CONNECT

THE MAGAZINE OF THE GLOBAL BBR NETWORK OF EXPERTS

Edition 7 | 2013

SETTING NEW COMPETITIVE BENCHMARKS

BBR Network reaches new heights in both technology and services

HEIGHT OF SUCCESS

Ground anchors installed for Roseires Dam

WALTZING OVER THE DANUBE

First use of BBR HiEx CONA Saddle for Danube Bridge

MAKING TRACKS IN THE SKIES

Light rail extension project underway in Malaysia

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, almost 70 years later, in that same ethos and enterprising style.
From its Technical Headquarters and Business Development Center 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 65 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).

NEW CHALLENGES, NEW LOOK

A new and economically challenging market demands more from us all – continued innovation in the way we meet customer needs, upping our game in terms of customer service and making sure the full advantages of our technology are understood, not only by customers but also the wider professional team.

Rolled out at the 2012 BBR Network Annual Global Conference, our motto – 'striving to reach new competitive benchmarks' – gives an indication of the a high standards to which we aspire. While we have developed the very latest technology and have some of the finest engineers the world has seen, we are aiming still higher.

As you turn the pages of this edition of CONNÆCT, you will see that we've adopted a new approach to presenting the magazine. We've done this to keep the content fresh and lively, as well as to make it even more relevant to current needs of BBR Network Members and the market place.

The Talking BBR section has been extended and contains the latest news and views from BBR HQ and around the BBR Network. A special guest article focuses on how post-tensioning advice at the concept or early design stage of a scheme delivers huge financial rewards to property developers.

In the Portfolio section, we celebrate the 50th anniversaries of BBR Network Members in both Australia and New Zealand with a review of their five decades at the leading edge of technology. Here, you can also appreciate the skills, scope and scale involved in projects undertaken by the BBR Network worldwide – from the segmental launching of numerous viaducts for Kuala Lumpur's new Light Rail System extension, to the complex and elegant Danube 2 and Rio Corgo Bridges – both feature the latest BBR HiEx CONA Saddle system which eliminates axial and fretting fatigue. An article on high performance ground slabs highlights durability and low maintenance aspects, as well as showcasing recent projects. Among many MRR projects, a report on the innovation harnessed to strengthen France's Bellegarde Viaduct – on the famous Autoroute Blanche – is sure to delight and inspire.

Meanwhile, in the Technology section, we reveal the rigorous conditions – both during laboratory testing and over many years of service – under which BBR technology has continued to perform well. Further coverage includes in-depth exploration of bridge launching methodology and one of the techniques for making new openings in existing post-tensioned slabs.

There is literally something for everyone in this edition – and we are confident that you will enjoy reading CONNÆCT 2013!

Marcel Poser
Chairman, BBR VT International Ltd

José Manuel Illescas
Vice Chairman, BBR VT International Ltd

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Technology section
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TALKING BBR

06 BUSINESS REVIEW
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success and smiles with the latest BBR Network awards

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Antonio Palumbo, Head of Real Estate for the Tectus Group presents his thoughts, as a property owner, on how post-tensioning can increase lettable space while saving money

BUSINESS REVIEW

BBR VT's General Managers review achievements and set out their vision for the future

STRIVING TO REACH NEW COMPETITIVE BENCHMARKS

It's bold, it's ambitious – and it's the theme that the BBR Network has adopted to guide their activities as they carry the business forward into a new technological and economic age. Dr. Antonio Caballero, General Manager – Head of Technology and Thomas Richli, General Manager – Head of Business Development of BBR VT International Ltd, go 'on the record' about both the theme and their strategy for the business.

Why did you adopt this theme?

TR: Ever since the start of the business, almost 70 years ago, the BBR team has constantly looked to refine and expand its portfolio, enabling them to deliver something new and leading edge as a response to the ever-changing market place. So, we wanted to capture this spirit in a simple expression that would encompass our approach and focus the entire BBR Network on the future as we take the business forward. Striving to remain best-in-class is part of our corporate DNA and it will always be this way for us.

AC: Yes, and the way our business is structured – as a global franchise – means that 'striving' is therefore a team process. Together with BBR Network Members, we are constantly reviewing ways to deliver customer requirements, seeking out technological enhancements and expanding our best practice portfolio. For example, with the launch of the European approved CONA CMX post-tensioning systems and the HiAm CONA stay cable range, we have set the benchmark for the best technology available. Now, we are aiming to set further technological and operational benchmarks.

"As well as having versatile innovative technology which benefits clients and designers, it is our flexibility – and speed of response – that gives us a huge advantage"

Is there really any more to be achieved on the technology front?

AC: Yes, absolutely – we are always working on something which improves our offering! Technologically, we have been 'striving' on several fronts. European Technical Approval for our stay cable system is on the cards and this will give us an even stronger position in the market.
We're also looking at further consolidating BBR technology in some markets – geotechnical and structural strengthening might be some examples. Further work involves developing an optimized technology range to satisfy the needs of specific local markets and new accessories that help our Members to meet the requirements of the projects they are involved in and to reduce their operational costs.
Meanwhile, it's great to see that our new BBR CONA HiEx Saddle – as it overcomes the disadvantages of friction saddles – has recently been used on the Danube Bridge 2 and Rio Corgo projects. It's definitely being recognized as a benchmark already.

TR: As much as anything, we need to consolidate what we already have by ensuring that the capabilities of BBR technology are fully exploited by the market. Our technology has the flexibility and capacity to tackle many different challenges. For instance, we pioneered the use of large capacity ground anchors for dam strengthening and stabilization work. ➤

How will you set operational benchmarks?
TR: As well as having versatile innovative technology which benefits clients and designers, it is our flexibility – and speed of response – that gives us a huge advantage and I believe we can align ourselves to work even smarter.
We are a very well established team and we can draw not only on seven decades of expertise, but also the individual strengths of BBR Network Members. Each of them has developed a range of specialist skills, knowledge and equipment in their home territories. In fact, there is a huge amount of value – driven by this local expertise – that is tucked away within the BBR Network. We need to harness these individual capabilities – unlocking the sometimes hidden potential – in a way which benefits the whole group.

AC: One of the ways we will be encouraging this process is through the launch of E-Trace 2 – a further development of our online trading and QA platform – which, as well as new monitoring and quality control facilities, contains a knowledge and exchange database. Since E-Trace was first launched three years ago, we have been collecting a list of needs and these things will now be implemented within E-Trace 2. This will allow Members to communicate directly with the BBR Network as a whole and quickly find out who is an expert in certain aspects of work, enabling them to build customized packages to satisfy customer requirements. There are six key modules within E-Trace 2 and these will be rolled out in stages. Already, BBR E-Trace has been helping to lower costs in the supply chain and underpinning a best-in-class QA procedure, now it will be even more directly helping the work winning process along too. It's a very powerful tool.

How will you help franchisees win work?
TR: Firstly, let's be absolutely clear that it is the BBR Network Members – our franchisees – who will always have the very best knowledge of their own local territories. BBR VT's role, as franchisor, is to open doors, make connections and provide information. We are implementing a project support facility which will help to build joint ventures between Members and offer bid writing help. Our main role will be collecting information and looking for suitable partners – this is something well suited to our central role.

AC: It's about unlocking and fully exploiting our potential again. Over the course of the next year, we will also be making new technical information available to support this drive and in turn this will be further explored during training courses. We also ensure that we remain competitive. It's about comparing our offering with that of the competition – and never being happy with the first solution we come up with!
Optimization of costs is a big issue for everyone and one of the key factors in ensuring competitiveness. As well as driving costs down, our range of technology – which, although still relatively new, is now well proven – was specifically designed to maximize value from every perspective.

What will you be talking about in CONNÆCT 2014?
TR: Even without a crystal ball to see into the future, we can say with complete confidence that we will be celebrating 70 years since the foundation of BBR. It will be a great time not just to reflect on past achievements, but also to focus on and set the scene for the next 70 years. As well as celebrating new BBR Network achievements, there will also be new and profitable international collaborations to announce. The way we do business will have changed and new trading relationships will have been formed. We will be in a new and dynamic cycle of business.

AC: Innovation has driven the development of the BBR Network to its present form and we will surely be setting new benchmarks in our vision of global construction engineering for the future. Our approach to the application of BBR technology will have broadened and we will be talking about – and demonstrating – ultimate flexibility of use. By then, our supply chain will have expanded. We've been developing relationships with more suppliers, in various locations, who can meet our quality criteria so that response times can be improved and transport costs or stock holding requirements are reduced. In the last year our capacity to supply our system in a short time was a key parameter for various clients and projects.
The scope for improvement and diversification is literally all around us every day and our franchisees, the BBR Network Members, are all focused on best-in-class technology and service delivery – you will read how we've listened to them and how their views have guided our actions. ●


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1 Dr. Antonio Caballero, General Manager – Head of Technology, BBR VT International Ltd (top).
Thomas Richli, General Manager – Head of Business Development, BBR VT International Ltd (bottom).

ANNUAL BBR GLOBAL CONFERENCE, **BINTAN, INDONESIA**

With the theme of 'striving to reach new competitive benchmarks' and its open forum, relaxed style, the 2012 Conference exceeded all expectations

CONFERENCE NOTES

Last March, the 7th annual BBR Global Conference was held in Bintan, Indonesia. Over 50 delegates from all around the world gathered on this small island off the coast of Singapore. Beth Skirrow, Franchise Co-ordinator for BBR VT International reports that the relaxed and informal atmosphere of the Bintan Lagoon resort made for a very different style of conference than in previous years.

Indonesian hospitality and friendliness was in full swing and well-appreciated throughout our stay here – the local people really went the extra mile to ensure all aspects of our meeting were successful.

Setting the tone

In customary fashion, the conference kicked off with a highly competitive golf tournament – and, although a close-run match, the cow bell trophy was carried back to the UK for the first time! At sunset, there was an opening cocktail party at the stunning beachfront location and the day finished with a superb international buffet – all of which set an excellent tone for the three days of presentations, discussions and networking which followed.

Opening presentations

The meeting opened on Day 1 with introductions from all the delegates. The first presentation was from KB-Vorspann-Technik who gave an awe-inspiring overview of their Sava Bridge project – Europe's largest single pylon stay cable bridge. Next up was a very informative session from Paul Wymer of BBR Contech about the earthquakes in Christchurch, New Zealand and local BBR expertise in this area. Following this, Roger Stables of Structural Systems (UK) Limited took centre stage with an excellent insight into the process of bidding in joint venture with other BBR Network Members.

Conference theme

Our theme was 'Striving to reach new competitive benchmarks' and focused on the BBR Network's strategic approach. The overall conference format was an open forum with several interactive workshops – allowing all delegates to participate actively and information to be shared freely. The workshops covered aspects of improving our systems, labor skills and supply chain, as well as cost optimization, gearing up for large scale projects and examining future opportunities and trends.

Site visit

Networking continued at the end of Day 2, throughout the excellent BBR Gala Dinner during which award presentations were made. On Day 3, delegates travelled by ferry to Singapore where John Mo from Singapore-based BBR Construction Systems had organized a technical site visit to the Yang Kee Logistics Warehouse where large ramps for massive container trucks were under construction using BBR CONA internal and CONA flat post-tensioning. While delegates attended the conference sessions, their spouses were able to experience local highlights – including a mangrove tour, shopping, plus an elephant ride and show.

Feedback from delegates affirmed that this year's conference was especially helpful and informative and that the informal style promoted some valuable exchanges of information. As the BBR family goes from strength-to-strength, so do the annual BBR Global Conferences. We are really looking forward to welcoming all delegates to our next Conference in Auckland, New Zealand in 2013. ●

BBR EUROPEAN TRAINING COURSE, **LONDON, UK**

Special fly-on-the-wall report from the three day session

CLASS OF 2012

As delegates from around Europe and Scandinavia gathered for the latest BBR Network training session in London, CONNÆCT Editor, Jane Sandy was unchained from her desk and – with notebook and pen in hand – set off to join them.

It somehow seemed appropriate that such an international gathering should take place in London whose cosmopolitan atmosphere is founded on centuries of welcoming people from other lands – most recently, as host to the 2012 Olympic Games.

Raising the roof

Noise levels were off the scale during the welcome dinner on the first night. Much to the shame of every Brit present, here were French, Swedish, Norwegian, Spanish, Croatian and Polish engineers conversing quite comfortably in English. The information exchange had well-and-truly begun – and the momentum was unstoppable. It continued through coffee and meal breaks, became more focused and formalized during workshop sessions and ran right through the practical exercises up until the moment delegates finally had to depart.

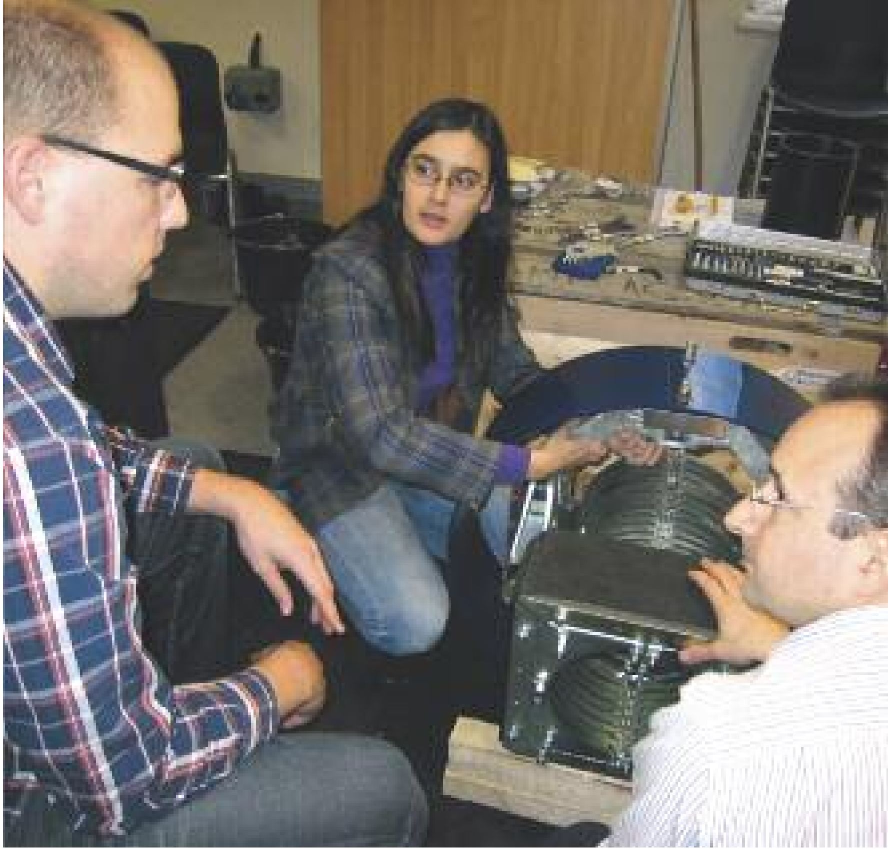
Technical talk

The first day began with an introduction to BBR post-tensioning products by Juan Maier, BBR VT International Ltd's Senior Product Manager. Next, he regaled the 20-strong band of engineers with technical information about BBR post-tensioning system specifications – and handed out the odd calculation to complete along the way. Bearing in mind this was, for some, the introductory or refresher part of the training course, the engineering calculations appeared to be extremely complex. However, the solutions were calculated with consummate ease by the BBR Network engineers who responded, almost in unison, with the right answers.

Vladimir Arteyev, BBR VT's Production & Supply Chain Manager led an overview of the BBR CONA HiAm stay cable system and delivered presentations on quality, supply chain and the electronic Factory Production Control and trading platform – BBR E-Trace. Delegates were treated to a dynamic start to the second day with a presentation on CONA CMX news from Dr. Antonio Caballero, Head of Technology at BBR VT. Antonio reviewed news of developments relating to BBR technology and the development of a Common Understanding of Assessment Procedure (CUAP) for stay cables, as well as supply chain arrangements.

1 Diana Cobos and David Fernandes of BBR PTE discuss aspects of the BBR Square Damper with Chris Roost.

2 Spanstaal's Ron van Dijk (right) leads a workshop session.



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"the solutions were calculated with consummate ease by the BBR Network engineers who responded, almost in unison, with the right answers."

Sharing experience
Three delegates generously shared experience of challenges on site. First up was Kresimir Bogadi from BBR Adria, the Croatia-based BBR Network Member, who provided a step-by-step guide to techniques for creating new openings in existing post-tensioned concrete floors (for complete guide, refer to page 94). Next, Diana Cobos from BBR PTE presented a lively account of the massive Danube Bridge 2 project (see also page 56) and finally, Ron van Dijk from Spanstaal led an illustrated discussion about application of the BBR VT CONA CME system on a railway bridge project in Anderlecht-Voorst, Belgium (for more details, turn to page 78).

Workshops
Further practical sharing of information was encouraged through a series of workshops covering tendering, project management, procurement, trouble-shooting on site and marketing. The themes were examined in detail by five different syndicate groups and culminated in presentations of their findings. The prize for the best presentation went to Mike Neylon of Structural Systems (UK) who delivered a lively report containing tips for trouble-shooting on site.

Going hands-on
Without doubt, the absolute highlights of the whole three day session were BBR VT's Christian 'Chris' Roost's two practical 'lab' sessions – one to assemble a BBR HiAm CONA anchor, the other to assemble a BBR Square Damper.
Chris gave detailed instructions, illustrated with some amazing animations, as to how the tasks should be approached. Plans and drawings were examined, quantities checked and measured – and sleeves were rolled up. Although these were new technology and techniques for the majority of those present, the tasks were completed with great style and in good time.
The local BBR Network Member, Structural Systems (UK) Limited, had arranged facilities – and some very much appreciated refreshments – for this particular element of the course.

Collaborative success
After awards were presented and thanks were given, delegates bade their farewells and gradually dispersed in the direction of their homelands.
One of the strongest impressions remaining at the end of the training course was how the BBR spirit of 'collaboration' crosses all boundaries – even the preparation for the course had seen input from four BBR Network Members, as well as engineers at BBR VT.
It was a great honor to have shared such deep technical insight, as well as to have been among some of the finest and most professional engineers in Europe. ●

MEET THE WINNERS

The BBR Network celebrates team and individual achievements

WINNING WAYS

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Within the BBR Network, we have some of the finest engineers in the world – highly qualified, experienced and committed to technical excellence. Their work has resulted in the realisation of challenging projects at the leading edge of modern construction.

FACTS & FIGURES

PROJECT OF THE YEAR – 2ND COEN TUNNEL IN AMSTERDAM

- Number of BBR CONA PT tendons – 72
- PT force
  – 161,000kN (outermost elements)
  – 187,000kN (innermost elements)
- Number of elements – 4
- Element length – 178m
- Sections in element – 7
- Section dimensions – 25.5m long, approx 30m wide, over 8m high
- Distance transported by sea – 160km

Project of the year

The 2012 Project of the Year Award was presented to BBR Network Member Spanstaal B.V. for the 2nd Coen Tunnel in Amsterdam and also recognised their long experience in post-tensioning of immersed tube tunnels.

The new structure for the 2nd Coen Tunnel was constructed with four massive post-tensioned immersed tube tunnel elements, built in a dry dock and towed by tugboats to the tunnel site where they were submerged. The four elements only just fitted into the dry dock, so good workflow, space and materials planning was vital. For a full project report, see page 69 of CONNÆCT 2012.

The judging panel were impressed by the in-depth knowledge combined with confidence in using innovative techniques for immersed tube tunneling displayed by Netherlands-based BBR Network Member Spanstaal on this project. The judges commented: "Spanstaal's track record of such projects is an inspiration for others in the BBR Network – and indeed a source of support for other members when executing similar work elsewhere."

Ben Grundlehner of Spanstaal added: "We're delighted to have our work in this sector recognised by this award, as many dozens of immersed tube tunnels have been built in the Netherlands using sections post-tensioned, by Spanstaal, with BBR technology."

Many congratulations to the Spanstaal team for their achievement!

New BBR PT Grand Master

The grade of 'BBR PT Grand Master' – the BBR Network's highest award for technical excellence in post-tensioning – has been achieved for only the second time in history. At the BBR Network European training session in London, Kresimir Bogadi, Operations Manager of Croatia-based BBR Adria was presented with his award by Juan Maier, Senior Product Manager of BBR VT International Ltd.

