network. In 2014, a major expansion project worth around CHF31m began. Rather than cleaning the old wastewater tanks, as this was too costly, it was decided to build a single 15.8m high tank.

The Stahlton team has post-tensioned the new 14.8m diameter tank using 22 BBR VT CONA CMI BT tendons and applied stressing from both ends. The entire expansion project is expected to reach completion and become fully operational during 2017. ●

TEAM & TECHNOLOGY

Owner – Abwasserverband Oberwynental
Main contractor – Erne AG
Technology – BBR VT CONA CMI internal
BBR Network Member – Stahlton AG (Switzerland)

1 The new 15.8m high wastewater tank at ARA Reinach takes shape.

1

TEAM & TECHNOLOGY

1 **Owner** – Department of Water and Sanitation
Main contractor – Group Five Coastal
Technology – BBR VT CONA CMG ground
BBR Network Member – SRG Limited (Australia)

2 **Owner** – SunWater Corporation
Principal contractor – SRG Limited (Australia)
Technology – PT bar ground anchor
BBR Network Member – SRG Limited (Australia)

3 **Owner** – SunWater Corporation
Principal contractor – SRG Limited (Australia)
Technology – PT bar ground anchor
BBR Network Member – SRG Limited (Australia)

4 **Owner** – Water Corporation of Western Australia
Main contractor – SRG Limited (Australia)
Technology – MRR range
BBR Network Member – SRG Limited (Australia)

5 **Owner** – Water Corporation of Western Australia
Main contractor – SRG Limited (Australia)
Technology – MRR range
BBR Network Member – SRG Limited (Australia)

STRENGTHENING PROJECTS, **HAWKE'S BAY AREA, NEW ZEALAND**

Solutions devised & delivered using carbon fiber reinforced polymer

DEVELOPING REGION-WIDE PARTNERSHIPS

1

Mention Hawke's Bay to a Kiwi and you'll likely get a smile in return. New Zealanders all have a soft spot for this part of the country, which has survived disaster and devastation to become a popular tourism destination.

So what was the disaster? It struck on 3 February 1931, with a 7.8-magnitude earthquake that lasted for a terrifying two-and-a-half minutes.

The city of Napier was hardest hit, with almost all of the buildings in its Central Business District (CBD) leveled to the ground. Elsewhere, the ground in some areas rose by up to 2.5m and about 4,000 hectares of seabed became dry land. Worst of all, 258 people in the region lost their lives.

The subsequent rebuilding of Napier, in the Art Deco design of the time, transformed the city forever. While some the distinctive buildings disappeared during the destructive 1960s and 1980s, most of the CBD is now recognized and protected as a heritage precinct.

The BBR Contech team has undertaken a number of projects in Hawke's Bay and its environs in recent years and, in doing so, has developed strong relationships with councils, clients and contractors in the region. The team always enjoys working there – not least because it's renowned for its balmy climate and award-winning wineries!

1 Supporting redevelopment

On visiting Cosmopolitan House on Napier's Marine Parade – a stunning, tree-lined boulevard that runs alongside the magnificent Pacific Ocean – it is hard to believe that this striking, ultra-modern building dates back to 1877.

Back then it was known as the 'Napier Cosmopolitan Club', a hub of the local community that survived for more than 100 years. However, social change in the late 20th century saw a drift to the suburbs, a decline in membership and increases in the costs of operation. In 2012, the Club decided to sell the two-storey building and merge with the neighboring club in Taradale.

The new owner, Wallace Development Company, recognized the site's commercial potential. Rather than 'bowl and build' it chose to 'build on the bones' by retaining and strengthening a section of the structure that dated from the 1980s. The result would be a four-storey building offering 3,100m^2 of premium office accommodation, built to 100% of the new building standards.

BBR Contech was commissioned in early 2013 to provide design assistance for and undertake the strengthening work. Having identified that the 1980s columns and beam ends did not meet building standards requirements, they used carbon-fiber-reinforced polymer (CFRP) to supplement the existing steel.

With the strengthening complete, the project proceeded at pace. The building proved to be a magnet for discerning tenants, with the first two moving into their glamorous new offices before the end of that year. ➤

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2 Enabling interaction

In 2015 the BBR Contech team was back in Napier, this time at the Napier War Memorial Conference Centre – another eye-catching building on Marine Parade. The Conference Centre is currently undergoing a two-year, NZ$5.4 million strengthening, restoration, expansion and upgrade project. It signals a transformation for the building, which was originally built by public subscription in 1956 to honor the Napier citizens who had lost their lives in World War II.

As a first step in the strengthening work, BBR Contech was asked to help Napier City Council to develop a CFRP-based engineering solution that would increase the building's seismic resilience while having minimal impact on the aesthetics of the new design.

In the resulting solution, the building's perimeter columns were strengthened for confinement, in some instances requiring CFRP ties to transfer the confinement forces through intersecting walls. Internal beams were strengthened by applying CFRP to the soffits, then strengthened in shear using CFRP U-wraps, which also enhanced the bond of the flexural detailing. The large exterior prestressed beams were strengthened in shear, with the connection to the supporting columns CFRP wrapped for confinement. CFRP ties were used to develop confinement continuity. As a result, the strengthening work is barely visible – making for one very happy client. The entire project is due for completion in early 2017.

3 Fixing the flow

BBR Contech also had an opportunity in 2015 to work in the city of Hastings, about 20km south of Napier. While this project was decidedly less glamorous than the War Memorial Conference Centre, its focus – the outfall for the local wastewater treatment plant – was arguably more beneficial to the citizens' wellbeing!

The project required the team to complete permanent repairs to the outfall, specifically to a 40m section of severely corroded concrete pipeline that had been repaired temporarily a few years earlier. Given the vulnerable structure, the volatile environment and the impossibility of decommissioning the outfall during the work, the team developed a comprehensive hazard and risk management plan and implemented and followed best practice health and safety standards.

The permanent solution involved wrapping CFRP around half of the pipe's 1,500mm diameter circumference and pressure-injecting polyurethane in the joints around the full circumference where the coupling seals had begun to fail. The key was to ensure that the result was strong enough to resist both the external soil and groundwater loads and the internal pressures created by frequent cycling between pressurized flow and part-full flow.

While projects like these could never be described as fun, the downsides are always outweighed by the satisfaction of a job well done. It's good to know that Hastings now as an outfall that should perform for many years to come.

1 The city of Napier's Art Deco heritage is now protected.
2 Cosmopolitan House, Marine Parade Napier – columns and beams were strengthened using CFRP.
3 War Memorial Conference Centre, Marine Parade, Napier – CFRP was used to increase the building's seismic resilience.
4 Outfall, Wastewater Treatment Plant, Hastings – strengthening of severely corroded concrete pipeline while still in service.
5 Mōhaka Township Bridge – BBR Contech helped Wairoa District Council with a structural strengthening program.

5

4 Strengthening connections

The tiny coastal settlement of Mōhaka – the Māori word for 'dancing' – can be found in the northern part of Hawke's Bay. It's close to the mouth of the Mōhaka River, well known as a rafting, kayaking and fishing destination, which flows for 170km from its headwaters before emptying into the Pacific Ocean.

In 2016, the BBR Contech team came to know Mōhaka via a project on the Mōhaka Township Bridge – a 230m long, 13-pier structure built in the 1930s – that, while not on the main arterial route, is nevertheless a key asset for the local community.

In 2013, Wairoa District Council became concerned about the bridge's safety. It imposed restrictions on the vehicles allowed to use it and began a repair and strengthening program by installing new pier and pile caps on the bridge. It then issued a request for tenders to strengthen the structure using CFRP.

That was the cue for BBR Contech to make their entrance and join the multi-stage project which began with helping the council to design an appropriate and reliable CFRP-based system to anchor the pier and pile caps in place.

Given that the CFRP was to be applied to the pier surfaces, the team also considered how to protect the entire installation from river debris and potential vandalism. The solution was to apply a high strength mortar to the underside of the piers, while those at road level were wet-sprayed with fire-resistant mortar containing phyllosilicate aggregates.

The project is now almost complete, with the final stage being to supplement the post-tensioned beams with an external post-tensioning solution. ●

TEAM & TECHNOLOGY

1 **Owner** – Wallace Development Company
Main contractor – Gemco Construction
Designer – Strata Group
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

2 **Owner** – Napier City Council
Main contractor – Gemco Construction
Designer – Strata Group
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

3 **Owner** – Hastings District Council
Main contractor – BBR Contech
Designer – MWH
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

4 **Owner** – Wairoa District Council
Main contractor – Quality Roading Services
Designer – Opus International Consultants
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

TEXTILE CENTRE, **AUCKLAND, NEW ZEALAND**

Seismic strengthening project

PRESERVING HISTORY

A seismic strengthening project in New Zealand has delivered a result that might have many clients worried – there's no visible evidence that the work has actually been done. But that's exactly what this client was looking for.

The seven month project centered on Auckland's century-old Textile Centre, a former wool store that's now a historic city landmark and home to high-flying technology, marketing and design companies. With a 13,850m^2 footprint, it provides four storeys of premium office space, complete with original timber beams, brick walls and saw-tooth roof.

The seismic strengthening project was always going to be a challenge. The Textile Centre was made up of three structures built in different decades and had been modified and strengthened several times during the previous century. As a result, the condition of the structure varied widely. In addition, the building's fabric comprised mostly unreinforced brick masonry, so some techniques – such as wet coring and cutting – were out of the question.

To complicate matters further, the building was to remain fully occupied throughout the project – a factor that, together with the close proximity of residential apartments, meant the daily hours available for noisy work were severely restricted. And the client required the seismic strengthening to have minimal – preferably zero – impact on the building's physical appearance.

1 Auckland's century-old Textile Centre has been invisibly strengthened using CRFP and PT bars.
2 The BBR Contech team installed 13 PT bars running vertically inside the building's masonry piers for around 20m.
3 Elements of the building were strengthened using over 1,400m of CFRP plate and 1,000m^2 of CRFP fabric.

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Developing innovative, cost-saving solutions

After reviewing the original strengthening design which required extensive steelwork, the BBR Contech team identified a way to reduce the work required and save the client time and money, while delivering a more effective and visually attractive result. It took a whole new approach to the project, with no expansive steelwork required for the exterior walls.

Fortunately for the BBR Contech team, the main contractor, NZ Strong and the design consultants liked the idea, so work began on:

- installing, post-tensioning and grouting in place 13 post-tensioned bars in cored holes running vertically inside the building's masonry piers. Each bar extended from the parapet level to the building foundation, a distance of about 20m. In addition, 44 shorter post-tensioned bars were installed around the parapet – the structure's weakest point – to prevent it falling in an earthquake
- strengthening other elements of the building with carbon fiber reinforced polymer (CFRP) fabric and CFRP plate. In total, the project used more than 1,400m of CFRP plate and more than 1,000m^2 of CFRP fabric
- undertaking crack repairs using epoxy injection with stainless steel reinforcement.

With the project now complete, credit must go to every member of the project team for their willingness to consider new ideas and unfamiliar techniques. Through a collaborative, consultative approach, all the major challenges were overcome – resulting in a building that not only met the client's brief and rigorous seismic standards, but also delivered significant savings in cost, time and money. ●

TEAM & TECHNOLOGY

Owner – Rockport Holdings Ltd Partnership
Architect – T Plus Architects
Main contractor – NZ Strong
Structural engineer – ISPS Consulting Engineers
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

MONASH FREEWAY BRIDGE STRENGTHENING, **VICTORIA, AUSTRALIA**

Carbon fiber strengthening work

FOUR BRIDGES STRENGTHENED FOR LARGER VEHICLES

The team from Australian BBR Network Member, SRG, used over five kilometers of near surface mounted rods (NSM rods), carbon fiber laminates (strips) and carbon fiber wrap (fabric) as a part of Monash Freeway Strengthening project.

Works to eight bridges in Melbourne's South East Region were delivered under cold winter conditions and traffic constraints. The project's goal was to deliver the works under night time lane closures in a way that enabled lanes to remain open during the works and the entire carriageway to be fully opened at the end of each shift.

Monash Freeway is one of the several major freeways in Victoria earmarked to be used by High Productivity Freight Vehicles (HPFVs) in the near future. These vehicles are longer and heavier than normal freight vehicles currently permitted on the State's road network. As part of the corridor upgrade, deficient bridges were to be strengthened to 75% SM1600.

Carbon fiber is a fiber reinforced polymer which has superior tensile strengths compared to steel, at a fraction of the weight and it does not corrode.

Strengthening of pier diaphragms, decks and beams was carried out in three methods on this project, including:

- CFRP laminates epoxied onto soffit of girders deficient in flexure (sag)
- Near Surface Mounted (NSM) rods installed and epoxied into grooves cut along the deck slab over piers to address beams deficient in flexure (hog)
- CFRP wraps epoxied onto pier diaphragms deficient in shear.

Ground penetrating radar was utilized to determine the thickness of bitumen on top of the concrete bridge deck to aid the cutting process. A number of preparatory methods were used for the under-deck works including wet abrasive blast, hydro-demolition and grinding.

Also a combination of preheated epoxy kits, groove preheating, heaters, heat enclosures and procedural improvements were implemented, thus achieving full setting of the epoxy prior to the end of each shift. A pull-off test on a sacrificial groove on-site showed that the accelerated curing measures implemented did not compromise the strengthening system and satisfactory adhesion to the concrete substrate was achieved. ●

TEAM & TECHNOLOGY

Owner – VicRoads
Main contractor – Cut & Fill Pty Ltd
Technology – MRR range
BBR Network Member – SRG Ltd (Australia)

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FONTERRA, **WHAREROA, TARANAKI, NEW ZEALAND**

Concrete repair and refurbishment

EARNING POINTS FOR PERFORMANCE

We all love working in clean and tidy environments, but New Zealand's BBR Contech team took it to a whole new level in a recent project for Fonterra – a global, co-operatively-owned company that's now the world's largest dairy exporter.

BBR Contech was engaged to provide concrete repair and refurbishment services for Fonterra's Whareroa milk-processing plant in Taranaki. Established in 1972, the plant collects about 14 million liters of milk each day and, every week, processes it into enough milk powder, cheese, cream, whey protein products and lactic casein to fill around 500 20-foot containers – or more than three Olympic-sized swimming pools.
In 2016, an investigation identified that water was seeping through the walls of one of Whareroa's milk powder towers. The cause was tracked down to poor original construction, as stitch joints holding together pre-cast concrete panels in the tower had not been properly secured in place. As a result, voids had been created, leading to 'honeycombed' concrete that was permeable to water.
BBR Contech's job was to remove and replace all 25m^3 of the defective concrete, drill for and install epoxy studs into the stitch joints and attach steel plates using grade 8.8 threaded rods and epoxy.
They completed the work in two stages. In the first, they repaired and refurbished the exterior wall joints and, in the second, as the result of an assessment of the damage to the interior, they worked inside the plant while it remained fully operational. That's when things got interesting.