"We congratulate all of the BBR engineers who achieved really excellent results during our recent training course," said Juan. "Kresimir distinguished himself particularly during the exams – reflecting his special ability to apply a deep technical knowledge under pressure."

Having joined BBR Adria in 2002 as a Site Manager, Kresimir has worked on some of the most challenging projects in the region – such as the Zagreb Arena in Croatia and the Drava Bridge in Ptuj, Slovenia, both of which have featured in previous editions of CONNÆCT.

As Operations Manager, he is involved in almost every contract handled by the company and is now working on aspects of the Port of Rijeka Authority's Container Terminal Brajdica project.

During the same training session, three new 'BBR PT Masters' also emerged – Rafal Bartkowski of BBR Polska, Richard Birgersson of Spännteknik in Sweden and Maciej Michalczyk of KB Spennteknikk in Norway.

Having joined BBR Polska just five months ago, Rafal Bartkowski will soon be managing a project for a new post-tensioned car park in Wroclaw. Recently, Richard Birgersson's main work has been in design and tendering for bridge projects in Sweden and he will shortly also be helping business development initiatives focused on the international offshore industry. Meanwhile, over the next year, Maciej Michalczyk – a new recruit for Spennteknikk – is looking forward to being involved in a variety of post-tensioning projects in Norway, as well as completing his MSc on the use of composite materials for post-tensioning. Many congratulations to Kresimir, Rafal, Richard and Maciej – we look forward to reading about their further achievements in the next edition of CONNÆCT!

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BBR CONNÆCT Awards

As is always the case, selecting the 2012 BBR CONNÆCT Award winners was an extremely challenging task – perhaps almost as challenging as some of the construction projects facing the BBR Network.

The BBR CONNÆCT Best Article Award was presented jointly to BBR Network Members ETIC (France) and BBR PTE (Spain) for their work on *Historic landmark*, about the Altiani Bridge in Corsica and *Spanning urban green* covering construction of the Las Llamas Bridge in Santander. As well as containing a good balance of local information and technical detail, the judges said that the articles were well constructed and "it was clear the writers loved the projects and felt a special sense of pride in their achievement."

KB Vorspann-Technik in Austria scooped the BBR CONNÆCT Best Photography Award for the illustration of their article about the Sava Bridge in Belgrade, Serbia – *Europe's largest single pylon stay cable bridge*. It is the special blend of technology and people which sets the BBR Network apart from the crowd and the selection of photographs reflected this perfectly – with many good shots showing the team going 'hands on' with BBR technology.

BBR Network Special Award

From time-to-time, the BBR Network Special Award is presented. This is not a regular occurrence, but something which happens under special circumstances.

In 2012, BBR Contech – the BBR Network Member in New Zealand – received the award in recognition of the company's sustained support of research. Over an extended period of time, BBR Contech has supported research into seismic construction engineering systems and techniques using post-tensioning. Even in the face of a growing workload – partially created by increased seismic activity in the region – they have continued to do this.The judging panel commented: "BBR Contech has set an excellent example of how the BBR Network is continually striving to set new benchmarks – and thus remain at the leading edge of construction technology." ●

1 BBR Project of the Year – one of the 2nd Coen Tunnel elements being towed out of the dock.
2 BBR PT Grand Master, Kresimir Bogadi, BBR Adria (right) receiving his award from Juan Maier, Senior Product Manager of BBR VT International (left).
3 The BBR CONNÆCT Best Article Award was presented jointly to BBR Network Members ETIC (France) and BBR PTE (Spain) for articles about the Altiani Bridge in Corsica (top) and Santander's Las Llamas Bridge (bottom) respectively.
4 The BBR CONNÆCT Best Photography Award went to KB Vorspann-Technik, the BBR Network Member in Austria for its stunning depiction of the Sava Bridge project in Belgrade and showing the team going 'hands on' with BBR technology.
5 BBR Contech received the BBR Network Special Award for supporting research into leading edge seismic construction engineering solutions aimed at reducing structural damage, such as Pres-Lam which incorporates laminated veneer lumber in conjunction with post-tensioning.

PERSPECTIVE

Early advice on how post-tensioning benefits a project and brings rewards for developers

MAXIMIZING INVESTOR RETURNS

Having quite recently discovered that post-tensioning helps to create significantly more high quality lettable space inside the same building envelope, as well as delivering budgetary savings and flexibility of use, Antonio Palumbo, Head of Real Estate for the Tectus Group – the parent company of BBR Holding Ltd – now shares his perspective.

One of the first tasks in my current role was to review and evaluate early plans for a new multi-storey commercial development project at Ringstrasse in Schwerzenbach, near Zurich, Switzerland. This is a mixed-use scheme incorporating heavy loading requirements for storage and logistics areas, offices and an underground garage. It soon became clear that the economics of existing plans didn't work.

We explored reducing the thickness of the very thick traditional concrete floor slabs and the weight of the entire structure. By reducing the weight of a building, you can also reduce the cost, time and materials used in the foundations. Next, we designed all floors with the same ceiling height. The solution for the storage areas was to plan part of the ground floor to be double height, over two floors – later, if the space is needed for offices, the 'missing' ceiling can easily be installed.

Time is money

What is more, we realised that when you build a concrete floor with post-tensioning, not only do you save money by using less building materials – such as concrete, reinforcing bar, formwork, etc – you consequently also require less time to physically construct the building and thus can achieve a faster floor-to-floor cycle time. We demonstrated that this could save three months on our construction program. Within an 11-month overall build program, this represents a major saving for us – we will be paying appreciably less interest on construction finance loans and, of course, the rental income flow will begin earlier. 'Time' is definitely 'money' in this respect!

Spacious & flexible

Two further factors convinced us to proceed with a post-tensioned concrete approach. By saving height through construction of thinner post-tensioned floor slabs, we are able to reduce the floor-to-ceiling heights – this allowed us to add an extra floor to the building without increasing the overall building height and resulted in more net lettable space.

The other persuasive factor was that, by adopting post-tensioned concrete floors, we are able to completely remove all columns inside the building – giving us huge column-free floors with ultimate flexibility to arrange the space as tenants wish, there are no layout restrictions.

For an investor, flexibility is one of the most important issues – and also plays strongly to the sustainability agenda. While you build with the needs of today in mind, the building will stand for perhaps 100 years. So, if you can build a structure with the flexibility to be adapted for different uses over time, you are creating a sustainable scheme.

Early advice

It's crucial that discussions about the benefits of using post-tensioning should happen early in a project – and take place directly with investors or developers. At the concept stage, before detailed engineering or architectural drawings have been completed, there is the greatest opportunity to make changes.

We expect our post-tensioning partners to understand and share our vision for the project and thus be able to help us achieve our goals. Sensitivity to budgetary issues is also an expectation – we look to them to offer us an integrated solution in which the application of post-tensioning provides the best value – maximizing the benefit.

The business case for using post-tensioned concrete floors was compelling and it's a model that we will most certainly be using for future projects. More space to let, available earlier and offering flexibility of use over the long term? Surely, it's every commercial property developer's dream!

PORTFOLIO

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five decades of excellence – celebration of the 50th anniversaries of BBR technology and engineering in Australia and New Zealand

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strengthening of the Bellegarde Viaduct, vital infrastructure on the Lyon to Geneva section of the A40 motorway

IN THE SPOTLIGHT

BBR Network Members in New Zealand and Australia reflect on their 50th anniversaries

FIVE DECADES OF EXCELLENCE

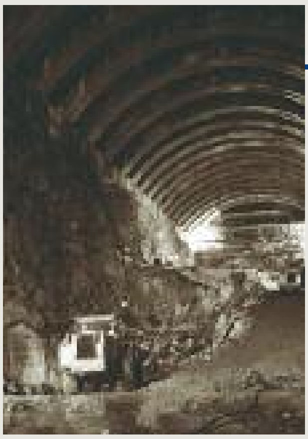
This year, the BBR Network Member in New Zealand – **BBR Contech** – celebrates the 50th anniversary of the foundation of the business. Meanwhile, across the Tasman Sea, the Australian BBR Network Member, **Structural Systems**, has also recently commemorated their Golden Anniversary. As they enter their sixth decade at the forefront of construction engineering technology, the two organizations share some reflections on their roots, longevity and aspirations for the future.

1

TIMELINE
BBR Contech & Structural Systems

1960s

→ **1961** – BBR Australia founded in Victoria, undertaking its first project to supply and install BBRV rock anchors for the Snowy Mountain Scheme. AUS



1963 – BBR New Zealand founded in Masterton. NZ

→ **1963** – Work in progress on New Zealand's Aratiatia Spillway Bridge project, part of Wairakei Geothermal Power development scheme. NZ

→ **1966** – Thorndon Overbridge – with its 300+ post-tensioned 'I' beams utilizing some 800t of prestressing, this was the first major post-tensioning project undertaken by BBR New Zealand. NZ

2

Both companies were born on the back of some large infrastructure developments in the early 1960s – and growing international excitement about Swiss BBR post-tensioning systems. BBR Contech was founded in 1963, while Structural Systems came into being two years earlier. In a sense, both companies owe their origins to journeys – one of them a honeymoon – made to-and-from Switzerland.

The early days

"The BBR New Zealand story actually has its beginnings in the 1950s, when the Government called for tenders for the Roxburgh Dam," explains Paul Wymer, BBR Contech's Managing Director. "That contract was won by an international joint venture that included Conrad Zschokke, a contractor from Switzerland."

"Once the project was complete, Zschokke established a local presence, joining a Masterton company to form Rigg Zschokke. When, in the early 1960s, projects started requiring post-tensioning technology, Zschokke's Swiss-based business associate – Bureau BBR – was in the perfect position to help – and the rest, as they say, is history. In 1963, BBR New Zealand was born."

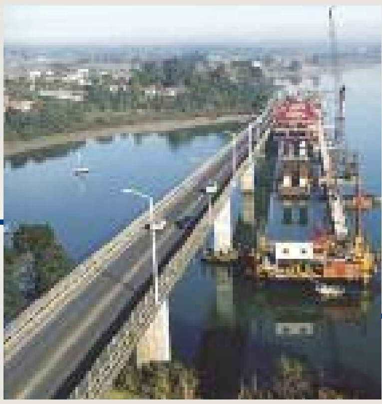
Adding to the story was a young engineering graduate called Rob Irwin, who had travelled to Europe in 1961 and secured a job with Conrad Zschokke. Antonio Brandestini, who had also worked for Conrad Zschokke, was one of BBR New Zealand's founders. Rob went on to gain post-tensioning experience in Switzerland, then returned in 1966 with his skills and experience to lead the team at BBR New Zealand.

"This was the start of BBR Contech as we now know it," says Paul. "As the company's owner, Rob was always on the lookout for business opportunities and smart ideas – he was well known for his innovative thinking, professional approach and pursuit of excellence. He was a lynchpin to our success, maintaining his association with the company for more than 45 years. Sadly, Rob died in 2010 – he would have loved to see us reach the 50-year milestone."

The introduction of BBR into Australia was also based on personal contact. ➤

1 Sky Tower, Auckland, New Zealand.
2 Wellington Dam, Western Australia.

1970s



→ **1972** – Upper Harbor Bridge – design input for bridge and balanced cantilever construction by BBRV in Zurich. The original bridge on the left and on the right, the 2004 'duplication bridge' also constructed with BBR post-tensioning. NZ

→ **1974** – Shell Gully bridge structures – one of many bridge projects BBR Contech worked on in the 1970s during development of city and motorway infrastructure in Wellington. NZ

→ **1973** – Cable-stayed footbridge, Melbourne. AUS

→ **1975** – Sydney Tower – start of cable stay installation for this landmark which was the highest structure in the Southern Hemisphere when constructed. AUS

3

"It has been an exciting journey which began with a young Swiss engineer named Josef Koch and his wife stopping over in Melbourne for a few days on their honeymoon," recounts Bob Freedman, Structural Systems' Chairman.

At this stage, the Snowy Mountains Scheme was underway and their engineers were looking at the new Swiss system of prestressed rock anchors which had been developed on mountain projects in Switzerland.

Josef made contact with the Swiss company, BBRV, which had developed and patented the famous BBRV 'button headed' multi-wire post-tensioning system. BBR Australia Pty Ltd was founded in 1961 in Victoria. The company was the sole Australian licensee for the successful BBRV post-tensioning system developed in Europe.

Evolving capabilities

Now, a half century later, it is clear that both companies have continually evolved in response to market demands and new opportunities.

A series of mergers and acquisitions has seen BBR New Zealand change names, market new skills and techniques and undertake a diverse range of projects in New Zealand and overseas. Throughout, its core capabilities have remained a constant – harnessing BBR's world-leading post-tensioning technology to complete bridging and building work, ground anchoring, construction engineering and structural maintenance, repair and retrofitting projects.

"Being part of the BBR Network has given us enormous credibility," says Paul. "It's enabled us to be at the forefront of many key projects in New Zealand and the Pacific."

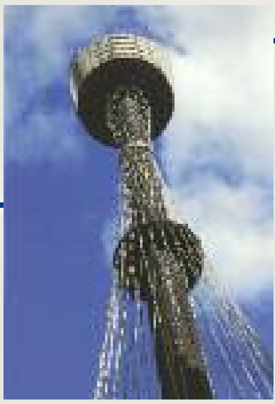
Today, the company is known as BBR Contech, with headquarters in Auckland, offices in Wellington and Christchurch, and a dedicated team of some 70 specialists working with clients nationwide. It's widely recognised for its outstanding technical expertise and is an active member of the international BBR Network, working in close collaboration with other members around the world.

"We've been proud to contribute to some of New Zealand's and the Pacific's most significant construction and remediation projects," enthuses Paul.

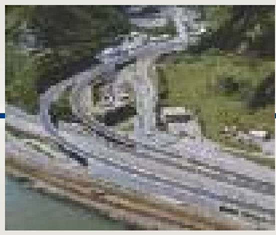
"We've worked on historic structures as well as projects involving world-first innovations, and today we're deeply involved in the post-earthquake Christchurch recovery program. We're also supporting new knowledge, such as through research projects with the Universities of Auckland and Canterbury that explore various post-tensioning and FRP applications in new building designs and as seismic retrofit solutions."

Meanwhile, by the early 1980s, BBR Australia had become a well-established professional engineering and contracting operation of national scope. It provided innovative specialist skills and techniques to the construction and mining industries and was an integral partner in several landmark Australian projects.

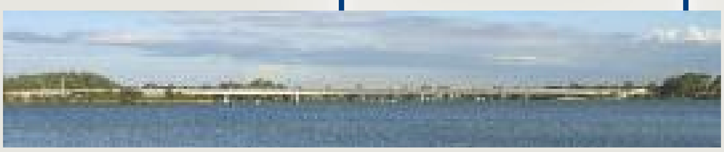
1980s



→ **1981** – Opening of Sydney Tower with its unique supporting net structure of BBR DINA stay cables. AUS



→ **1982** – Construction of twin-curved Ngauranga 'flyover' bridges in Wellington was carried out using the incremental launching method for the first time in Australasia and featured BBR post-tensioning. NZ



→ **1982** – Opening of the longest road bridge in Western Australia – Mount Henry Bridge, Perth which featured BBR post-tensioning. AUS

1983 & 1984 – A period of significant rail bridge infrastructure construction in New Zealand uses BBR CONA technology including Mangaweka Rail Deviation Bridge (1983) and Rangatiki Rail Bridge (1984). NZ

→ **1984** – First incrementally launched bridge project for Structural Systems – Killawara Bridge, New South Wales. AUS

1987 – BBR Australia goes public and is listed on the Australian Stock Exchange, changing its name to Structural Systems. AUS

4

"The decision was taken to convert the company to public ownership to provide the capital base necessary for growth into overseas markets and large-scale projects," explains Bob Freedman. "So, in 1987, the business was listed on the Australian Stock Exchange as Structural Systems Limited."

Once established as a public company, Structural Systems set about positioning itself as the foremost specialist construction contractor in the Australian market.

Investment in technologies allowed even the largest civil projects to be undertaken.

Quality engineering design was identified as being a key driver of value with customers and, through the 1990s, the company developed a specialist design centre, based in Melbourne.

This strong technical foundation has allowed the acquisition of key complementary business assets across Australia. These have included ROCK Australia who provide specialist supply and contracting services for mining and civil projects, Refobar Australia who manufacture materials and products for the post-tensioning, construction and mining industries and a concrete services business – Meridian Concrete. Recent major expansion of Structural Systems' remedial division has established the company as one of Australia's leading structural remediation operators.

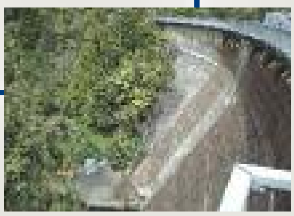
In parallel with its growth in capability, Structural Systems has moved to establish permanent operational bases to service the growth markets of the Middle East and Africa, as well as enhancing its joint venture partnerships within the South East Asian and Pacific regions. ➤

3 Emirates Tower, Dubai – one of many landmark structures in the Middle East which has benefitted from Structural Systems' expertise.

4 K-Mart distribution warehouse, South Auckland, New Zealand – an award-winning project, where BBR Contech was responsible for design and post-tensioning installation in the high performance warehouse slab.

1990s

→ **1990** – Design and construction of post-tensioning and slipform systems for three large LNG containment vessels in Kwinana, Western Australia. AUS



→ **1992-93** – Installation of BBR CONA rock anchors for Waitakere Dam, Auckland, New Zealand. NZ

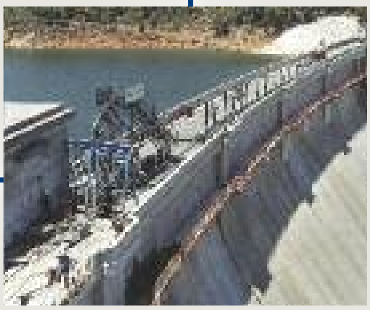
→ **1995** – Sky Tower, Auckland, New Zealand – BBR Contech developed the BBR Multiwire Z36 internal anchorage which was the first time a BBR center stressing anchorage of this size had been used anywhere in the world. NZ

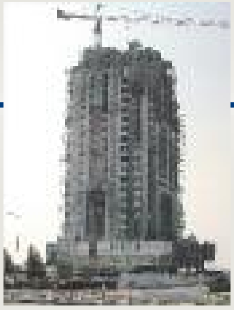
→ **1999** – Otira Viaduct – balanced cantilever bridge built in the remote Southern Alps, New Zealand. NZ

Reflections & outlook
"You name it, BBR Contech has probably worked on it," declares Paul Wymer. "The BBR Contech portfolio is vast – from retail outlets and shopping centers to business parks, universities, warehouses, dams, highways, factories, rail lines, tunnels, bridges, reservoirs, sewers, wharves, museums, art galleries, car parks, stadiums, hangars, hotels and recycling and wastewater facilities."
The company's performance has been recognised by a raft of awards from its peers. These have included the 2007 Supreme New Zealand Engineering Excellence Award for work on strengthening the foundations of the nation's electricity transmission pylons and the 2009 New Zealand Concrete Society's Concrete and Technology Awards for its work on Wellington's Alan MacDiarmid Building. The latter was New Zealand's first multi-storey unbonded post-tensioned precast concrete building, built using the innovative PRESSS (PREcast Seismic Structural System) technology which incorporates BBR CONA post-tensioning.
The Structural Systems track record is no less impressive. They have been involved in the design and construction of many iconic projects throughout their five decades in business – including Sydney Tower, numerous sporting facilities, including the ANZ and Etihad stadiums, the Rod Laver Arena in Melbourne as well as the Emirates Tower Project in Dubai and the West India Quay project in London. Other schemes have included major mining projects, such as Argyle Diamond Mine and the Koolan Island Iron Ore project, as well as many cryogenic containment vessels for LNG and LPG – some of truly mammoth proportions.
"Now, 50 years on from that first project," says Bob Freedman, "our organization has grown from a small privately owned specialist post-tensioning company to a diverse international contractor which has never been afraid of taking on a challenge."
"Today's construction, mining, oil and gas markets face very different challenges from the early days and our objective is to provide technical solutions to the highest construction standards."