Health, safety and hygiene to the fore
As is to be expected in any food processing facilities, the BBR Contech team had to meet stringent health, safety and hygiene requirements once they were past the 'red line' airlock door at the plant's entry point. For example, hard hats and equipment had to be sterilized, work clothes exchanged for dust-free, disposable overalls and any other items that could possibly be sources of contamination left behind. The team also had to comply with Fonterra's 'permit to work' system which included completing a hazard assessment form, at the start of every shift or change of location, and making it available to the company's health and safety supervisor.
As for the work itself, the team had to eliminate the risk of dust by enclosing the relevant area in plastic, fitting vacuum attachments to all dust-emitting tools and, promptly and appropriately, collecting and disposing of all dust and debris.
The BBR Contech team, together with co-workers from scaffolding company Fitzroy Engineering, were only too happy to co-operate on all fronts – despite the inevitable heat generated by working at heights of up to 60m surrounded by plastic. Their efforts were rewarded – the team was consistently rated highly by Fonterra staff in regular and anonymous in-house culture surveys, and Fonterra management gave very positive feedback on their communication, proactive attitude and performance overall. ●

1 Fonterra's Whareroa milk-processing plant in Taranaki where major repairs were undertaken without disrupting production.

TEAM & TECHNOLOGY

Owner – Fonterra Limited
Main contractor – BBR Contech
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

TECHNOLOGY

82 **RESEARCH & DEVELOPMENT**
introduction of new generation of advanced monostrand PT, plus a report on cryogenic testing for BBR VT CONA CMI internal system

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overview of BBR HiAm CONA stay cable technology and installation procedures

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durability of BBR stay cable technology proven again with inspection of RAMA VIII bridge in Bangkok, Thailand

RESEARCH & DEVELOPMENT

BBR VT CONA CMM Single S2

NEW ADVANCED GENERATION OF MONOSTRAND PT

BBR's experience in post-tensioning slabs dates back almost 60 years – and extends across many countries around the world. All the time, BBR has continuously developed and optimized its post-tensioning systems to suit the ever-increasing demand for still more efficient and economical construction methods. Dr Behzad Manshadi, BBR VT International's Head of Research & Development, now introduces the new advanced BBR VT CONA CMM Single S2 system and outlines its advantages – including a 'world first' feature.

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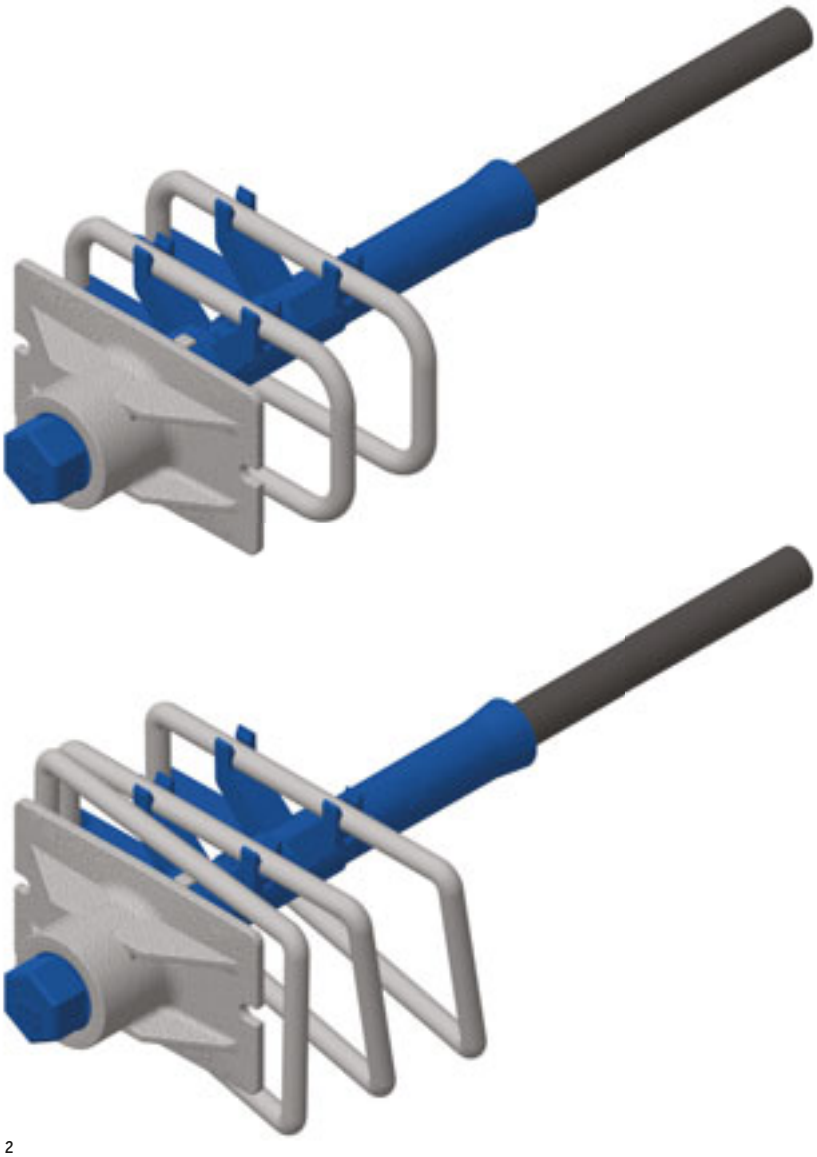
In our continuous quest to maintain constant improvement across all our technologies, the R&D team here in Switzerland has recently completed the development of a new advanced generation of monostrand unbonded or bonded post-tensioning – the CONA CMM Single S2 system. This new system offers significant benefits for owners, designers and contractors – and is the only one of its type on the international market today.

Existing system

As its name suggests, it is based on the existing BBR VT CONA CMM Single system for 0.6" diameter strand. This unbonded/bonded system is very widely used for post-tensioning thin slabs. It is mainly used where small post-tensioning units are required, such as in suspended flat slabs of car parks, apartment buildings, commercial office developments and shopping centers, as well as in slab-on-grade applications in distribution warehouses. For unbonded tendons, the strand is greased or waxed and individually sheathed in the factory with a continuously extruded HDPE sheathing to provide corrosion protection. In the case of bonded tendons, a corrugated metal or plastic duct is used which is then grouted, after completion of stressing operations, with a high performance BBR grout.

New CONA CMM Single S2

The CONA CMM Single S2 is an enhanced version of the current CONA CMM Single, developed for 0.5" and 0.6" diameter strands. It features lighter anchorages which have been optimized to save around 35% of the total weight. Of all the available solutions on the market, this system offers designers the smallest center spacing and edge distance for stressing at the very low concrete strength of 18/22MPa.