5

2000s


→ **2001** – World record set by Structural Systems in 2001 when they installed the largest permanent and restressable ground anchors at Canning Dam, Western Australia. AUS


→ **2003** – Structural Systems' first project in Qatar completed – the 24-storey Bilal Suites Tower in Doha. AUS


→ **2007** – Structural Systems UK's largest project to date, the South Hook LNG tanks in Milford Haven in South Wales began. AUS

2008 – Structural Systems established a permanent office in Johannesburg, in time for the start of the first project in South Africa, the Koeberg Interchange. AUS


→ **2008** – New Zealand's first PRESSS (Precast Seismic Structural System) building – the Alan MacDiarmid building at the Victoria University of Wellington features BBR CONA tendons in an innovative damage-resistant design application. NZ

6

7

"Our most valuable asset is our people," he continues, "their professionalism, dedication, entrepreneurial spirit, innovative engineering and commitment is why Structural Systems have been meeting or exceeding our clients and partners expectations for the last 50 years."

"We look forward to our future, confident in meeting new challenges with innovation and the experience and knowledge gained through our 50-year history," he concludes.

Paul Wymer shares Bob's pride and commitment. "BBR Contech's success in the competitive New Zealand market is of course a reflection of the knowledge, expertise and experience of the people who work there," he states.

"Our people have always been central to our success – and I'm delighted that many have been with us for so many years," says Paul, who's a 20-year veteran himself. "Instead of marking years with the business, we're now marking decades – our longest-serving team member has been with us for approaching 50 years and many others for more than 20. We still get input from Rob Robinson, one of the founding New Zealand employees back in 1966 who became one of our most senior managers. He worked side-by-side with Rob Irwin and representatives from Switzerland right from the start. He is now assisting and mentoring our newer employees, particularly in Christchurch where post-tensioning is in strong demand for rebuilding work following the recent earthquakes."

The secret behind this extraordinary retention rate may be quite obvious to other members of the BBR Network, nevertheless, Paul explains: "We offer a huge variety of work, in interesting environments and using world-leading technology. Our people have direct exposure to projects that challenge them on all sorts of levels and the opportunity to contribute to the world in which we live. It's a pretty amazing business with which to be involved – and will continue to be for many years to come." ●

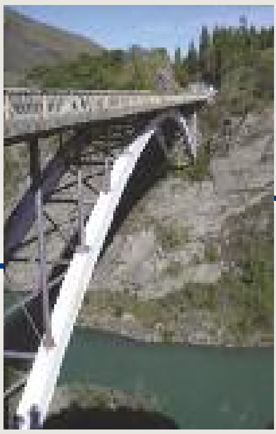
5 Australia's second longest stay cable bridge, the Eleanor Schonell or 'Green' Bridge, Brisbane, Australia, where Structural Systems installed BBR CONA stay cables.

6 Ormiston Road Bridge, Auckland, New Zealand – built in 2008, this was the country's first cable-stayed road bridge and features BBR DINA stay cables installed by BBR Contech.

7 Sylvia Park shopping center car park, Auckland, New Zealand – BBR Contech, in collaboration with Structural Systems, created some 20,000m^2 of parking slabs over four floors using BBR CONA flat post-tensioning.

2010s

→ **2008** – Kawarau Bridge, Queenstown – BBR Contech used innovative techniques to strengthen a steel arch bridge to bring it in line with current seismic standards. NZ



→ **2011** – Thorndon Container Terminal and Dock Wharf Concrete Repairs and Cathodic Protection, Port of Wellington, New Zealand. NZ

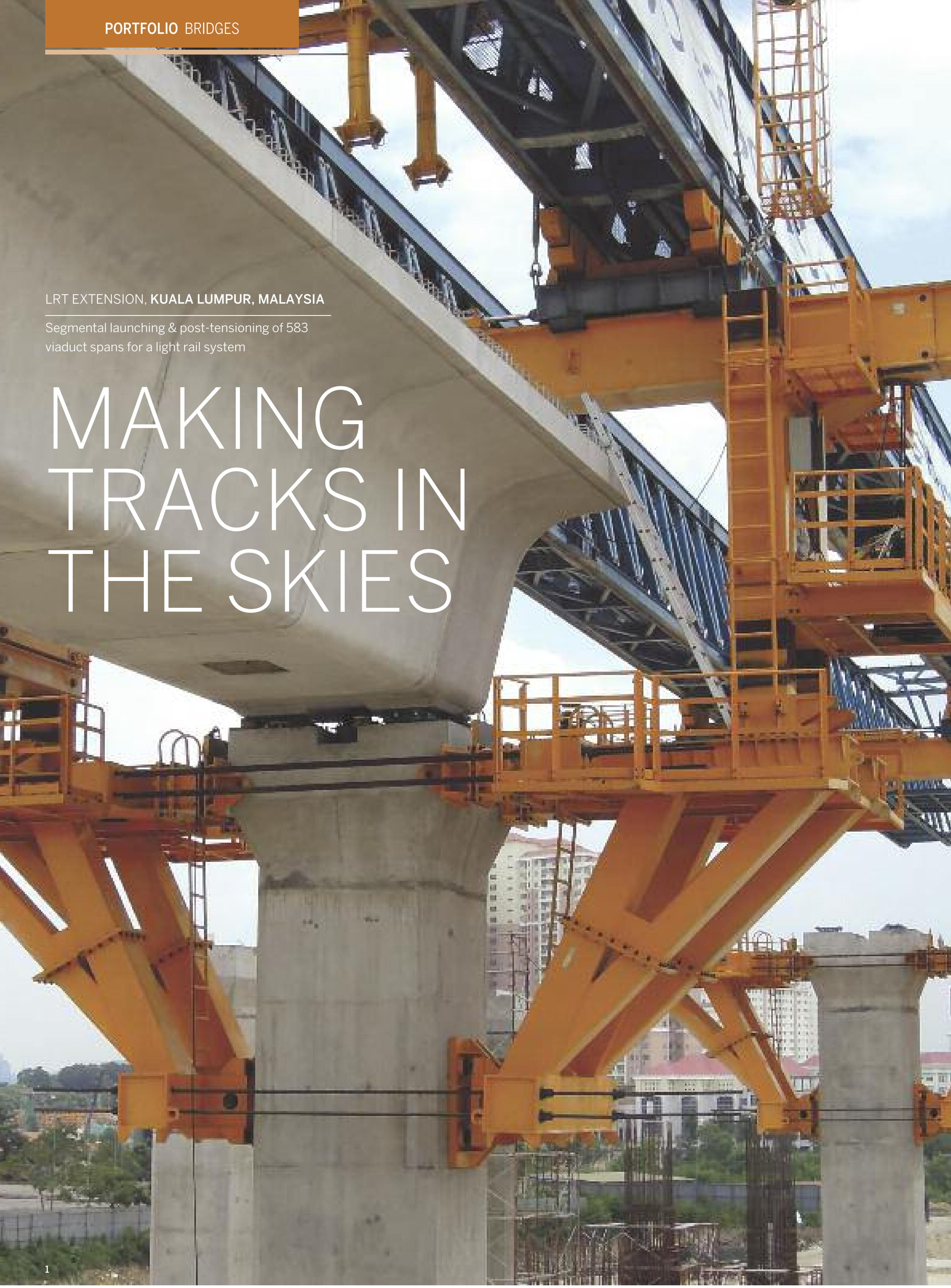
→ **2012** – Structural Systems completed their first overseas dam contract – the Roseires Dam Heightening project in Sudan. AUS

→ **2013** – With completion of the Fonterra Darfield development, BBR Contech will have produced more than 1.5 million square meters of post-tensioned floor slabs in over 250 projects, having first introduced post-tensioned slabs to New Zealand in the late 1960s. NZ

LRT EXTENSION, **KUALA LUMPUR, MALAYSIA**

Segmental launching & post-tensioning of 583 viaduct spans for a light rail system

MAKING TRACKS IN THE SKIES



1

The continuing development of satellite towns and areas around Kuala Lumpur, the capital of Malaysia, has made it necessary to extend the existing Light Rail Transit (LRT) lines to improve access to and from the western side of the city. Chang Chee Cheong of Malaysia-based BBR Construction Systems outlines the project and the approach to this major construction engineering task.

Ten years ago, two 29km long LRT lines were built – one from Sultan Ismail to Kelana Jaya (Kelana Line) and the second from Ampang to Bukit Jalil (Ampang Line). BBR technology was used for the Kelana Line and now both lines are being extended.

The challenge
Amid fierce competition, BBR Malaysia secured the launching and prestressing works for both packages of the Kelana Line Extension – Package A from Trans Resources Corporation Sdn Bhd and Package B from Sunway Construction Sdn Bhd. The total length is 17.3km and almost the entire line will run on elevated viaducts with only a small proportion of track at ground level.

"The total length is 17.3km and almost the entire line will run on elevated viaducts with only a small proportion of track at ground level."

FACTS & FIGURES

- Spans, Package A – 318
- Spans, Package B – 265
- Double track standard spans – 27m, 30m & 36m
- Single track standard spans – 18m, 21m, 24m & 27 m
- Special crossing span configurations – 42m + 65m + 42m – 65m + 100m + 65m
- Viaduct depth – 2.2m
- Width, double track viaduct – 7.77m
- Maximum segments in span – 12 (36m spans)

Viaduct types & configuration
The double track sections will carry both north and southbound train services and when approaching a station, they diverge into two 5.2m wide single tracks which go around the platforms of the elevated station. Single track is also being used to provide access to the depot.
Male and female shear keys are cast between the segment joints – 'dry joints'. The precast segments are launched by a launching gantry (LG) – supplied by our clients. Upon closure of all joints between the segments by the LG, the external tendons are post-tensioned for strength. Next, the entire span is lowered onto flat jacks for level and alignment adjustment. Then the LG is advanced to the next span – thus span-by-span erection.
Where the tracks span over the existing highway, railway line and traffic junctions, the spans become longer creating 'Special Crossings' with longer span configurations. The precast segments are erected using the balanced cantilever method. A pair of segments are installed using mobile cranes or segment erectors and then the internal tendons are stressed with hydraulic jacks. ➤

Launching gantries

Overhead LGs were used for this project because there were no overhead height restrictions and the need to maintain a minimum traffic height clearance of 5.4m under the bridge meant that an underslung type of LG would not have been suitable here.

The four LGs for Package A were designed and fabricated in China, then shipped to Malaysia after trial assembly and fitting. On site, the truss members – top chord, bottom chord and diagonal members – were assembled on temporary supports.

The three LGs needed for Package B were fabricated locally and each truss section was assembled in the fabrication yard. The truss sections were transported to the site on trailers.

Each LG is equipped with three support legs – two for supporting the LG and one on top of the next pier. The saw-toothed support legs are clamped onto the top of the pier by prestress bars.

2

> "Where the tracks span over the existing highway, railway line and traffic junctions, the spans become longer creating 'Special Crossings' with longer span configurations."

3

4

5

1 Launching gantry advancing to next span (page 22).
2 Completion of first single track span.
3 Lifting of second main truss onto transverse support beam.
4 Full span load testing of LG to 125% Working Load.
5 View of external tendons running through deviator holes.

Segment launching sequence

After delivery of the segments by trailer to the area below the LG, a suspension beam is fixed on top of each segment. The suspension beam is secured by four 32mm diameter vertical bars. The crane lifts the segment off the trailer and rotates the segment to the bridge orientation. Then the segment is lifted vertically and horizontally to the required position, where levels and alignment are checked by a surveyor. Next, three hanging bars are installed to suspend the segment to the LG truss. A three-point support system allows easy adjustment of the levels of the four corners of each bridge segment.

In Package B, two 50mm bars are used to lift each segment. The advantage is that it is quicker to install and remove two bars rather than four. When the segment is in position, the two bars are coupled up to two hanging bars from the truss. As the segment is lifted at the center of gravity, it is possible to tilt the segment by hand to the required longitudinal slope before securing it to the LG truss.

The segments are also tied and restrained horizontally to the previously launched segment at the top and bottom of the box girder. The two bars connecting the suspension beams are tightened to close the gap between the shear key joints of the segments. Instead of using concrete blisters to anchor the bottom ties, an innovative method of using T16 rebar hooks is being used to anchor the bottom ties which are made of threaded bar turnbuckles.

External post-tensioning

Each span is simply supported on bearings and has between four and ten BBR CONA external 1906 and 1206 tendons, installed by our multidisciplinary launching crew. Twelve lengths of HDPE ducting are joined together by electro butt-fusion equipment and inserted, via deviator holes, into the anchorages at both ends and then 15.2mm diameter strands are threaded into the ducts by strand pushers. A pair of tendons are stressed simultaneously using two 480t hydraulic jacks suspended by movable trolleys from the LG. ➤

"Instead of using concrete blisters to anchor the bottom ties, an innovative method of using T16 rebar hooks is being used..."

6

7

Span lowering and adjustment

After stressing, the load from the box girder span is transferred to the flat jacks placed on top of the piers. The Surveyor checks the levels and horizontal alignment of the box girder and horizontal transverse and longitudinal adjustments are made with the flat jacks which rest on sliding bases.
On achieving the final level and position, the load is transferred from the flat jacks onto sand jacks. Next, the permanent pot bearings are grouted, by others, and after the epoxy grout has achieved the minimum strength, sand is let out of the sand jacks, thereby lowering the box girder slightly and transferring the load onto the permanent bearings.

Advancing LG to next span

Preparation includes jacking up all the LG trusses to a horizontal level. Next, an electric winch is engaged to pull the LG truss forward so that the cantilevering LG truss nose can reach the transverse beam of the next pier.
On Package B, the LG truss is advanced in short incremental movements of 500mm to the next span by using a pair of long stroke hydraulic jacks. This method is slower, but it has the advantage of being able to launch on longitudinal slopes not exceeding 5%.

Erection cycle time

The cycle time is dependent on the specific site conditions at each span location. For the spans above the centerline of the road, for example, the segments could only be delivered to the LG at night – with partial closure of traffic lanes, between 11pm and 5am. Therefore, for the shorter spans, it is possible to deliver and hang all the segments in one span during that time, while the longer spans require two nights. On average, our erection cycle time was three days per span – making an average of around two spans a week.

Key client benefits

By combining the specialist works of post-tensioning with launching, we are able to enhance the efficiency of the launching crew and the overall project. The clients not only enjoy the cost and program savings generated by our efficient work methods, but they also benefit from the reliability of our proven BBR technology and expertise. Thanks to the sound technical advice our engineers are able to give, Resident Engineer approvals are usually secured promptly, allowing the LG to advance to the next span and the project to progress. ●

"By combining the specialist works of post-tensioning with launching, we are able to enhance the efficiency of the launching crew and the overall project."

TEAM & TECHNOLOGY

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)

6 Compression test on sand jack.
7 View along LG truss showing crane lifting precast segment.

SOUTH ROAD SUPERWAY, **ADELAIDE, SOUTH AUSTRALIA**

Post-tensioning of elevated highway structure

URBAN SUPERWAY

BBR Network Member **Structural Systems** is currently providing post-tensioning services on the South Road Superway, an A$842 million project which features a 2.8km elevated structure over the existing South Road in South Australia. The scope of work includes transverse post-tensioning in the precast segments, along with four 2706/3106 tendons in the tie-beam of the piers.

TEAM & TECHNOLOGY

Owner / Client – Department of Planning, Transport and Infrastructure

Main contractor – Urban Superway Joint Venture

Designer – GHD in conjunction with IBT & SMEC

Technology – BBR VT CONA CMI internal, BBR CONA flat

BBR Network Member – Structural Systems Limited (Australia)

VIADUCTO DEL ROMERAL, **A7 TARAMAY-LOBRES, SPAIN**

Precast segmental bridge using cantilever method, BBR VT CONA CMI and deck positioning system

COASTAL HIGHWAY CANTILEVER

The A7 Mediterranean Highway runs along the Mediterranean coastline from Algeciras to Barcelona and joins the south with the north of Spain. The Romeral Viaduct is situated near Almuñecar, in the Granada region of Andalucía province, and connects the three main coastal villages of Granada – Motril, Salobreña and Almuñecar. David Olivares Latorre from Spanish Network Member, BBR PTE, reports on the project.

1

2

"Positioning of the precast segments was carried out using four 1,700t vertical and eight 167t horizontal synchronized jacks, equipped with force and displacement instrumentation."

The 570m long bridge, which has six intermediate piers, is divided into seven spans – two 55m end spans and five 92m intermediate spans. The bridge was built by the balanced cantilever method using a self-launching gantry to place the precast segments.

The bridge deck was built with more than 750t of prestressing strand in the form of BBR VT CONA CMI tendons, with a nominal strand diameter of 15.7mm and cross-sectional area of 150mm^2. Work was executed using an auto propelled hydraulic robot to place the 750t stressing jacks inside the deck. During construction, every symmetrical pair of precast segment sets was stressed. The slab interior prestressing is made of 808 CONA CMI 3106 anchorages.

There were two different activities during the viaduct construction – positioning of precast segments and stressing.

Positioning of the precast segments was carried out using four 1,700t vertical and eight 167t horizontal synchronized jacks, equipped with force and displacement instrumentation.

1 A self-launching gantry helps place precast segments.
2 The self-launching formwork rested on the constructed bridge sections.
3 Precast segments were joined with BBR VT CONA CMI tendons.


3

> "The bridge deck was built with more than 750t of prestressing strand in the form of BBR VT CONA CMI tendons..."

First, the synchronized equipment was placed over the pier. Then the first three precast segments were positioned over the vertical hydraulic jacks. Initially, the segments were joined together by bars – a theoretical preliminary positioning was made to guarantee that their construction was correct. The following step was to place the precast segments that would now be joined with CONA CMI stressed tendons. When 43 precast segments had been stressed, it was time to make the final synchronized positioning. This process covered 92m and ran to the middle of the span length – making a 'T' shape with the pier. Of course, we also installed and stressed CONA CMI tendons to join the 'T' sections together. The self-launching formwork rested on the constructed sections of the bridge, thus construction began from one abutment and finished at the other – so travel was in one direction only. Corrosion protection for the stressed tendons is provided by grouting which was carried out according to EN 445, 446 and 447. The construction process was very efficient, with each 'T' section being completed in around three weeks. ●

TEAM & TECHNOLOGY

Owner – Ministerio de Fomento
Main contractor – FCC Construcción S.A.
Technology – BBR VT CONA CMI internal, Balanced cantilever, PT bar
BBR Network Member – BBR PTE, S.L. (Spain)

WADI MISTAL BRIDGE, **SULTANATE OF OMAN**

FIRST BRIDGE PROJECT IN OMAN

A new bridge is taking shape at Ghubra village, reports Operations Manager, John Mathew from NASA Structural Systems, the BBR Network Member based in the United Arab Emirates.

TEAM & TECHNOLOGY

Client – Ministry of Transport and Communication, Sultanate of Oman
Main contractor – Khalid Bin Ahmed & Sons LLC, Sultanate of Oman
Consultants – NESPAK, Sultanate of Oman
Technology – BBR VT CONA CMI internal
BBR Network Member – NASA Structural Systems LLC (United Arab Emirates)

The Wadi Mistal Bridge is the first bridge project we have carried out in the Sultanate of Oman. We were appointed to supply, install and execute the post-tensioning services for 45 precast I-girders.
Part of an 18km long road project, the bridge will carry the new road across a wadi – or valley. The bridge has nine spans and there are five 29.9m girders per span. We used four BBR VT CONA CMI 1206 tendons in each girder and these were stressed from both ends simultaneously. The total quantity of prestressing steel used was 67t and 360 CONA CMI 1206 anchorages were placed. The whole post-tensioning operation, from start to finish, took around four months to complete. ●

SAVA BRIDGE SOUTH APPROACH ROADS, **BELGRADE, SERBIA**

Post-tensioning of bridge segments & girders for major transport intersections

REALIZING THE CONNECTIONS

1

While Europe's largest single pylon cable-stayed bridge – the Sava Bridge in Belgrade, Serbia – stands proudly on the landscape, work is now in full swing to provide major infrastructure connections surrounding it. Norbert Bogensperger of BBR Network Member KB Vorspann-Technik describes his company's work on the South Approach Roads.

The South Approach Roads (SAR) project is almost as large and as complex as the Sava Bridge itself. Construction work has been arranged around existing infrastructure and to accommodate new infrastructure in this busy location on the western fringes of the Serbian capital city. Construction of the SAR scheme has been divided into four sections – Radnicka Street Interchange and Inner City Semi Ring Road (ICSRR) Phases 1A, 1B and 1C.

SAR project outline

Radnicka Street Interchange comprises construction of a new three level, grade separated interchange divided into three sections:

- Section 1 – two viaducts for a 380m elevated length of the 2 x 2 lane ICSRR and one viaduct for a 375m elevated length of the future two track Belgrade Metro (BGM) including a new station.
- Section 2 – an elevated two lane roundabout and 381m long associated elevated on / off ramps, including two road-over-rail bridges and at-grade link roads connecting to Radnicka Street and Vojvode Mišica Street.
- Section 3 – 390m long, 2 x 3 lane overpass of the existing five track railway and Topcider River, several elevated on / off ramps connecting the elevated roundabout and the ICSRR. River bridges, elevators, staircases, elevated walkways and paths to accommodate pedestrian and bicycle traffic.

The Inner City Semi Ring Road also has three phases:

- ICSRR Phase 1A – Hippodrome Interchange – comprises construction of a new two level, grade separated interchange and 600m elevated four lane, dual carriageway.
- ICSRR Phase 1B – Požeška and Paštroviceva Streets – comprises construction of 600m new elevated four lane, dual carriageway and reconstruction of 1,300m existing two lane, single carriageway.
- ICSRR Phase 1C – Connection of Hippodrome and Radnicka Street Interchanges – comprises construction of a new road over rail bridge, 500m four lane, dual carriageway, 1,000m at grade, two lane, single carriageway.

1 Segment 1 for Radnicka South was constructed above the line of the new road and lowered into place.
2 Visualization of the completed SAR project.

2

PT operations

Our expertise has been required for many of the structures involved. In total, we have installed post-tensioning for 90 bridge segments using BBR VT CONA CMI 19, 22 and 27 systems. Most of the tendons cover two segments and are arranged in a staggered pattern, with just half of the tendons being coupled, with fixed couplers, in one joint.

Central to the whole SAR project is the elevated roundabout with its eight on / off ramps. There was much excitement in March last year, when the largest concrete pour of the entire SAR scheme took place here. This included a 1,206m³ pour for the fifth and final segment of the elevated roundabout superstructure. The pour was carried out continuously over a 20 hour period. Work on the BGM structure was also progressing – with the eighth of the 11 segments required being cast. The link between the BGM and the Sava Bridge was completed in early April.

Radnicka junctions

At Radnicka, two 25-year old steel structures were to be demolished and replaced with two new ones. The first of these, Radnicka South, was completed and opened to traffic before demolition of the second could begin. Segment 1 for Radnicka South was particularly interesting, as it had to be constructed in an elevated position and lowered down into place. This was because the new road passes over the railway tracks with only a few centimeters clearance above power transmission lines – leaving no room for formwork. Our work at Radnicka North will run from May to September 2013 and we will be following the same process as for Radnicka South – again, using 12 segments and with the first of these being constructed above its final position and lowered into place.

PT girders

As well as post-tensioned segments, we have also provided PT girders. The Topcider river, one of 40 watercourses flowing through – or now in culverts beneath – Belgrade, joins the Sava in this location. Using the BBR VT CONA CMI 12 and 19 systems, we stressed 19 x 26m long precast girders for the bridge to carry the new road over the river.

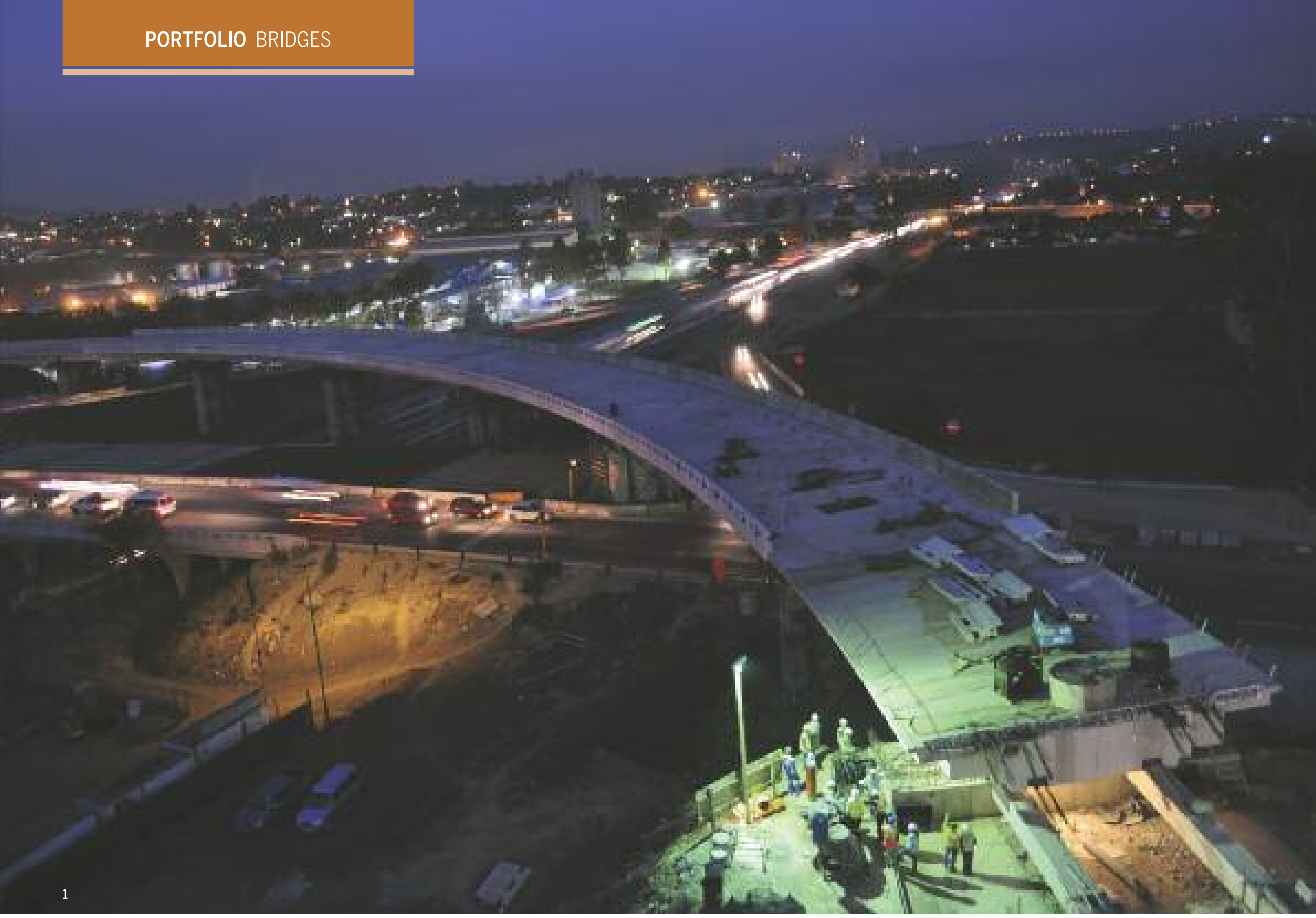
Also worthy of note is the fact that this was probably the first time that grouting according to EN 445, 446 and 447 had been carried out in Serbia.

Without doubt, this has been one of the most challenging infrastructure projects in Europe, however, there will be a great sense of satisfaction when it is completed as we will have used the latest and best technology and techniques in its realization. It is a project of which everyone involved should be very proud indeed – not just in terms of construction, but also in terms of the benefits it will bring to the region. ●

> "Our expertise has been required for many of the structures involved. In total, we have installed post-tensioning for 90 bridge segments using BBR VT CONA CMI 19, 22 and 27 systems."

TEAM & TECHNOLOGY

Owner – City of Belgrade
Main contractor – Ogranak Porr Bau GmbH
Technology – BBR VT CONA CMI internal
BBR Network Member – KB Vorspann-Technik GmbH (Germany)



1

B0107 CHOTA MOTALA INTERCHANGE, **PIETERMARITZBURG, SOUTH AFRICA**

Temporary works, incremental launching and post-tensioning of bridge for new traffic interchange

EMBRACING LATEST TECHNOLOGY & METHODS

Commuter traffic coming into, out of and through Pietermaritzburg city centre has had to cope with the large volumes of traffic that cause a bottleneck at the single N3 flyover. Sean Kelly – of BBR Network Member SSL Structural Systems (Africa) Pty Ltd – describes how commuters using the flyover had their prayers answered when the South African National Roads Agency Limited (SANRAL) initiated a major interchange upgrade.

The main drawcard of the project was a 13-segment, 220m long, incrementally launched post-tensioned concrete box girder which had to be built and launched with precision on a 175m horizontal radius. With the N3 and its existing flyover remaining in operation, the incremental launch method (ILM) offered the contractor and client a massive advantage by minimizing the disturbance to surroundings. While the ILM was a first for the JV contractors, it was the fourth ILM bridge to start within a three year period for us at the Structural Systems Group in Africa (SSA).

1 The project involved a 13-segment, 220m long incrementally launched bridge.
2 Temporary piers were built alongside the permanent ones to ensure temporary bearings could be positioned under the bridge webs.

Temporary works considerations
As part of SSA's subcontract, all incremental launching temporary works had to be designed and detailed to make the client's vision a reality. There were a number of special design considerations that had to be implemented to ensure the smooth running of the project, which were unfailingly adhered to by our South Africa-based temporary works designers, NYELETI Consulting.

Temporary piers
Supporting a main central span of 36m, four secondary spans of 33.5m and two end spans of 25m are six permanent piers – each shaped like a Vuvuzela, a plastic horn used predominantly at African soccer matches and synonymous with the 2010 Soccer World Cup. Temporary piers, 15m high, either side of the 'Vuvuzelas' had to be designed and constructed independently of the permanent piers to ensure the temporary bearings could be positioned under the bridge webs.
After launching operations, continuity prestressing and permanent bearing installation, the temporary piers were demolished to unveil the well-constructed and aesthetically pleasing piers.

Launch girder
Being on a 175m radius, the detailing of the girder was done in such a way to ensure fabrication and erection was not an onerous task. This was achieved by connecting two straight steel sections with a tapered infill piece, such that the girder guide rail could be easily fabricated to the tight radius whilst remaining fixed along its full length at a reasonable distance from the girder webs.

Launching equipment
The structure was designed on a 0.5% gradient from abutment-to-abutment which removed the need for an active running restraint system or park brake system. With this in mind, the conventional lift-and-push method and system was chosen.
The system was set up on the bridge abutment and allowed a maximum lifting load of 1,000t, with a maximum shifting force of 4,060kN. In some cases, the bridge had to be pulled back for minor alignment adjustments which was done within the system's 2,100kN pull back force capacity.

The incremental launching system consisted of two lifting jacks, each accompanied by two shifting jacks which were positioned directly under the inner and outer sliding surfaces / webs. All elements were controlled with precision by a single SSA operative on a hydraulic power pack.

Temporary bearings / sliding surfaces
With the ever-so-slight gradient, keeping the friction coefficients down to a minimum was critical to limit the shifting force required to complete each 250mm launch stroke. Stainless steel temporary bearings were used in conjunction with reinforced Teflon coated launching / sliding pads.

Casting yard
With the 175m radius and varying bridge cross-fall being a result of the ellipse launch path, the setting up of the casting yard form – deck shutter and skid beams – was absolutely crucial in meeting the geometric specifications and limit friction during launching. The temporary works designer's 3D model allowed the designer to extrapolate the levels of the finished bridge back into the casting yard. This gave the project team piece of mind, by knowing that no anomalies would arise as the launch progressed.
A two week cycle was easily achieved between each segment launch, with the 17m segments typically being launched within three hours after approval of concentric prestress tensioning. ➤

> "The main drawcard of the project was a 13-segment, 220m long, incrementally launched post-tensioned concrete box girder which had to be built and launched with precision on a 175m horizontal radius."

STRESSING FORCES
- BBR VT CONA CMI 1206 concentric tendons – 2,478kN
- BBR VT CONA CMI 1206 draped tendons – 2,578kN
- BBR VT CONA CMI 1506 draped tendons – 3,223kN
- Top girder connection bars – 906kN
- Bottom girder connection bars – 984kN


2

Girder connection

The launch girder was connected to the deck via a total of eight 40mm threaded bars in the top and 16 x 40mm threaded bars in the bottom. The concrete haunch on the top of the deck was accompanied by a localized thickened web to transfer the forces from the launch girder into the structure.

> "All concentric prestress was designed using BBR VT CONA CMI 1206 tendons which made installation and stressing easy for the SSA crew."

Concentric prestress

All concentric prestress was designed using BBR VT CONA CMI 1206 tendons which made installation and stressing easy for the SSA crew.
Twelve tendons – eight top and four bottom – extended for the length of the bridge, with each tendon being two segments in length and connected by fixed 'K' couplers. An additional six tendons, four top and two bottom, were required for the first three segments to take control of the induced incremental launching forces experienced as a result of the girder nose cantilevering the larger spans. Typically the stressing of six tendons at each segment end took three hours and was completed with the help of overhead cranage. A 300t multistrand centre-hole jack with the 12-strand CONA CMI configuration was used throughout.
During launching, our own custom-made grout caps were bolted to the coupler to allow immediate grouting after each launch and ensure there were no clashes between grouting activities and the progression of the trailing segments formwork and reinforcement.

3

4

3 Setting up of the casting yard form – deck shutter and skid beams – was absolutely crucial in meeting the geometric specifications and limit friction during launching.
4 The six permanent piers are shaped like Vuvuzelas – plastic horns used predominantly at African soccer matches and during the 2010 Soccer World Cup.
5 The launching nose helped guide segments over piers during launching operations.

5

Continuity prestress

Fourteen draped / continuity tendons were pushed and stressed after the launch was completed and these consisted of ten 1206 and four 1506 tendons – each roughly 80m long. With a very shallow profile, headroom inside the bridge was an issue, but was overcome by the design and implementation of mobile hoisting equipment that supported the jack from the 'belly side'.
The stressing activities were completed according to the designer's preferred stressing sequence and were completed within four days. Access into the bridge was limited to through the deck soffit, but the SSA team overcame this hurdle through good planning and implementation.

"With the ever-so-slight gradient, keeping the friction coefficients down to a minimum was critical to limit the shifting force required to complete each 250mm launch stroke."

Permanent bearings

Our expertise was called on again, late in the contract, for the installation of permanent bridge bearings. The average total dead load on each pier was 8,200kN, however, the curvature of the bridge meant that the outer bearings experienced a larger percentage of the total load.

Six 250t locking collar jacks were used at each pier and two pumps ran three jacks each – such that uneven jacking height problems caused by the difference in load distribution could be managed. The outcome was that adjacent difference in lifting heights was contained to no more than 1mm. Dial gauges ensured an accurate mode of vertical jacking height measurement and the best load distribution at load transfer.

Launching – the way forward

SANRAL has experienced the advantages of the ILM for prestressed concrete bridges and is certainly not shying away from pushing at the boundaries of modern construction technology and methods.

Currently, we are involved with two more ILM bridges in Durban as the IL and PT specialists – as well as the PT suppliers to two additional ILM bridges also in the Durban area.

Further growth of the province's largest city has also called for the development of a major interchange project north of the city centre in which we are hoping to be involved – this scheme is set to produce three ILM bridges within a close proximity of each other and that is sure to be a spectacle for all to see. ●

TEAM & TECHNOLOGY

Owner – The South African National Roads Agency Limited (SANRAL)

Contractor – Group Five Joint Venture in consortium with Phambili

Designer – ILISO Consulting and AURECON Cape Town JV (Bridge), NYELETI CONSULTING (Pty) Ltd (Temporary Works)

Technology – BBR VT CONA CMI internal, Incremental launching, Heavy lifting

BBR Network Member – SSL Structural Systems (Africa) Pty Ltd

UMGENI INTERCHANGE UPGRADE, **SOUTH AFRICA**

IMPROVING TRAFFIC CONDITIONS

SSL Structural Systems (Africa) Pty Ltd has been awarded the post-tensioning material and equipment supply to Durban's Umgeni Interchange Upgrade project which has been designed to alleviate the critical levels of traffic congestion currently being experienced. The project contains two curved incrementally launched bridges and four post-tensioned continuous cast in-situ structures. A total of 280t of 15.7mm strand and in excess of 600 anchor and coupler heads will be needed to complete the project. ●

TEAM & TECHNOLOGY

Owner – The South African National Roads Agency Limited (SANRAL)

Main contractor – Rumdel Cape / EXR Construction / Mazcon JV

Designer – GOBA Consulting Engineers & Project Managers

Technology – BBR VT CONA CMI internal

BBR Network Member – SSL Structural Systems (Africa) Pty Ltd

1

2

BRIDGE PROJECTS, **NETHERLANDS**

BBR VT CONA CMI post-tensioning, expansion joints and bearings installed for railway and motorway bridges

TRANSPORTATION TRIO

Infrastructure in the Netherlands is constantly evolving to meet the needs of its population and the economy. Ben Grundlehner of Spanstaal B.V. the Dutch BBR Network Member, outlines three recent projects which have required their specialist services.

1 South Willemsvaart railway bridge takes shape over the new canal.
2 The new motorway intersection bridge at Vaanplein is post-tensioned with BBR VT CONA CMI tendons.
3 Installation of post-tensioning tendons for the Kruisdonk Viaduct.

A railway bridge over a new canal at South Willemsvaart, a bridge at Vaanplein, near Europe's largest port at Rotterdam and a viaduct near Maastricht are all set to improve the country's transportation links for the future.

1 Railway Bridge, Tivoliweg

At South Willemsvaart, to the east of 's-Hertogenbosch, work is underway on the construction of a 9km long canal to give larger container ships a new access route between Rotterdam and south east Brabant. New infrastructure connections to the road and rail network are also being realized and the railway bridge at Tivoliweg is one such example. The new structure has been designed as a twin track prestressed concrete trough bridge – a type of design often used for railway crossings. One major advantage of this type of structure is the low rail height relative to the overall bridge height which limits the scope for trespassing. Shear and torsion require particular attention when designing trough bridges – longitudinal and transversal post-tensioning, along with reinforcement and hangers, contribute to an efficient bridge design.

The 0.8m thick bridge deck is 114m long and 14m wide and is supported on 3.5m high girders. Longitudinal post-tensioning consists of 24 BBR VT CONA CMI 3106 tendons, spread across two longitudinal girders. The transverse post-tensioning consists of 113 BBR VT CONA CMI 2206 tendons, evenly distributed over the length of the deck. The number of strands per anchor varies, partly because of a steel bicycle bridge which will be hung on one side of the deck on the spar. After stressing, the tendons were grouted according to EN 445 and 447.

The railway track bed rests on various sizes of pot bearings. Meanwhile, for the associated highway bridge here, we installed 18 BBR VT CONA CMI 3106 tendons. The road bridge has also been fitted with expansion joints and laminated elastomeric bearings of various sizes.

"Shear and torsion require particular attention when designing trough bridges – longitudinal and transversal post-tensioning, along with reinforcement and hangers, contribute to an efficient bridge design."

3

2 Intersection Bridge, Vaanplein
This project is part of the widening of the A15 motorway to accommodate the large increase in freight traffic expected from the new Maasvlakte 2, the second major port area currently under construction on land reclaimed from the sea in Rotterdam's massive Europoort complex. Our work involved the supply and installation of post-tensioned precast concrete beams for the bridge deck at the A15-A19 intersection at Vaanplein. We used BBR VT CONA CMI tendons of lengths between 11.3m and 16.8m. Additional work included filling the joints between the beams, supplying 300 bridge bearings and installing 15 expansion joints. Work here is expected to be completed in 2014.