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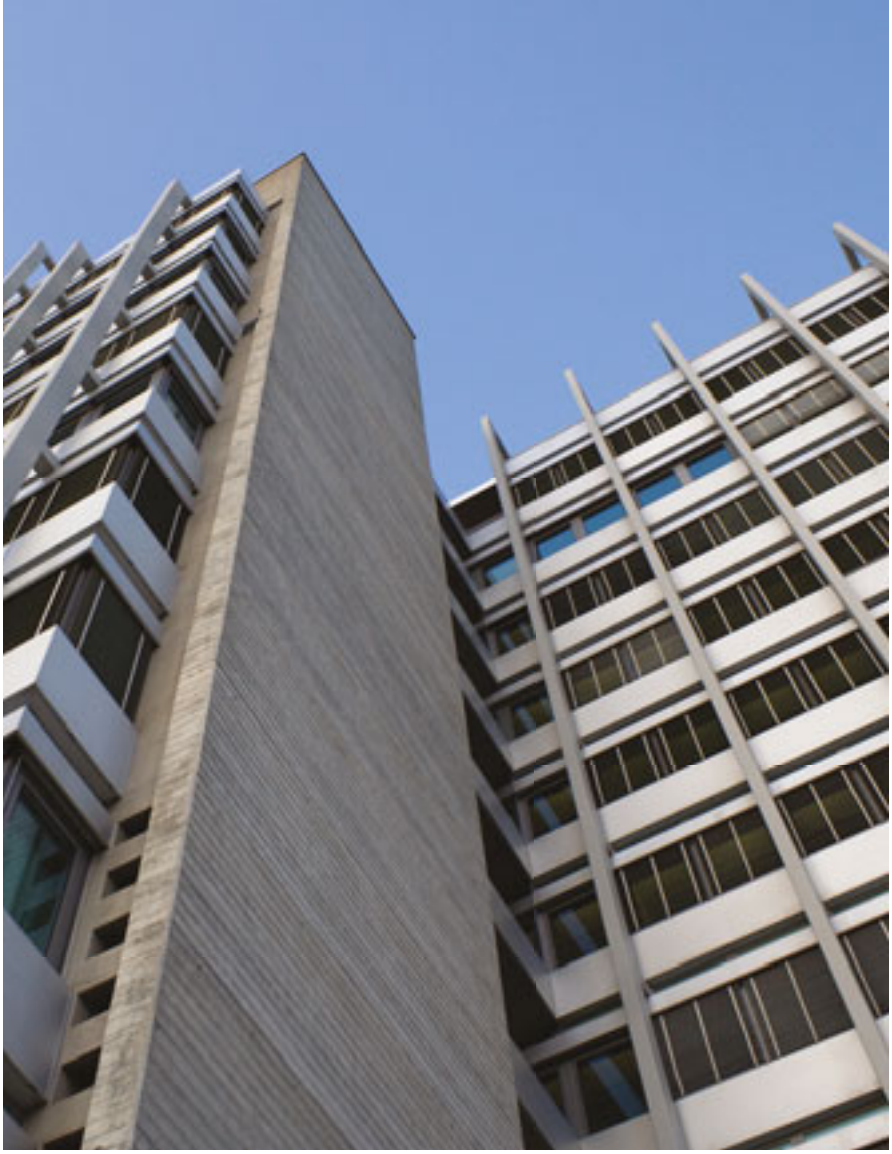
1 The Business Garden office development in Warsaw, Poland features post-tensioned slabs throughout – even in the underground car park. The BBR VT CONA CMM Single unbonded system was best suited to the project's needs.
2 Visualizations of the new CONA CMM Single S2 tendons – shown with stirrup (top) and helix (below) reinforcement.



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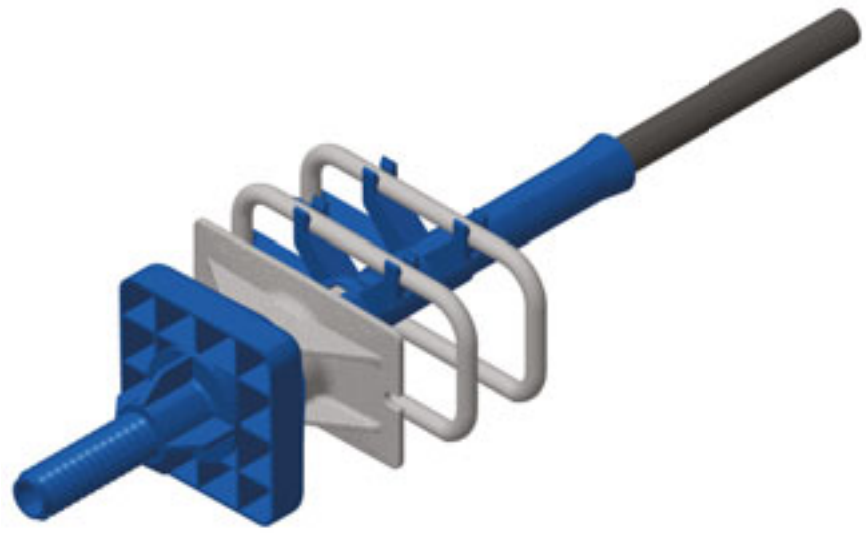
Saving labor time & costs
The new system – which targets a reduction of up to 20% in labor time and costs – also features two alternative solutions:

Anchorage with local reinforcement
The amount of local reinforcement needed in the anchorage zone of our new system has been minimized. Meanwhile, two different types of reinforcement – either helix or stirrups – can be used, depending on the needs of the project. Moreover, the system has been equipped with new accessories that make the installation of reinforcement easier and faster.

Anchorage without reinforcement
For this solution, no bursting reinforcement for the local anchorage zone is required – again this saves on installation time and also on materials.



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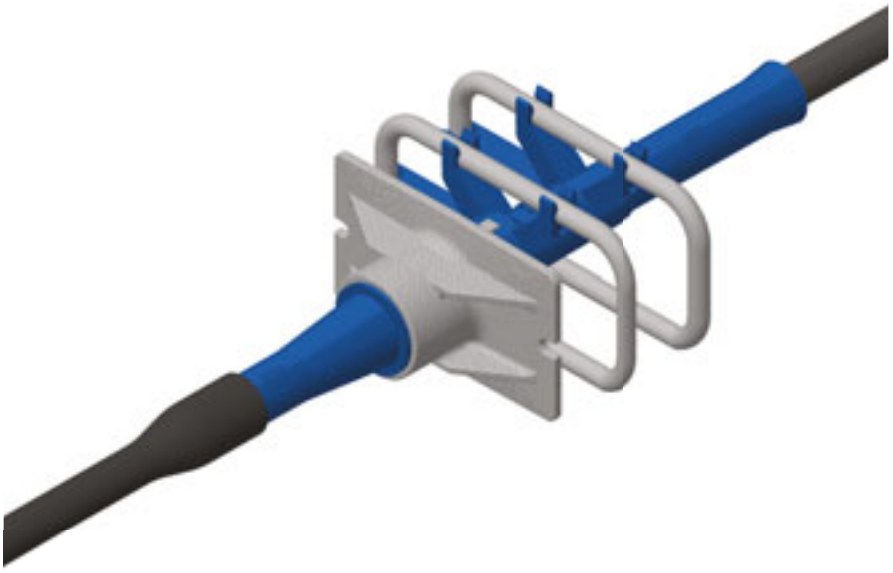
Fixed & stressing anchorage
The fixed and stressing anchorages are identical. For construction works, the seating of wedges in the anchor head of inaccessible fixed anchorages is achieved by special wedge retaining measures and these are protected by a protection cap during concreting.
On stressing anchorages, the pocket former set allows an easy and quick assembly of the anchorage within the formwork, creates a recess for the stressing jack and, finally, provides an adequate concrete cover. Alternative types of pocket former offer the option of using the most suitable method of cutting excess strand based on the construction conditions. A tight protection cap, which fits into the recess, is installed on the anchor head. Lastly, the recess is filled with mortar.
On both fixed and stressing anchorages, the concrete or mortar – together with the protection cap which is filled with a corrosion-inhibiting compound – provide efficient corrosion protection for the complete anchorage.