3 Kruisdonk Viaduct, Meerssen
The Kruisdonk Viaduct, at the intersection of the A2 and A79 at Meerssen, is part of the project to reconfigure the A2 motorway near Maastricht to provide better access and traffic flows, while enhancing road safety and the local living conditions, as well as creating new opportunities through urban renewal and accessibility.
We supplied and installed 18 x 122m long BBR VT CONA CMI 2706 tendons for the bridge traffic deck and 15m long CONA CMI tendons for transverse post-tensioning. For the post-tensioned pillar beams, we used 24 CONA CMI tendons which were 11m long. Our contract here also included the supply of bridge bearings and expansion joints. ●

TEAM & TECHNOLOGY

1 **Owner** – Rijkswaterstaat / ProRail
Contractor – MNO Vervat – Concrete
Designer – Witteveen and Bos
Technology – BBR VT CONA CMI internal, Expansion joints, Bearings
BBR Network Member – Spanstaal B.V. (Netherlands)

2 **Owner** – A-Lanes A15
Contractor – A-Lanes A15, Civil VOF
Technology – BBR VT CONA CMI internal, Expansion joints, Bearings
BBR Network Member – Spanstaal B.V. (Netherlands)

3 **Client** – Projectbureau A2 Maastricht
Contractor – Avenue2 Infra v.o.f.
Technology – BBR VT CONA CMI internal, Expansion joints, Bearings
BBR Network Member – Spanstaal B.V. (Netherlands)

WS-02A VIADUCT, **MIEDZYRZEC, POLAND**

Design and launching solution for complex motorway viaduct

LAUNCHING ON INCREDIBLE LATERAL SLOPE

1

After positive experiences during the construction of a cantilevered bridge in Sandomierz, Pawel Surman, Site Manager for BBR Polska reports that Mota-Engil Central Europe chose them to realize post-tensioning and incremental launching on the Ws-02a Viaduct project at Miedzyrzecz South.

The Ws-02a Viaduct is on the Swinoujscie to Lubawka section of the S3 expressway currently under construction. The area is covered by the Natura2000 program and the choice of a viaduct here means that animals can roam freely beneath it and that interference with the natural environment is minimized.

It is worth noting that apart from the BBR Polska Site Manager and one post-tensioning supervisor, none of the construction workforce had ever worked on a launching project before. For us, it was a huge commitment in terms of preparation and technology and knowledge transfer to the general contractor before we could arrive at a weekly working cycle.

The viaduct consists of two independent, pre-stressed concrete single cell box girders. The western deck is 708m long (26.5m + 2 x 40m + 9 x 45m + 3 x 40m + 45m + 31.5m) and the eastern deck is 723m long (31.5m + 2 x 45m + 3 x 40m + 10 x 45m + 31.5m). Each deck is 3m deep and is designed to carry two 3.5m wide traffic lanes in each direction, plus a 2m wide hard shoulder.

Each deck is divided into 34 segments varying between six and 22.6m long. On plan, the longitudinal axis of the structure describes a curve with a 1,200m radius. The lateral slope is 4.5% and longitudinal is 0.65%.

The total weights which will be launched in the last phase are 14,500t (West) and 15,200t (East).

Each segment has continuous tendons, located in webs, and these must be placed individually on welded supports. The viaduct contains around 806t stressing steel with strands of 15.3mm nominal diameter, cross-section of 140mm^2 and a tensile strength of 1,860MPa.

Launching a deck on a 4.5% lateral gradient offers many challenges, as the structure wants to move across the site under its own gravity. For launching each section of deck, we use four 150t capacity jacks each with a 600mm stroke.

In the early stages of launching, we used only two cylinders – other cylinders were activated as work progresses.

We provided the comprehensive project launching technology – design casting yard, traction system, front and rear pulling beam, launching nose, temporary sliding bearings – as well as delivering temporary sliding and elastomeric bearings with grease pockets and launching bars.

Our scope of works apart from post-tensioning has included setting up the casting yard, launching and raising the launching nose before entering a pier – and advising the general contractor on the purchase of the comprehensive hydraulic equipment necessary for launching.

We first introduced cantilever construction to the Polish market in the 1990s, we are currently the market leader for launching steel structures and now we have proven that we can provide a comprehensive design and launching solution for even the most complicated concrete structures. ●

1 Launching of the 34 segments took place on a challenging lateral gradient of 4.5%.

2 On plan the longitudinal axis of the bridge structure describes a curve with a 1,200m radius, as shown here by the position of the bridge piers.

2

TEAM & TECHNOLOGY

Owner – General Directorate for National Roads and Motorways

Main contractor – Mota-Engil Central Europe

Designer – Transprojekt Krakow Sp. z o.o., CEPAS, Switzerland (casting yard, traction system), POMOST S.C. (launching nose), BBR Polska (temporary sliding bearings)

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

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

BRIDGE B526A, **DURBAN, SOUTH AFRICA**

Incremental launching downhill on vertical curve

LAUNCHING OVER RIVER

Preparation of the launching nose for Structural Systems Africa's project for two 285m incrementally launched bridges over the Umhloti River. The bridges are to be launched downhill on a vertical curve and then longitudinally stitched together to the existing two, two lane bridges. ●

TEAM & TECHNOLOGY

Owner – The South African National Roads Agency Limited (SANRAL)

Main contractor – Group Five / Fynn and James JV

Designer – Vela VKE Consulting Engineers (Bridge), Nyeleti Consulting (Pty) Ltd (Temporary Works)

Technology – BBR VT CONA CMI internal, Incremental launching

BBR Network Member – SSL Structural Systems (Africa) Pty Ltd

ORLY AIRPORT BRIDGE, **PARIS, FRANCE**

Slimmest launched bridge in France

BRIDGE SLIDE FOR RAIL LINK

Cast on one abutment, the new Orly Airport Bridge – to carry the new TRAM T7 Paris-Orly rail connection – was launched over the N7 road by ETIC. Weighing 2,400t and 94m long, with a 1.3m thick deck, this bridge is the slimmest launched bridge ever built in France. The concrete has a compressive strength greater than 90MPa and nearly 90kg/m^3 of prestressing steel was used – rather than the typical 40MPa and about 5kg/m^3 respectively. ●

TEAM & TECHNOLOGY

Owner – RATP

Main contractor – Demathieu et Bard

Main designer – SETEC- SYSTRA

Designer – Prodetis (for Demathieu et Bard)

Technology – BBR VT CONA CMI internal, Incremental launching

BBR Network Member – ETIC S.A. (France)

PROJECT HIGHLIGHTS

Brief overview of four BBR Network bridge projects

STRENGTH FOR STRUCTURES

As shown in these four project summaries, whether for railway bridges, road reconstruction or river bridges, BBR Network Members have the latest technology and know-how to deliver and install the most effective post-tensioning solution.

1 Railway bridges, Motala, Sweden

The Swedish Transport Administration is expanding a 26km railway line between Motala and Mjölby in southern Sweden from single track to double track. Spännteknik AB has provided post-tensioning for two new rail bridges – over the River Motala and Highway 50 – using the BBR VT CONA CMI system.

2 A10 motorway interchange, Austria

After more than 70 years of service, the Salzburg Süd interchange on the A10 motorway in Austria needed rebuilding to comply with modern road traffic standards and demands. KB Vorspann-Technik supplied and installed the post-tensioning for the project, using BBR VT CONA CMI 1206 tendons of up to 63m long.

3 Jeram River Bridge, Kuala Terengganu, Malaysia

Construction of this twin 200m long balanced cantilever box girder bridge required BBR Malaysia to provide post-tensioning for an altered design based on the pile bent system – saving program and budget. After detailed analysis, the team devised and installed a PT system using BBR CONA internal 1206 for the top tendons and the 1506 and 1906 systems for bottom tendons.

4 River Sora Bridge, Slovenia

The bridge spans the Sora River and is located on the R1-210/1110 Poljanska bypass. The bridge superstructure is a monolithic slab with two longitudinal prestressed beams and features crossing spans of 26m + 32m + 32m + 26m. BBR Adria prestressed each beam with five BBR VT CONA CMI 1706 tendons.

TEAM & TECHNOLOGY

1 **Owner** – Trafikverket (Swedish Transport Administration)
Main contractor – Peab Sverige AB
Designer – WSP Samhällsbyggnad AB
Technology – BBR VT CONA CMI internal
BBR Network Member – Spännteknik AB (Sweden)

2 **Owner** – ASFINAG (Austrian Motorway Authority)
Main contractor – TEERAG ASDAG AG
Designer – Wörle Sparowitz Ingenieure Ziviltechniker GmbH
Technology – BBR VT CONA CMI internal
BBR Network Member – KB Vorspann-Technik GmbH (Austria)

3 **Owner** – Public Works Department, Malaysia
Main contractor – MZ Hakujaya Sdn Bhd
Designer – Mecip (M) Sdn Bhd
Bridge contractor – BBR Construction Systems (M) Sdn Bhd
Technology – BBR CONA internal
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

4 **Owner** – Republic of Slovenia, Ministry of Transportation, Directorate for Roads
Main contractor – CM Celje d.d., Celje, Slovenia
Designer – SPIT d.o.o.
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR Adria d.o.o. (Croatia)

SHOPPING MALLS & CAR PARKS

BBR post-tensioning systems provide large open spaces, structural strength, flexibility of use, plus reduced maintenance costs and environmental impact

ACCESSING ADVANTAGES

In today's digitally driven world, access has become a priority – in every sense – for businesses competing to win our attention and custom. Shopping malls provide a solution to many access issues facing retailers – in turn, the BBR Network has both technology and experience to contribute to the long term success of these huge structures. ➤

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> "During the first three months on site alone, Structural Systems completed installation of 44,000m² of suspended slabs."

Shopping malls offer a personal interface with customers, while also presenting them with easy public transport links or car parking. At the same time, malls create an efficient hub for stock deliveries. As with many structures, BBR post-tensioning systems contribute to the success of the shopping mall and its facilities – both during and long after construction.

In retail or car park environments, visibility is a prime consideration – designing with BBR post-tensioning technology can produce large open spans, for both retail and parking spaces. Equally, where extra strength is needed – for ramps, loading bays or warehouse ground slabs – a post-tensioned approach to construction will deliver both strength and durability, as well as saving maintenance costs going forward. BBR post-tensioning systems are also sufficiently robust and flexible to allow structures to adapt and evolve alongside market demands over time. Some of the BBR Network's recent projects, described here, demonstrate the capability of our systems and people.

1 Stockland Shellharbour, New South Wales, Australia

One of the largest shopping centers in the south coast area, Stockland Shellharbour is approximately 20km south of Wollongong in New South Wales, Australia.

The post-tensioning works include retail spaces, two multi-level car parks, loading docks and associated back of house areas. A great deal of design co-ordination is taking place between all parties, to ensure that the shop drawings incorporate any last minute modifications before construction of that element.

During the first three months on site alone, Structural Systems completed installation of 44,000m² of suspended slabs. When complete, the new-look shopping centre will include a Myer department store, two discount department stores, two supermarkets and 220 speciality stores, with more than 3,000 car parking spaces. The A$330 million project is scheduled for completion by Christmas 2013.

2 Mepas Mall, Mostar, Bosnia & Herzegovina

Mostar's Mepas Mall – the largest of its type in Bosnia and Herzegovina – together with the penthouse hotel, covers an impressive gross floor area of 99,408m² and offers a quality shopping, entertainment, catering and business experience.

The development features three levels of underground parking, a five level shopping center, office spaces, five theatres, a bowling alley and luxury five-star hotel on two levels.

BBR Adria used the BBR VT CONA CMM system to post-tension more than 70,000m² of floor slabs. At the peak of operations and over a five month period, the team installed more than 40t of strand per month, with slabs being cast every five days.

1 Stockland Shellharbour, New South Wales (page 41).
2 Mepas Mall, Mostar, Bosnia & Herzegovina.
3 ZTC Rijeka, Rijeka, Croatia.
4 Car Park, Yas Mall, Yas Island, Abu Dhabi.


3

“Time, costs and environmental impact were reduced by adopting an alternative design with a system of PT slabs with shallow beams...”

3 ZTC Rijeka, Rijeka, Croatia

ZTC Rijeka shopping mall is a six storey building, with a total gross surface area of about 57,000m^2. It offers three commercial floors for 60 stores, two parking levels for 950 vehicles – and has created 800 new jobs.

The original concept was for monolithic reinforced 400mm thick concrete floor slabs in the garage levels and 600mm thick slabs using void formers for the shopping levels.

Time, costs and environmental impact were reduced by adopting an alternative design with a system of PT slabs with shallow beams, installed by BBR Adria. This alternative concept enabled significant weight reduction and enlargement of useful shopping space – while maintaining the same overall building height as in the original solution.

Basement excavations were protected by a piled wall anchored with 5,400 linear meters of permanent geotechnical anchors.

4 Car Park, Yas Mall, Yas Island

Yas Island, close to Abu Dhabi city, is being developed as a holiday and entertainment destination in the emirate of Abu Dhabi. Yas Mall features 235,000m^2 of retail space and a variety of entertainment and restaurant venues.

With 10,000 covered car parking spaces, the mall will be the second biggest shopping destination in the UAE after Dubai Mall.

Structural Systems Middle East LLC have helped to construct the mall’s car park by executing the post-tensioned slabs.

The PT configuration comprised BBR CONA flat 0405 and 0505, with typical slab thicknesses of 200mm between band beams, and BBR CONA flat 0506 with a band beam depth of 600mm for all levels – excluding Level 1 of the North West car parking area. For the latter, BBR VT CONA CMI 1206 anchorages were used to construct a 1200mm deep beam. ●


4

TEAM & TECHNOLOGY

1 **Owner** – Stockland Corporation Limited
Main contractor – Brookfield Multiplex
Designer – Structural Systems Limited
Technology – BBR CONA flat
BBR Network Member – Structural Systems Limited (Australia)

2 **Owner** – Brodomerkur d.o.o.
Main contractor – A3 d.o.o.
Designer – Gradal Inženjering d.o.o.
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o. (Croatia)

3 **Owner** – Universale International GMBH
Main contractor – ALPINE Bau Zagreb d.o.o.
Designer – ATP projektiranje d.o.o.
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o. (Croatia)

4 **Owner** – Aldar Properties, Abu Dhabi, UAE
Main contractor – Six Construct Co. Ltd
Consultant – AECOM Middle East
Technology – BBR CONA flat, BBR VT CONA CMI internal
BBR Network Member – Structural Systems Middle East LLC (United Arab Emirates)

WOOLWICH CENTRAL, **SOUTH LONDON, UK**

PT beams and slabs for fast-track mixed-use development

RETAIL INNOVATION CREATES COMMUNITY

In an innovative move, the UK's market leading supermarket chain, Tesco, is planning to build a series of schemes – dubbed 'Tesco Towns' – which will provide not only supermarket space, but also further retail units, housing and other community facilities. Richard Gaskill of UK-based BBR Network Member, Structural Systems (UK) Ltd, outlines the first of these developments.

> "In addition to the slabs, there were over three miles of post-tensioned beams, at various points throughout the structure..."

1 The team also grouted up the precast columns for the residential blocks which were dowelled to the columns below for continuity.
2 Post-tensioning was installed for over 54,000m² of floor slabs.

Construction of the £86m Woolwich Central development in South London is now well-advanced, with overall completion and handover scheduled for July 2013. Developer, Spenhill – a wholly-owned subsidiary of Tesco stores – set about creating a large mixed-use development to accommodate an 8,000m² Tesco superstore, seven further retail units, car park, police station and 259 apartments. Such is the scale of the development that main contractor Willmott Dixon combined all three parts of its Capital Works division – major contracting, house building and interior design and fit-out – to help complete the scheme.

1

Largest current PT scheme

The scheme is widely regarded as the largest post-tensioned project currently underway in the UK. Its construction has consumed 100,000t of concrete and, to complete the frame, some 5,000t of reinforcing steel. Around 85,000m³ of excavated material was taken away, however, environmental initiatives have seen 50,000t of demolition material re-used. Other initiatives were employed – including slipforming the cores to take them off the critical path and to improve craneage 'hook time' for follow-on trades. There were huge concrete pours to Level 1 and the use of precast columns for the residential blocks. We were involved in grouting up the precast columns which were dowelled to the columns below to provide continuity. In addition to the superstore, the 17-storey project will house basement car parking for both Tesco customers and residential owners.

New homes

Residential accommodation is split between private sale and affordable rent markets. Out of the 259 new homes – which consist of a mixture of one, two and three bedroom apartments – 189 units will be available for private sale, with a further 70 for affordable rent. The apartments are arranged in eight separate blocks running from Level 8 upwards. The tallest of these blocks will be eight storeys high – giving Woolwich Central a maximum above ground height of 16 floors.

"The scheme is widely regarded as the largest post-tensioned project currently underway in the UK."

PT installation

We have installed BBR VT CONA CMF tendons of varying sizes into the concrete frame, including tendons with 12.9mm and 15.7mm diameter strand which were installed in both slabs and beams. Tendons with 12.9mm diameter strand were mainly used on Level 1, the slabs on Level 2 and for all the residential blocks. In all other areas, we used tendons made of 15.7mm diameter strand. In total, post-tensioning was installed for over 54,000m^2 of floor slabs, with a variety of slab depths ranging from 180mm to 350mm deep. In addition to the slabs, there were over three miles of post-tensioned beams, at various points throughout the structure, and these varied in size from 500mm to 1500mm deep and up to 2000mm wide.

The largest pour was on the podium slab at Level 8. This was scheduled to be carried out in five pours – totaling a staggering 3,267m^3, which included eighteen beams with multistrand BBR VT CONA CMI anchors with between 10 and 12 strands per anchor. The PT slab running over the top of the beams covered an area of just under 8,500m^2. The largest pour was approximately 1,400m^3 and was completed in a single day. Within the beams, we also used BBR VT CONA CMF anchors with three and four strands per anchor and up to nine tendons per beam.

2

Fast program

So driven was the program that the concrete frame was completed within just a 10 month period from October to July 2012. The new superstore is already open, along with the first wave of the residential units – the remainder of the development and associated apartments are being completed in several stages.

The scheme brings huge inward investment to Woolwich, which it is hoped will create new jobs and further growth with the arrival of new skilled people who will be attracted by the modern apartments in a great location. ●

TEAM & TECHNOLOGY

Owner – Spenhill
Main contractor – Willmott Dixon
Architect – Sheppard Robson Architects
Structural engineers – Walsh Associates
Technology – BBR VT CONA CMI internal, BBR VT CONA CMF flat
BBR Network Member – Structural Systems (UK) Limited

LOCAL INSIGHT

WOOLWICH

The breathtaking Thames Flood Barrier sits astride the River Thames just a mile from Woolwich. Opened in 1984, it is the world's second largest movable flood barrier and is raised when high water levels in the river threaten London. The original design concept, based on rotating cylinders, was conceived in the 1950s. The gates are hollow and made of 40mm thick steel. The four large central gates are 20.1m high and weigh 3,700t.

Believed to have derived its name from early wool trading activities, over several centuries Woolwich grew into a hub for naval and military operations. By the early 20th century, the town and surrounding industries were thriving – but, in more recent decades, changed economic conditions led to a decline. Woolwich has always been a place ready to pioneer new concepts, such as currently with Woolwich Central – and was even home to the UK's first McDonald's franchisee. ●

PROJECT HIGHLIGHTS

Brief overview of five BBR Network building projects

BUILDING BENEFITS

The expert application of BBR technology has delivered a range of benefits to these five projects – two hospitals, a residential development, school and a car park – in Austria, Singapore, Spain and the UK.

TEAM & TECHNOLOGY

1 **Owner** – Gobierno de Cantabria
Main contractor – FCC Construcción+Isolux, Corsán+Ascan JV
PT Designer – Pondio Ingenieros, S.L.
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR PTE, S.L. (Spain)

2 **Owner** – Circle Housing Group
Main contractor – Willmott Dixon
Architect – bptw partnership
Technology – BBR VT CONA CMF flat
BBR Network Member – Structural Systems (UK) Limited (UK)

3 **Owner** – Stadt Villach
Main contractor – STRABAG AG & Alpine Bau GmbH
Designer – Lackner & Raml Ziviltechniker GmbH
Technology – BBR CONA VT CMM monostrand
BBR Network Member – KB Vorspann-Technik GmbH (Austria)

4 **Owner** – Ministry of Education of Singapore
Technology – BBR CONA flat
BBR Network Member – BBR Construction Systems Pte. Ltd (Singapore)

5 **Owner** – Sisters of Charity, Schwarzach
Main contractor – Spiluttini Bau GmbH
PT Designer – Herbrich Consult ZT GmbH
Technology – BBR VT CONA CMM monostrand
BBR Network Member – KB Vorspann-Technik GmbH (Austria)

1 Marques de Valdecilla Hospital extension, Santander, Spain
The low strength stressing ability of the BBR VT CONA CMM system allowed earlier removal of formwork and ultimately resulted in a shorter floor-to-floor cycle time for this 110,000m^2 extension project. Ground level slabs were executed using BBR VT CONA CMM 0106 bonded PT tendons – average tendon length was 35m and BBR PTE used over 128t of PT steel.

2 Bell Green residential development, Sydenham, UK
With BBR VT CONA CMF tendons inside a 70mm flat duct, curving the tendons to suit the circular building shape meant ducts had to be faceted to the required profile – and tendons stressed in the correct sequence – to prevent trapping an unstressed tendon. Structural Systems (UK) Limited have proved that a bonded system can still perform and function perfectly well in such situations.

3 Car park, Warmbad Villach, Austria
Speed, lightweight and adjustability were all crucial considerations for this project – and with BBR CONA VT CMM tendons, KB Vorspann-Technik contributed to the perfect prefabricated solution. Fixed anchors were grouted and stressing anchors were also pre-installed in the factory, but remained movable so that they could be adjusted into the right position after the slab elements were laid on site.

4 School sports hall, Singapore
PT beams and slabs were ideal for achieving the large clear span required for the multi-purpose hall. Beam span varies from 20m to 34m and supports various types of loading. To maximize the capacity / self-weight ratio, BBR Construction Systems designed all beams individually, based on their length, applied load and sizes of BBR anchorages to be used.

5 Schwarzach Hospital, Salzburg, Austria
Within the steadily growing complex of the Kardinal Schwarzenberg'sches Krankenhaus, owned by the Sisters of Charity in Schwarzach, the new children's department should be finished in 2013. KB Vorspann-Technik has installed the BBR VT CONA CMM system for the flat slabs on five floors.

PT FOR COMMERCIAL DEVELOPMENTS

BBR post-tensioning technology and expertise supports wide range of commercial needs and encourages ambitious architectural design

COMMERCIAL COMBINATIONS

Sustainability, aesthetically pleasing, ergonomically designed, fast program and budget-friendly – once-upon-a-time, these might have just been 'nice to have' features of commercial developments, now in our increasingly environmentally aware, socially conscious and competitive world, they have become everyday requirements. The good news is that BBR technology and expertise delivers results on all criteria. ➤

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> "To meet the client's desire for something distinctive and which reflected Malaysia, BBR Construction Systems incorporated star-shaped drop panels – representing the Malaysian Islamic star – in the design for their flat slab system."

Recent projects in Australia, Malaysia, Singapore and the UK illustrate not only the BBR Network's ability to meet the most demanding client requirements and local conditions, but also the wide range of BBR technology available to deliver successfully even the most challenging commercial sector schemes.

We present a brief overview of the projects which now enhance a variety of townscapes and are providing practical backdrops to thriving customer businesses.

1 WorkZone, Perth, Western Australia

Located on the Perth CBD fringe, WorkZone is a sustainable office campus development comprising of two seven level buildings, ground floor over site and a basement raft slab. The development will contain over 520t of post-tensioning.

Structural Systems were employed to provide the full slab design and installation of post-tensioning. Design responsibilities were undertaken at the Sydney Office whilst project management and labor were resourced locally at the Perth Office.

A combination of 12.7 and 15.2mm diameter multistrand tendons were used to create an economical and efficient alternative to conventional reinforced concrete.

A BBR VT CONA CMI 1906 multistrand system was utilized to support the six level stair core from the first floor level, in addition to a typical flat slab post-tensioning system.

2 Ealing Premier Inn & Data Centre, West London, UK

A regeneration project in Ealing, West London, has led to the development of a leading co-located five storey data centre storage facility and a nine storey 165-bed Premier Inn hotel totaling 4,636m^2.

Structural Systems (UK) Limited have used BBR VT CONA CMF 0406 bonded post-tensioning for slabs and beams throughout the scheme.

The ground floor slab for the hotel and the data centre was a combination of one way spanning post-tensioned slabs and PT beams.

The hotel's mezzanine level has a 300mm to 350mm thick PT flat slab to cater for the hefty imposed live loads. The first floor of the data center required a 300mm thick PT slab with a 2,250mm wide x 750mm deep PT transfer beam to carry the transfer loads from above.

1 WorkZone, Perth, Australia (page 47).
2 Ealing Premier Inn & Data Centre, UK.
3 Eclipse Tower, Parramatta, Australia.
4 New facility for JST Connectors, Tanjung Pelepas, Malaysia.
5 Metropolis office buildings, Singapore.


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3 Eclipse Tower, Paramatta, Australia

Standing approximately 100m tall, the Eclipse Tower is an iconic landmark developed by Leighton Properties and Grosvenor Australia.

It is the tallest building in Parramatta's Central Business District (CBD), which is located 23km west of the Sydney CBD in New South Wales. The striking commercial office tower has a five star Green Star and a five star energy rating.

Eclipse consists of two basement levels and 21 storeys above ground level with a total area of 32,000m² of post-tensioned slabs. The one-way banded structures were successfully completed in only 10 months, a great and timely effort from both Structural Systems and the builder John Holland.

4 New facility for JST Connectors, Tanjung Pelepas, Malaysia

At their facility at the Port of Tanjung Pelepas, JST Connectors needed an extension consisting of four post-tensioned floors designed for office use, M&E area, canteen, brazing shop and green roof.

To meet the client's desire for something distinctive and which reflected Malaysia, BBR Construction Systems incorporated star-shaped drop panels – representing the Malaysian Islamic star – in the design for their flat slab system.

The drop panels were created by attaching six cantilever beams to the hexagonal columns and were not only designed to resist punching shear, but also as a platform to support construction load and concrete weight during the construction stage. BBR CONA flat tendons were placed in both directions and profiled to balance the loadings.

5 Metropolis office towers, Singapore

The Metropolis comprises two soaring office towers that are earmarked to serve as headquarters for leading multinational corporations and will set new standards for prestige, comfort and convenience.

A range of innovative solutions for water and energy conservation, carbon dioxide emission reduction and responsible construction – with the help of cast in-situ post-tensioning systems – has been employed to help minimize the impact on the environment and has earned The Metropolis the coveted Green Mark Platinum certification by the Building & Construction Authority of Singapore.

Singapore-based BBR Construction Systems constructed beams and floor slabs using BBR CONA internal and BBR CONA flat 0405 post-tensioning systems respectively. The post-tensioning system was selected for its ability to provide large floor plates of uninterrupted, regular-shaped column-free space and to offer optimal space efficiency and flexibility, while the shallower beam depth helps to provide higher clear floor height and large windows for ample natural light for a bright working environment – not to mention the great views! ●

TEAM & TECHNOLOGY

1 **Owner** – Charter Hall Group
Main contractor – Broad Construction Services (WA) Pty Ltd
Designer – Structural Systems Pty Ltd
Technology – BBR VT CONA CMI internal, BBR CONA flat
BBR Network Member – Structural Systems Limited (Australia)

2 **Owner** – Whitbread plc & Redwire DC Ltd
Main contractor – MACE
Technology – BBR VT CONA CMF flat
BBR Network Member – Structural Systems (UK) Limited

3 **Owner** – Leighton Properties & Grosvenor Australia
Main contractor – John Holland
Technology – BBR VT CONA CMI internal, BBR CONA flat
BBR Network Member – Structural Systems Limited (Australia)

4 **Owner** – JST Connectors Malaysia Sdn. Bhd.
Main contractor – Nakano Construction Sdn. Bhd.
Technology – BBR CONA flat
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

5 **Owner** – Ho Bee Group
Main contractor – Lum Chang Building Contractor Pte. Ltd.
C&S consultant – KTP Consultants Pte. Ltd.
Technology – BBR CONA internal, BBR CONA flat
BBR Network Member – BBR Construction Systems Pte Ltd (Singapore)

PT BEAMS IN **POLAND**

Maximizing architectural design while optimizing budgets using post-tensioned construction

BEAMING WITH SUCCESS

Post-tensioning is still generally viewed by the Polish market as a technological innovation in structural engineering – and to be avoided – despite the fact it brings notable economic benefits. Nowadays, in an era where investment costs must be optimized, a great opportunity appears to challenge the traditional practice of using heavy reinforced concrete beams – replacing these with slender post-tensioned elements which offer much greater architectural design potential. Bartosz Lukijaniuk and Bartosz Chmielewski of BBR Polska take up the story.

1 Silesian Museum

The freedom of expression and opportunity to create large column free spaces offered by post-tensioning was embraced for the new Silesian Museum building in the south of Poland. The structure is located in a mining region and the museum itself is below ground, on the site of a former coal mine. We were contracted to design and construct post-tensioned beams over the two storey main exhibition halls and three storey underground parking lot.

For the exhibition halls, we used BBR VT CONA CMI multistrand tendons ranging from 07 to 22 strands – in total, 90t of stressing steel was needed. In the parking lot, we used BBR VT CONA CMM 0106 and 0406 tendons and a total of 21t of stressing steel.

Over the exhibition halls, the beams are of two types – two span (22 + 12m) and single span with a cantilever (22 + 3m), while beams for the parking slabs are 32m long and stretch over two spans.

1 Silesian Museum – PT beams were constructed over exhibition halls and the underground parking lot.
2 Alchemia office building, Gdansk – PT beams transfer loads to the walls of the 19m span structure.
3 East European Congress and Sports Centre expansion, Arlamow – PT beams will increase structural stiffness together with optimization of the structural element size respective to the span.
4 Music Academy, Wroclaw – a combination of PT systems permitted a thinner slab and increased construction efficiency.

1

2 Alchemia office building, Gdansk

During construction of the Alchemia office building in Gdansk, PT beams were designed to transfer massive dead loads from the concrete flat slab and ground layers to the walls of the 19m span structure. These spans are not achievable for typical reinforced concrete beams – irrespective of their dimensions.

A slab was constructed to cover the swimming pool area and for use as a green roof. Post-tensioning technology offers increased water tightness and a significant reduction in dead load deflection. We used BBR VT CONA CMI 1906 bonded tendons of 15.7mm nominal strand diameter, characteristic tensile strength of 1,860MPa and load capacity of 4,000kN.

Works were completed by injecting grout into the tendon ducts to protect against corrosion and to ensure the adhesion of the tensile elements to the structure.

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3 East European Congress & Sports Centre, Arlamow

Post-tensioned beams used on the East European Congress and Sports Center expansion project, in Arlamow, were designed to increase the stiffness of the structure together with optimization of the structural element size respective to the span. Our scope of works involved stressing 92 beams using the BBR VT CONA CMI bonded post-tensioning system in seven interconnected segments.

4 Music Academy, Wroclaw

The advantages of post-tensioning a structure such as the Music Academy in Wroclaw can be found in a combination of factors – optimization of the structure's weight and reduction in dead load deflection while maintaining the required sound insulation performance.

To meet the above client requirements, we used two post-tensioning systems in a two-way beam supported slab. The beams and slabs were post-tensioned using BBR VT CONA CMI bonded and CONA CMM unbonded systems respectively. This arrangement permits a thinner slab and the use of a combination of PT systems increases the construction efficiency. ●

TEAM & TECHNOLOGY

1 **Owner** – Silesian Museum
Main contractor – Budimex S.A.
PT Designer – SDS + BBR Polska
Technology – BBR VT CONA CMI internal, BBR VT CONA CMM monostrand
BBR Network Member – BBR Polska Sp. Z o.o.

2 **Owner** – Torus Sp. z o.o. Sp. k.
Main contractor – Torus Sp. z o.o. Sp. k.
PT Designer – SDS
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR Polska Sp. Z o.o.

3 **Owner** – Hotel Arlamow
Main contractor – Resbex Sp. z o.o.
PT Designer – SDS + BBR Polska
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR Polska Sp. Z o.o.

4 **Owner** – Music Academy
Main contractor – Budimex S.A.
PT Designer – SDS + BBR Polska
Technology – BBR VT CONA CMI internal, BBR VT CONA CMM monostrand
BBR Network Member – BBR Polska Sp. Z o.o.

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GROUND SLAB CONSTRUCTION

Benefits of post-tensioned technology for slab-on-ground projects are being appreciated by businesses worldwide

HIGH PERFORMANCE SLABS

'Performance' is a word that most people today are likely to associate with high specification cars, rather than concrete ground slabs. However, the reliable performance of a ground slab – for warehouses or loading bays – is a critical factor in day-to-day operations for many businesses because it literally forms the base from which they work. Increasingly, customers are choosing a post-tensioned approach to slab construction and benefitting from the many advantages it offers.

When undertaking new developments, factors such as speed of construction and reduced lifecycle costs or maintenance can make a real difference to a company's competitive position within the market place. The use of post-tensioning technology means that a new facility can be up-and-running quickly and maintenance downtime is minimized by the excellent performance qualities of the PT slab. The particular aspects of post-tensioned slab construction which help customers to meet their objectives include:

- Strength & efficiency – extra strength and stiffness offered by a PT solution means that the slab resists bending caused by soil movement, thus is less prone to cracking.
- Speed of installation – fewer materials are required for a PT slab, therefore less time is needed for construction than a traditional reinforced solution.
- Enhanced reliability – highly crack-resistant, with any cracks that do form being kept tight by the post-tensioning, thereby reducing water ingress and other problems which might cause down-time.
- Low maintenance – the ability to create large areas of joint-free slabs means that less time is spent on maintaining the surface.
- Cost savings – fewer materials, less labor, faster program and reduced long-term maintenance.

Recognition for these benefits is growing and BBR Network members are finding that slab on ground projects feature more often on their order books.

1 Work in progress for Liebherr-Australia's office, storage and crane maintenance facility in western Sydney.
2 PT tendon installation for BMW South Africa's new engine assembly plant and storage facility.
3 Slabs-on-ground were installed for Linfox's new office and distribution depot in Western Australia.
4 Construction of PT slabs for Fonterra's new milk processing plant near Christchurch, New Zealand (page 54).

1 Offices & crane maintenance warehousing, Sydney, Australia

Liebherr-Australia has commissioned the construction of a crane manufacturing and maintenance facility in western Sydney.
The building consists of a four-storey office complex, three storey parts storage area and a high-bay crane maintenance warehouse.
"Performance quality for the ground slab was a major issue here," explains Shaun Sullivan of Structural Systems, "Liebherr needed a strong, low maintenance surface to ensure that they can serve their customers' needs efficiently and effectively. We designed and fully documented all the post-tensioned elements in-house to meet their specific requirements."
Once completed, the building will form Liebherr-Australia's new regional headquarters in Sydney Australia for mobile crane and earthmoving equipment. The site is ideally located within easy reach of Sydney's M2, M4, M5 and M7 motorways.

KEY FEATURES

- BBR CONA flat 0405 and 0505 anchors
- 16,000m^2 external post-tensioned hardstand area, including a post-tensioned test slab designed for a 408t outrigger crane
- 3,000m^2 suspended post-tensioned office
- 1,800m^2 suspended post-tensioned parts store warehouse
- 3,000m^2 joint-free warehouse slab on ground

2 BMW engine assembly plant & storage facility, South Africa

Structural Systems Africa's first bonded post-tensioned slab on grade project has been carried out for BMW South Africa.
The slab was designed and installed over an existing conventionally reinforced concrete slab to provide large joint free areas for the high volume of forklift traffic in the engine assembly plant and storage areas.
"We designed the slab in three phases to allow the movement of racking and stock within the plant, which meant the downtime for the owner was kept to an absolute minimum," explained Operations Manager Sean Kelly.
Concreting operations were split across four pours. Couplers were used across construction joints and the armored movement joint was introduced in the transverse direction to reduce PT tonnage per square meter.

KEY FEATURES

- BBR CONA flat 0405
- 12.7mm strand
- 30t post-tensioning steel
- 7,000m^2 post-tensioned assembly plant
- 150mm thick slab
- 10m interior column grids

"The use of post-tensioning technology means that a new facility can be up-and-running quickly and maintenance downtime is minimized by the excellent performance qualities of the PT slab."

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"This is our tenth project for Fonterra in the past six years and brings the total floor area we've constructed for them to over 150,000m²."

TEAM & TECHNOLOGY

1 **Owner** – Liebherr-Australia
Main contractor – Thiess Pty Ltd
Designer – Structural Systems (PT)
Bridge contractor – BBR Construction Systems (M) Sdn Bhd
Technology – BBR CONA flat
BBR Network Member – Structural Systems Limited (Australia)

2 **Owner** – BMW South Africa
Main contractor – Concrete Laser Flooring Pty Ltd
Designer – Structural Systems (PT)
Technology – BBR CONA flat
BBR Network Member – SSL Structural Systems (Africa) Pty Limited

3 **Owner** – Goodman's Stockyards for Linfox Logistics
Main contractor – Vaughan's Constructions
Designer – Structural Systems (PT)
Technology – BBR CONA flat
BBR Network Member – Structural Systems Limited (Australia)

4 **Owner** – Fonterra
Main contractor – Calder Stewart Industries – Drystore warehouses, load out aprons and heavy duty external pavements, Ebert Construction – Packing house
Designer – Babbage Consultants and Connor Consulting (Drystores), Opus International Consultants (Pavements), BBR Contech (PT)
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

3 Offices & distribution facility, Hazelmere, Australia

The Linfox development in Hazelmere is a new office and distribution facility designed to meet the booming demands of resources projects in Western Australia. Chosen by Linfox for its efficient links to major highways, the eight hectare Hazelmere facility became operational in June 2012.

Richard Blair of Structural Systems highlights their scope and capability: "We were awarded the contract to provide structural design and documentation, as well as supply and installation of post-tensioning works. Design was undertaken at our Sydney office whilst project management and labor were resourced locally at the Perth office."

Slabs on ground are typically 220mm with 15.2mm post-tensioning strand and 170mm with 12.7mm strand for external and internal areas respectively. All slabs were designed with conventionally reinforced perimeter thickenings and were checked for design compliance prior to pouring.

KEY FEATURES

- 56,000m² post-tensioned slabs
- 250t post-tensioning steel
- 100t reinforcement bar and mesh

4 Milk-processing Plant, Darfield, New Zealand

BBR Contech is working on a massive post-tensioning project for Fonterra – alongside main contractors Calder Stewart Industries and Ebert Construction – installing a number of post-tensioned slabs for a new milk-processing plant at Darfield, on the outskirts of Christchurch, New Zealand. Once complete, it will process about 6.6 million liters of milk a day, producing high-quality whole-milk powder for markets such as the Middle East, South East Asia and China.

Peter Higgins, BBR Contech's Southern Regional Manager explains: "This is our tenth project for Fonterra in the past six years and brings the total floor area we've constructed for them to over 150,000m². As the world's largest exporter of dairy products, it's vital that the company can use their new plant as soon as possible, so the project has been staged to allow this to happen progressively."

KEY FEATURES

- 50,000m² post-tensioned slabs for drystore warehousing and load out areas
- 4,000m² post-tensioned slabs for two packing stores
- 23,000m² external heavy duty pavement area
- 650t post-tensioning steel


Photograph: Bruce Clarke – Incredible Images © Hawkins Group Ltd

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VIADUCT EVENTS CENTRE, **AUCKLAND, NEW ZEALAND**

Joint-free post-tensioned floor reduces weight on wharf and provides flexible space

VERSATILE FLOOR FOR PREMIER VENUE

Built on an operational marine and fishing wharf, the billowing roofline of Auckland's new Viaduct Events Centre in Wynyard Quarter reflects its maritime environment. At its heart is the 'Waiheke Room' – the largest banquet space available in the central city, with floor design and post-tensioning installation by BBR Contech.

The 2,245m^2 Waiheke Room can be used for cocktail parties, exhibitions, lectures and sit-down banquets – and has already hosted both national and international events. Its vast, joint-free, post-tensioned concrete floor was specifically chosen to reflect the architects' rigorous design, construction and fit-out standards – delivering an aesthetically pleasing, highly polished finish and a tough, durable surface.

Variations in the wharf deck elevation were largely corrected by installation of polystyrene packing as a leveller before the 150mm post-tensioned floor was installed. As well as meeting the requirements for a joint-free appearance, the floor's thinner structural depth helped to reduce the total weight on the wharf structure.