Intermediate anchorages with continuous strand

A new compact intermediate anchorage has been also developed, so that it can be installed at intermediate points of the tendon if a structure is to be concreted and post-tensioned in sections. At the construction joint, the tendon is prestressed and the remaining length of the tendon is kept coiled, ready to be installed in the adjacent section.

Intermediate anchorages with coupling

For situations where use of the intermediate anchorage is not practical, a monolithic coupling anchorage – with an integrated, preinstalled wedge – has been developed. This can be easily coupled to a normal anchor head using a coupling thread.
All the components of the CONA CMM Single S2 system – i.e. fixed/stressing anchorages, intermediate and coupling anchorages – have been equipped with new superior accessories, different protection and transition pipes. These accelerate the installation process and thereby reduce labor costs while achieving the high corrosion protection level required for the complete tendon.
Our CONA CMM Single S2 system is easy to install, very reliable in application and offers versatile solutions to the designer which can save valuable program time and material, while reducing impact on budgets and environment. But there is even more – our system has been independently tested in accordance with test procedures set out in European Technical Approval Guideline (ETAG 013).



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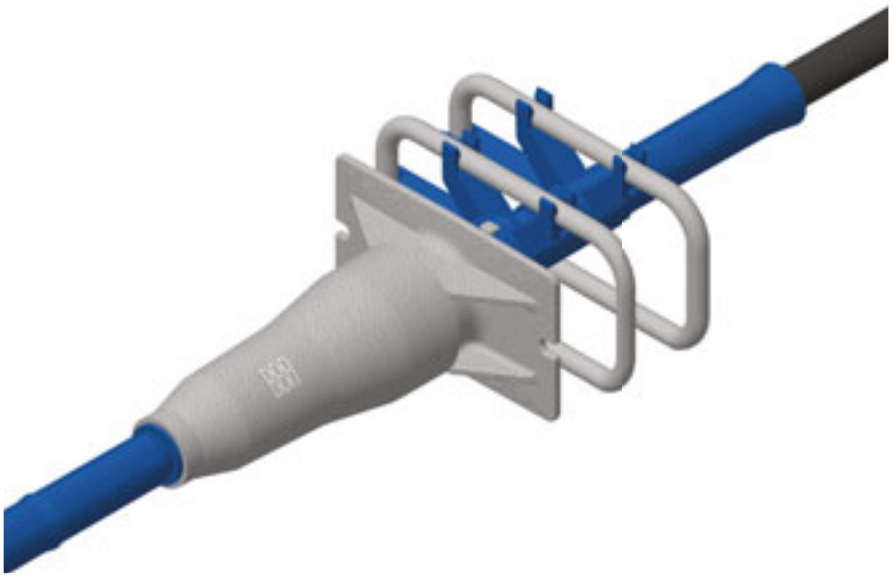

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3 An early example of a building post-tensioned with BBR technology – the 14-storey Zur Palme building in Zurich, Switzerland. Construction for this project began in 1959.
4 Visualization of a new CONA CMM Single S2 tendon with pocket former and stirrup reinforcement. Alternatively, Helix reinforcement could be used here.
5 Visualization of the new compact CONA CMM Single S2 intermediate anchorage with continuous strand.
6 Visualization of the CONA CMM Single S2 intermediate anchorage with a new innovative coupling which features an integrated, preinstalled wedge.
7 In Varaždin, Croatia, the BBR VT CONA CMM Single unbonded system was chosen for post-tensioning the beams and slabs of a new car park beneath Kapucin Square.

1

CRYOGENIC TESTING OF BBR VT CONA CMI SYSTEM

Proving cryogenic performance of post-tensioning technology

TOTAL SYSTEM RESILIENCE

BBR technology has exceeded every requirement for post-tensioning products operating in cryogenic conditions. Dr. Behzad Manshadi, Head of R&D at BBR VT International, provides some background on the need for cryogenically proven technology and outlines the testing process.

The need for cryogenic storage facilities first arose in the 1960s, following the success of the first trial LNG shipments in 1959. LNG is a natural gas that has been condensed to a liquid for ease of storage and transport. The phase change is achieved by cooling the gas to below its boiling point – that means cooling it to -162°C.

Cryogenic containment

Under these cryogenic conditions, it is critical that LNG/LPG containment vessels should feature minimal permeability and structural resilience. The application of post-tensioning increases structural resilience while allowing reduced wall thickness and reducing crack widths. These characteristics make post-tensioned concrete tanks suitable as a structural system and 'secondary containment' skin. The BBR Network is used to operating in such environments, with its long history in the nuclear and oil and gas industries where unique and tailored solutions are required to meet strict client, regulatory and construction demands.

A full containment tank consists of a primary container and a secondary container which together form an integrated storage tank. The primary container is a self-standing steel structure holding the liquid product. The secondary container is a self-supporting membrane which is often a post-tensioned concrete tank equipped with a domed roof. In case of leakage from the primary container – for instance because of a seismic event – the post-tensioned secondary container should:

- contain all liquid product
- remain structurally vapor tight – venting release is acceptable, but must be controlled via a pressure relief system.

In the event of an accident, the internal bonded post-tensioning tendons with anchorages – that is, the anchor head, load transfer element and wedges – might be exposed to temperatures below -20°C. Therefore, the post-tensioning system must be designed and installed under strict quality controls, with materials and processes meeting specific certification and performance requirements under cryogenic conditions.

1 Increased structural resilience while allowing reduced wall thickness and reducing crack widths make post-tensioned concrete suitable as a structural system for LNG storage vessels and 'secondary containment' skin.

ETA requirements

The Guidelines for European Technical Approval of Post-Tensioning Kits, ETAG 013, outlines supplementary technical requirements for special optional use categories, for instance tendons subjected to cryogenic conditions. BBR VT International has already exceeded every requirement by carrying out tensile testing of single and multi-strand tendons in which the entire tendon length, including both anchorages, was completely submerged into a liquid nitrogen bath.

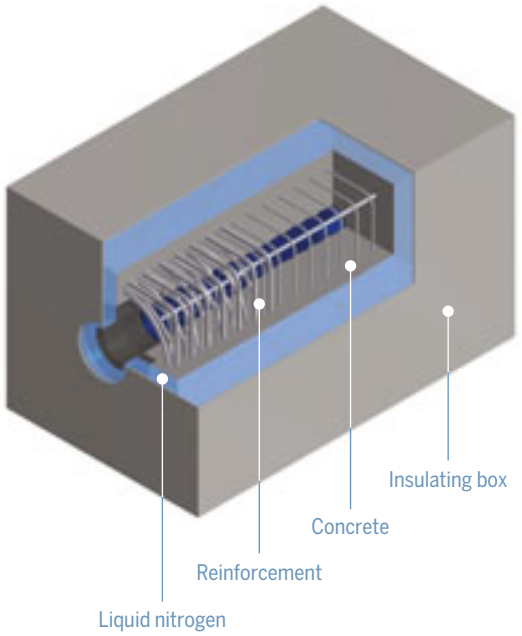
Superior test procedure & ductility

This superior test procedure allowed assessment of the ultimate failure force and the ductility of the post-tensioning system under cryogenic conditions. Ductility is an important factor as, in some circumstances – such as when considering dynamic loads – it becomes an important resistance characteristic. Without ductility, or the ability to deform under tensile stress, structures would be vulnerable to brittle failure. The successful test results obtained confirmed the ductile performance of the BBR VT CONA CMI post-tensioning system and proved that it is in full compliance with – and even exceeds the requirements of – the ETAG 013 testing regime under cryogenic conditions.