The Viaduct Events Centre is one of a trio of BBR Contech projects associated with Auckland's Wynyard Quarter – New Zealand's largest urban revitalization project covering 37 hectares of land and almost three kilometers of coastal frontage.

1 Auckland's new Viaduct Event Centre has already been used for events, such as the Auckland International Boat Show, New Zealand Fashion Week and the Auckland Seafood Festival.
2 BBR Contech's other work in Wynyard Quarter has included gunite repairs to the underside of the North Wharf and supplying stay cables for the new Wynyard Crossing pedestrian bridge.
3 The post-tensioned, joint-free polished concrete floor is aesthetically pleasing and able to withstand loading generated by delivery trucks, fork hoists and exhibition displays.

TEAM & TECHNOLOGY

Owner – Auckland Council Regional Facilities
Main contractor – Hawkins Construction
Architect – Moller Architects®
Principal designer – Holmes Consulting
Flooring contractor – Conslab Ltd
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)


Photograph: Bruce Clarke – Incredible Images © Hawkins Group Ltd

3

DANUBE BRIDGE 2, **VIDIN-CALAFAT, BULGARIA & ROMANIA**

Major post-tensioning and stay cable bridge construction featuring first use of BBR HiEx CONA Saddles

WALTZING OVER THE DANUBE

1

The BBR Network construction team working on the new Vidin-Calafat Bridge has performed a finely-tuned sequence of maneuvers, worthy of any grand ball, to deliver an innovative – and massive – project. Also known as Danube Bridge 2, the new structure is a road and railway bridge connecting the cities of Calafat and Vidin – in Romania and Bulgaria respectively and is the second bridge spanning the River Danube between these two countries. It forms part of the IV Pan-European Corridor that will allow direct motorway access between Dresden in Germany and Turkey's largest city, Istanbul. Diana Cobos, Project Manager on site from BBR PTE – the Spanish-based BBR Network Member – describes this marathon of a project.

The Vidin-Calafat Bridge has three distinct components – a low level rail Approach Viaduct with 40m long spans on the Bulgarian river bank, a single-cell box girder bridge over the Main Navigation Channel and a viaduct over the Non-Navigable Channel. The latter is 612m long and has eight spans, of which all but the first are 80m long. The Main Navigation Channel bridge has five spans – three spans of 180m, one of 124m and one of 115m – all of which are sustained by stay cables.
Each of these distinct components involved specific construction methods and their own special technical challenges. For an overall impression of the scale of project, it might help to know that we have installed 2,100t of BBR VT CONA CMI tendons – most of them 31 strands – plus 65,000km of plastic duct and 208 stay cables. ➤

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"For an overall impression of the scale of project, it might help to know that we have installed 2,100t of BBR VT CONA CMI tendons – most of them 31 strands – plus 65,000km of plastic duct and 208 stay cables."

Project overview

The Approach Viaduct has a total length of 720m, divided into 18 spans each 40m long, eight of these rest on the Non-Navigable Channel viaduct. These spans are concreted in-situ using a girder.

The 80m Non-Navigable Channel viaduct was built using the balanced cantilever method. Each span has 37 precast concrete segments, each 2.15m long and weighing up to 105t. The segments were brought to the abutment by truck, then loaded onto a movable gantry crane – nicknamed the 'elephant' – and guided to the girder over the previously built part of the deck.

The 180m Main Navigation Channel bridge was also built using the balanced cantilever method. Each span has 42 precast concrete segments, each of these was 4.30m long and weighed up to 230t. Although the construction method looked similar, it involved different equipment and devices. The segments were loaded in pairs onto a barge and brought to the piers, three kilometers away, then a mobile crane lifted them from the barge and finally the tendons and stay cables were stressed.

Post-tensioning challenges

The first challenge we faced when we arrived on site was getting the grouting technique approved. The lack of space in the precast segments led us to adopt the option of vacuum grouting without intermediate vents and regrouting using thixotropic grout. Complete suitability testing and full-scale – 80m long – tests were performed successfully.

Our second challenge was adapting the plastic duct system for in-situ works. Ensuring that duct coupler joints are leak-proof is always important, but becomes absolutely essential when working with a vacuum grouting system. We grouted 205m long tendons with 40 couplers each using this method – and there were no voids in the anchorage vents after 24 hours.

The third challenge we faced was in the organization of the site itself. Post-tensioning work was not distributed throughout the program in a regular way – as a result of the balanced cantilever operation, it tended to come in waves. At the height of operations, we were stressing tendons in the four piers of the Main Navigation Channel bridge, the Approach Viaduct and the Non-Navigable Channel viaduct second stage at the same time – we threaded, stressed and grouted more than 250t of tendons in just one month. Meanwhile on site, we had 15 multistrand jacks to cover the different sizes required and six threading machines.

> "This is the first site where BBR HiEx CONA Bundle Saddles have been installed."

Stay cable installation
Each of the four main piers of the Main Navigation Channel bridge has an H-shaped pylon and a total of 52 stay cables, divided into 13 levels. This is the first site where BBR HiEx CONA Bundle Saddles have been installed. A few months later, an unbonded HiEx system was also installed by BBR PTE for the River Corgo Viaduct in Portugal (see page 63 for full story).

During the saddle operations, we overcame the following challenges:

- first ever installation of the new bundle saddle system
- installation of 4m long tendons with 55 strands, stressed at 80% of breaking load
- restressing from both ends to install shims to compensate for load loss due to wedge penetration
- vacuum grouting from the top of the pylon

All these factors made saddle installation a really challenging post-tensioning operation. It took about three weeks to complete each pylon. The big advantage was that all the saddles on one pylon were installed before starting stay cable installation.
The 208 stay cables range from 22 to 55 strands and are 30 to 90m long. Even though they are not very long or very big, the fact was that four per level had to be installed at the same time and on the same day.

The typical construction sequence was:

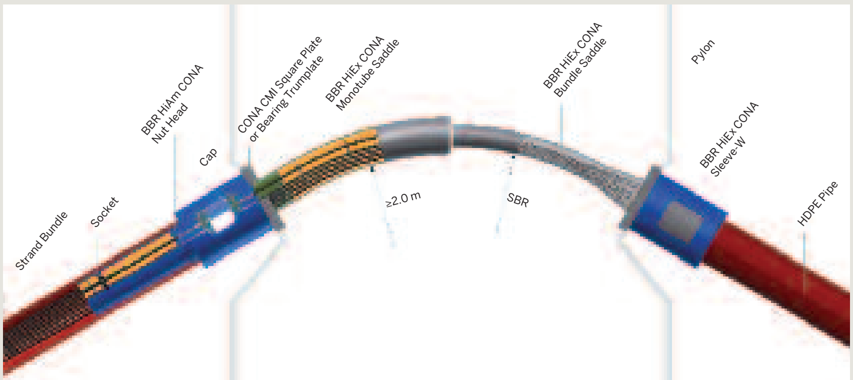
- lifting of a pair of segments
- post-tensioning operations
- concreting the second and third deck wing stages (if they had been precast in the segment plant, they would have been too heavy to be lifted)
- lifting and stressing the four stay cables per level

As surveyors' control always had to be done at first light in the morning to avoid thermal strain effects, not finishing during the day would have meant delaying all the following operations for a complete day – not just a few hours.
With all these works in progress on the deck at the same time, space was at a real premium and there were very tight timescales for advance preparation of the ducts and strands for each level.
With our construction sequence, we managed to place two pairs of segments per pier in one week. Then, if you add to that the fact that two pylons were being worked on simultaneously, at the peak of works, we were installing 16 stay cables in one week. ➤

TECHNICAL INSIGHT

BBR HiEx CONA CONFIGURATIONS

The standard BBR HiEx CONA Saddle configuration consists of a parallel arrangement of individual guiding systems surrounded by a high strength grout – all enclosed in a curved smooth steel pipe – BBR HiEx CONA Monotube Saddle. Seven-wire HDPE-sheathed prestressing steel strands – factory provided with corrosion protection filling material – are inserted through the guiding system and connect the coupler heads placed at both sides of the pylon. While the high strength grout provides a stiff environment, strands are fully replaceable as there is no bonded connection between the guiding system and the external HDPE of the strands. The minimum radius of this saddle configuration, SMR is 2.0m. Alternatively, a bundle of bare strands bonded / unbonded to the pylon might also be used if permitted at the place of use – BBR HiEx CONA Bundle Saddle. The minimum radius of this saddle configuration, SBR, depends on the degree of filling and maximum contact pressure permitted at the place of use.



1 The new Danube Bridge 2 will carry both road and rail traffic (page 56).
2 A launching girder was used to help place bridge segments (page 57).
3 Stay cable installation – 52 stay cables were installed on each of the four main piers.
4 The 208 stay cables range from 22 to 55 strands and are 30 to 90m long.

> "The second reason that made it so special was the amount of technical innovation that was developed and installed – such as the BBR HiEx CONA Saddle system and vacuum grouting."

5 Front stressing – more than 250t of tendons were threaded, stressed and grouted in just one month.
6 Specialist lifting services were needed to orientate the deck at the end of each cantilever construction.
7 Segment lift underway.

5

6

Additional tasks
In addition to installing the BBR post-tensioning system, BBR PTE also performed other tasks, such as supply and stressing of steel bars in sizes ranging from 32mm up to 75mm in diameter. However, the main additional activities we have carried out over the last three years have been lifting maneuvers of two separate types.
The first of these types was lifting, turning, placing and finally stressing 152 precast concrete vessel impact protection units, weighing up to 130t each. This maneuver was performed with heavy lifting equipment and was the subject of an article in last year's edition of CONNÆCT.
The second type of lifting was needed to orientate the deck at the end of each cantilever construction for each pier of the Non-Navigable Channel viaduct and after placing five pairs of segments for the Main Navigation Channel bridge. This maneuver was performed using four sets of jacks – each with a lifting capacity of 1,700t – supplemented with longitudinal and transverse movement jacks. This allowed us to move the deck in any direction to correct its position before concreting the closure joint segment in-situ.

Special for three reasons

The Vidin-Calafat Bridge project has been a very unusual project mainly for its huge dimensions – in every respect. We first arrived on site at the beginning of 2009 – at a very early stage – and the deck was closed in October 2012.

The resources required to execute this work were also absolutely amazing – during the peak of activity, we had up to three engineers, a foreman and 15 BBR PTE qualified workers on site. If we also include our auxiliary workers, we had a team of more than 80 people involved in this project. Equipment logistics were no less important – we had plant on site which included more than 20 stressing jacks, 10 threading machines, two deck orientation systems and two sets of heavy lifting equipment.

The second reason that made it so special was the amount of technical innovation that was developed and installed – such as the BBR HiEx CONA Saddle system and vacuum grouting.

The last reason it was such a unique project was the quantity of difficult maneuvers that had to be performed – represented by all types of heavy lifting techniques and calibrations.

For all these reasons, I personally consider this project to be the most challenging I have ever faced as Project Manager on site – and it will always have a special place in the memories of all members of the BBR PTE team involved.

7

FACTS & FIGURES

- Approach viaduct – 720m, 18 spans
- Non-Navigable Channel viaduct – 612m long, 8 spans
- Main Navigation Channel bridge – 779m long, 5 spans
- Stay cables installed – 208, from 22-55 strands & 30-90m long
- Weight of BBR VT CONA CMI tendons – 2,100t
- Plastic duct installed – 65,000m

TEAM & TECHNOLOGY

Owner – Ministry of Transport (Bulgaria)

Main contractor – FCC Construcción S.A: Klon Bulgaria

Designer – Carlos Fernández Casado S.L.

Technology – BBR HiAm CONA stay, BBR HiEx CONA Saddle, BBR VT CONA CMI internal

BBR Network Member – BBR PTE, S.L. (Spain)

STAY CABLES FOR IRON ORE AND WATER PROJECTS, **AUSTRALIA**

Delivery of durable stayed solutions to customer challenges

INNOVATIVE USE OF STAY CABLES

BBR Network Members around the world have developed a reputation for finding innovative new ways to use BBR technology and deliver solutions to customer challenges. Recent stay cable projects carried out by **Structural Systems,** the Australian BBR Network Member, have included installations to support conveyors at an ore handling facility in Newman, Western Australia. Now, a further project for the ore mining industry – at a site just a couple of hundred miles to the north – has just got underway. Meanwhile, on the other side of the country, in Melbourne, stay cables are literally keeping the lid on things at a sewage treatment plant.

1 Karara Iron Ore Project, Western Australia

The Karara Iron Ore Project consists of the development of port, rail and mining site facilities for the export of magnetite and hematite products, mined from the iron ore deposits located at the Karara mine site, approximately 320km north-east of Perth in Western Australia.

A stockyard, stacking and product reclaim area forms part of the project. Structural Systems have been engaged to assist in design, supply and assist in installation of the eight cable stays which will be supporting the cantilevered section of the stacking conveyor. Each cable stay consists of a forked clevis connection at the top with an adjustable anchorage at the bottom.

The cable stays will be permanently loaded, supporting the cantilevered conveyor truss. Loads will vary according to conveyor belt operating capacity, wind and seismic activity.

The BBR HiAm CONA 01206 system, with cables ranging from 24 to 42m long, was selected to meet design requirements of continuous operation, equipment reliability, operability and maintainability.

2 Water Treatment Plant Upgrade, Melbourne, Australia

As part of a A$48 million plant upgrade project at Melbourne Water's Western Treatment Plant in Werribee, an existing treatment lagoon cover is being replaced. The cover captures bio gas produced as a by-product of the sewage treatment and converts it to electricity to power the plant. The covers on the 1.5km long, 200m wide lagoons are built in-situ from polyethylene sheeting with a system of floats and ballast pipes to direct the methane to extraction points. To secure the cover in place, Structural Systems were engaged to design, supply and install a series of cable stays which traverse the lagoon in a convex and concave pattern. BBR's HiAm CONA system was adopted for the 11 cable stays comprising 2 x 15.2mm strand of 220m in length – individually waxed and sheathed, then housed in 63mm diameter secondary polyethylene ducting sealed to the anchorage for corrosion protection.

TEAM & TECHNOLOGY

1 **Owner** – Karara Mining Limited
Main contractor – Worley Parsons Services
Designer – Maison Worley Parsons
Technology – BBR HiAm CONA stay, BBR Pin Connector
BBR Network Member – Structural Systems Limited (Australia)

2 **Owner** – Melbourne Water
Main contractor – Water Resources Alliance (Melbourne Water, Baulderstone, Beca, SKM, United Group)
Designer – SKM
Technology – BBR HiAm CONA stay, BBR Pin Connector
BBR Network Member – Structural Systems Limited (Australia)

RIO CORGO VIADUCT, **PORTUGAL**

Post-tensioning and stay cable bridge construction using BBR HiEx CONA Saddles

ELIMINATING SADDLE FATIGUE

The Corgo Viaduct is the most striking structure of the Auto-Estrada Transmontana – the nearly 140km long motorway which connects the cities of Vila Real and Bragança – a step further along the way to completing the great northern highway of Portugal, linking Oporto to the Spanish border. Piedad Lucas describes this project and Spanish BBR Network Member **BBR PTE**'s part in its realization. ➤

1

The impressive topography of the mountains at Trás-os-Montes and the deep valley formed by the River Corgo passing through Vila Real make this project quite extraordinary.
The 42-span Corgo Viaduct is 2,796m long overall. It consists of three distinct parts – divided for structural reasons, as well as by construction methodology. There are two lateral approach viaducts – the 855m long, 15 span West Lateral Sub-Viaduct and the 1,167m long 20 span East Lateral Sub-Viaduct. Then, there is the central part – the seven span Central Sub-Viaduct – which is 768m long in total and features stay cables and a central span of 300 m.
In cross-section, the viaduct consists of a 10m wide, 3.5m high box girder concreted in-situ and an upper slab generally 25.3m wide, but increasing up to 28m in the cable-stayed section to allow for installation of stay cable anchorages. The overhanging width of the upper slab is supported by prefabricated concrete struts.

Lateral viaducts

The challenge of constructing the deck over pillars up to 113m high was solved by using launching girders for both lateral viaducts, each with different characteristics and employing a different construction methodology. The launching girder used for the East Lateral Viaduct consisted of lower trusses with 'organic' behavior – achieved through exterior steel cables allowing deflection adjustments during concreting. The box girder section was erected in two phases, first bottom slab and webs followed by the upper slab.
The launching girder system used in the West Lateral Viaduct consisted of upper beams with hydraulic interior scaffolding, allowing concreting of the box girder section in one stage. This launching girder was adjustable and, in the early spans, described a curve with a 700m radius.
Finally, at both lateral viaducts the upper slabs were widened and struts were installed using a cantilever form traveler.
For all spans, internal bonded post-tensioning was a requirement. For the standard 60m spans, using BBR CONA VT CMI 2706 tendons, the arrangement was that there were eight tendons in the webs and a further eight in the upper slab. In particular segments, various sized tendons – with 4, 7, 12, 15 and 19 strands – were used to allow maximum efficiency from the reinforced concrete section to be achieved.

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"By the end of the project, BBR PTE will have installed 88 stay cables – 22 pairs per pylon – and the longest cable was 159m long."

Central viaduct

The central stayed viaduct consists of seven spans in the configuration of 48m + 60m + 126m + 300m + 126m + 60m + 48m. The use of stays was essential because of the difficulty in placing pillars on the sheer banks of the river and the sloping terrain. The 63m high pylons tower above the 130m high bridge pillars, while the valley floor lies 70m further below the pillar foundations.

By the end of the project, BBR PTE will have installed 88 stay cables – 22 pairs per pylon – and the longest cable was 159m long. We used BBR HiAm CONA anchorages, ranging between 42 and 69 strands, resulting in 660t of steel being used for stay cables.

The key element which distinguishes the stay cable system here is the use of the BBR HiEx CONA Saddle. This is the very latest BBR technology – not only does it retain the advantages of traditional saddles, like the design of a massive pylon of reduced dimensions, but it also offers additional advantages, such as the elimination of saddle fatigue and the risk that different forces might be introduced into each stay cable, even in the same pair.

The three central spans were built using a cantilever form-traveler which concretes a 28m deck width and 6m long segments in one phase. One stay has been installed per segment. The concreting of each pair of segments was only completed after tensioning of the 30 BBR VT CONA CMI 0406 transversal tendons, the 96 longitudinal post-tensioning bars and the previous pair of stays on the adjacent segments.

The installation of stay cable pairs at each pylon was carried out simultaneously by the strand-by-strand method – there was just one strand difference between the sides. HDPE duct and strand preparation and installation fitted perfectly with the demanding seven day working cycle between concrete pours. ●

1 The deck was constructed over pillars up to 113m high using launching girders (page 63).
2 Threading the BBR HiEx CONA Sleeve-W onto the BBR HiEx CONA Saddle.
3 BBR HiAm CONA stay cable installation underway on the 63m high pylons.
4 Strand-by-strand installation of HDPE coated strands.

TEAM & TECHNOLOGY

Owner – Estradas de Portugal

Main contractor – CAET XXI (FCC Construcción + Ramlho Rosa Cobetar + Soares da Costa)

Designer – LCW

Technology – BBR HiAm CONA stay, BBR HiEx CONA Saddle, BBR VT CONA CMI internal

BBR Network Member – BBR PTE, S.L. (Spain)

STAY CABLE STRUCTURES, **POLAND**

Four cable stayed projects featuring BBR HiAm CONA technology

STAY CABLE QUARTET

During the last two years, BBR Polska has completed several contracts for cable-stayed bridges in Poland. As well as delivering elegant new infrastructure, the team's work has produced some new records – including Europe's first cable-stayed bridge for trams.