Testing beyond requirements

Recently, we have even taken one step further and gone far beyond every requirement to verify a post-tensioning system's performance under cryogenic conditions. Our R&D department has carried out the load transfer testing of BBR VT CONA CMI tendons following the ETAG 013 testing procedure, but subjected to cryogenic conditions in which the entire testing concrete block – including the bearing trumplate as the key load transfer element and the anchorage zone reinforcements – was completely submerged into a liquid nitrogen bath. This test examined the load transfer efficiency of the system under these extreme conditions.

The successful test results verify the performance of the BBR VT CONA CMI post-tensioning 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. ●



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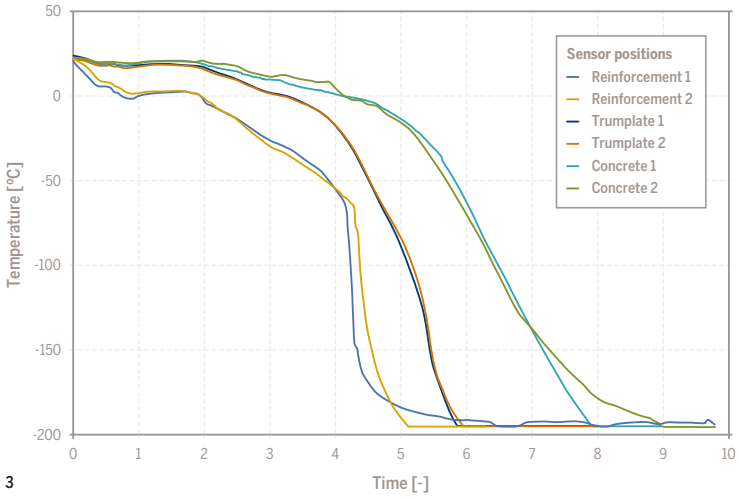

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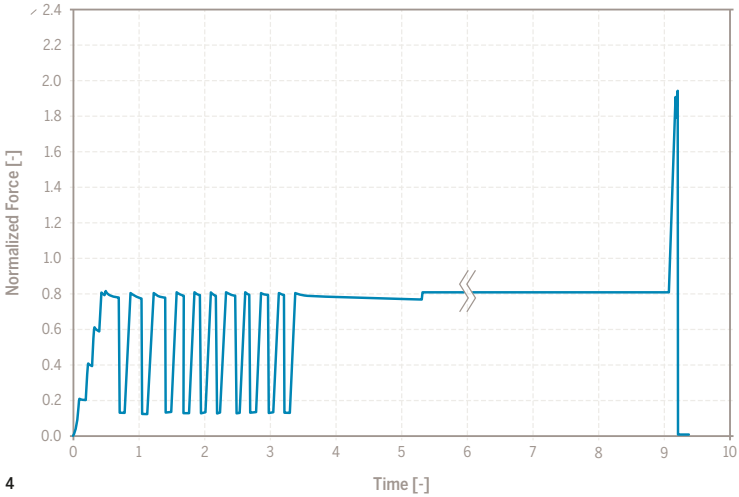

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2 This is a 3-D model of the specimen subjected to load transfer testing under cryogenic conditions.
3 This graph relates to the test where the whole concrete block was inserted into a liquid nitrogen bath. There were six sensors inside the block – two in the concrete, two attached to the reinforcement and the final two attached to the trumplate. The decrease in temperature was monitored over time, to a temperature of -195°C which is the lowest temperature that liquid nitrogen achieves.
4 This graph records the test results of the force from when we started loading the specimen in 10 cycles up-and-down.

TECHNIQUES

Overview of stay cable installation

INSTALLATION OF STAY CABLES

The BBR® HiAm CONA parallel strand stay cable system remains the best product in the international market place. It has the highest capacity, most compact and widest range of anchorages available up to 217 strands. The BBR HiAm® CONA® stay cable system can be used for cable-stayed bridges, arch bridges and roofs. It fulfills latest international standards and recommendations including *fib* Bulletin 30, as well as PTI and Setra recommendations.

Stay cable system configuration

HiAm CONA cables are made up of a compacted bundle of a predetermined number of parallel seven-wire strands enclosed in a co-extruded (carbon black internal and colored external) ultra-violet resistant high-density polyethylene (HDPE) sheath of circular cross-section. The individual strands generally have a diameter of 15.7mm, are of low relaxation grade, with nominal cross-sectional area of 150mm^2 and a minimum Guaranteed Ultimate Tensile Strength (GUTS) of 1,860MPa.

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The strands are galvanized, corrosion inhibited and individually sheathed with a continuous and wear resistant HDPE coating, providing each strand with an individual multilayer protection system with three nested barriers.

Anchorage configuration

In the anchorage zone, the strand bundle passes a deviator and spreads out towards the compact socket, where each strand is individually guided, sealed leak tight and locked in the anchor heads with specially designed high amplitude fatigue resistant HiAm CONA wedges.
Ring nuts screwed onto the anchor heads transfer the cable loads by contact pressure onto the structure (HiAm CONA Nut Head configuration). Alternatively, the anchor heads may transfer the loads directly to the structure (HiAm CONA Uni Head configuration).
All BBR HiAm CONA anchorage components have been designed for a stress range greater than 300MPa and to withstand the ultimate breaking load of the strand bundle with adequate safety.
In addition to the standard anchorage configurations, a compact version is also offered which suits smaller openings in the bearing plate.

1 BBR HiAm CONA stay cables anchored at a pylon.

Installation & strand replacement

Installation of the BBR HiAm CONA system is typically performed on site in six broad steps, illustrated here. The strand-by-strand installation is normally used. This is where each strand is tensioned immediately after installation, using the BBR ISOSTRESS tensioning method, ensuring an equal stress distribution among the strands of an individual cable. Alternatively to single-strand installation, fully or partially prefabricated cables can also be installed and tensioned using a multi-strand jack if access space is available.
Each individual strand installed in a BBR HiAm CONA system can be replaced at any time during or after the installation – allowing not only for subsequent restressing, but also for selective removal, inspection, replacement or addition of individual strands.

Finishing works

After successful cable installation, there are a number of finishing activities that are necessary before the structure can be handed over to the client. These are associated with injection of corrosion protection and include cutting the overlength strand, closing of the working gap and welding of HDPE pipes. Ultimately, the finishing activities provide the newly-installed stay cables with three layers of corrosion protection and can optionally include installation of dampers and anti-vandalism pipes to give greater protection and durability.

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STEP-BY-STEP GUIDE

1 Firstly, the upper/pylon and lower/deck (pictured here) BBR HiAm CONA anchorages are installed.

2 Preparation of the stay cable pipe. The pipes are mirror welded to create a pipe of the correct length and flange connections are made.

3 The preassembled stay cable pipe is hung between the two anchorages using two master strands. The stay cable pipe is now used as a guide passage from anchorage-to-anchorage.

4 The strand is positioned at deck level and pulled up through the stay pipe and the upper anchorage and inserted into the lower anchorage.

5 Each strand is tensioned immediately after installation, using the BBR ISOSTRESS tensioning method, ensuring an equal stress distribution among the strands of an individual cable. Stressing can be performed at the pylon or deck anchorages, depending on access conditions.

6 Finishing works, after stay cable installation, include injection of corrosion inhibitor, closing of the working gap and HDPE welding, cutting of overlength strand, installation of protection cap and injection of corrosion inhibitor into the protection cap.
Dampers and anti-vandalism pipes (pictured here) are optional items which can be installed to give greater protection and durability. Dampers reduce cable vibration, while anti-vandalism pipes protect the lower anchorages against willful damage. ●

INSIGHT

Durability of BBR stay cable technology

DESIGNED TO DELIGHT & ENDURE

A recent inspection at the Rama VIII Bridge in Bangkok, Thailand has yet again proved the long-term durability of BBR stay cable technology. BBR VT International's Head of Research & Development, Dr Behzad Manshadi, presents an overview of the bridge, then shares the inspection methodology used and findings from the project.

The Rama VIII Bridge is a cable-stayed bridge crossing the Chao Phraya River in Bangkok, Thailand. It was conceived to alleviate traffic congestion on the nearby Phra Pinklao Bridge. Construction began in 1999, the bridge opened to traffic in May 2002 and was inaugurated on 20th September, which is the birthday of the late King Ananda Mahidol (Rama VIII), after whom this landmark structure is named.

Bridge design

The bridge has an asymmetrical design, with a single 160m tall pylon in an inverted Y-shape located on the western bank of the river. Its 84 stay cables are arranged in pairs on the side of the main span and in a single row on the other.

Most of the bridge, which is 475m in total length, is constructed of reinforced and prestressed concrete, except for the 300m main span which has a steel structure with a composite concrete deck. The bridge deck passes through the two legs of the pylon and carries two carriageways of two lanes each, as well as shared pedestrian and cycle ways on both sides.

The bridge was one of the world's largest asymmetrical cable-stayed bridges at the time of its completion.

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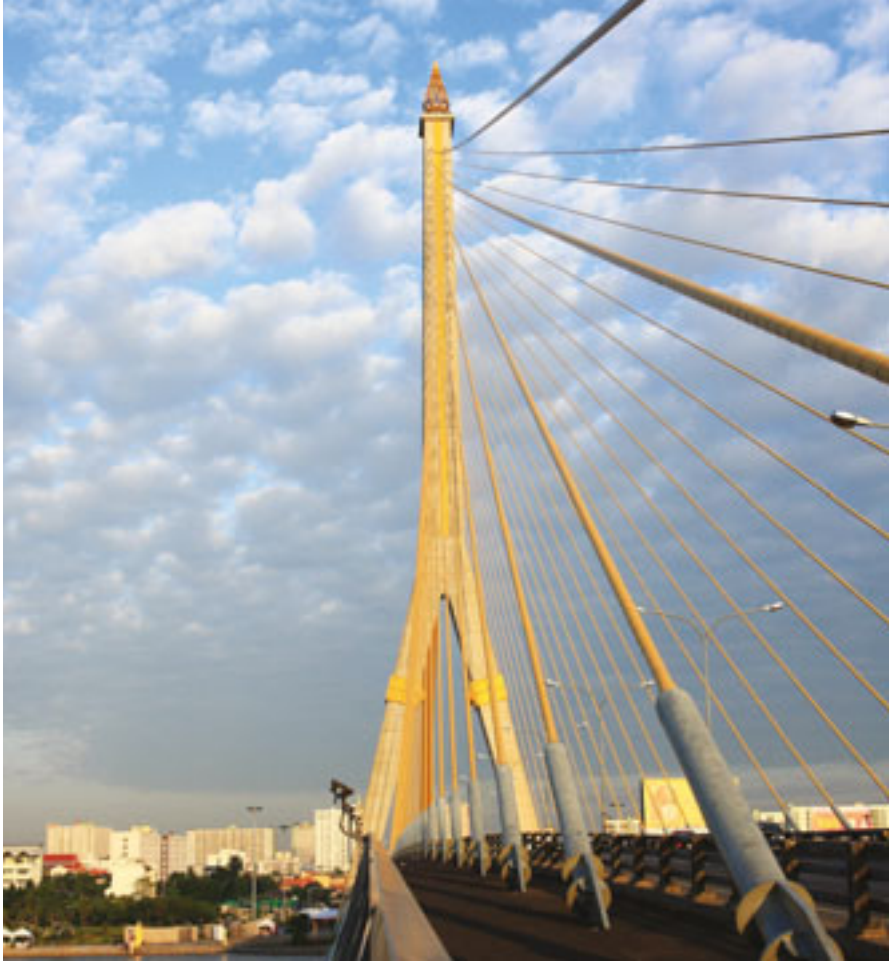
1 The Rama VIII Bridge, Bangkok, Thailand was one of the world's largest asymmetrical cable-stayed bridge at the time of its completion.
2 The recent inspection of the stay cable installation for the Rama VIII Bridge was carried out in two stages – involving a visual anchorage check and detailed anchorage control.
3 The detailed anchorage control operation during which the protective caps of selected anchorages were removed, confirmed that no serious corrosion had occurred during the 15 years since installation.



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Stay cable configuration

There are 56-six stay cables supporting the 300m long main span, while a further 28 cables – arranged in a single plane in a near-harp configuration – connect the tower to the median of the anchor span. The length of the 56 main stay cables ranges from 65m to 325m and they are arranged in 28 pairs to form two planes, each in a semi-fan configuration. Each stay cable was manufactured from 15 to 29 high tensile 7-wire HDPE sheathed and waxed 15mm diameter strands.
The bridge's design received multiple international awards for engineering excellence and has also been depicted on the back of the Series 15 20-baht banknote, behind a portrait of King Ananda Mahidol.

Stay cable inspection

Recently, a team from BBR Headquarters R&D and local BBR Network Member, BBR Construction Systems Malaysia, carried out an extensive inspection of the Rama VIII Bridge stay cables, as requested by the Bangkok Metropolitan Administration's (BMA) Department of Public Work.
The inspection consisted of two stages – one purely visual, the second requiring selective removal of the protective caps covering the anchors.

1st stage: Visual anchorage check

All BBR anchors and stay cables are designed for easy maintenance and control operations. Thus, this maintenance program was possible because all anchorages are accessible at any time.
The anchors, whether fixed or stressable, are protected with a removable cap filled with a corrosion protection compound.
Visual checks were performed as follows:

- On the upper (at pylon) and lower (at deck) anchors – without opening the protective caps – and components in the transition zones, such as deviators, dampers and anti-vandalism protection pipes.
- External elements of the cable checked for damage.
- Seals inspected for damage.
- Status assessment of concrete around anchor zone.

2nd stage: Detailed anchorage control

This procedure consists of opening the protective caps of the stay cable anchorages in order to check the status of the anchor head and corrosion protection material. It was based on a random selection of the anchorages.

When closing caps again one should ensure that seals and local corrosion protection are reintegrated. In this case, a total of six anchorages from different stay cables on both the deck and pylon sides were opened and carefully controlled.
Our inspection confirmed that the anchorages are in good condition – after more than 15 years' performance. No signs of corrosion were observed on the anchor heads, wedges or strands.
These results have once again proven the quality and long-term durability of earlier generations of BBR stay cable systems, such as CONA stay. However, this performance has been continuously improved and today, the latest BBR HiAm CONA stay cable system features a three layer corrosion protection system. It has also passed all of the stringent corrosion and leak tightness testing required by the most recent international specifications from the PTI and *fib*. A service life of 100 years and more can now be confidently projected for structures incorporating the HiAm CONA stay cable system. ●

Richard Simpson, General Manager – Civils, Group Five Civil Engineering (Pty.) Ltd, the BBR Network Member for South Africa reflects on recent business experiences.

HARNESSING INTERNATIONAL STRENGTHS

After a period when stormy skies were increasingly gathering over the South African economy, last year we took some major action to realign our business and brand with the new trading situation here. While setting our business on track for future success, we became acutely aware of some special assets which we had not consciously recognized as fundamental to who and what we are.

The story begins when I was invited to give a presentation about our local situation at one of the BBR Annual Global Conferences. Accordingly, I produced an overview which also reflected the impact on the construction industry and the situation we were having to deal with and adapt to in order to survive. In short, it held nothing back – after all, I was talking to my international family and knew that they would respect any confidences shared. Clearly, we had a number of challenges in common with other BBR Network Members who were also affected by the downturn in the global economy and decline in the mining and construction sectors in particular. Their reaction was amazing and they joined forces to support our business here.

We have had to transform our approach to the changing market by rethinking our business and learning to diversify our service offerings. Effectively, we have restarted and reinvented the business. It has been a difficult task, requiring much adjustment and it has been quite a challenge too. By harnessing two key strengths, the power of the BBR Network and our own engineering training, New Year 2017 began with many positive indications.

We have truly appreciated the importance and significance of our relationship with the BBR Network. Several of the Members have worked very closely with us, generously sharing relevant experience and technical know-how which has supported our realignment with the market place. We now understand how the BBR brand of international expertize is transferred around the world.

As engineers, we are all taught – from the very beginning – how to think. The experiences of the past year have reminded me why this is so central to our learning and it is as relevant now, as it was when I was a student. We must constantly strive to deliver excellence in every sphere of our work. We must initiate and embrace change – even before change is needed, but not just for the sake of it. We must ensure continuous learning and improvement in our work, services and the technologies that we deliver to our customers. These may seem like basic concepts, but their evaluation and reassessment should be a continual process.

By remembering our roots as engineers and sharing experience within the BBR Network, we can all weather fluctuations in the economic climate – or indeed any other adversity – and come out of it more resilient and stronger than before. During past months, we have learned to confront the challenges head on and consider ourselves very fortunate to have had some world-class travelling companions – our fellow BBR Network Members – on our journey. Together, we have created a silver lining to the economic black clouds and the scene is set for our newly reinvented business to thrive. ●

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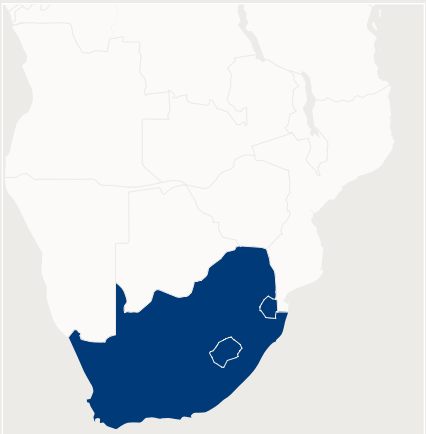

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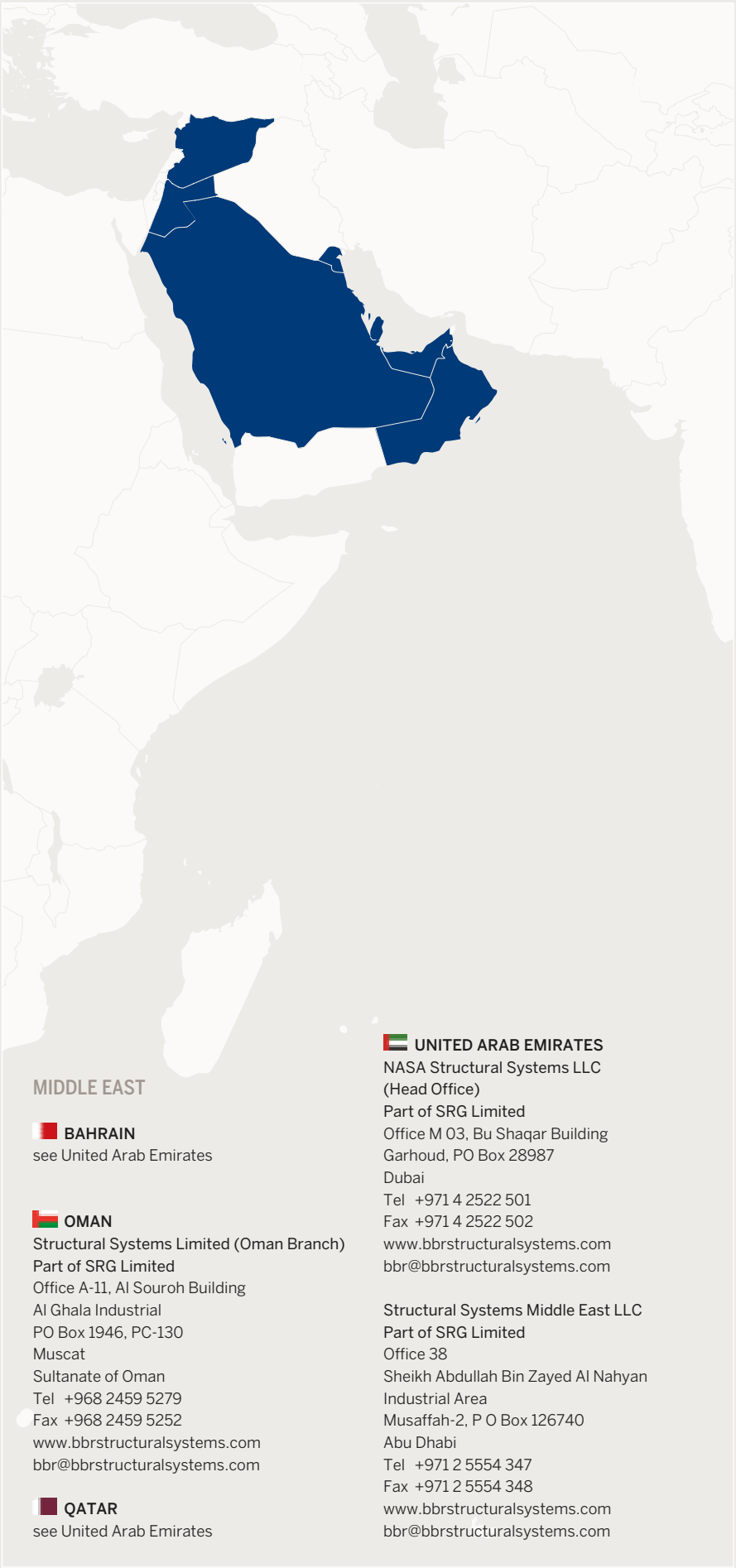

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