TEAM & TECHNOLOGY

1 **Owner** – Local Management of District Roads, Krakow
Main contractor – Mota-Engil Central Europe S.A.
Designer – Promost Consulting
Technology – BBR HiAm CONA stay, BBR Pin Connector, BBR VT CONA CMI internal,
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

2 **Owner** – Local Management of District Roads, Bydgoszcz
Main contractor – PRM Mosty-Lodz S.A., Gotowski BKiP Sp. z o.o., PBDiM Kobylarnia Sp. z o.o.
Designer – Transprojekt Gdanski Sp. z o.o.
Technology – BBR HiAm CONA stay, BBR VT CONA CMI internal, Expansion joint
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

3 **Owner** – Local Management of District Roads, Bydgoszcz
Main contractor – Gotowski BKiP Sp. z o.o.
Designer – Gotowski BKiP Sp. z o.o.
Technology – BBR HiAm CONA stay
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

4 **Owner** – General Directorate for National Roads and Motorways, Lodz
Main contractor – PRM Mosty-Lodz S.A., SRB Civil Engineering Ltd Wilton Works
Designer – Mosty Katowice, DHV, Transprojekt-Warszawa Sp. z o.o.
Technology – BBR HiAm CONA stay, BBR VT CONA CMI internal, Expansion joint
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

1 Dobczyce Bypass Flyover
This 16-span post-tensioned flyover is part of the Dobczyce bypass. It has a total length of 463m and a 178m long three span main bridge. Two pylons carry 64 x 12-strand stay cables, terminating with BBR Pin Connectors at the top.

2 Bydgoszcz Bridge
The city of Bydgoszcz is going to have a new monument – a dramatic 200m long stay cable bridge with a unique 70m high central pylon which consists of two intersecting 'horseshoes'. BBR Polska is also post-tensioning the side flyovers and installing expansion joints.

3 Tramway Bridge, Bydgoszcz
In Bydgoszcz, Europe's first cable-stayed bridge for use primarily by trams has been completed. It features a 70m span and six pairs of main stays plus three pairs of back stays. To enhance the structural efficiency of the bridge, the 'A' shaped pylon is inclined at an angle of 15° towards the river.

4 A1 Highway Arch Viaducts
On the A1 highway, several architectural structures – arch viaducts – are under construction. BBR Polska is constructing four viaducts which all feature post-tensioned deck slabs, have a 66m span and 10 vertical stays transfer the loads to the steel arches.

PRZEMYSL BRIDGE, **SOUTHERN POLAND**

Installation of stay cables using BBR HiAm CONA system and BBR Pin Connectors

SYMBOL OF DEVELOPMENT & MODERNITY

The rapid development of road infrastructure in Poland has also included the southern part of the country where, near the border with Ukraine, the region's largest stay cable bridge has been built. It forms part of the Przemysl ring road and, as well as helping to steer traffic away from the city centre, the new bridge will stand as a symbol of the development and modernity of the region. Jacek Sowa and Tomasz Borsz of BBR Polska describe the construction process. ➤

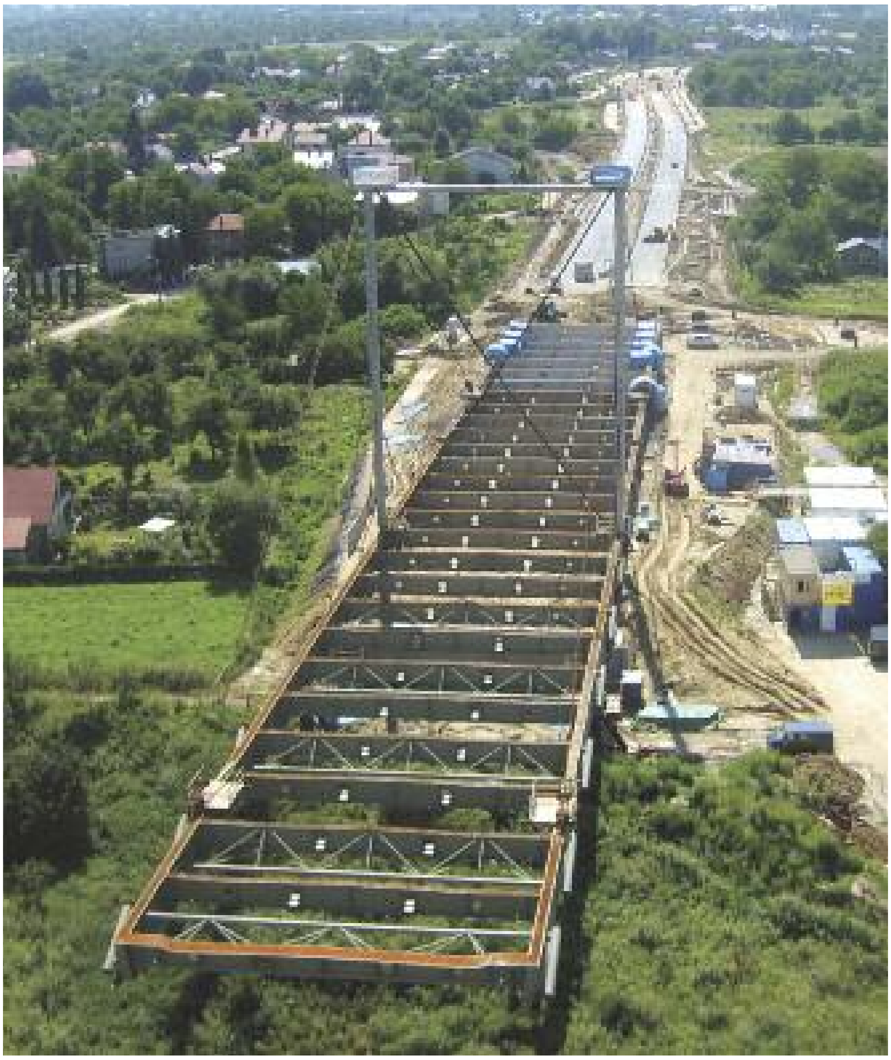
1

> "The structure behaved exactly as intended during construction – the result of a detailed analysis of the structure at the design stage and well-planned and executed works on site."

Technological background

The final design and technology for erection of the bridge was agreed in consultation between the main contractor, BBR Polska and the steelwork contractor. The assembly of the steel section was performed by incremental launching prior to the concrete bridge slab being poured. The first phase of stay cable tensioning was carried out simultaneously with the deck slab concreting, the secondary phase of tensioning works was executed after pouring the deck slab and before finishing works. Pouring of the deck slab was completed symmetrically for the two spans. Driven by the need to preserve the balance of forces in the pylon, both the primary and secondary phases of tensioning works were carried out symmetrically, using four light single strand hydraulic jacks. The final shape of the road line was achieved by secondary tensioning of the stay cables.

2



3

Steel construction assembly technology

The steel frame with anchor brackets was assembled off the bridge line as we were not permitted to install temporary supports in the water. The only option was to erect light steel temporary supports on the banks of the river for the assembly of the steel girders – and to avoid additional loads from the concrete deck slab by pouring it in-situ later.

The final location was achieved by using a longitudinal launching method with a temporary steel pylon and four individual pairs of seven strand back-stay cables. Launching was carried out in four stages, with four temporary supports. The steel structure of the bridge and the temporary pylons were shifted between the arms of the concrete pylon. The maximum temporary span achieved during launching was 66m.

1 Assembly of the steel framed bridge deck (page 67).
2 View of the bridge deck and pylons taking shape.
3 The bridge deck was placed into its final location using the longitudinal launch method.

"The final location was achieved by using a longitudinal launching method with a temporary steel pylon and four individual pairs of seven strand back-stay cables."

Bridge suspension technology
We established the staging for deck slab concreting and stay cable installation works using the baseline for our calculations as the structural condition after launching the steel structure onto the target supports including removal of the temporary launching pylon.
Our schedule for tensioning the stay cables assumed the temporary supports, used earlier for launching the steel girders, would be in place and would only gradually be dismantled after stressing the stay cables. The temporary supports had to be designed for carrying vertical and horizontal loads from the bridge bearings and from wind induced forces. The stay cable installation works were divided into six construction stages – each consisting of the successive installation of formwork, placement of reinforcement, deck slab concreting and sequential installation of stay cables.
To achieve equal forces in the strands, we used the BBR ISOSTRESS method, combined with an additional load change monitoring system based on extensometer load cells. Primary tensioning of the stay cables was carried out during the concreting of the deck slab in the first five stages. In the sixth and final stage, secondary tensioning was applied to the stay cables prior to the completion of finishing works.

Constant monitoring
At every construction stage, surveyors maintained constant monitoring and control of the displacements in the pylon in order to compare the real bridge behavior with our set of initial structural calculations. It was not necessary to make any additional adjustments to the stay cables in order to achieve the final road line after the completion of finishing works.
The structure behaved exactly as intended during construction – the result of a detailed analysis of the structure at the design stage and well-planned and executed works on site.

New technology
The Przemysl Bridge construction project – which ran in parallel with the smaller extradosed bridge scheme in Dobczyce, where we used BBR HiAm CONA 01206 with BBR Pin Connectors at the pylons – was the first project carried out by BBR Polska using the new BBR HiAm CONA system.
Our successful approach to the project and performance of the work was the result of experience gained on previous major implementations – and a key factor was also the generous sharing of information, for which we are most grateful, by colleagues from KB Vorspann-Technik who worked on the huge bridge over the River Sava in Belgrade. ●

TEAM & TECHNOLOGY

Owner – Local Management of District Roads, Przemysl
Main contractor – Mota-Engil Central Europe S.A.
Designer – Promost Consulting
Technology – BBR HiAm CONA stay, BBR Pin Connector
BBR Network Member – BBR Polska Sp. z o.o. (Poland)

PROPYLENE STORAGE TANKS, **AL RUWAIS, UNITED ARAB EMIRATES**

Specialist post-tensioning design and installation for safe LPG storage

TANK CONSTRUCTION TRIO

The massive scale of storage tanks for liquid gases demands the application of highly specialized technology and expertise during their construction – with many such projects under their belt worldwide, the BBR Network has much experience in this sector. Recently, with the post-tensioning of three liquid propylene gas (LPG) storage tanks, UAE-based BBR Network Member Structural Systems Middle East has added Abu Dhabi Oil Refining Company (TAKREER), the largest oil refiner of UAE, to its client list, reports Manager – Civil Projects, Ravindra Kumar Chauhan.

This recent project strengthens our long and successful working relationship in the UAE with designer and tank subcontractor, Chicago Bridge & Iron (CB&I) and is a step towards establishing our relationship with South Korean engineering leader, Daewoo Engineering & Construction who are the EPC Contractor for this project.
CB&I contracted us to carry out design and detailing of the hoop and vertical post-tensioning tendons based on their long term prestressing force and to provide methods of installation, shop drawings, material, supervision and specialist equipment required for the installation, stressing and grouting works.

"The grout material and properties were verified according to the requirements of BS EN 445 and 447 standards – for conformity, grout trial mixes were conducted at site."

1

1 In each tank there were 34 hoop, or horizontal, tendons anchored at the stressing buttresses.
2 Mast climber platforms gave the site team access to the PT works, while tower cranes provided lifting services for equipment such as stressing jacks.
3 The trio of tanks here brings Structural Systems tally of post-tensioned LPG storage tanks constructed in the UAE to 17.

2

Construction method

We fabricated 'U' tubes with a bend radius of 650mm from rigid seamless galvanized mild steel pipe. These featured a special connection with the vertical duct and provision for a grout inlet at the bottom of the 'U' bend which was installed in the base slab before casting.

The inner steel liners for the tanks were fabricated and erected in position, then welded in-situ over the full height of the tank. The vertical and horizontal tendon ducts were installed in the concrete wall in nine equal lifts of nearly 3.5m each. A cycle of 15 days per lift was achieved during concreting of the wall – jump form timber formwork was used for the outside face.

The post-tensioning anchorages and corrugated galvanized iron ducts were placed prior to concreting, while prestressing steel was installed after the wall pour. Mast climber platforms were erected to enable PT works to proceed in an efficient manner, while tower cranes provided the necessary hoisting requirements for equipment such as stressing jacks.

> "In each tank, there were 34 x 19 strand horizontal (hoop) tendons and 67 four strand U-shaped vertical tendons."

Prestressing system

In each tank, there were 34 x 19 strand horizontal (hoop) tendons and 67 four strand U-shaped vertical tendons. We used BBR VT CONA CMI BT 1906 and 0406 anchorage systems for hoop and vertical tendons respectively.

All the tendons were stressed from both ends when the concrete achieved 50MPa cube strength. Horizontal hoop tendons were anchored at the four equally spaced stressing buttresses and vertical 'U' tendons were anchored at the top of the tank wall.

The tendons were stressed in three stages:

- Stage 1 – Ring beam hoop tendons prior to casting of the top roof
- Stage 2 – Hoop tendons above temporary construction openings (TCOs) and all the U-shaped tendons, except those passing through TCO
- Stage 3 – Remaining hoop and U-shaped tendons passing through TCOs upon casting and closure of TCO.

The grout material and properties were verified according to the requirements of BS EN 445 and 447 standards – for conformity, grout trial mixes were conducted at site.

The tally of post-tensioned LPG storage tanks in the UAE constructed for CB&I by Structural Systems rises to 17 with the successful completion of these three tanks.

FACTS & FIGURES

- Tank wall height – 31.8m
- Internal diameter – 52m
- Wall thickness (at base) – 900mm
- Wall thickness (from 7.10m upwards) – 500mm
- Hoop tendons per tank – 34
- U-shaped vertical tendons per tank – 67
- PT strand specification
  - 15.7mm diameter
  - 150mm² steel area
  - 1,860MPa GUTS
  - 279kN MBL
  - BS 5896
- Ducting
  - 17km of 100mm diameter
  - 13km of 50mm diameter
- PT strand – 510t

TEAM & TECHNOLOGY

Owner – Abu Dhabi Oil Refining Company (TAKREER)

Main contractor – Daewoo Engineering & Construction

Designer / Tank subcontractor – Chicago Bridge & Iron Company

Technology – BBR VT CONA CMI internal

BBR Network Member – Structural Systems Middle East LLC (United Arab Emirates)

3

ROSEIRES DAM, **REPUBLIC OF SUDAN**

Installation of permanent anchors for dam heightening project

HEIGHT OF SUCCESS

Roseires Dam is in Sudan's Blue Nile State, on the Blue Nile River, near the town of Ad Damazin, 550km south east of Khartoum – seven hours by car. The dam is now being heightened to increase capacity and anchors have been installed to strengthen the structure for the additional load. The project will boost hydroelectric power generation from existing units that produce 1,200 GWh per year to 1,800 GWh per year – at no additional cost. Mark Seisun of Australian BBR Network Member, **Structural Systems**, takes up the story.

The dam was designed as a two-stage project. The first stage, completed in 1966, has 1,000m of concrete dam wall reinforced with buttresses, an integral spillway, deep sluice gates, a power station and is flanked by earth embankments 12.5km long. The upgrade heightens the dam by 10m and stretches the embankments by 11.6km – extending dam capacity from 3.0 billion cubic meters to 7.4 billion cubic meters.

The US$450 million project is being run by the Sudanese Government's Dams Implementation Unit and engineering consultancy services are being provided by SMEC, in association with Lahmeyer International. Structural Systems have been subcontracted by a Chinese Joint Venture, CCMD JV, to supply and install the dam anchors for the project.

1

"We installed 14 x 25m long, 55-strand inclined anchors at an upper level on spillway buttresses, with another 14 x 32m long, 55-strand inclined ground anchors being installed at a lower level…"


2


3

Permanent anchors

With the dam height raised from 68m to 78m and the spillway buttress widened, anchors were being installed to strengthen the dam, so that it could cope with the additional load imposed by the increased dam capacity. We installed 14 x 25m long, 55-strand inclined anchors at an upper level on spillway buttresses, with another 14 x 32m long, 55-strand inclined ground anchors being installed at a lower level – both sets of anchors tie the widening of the buttresses into the existing concrete. The bond length for the spillway anchors was 15m. We installed 201 x 15m long, 12-strand vertical anchors and eight 15m long, eight-strand vertical anchors on the dam crest to tie the new upper section into the existing dam wall. The bond length for the 15m anchors was four meters. ➤

1 Work underway to heighten the Roseires Dam.
2 A total of 237 BBR VT CONA CMG ground anchors were fabricated and installed.
3 Anchor holes were on a gentle slope, so a special deflector mechanism was used to alter the angle of the anchor, as it was lowered, to align with the hole.

4

> "Like a safari on camel back through the hot north African deserts, delivering this project has had its challenges."

5

4 Stressing of the new spillway anchors.
5 A rock anchor being transported to the side of the dam.
6 Once unloaded, the anchors were lifted over the dam crest by a 50t mobile crane – and then transferred to a tower crane which slewed them into position for installation.

LOCAL INSIGHT

THE BLUE NILE

The Blue Nile flows from Ethiopia, through Sudan and joins the White Nile at Khartoum where it becomes the River Nile and travels onto Egypt and finally into the Mediterranean Sea at Alexandria.
About 30-40km downstream from its source at Lake Tana in Ethiopia, the Blue Nile shows its immense power at the 45m high Tis Issat – or Blue Nile – Falls.
The 1,450m long Blue Nile, along with the White Nile, is one of two major tributaries of the Nile. The upper reaches of the river are called the Abbay in Ethiopia, where it is considered holy by many and is believed to be the River Gihon mentioned as flowing out of the Garden of Eden in Genesis 2 of the Holy Bible. ●

The challenges

The contract duration for the supply and installation of the anchors was nine months. By the end of July 2012, installation and grouting of the spillway anchors had been completed with the dam crest anchors 50% complete – the project was on schedule. Like a safari on camel back through the hot north African deserts, delivering this project has had its challenges. All the materials and equipment used on the project – except water, ice and fuel – were imported into Sudan. Materials, plant and equipment were sourced from Japan, South Africa, Europe and Australia. We used oil well cement – a special type of cement well-suited to high pressure injection – imported by the Chinese Joint Venture from China. As expected, the project team had to do a lot work to ensure that works complied with Structural Systems' strict safety standards – and the works progressed without incident.

The coffer dam access road below the dam wall, which was used for delivery of the spillway anchors, was flooded midway through their installation. In the end, the anchors were delivered from the dam crest. As the anchors were much longer than the reach of the tower cranes mounted on site, they had to be lifted over the dam crest by a 50t mobile crane – and then transferred to a tower crane which slewed them into position for installation. Feeding the anchors into anchor holes at a gentle slope, rather than vertically where gravity helps, was another challenge for the team. We used a special deflector mechanism which altered the angle of the anchor as it was lowered to align with the hole – in some cases this was only six degrees below horizontal.

A site team of 20 delivered the works and included seven members from Structural Systems Australia, several from Structural Systems Dubai and the balance from the local Sudanese labor force.

When commissioned during 2013, as well as increasing power generation capacity, the heightened Roseires Dam is expected to support an expansion in irrigated farming and increased fish stocks in the lake. ●

6

FACTS & FIGURES

- 28 x 5506 inclined permanent anchors to 31.7m
- 201 x 1206 vertical permanent anchors to 14.7m
- 8 x 0806 vertical permanent anchors to 14.5m

TEAM & TECHNOLOGY

Owner – Dams Implementation Unit, Khartoum, Republic of Sudan

Main contractor – CCMD Joint Venture (JV of 2 Chinese State construction companies, Beijing, China)

Designer – SMEC (Snowy Mountains Engineering Corporation), Australia

Technology – BBR VT CONA CMG ground

BBR Network Member – Structural Systems Limited (Australia)

RAIL BRIDGE B1108, **PIETERMARITZBURG, KWAZULU-NATAL, SOUTH AFRICA**

Vertical jacking of rail bridge by 700mm

CALCULATED SOLUTION

A dual track railway bridge over National Route 3 (N3) in Pietermaritzburg, South Africa had to be jacked vertically by 700mm to achieve a head clearance of 5.4m. Sean Kelly, from BBR Network Member SSL Structural Systems (Africa) Pty Ltd, reports on the vertical jacking which was required as a result of the new concrete overlay under construction on the operational N3 below.

1

> "The adaptor plates worked as expected and ensured a highly safe and controlled jacking operation."

The programming of works to allow uninterrupted traffic flow on the north and southbound carriageways took a lot of planning, as did liaising with the railway authorities during the decommissioning and switching of lines.

Rail traffic over the dual carriage highway is currently on two separate bridge decks – weighing 4,500kN each – which are aligned side-by-side with a water stop joint separating them. The separation of the two bridge decks allowed rail traffic to remain operational on the non-jacking side throughout the construction period. The bridge decks are two-span continuous structures with increasing cross-sections from the abutments towards the central pier. It had been flagged by the designers that the support reactions were very sensitive to changes in jacking positions, which is why jacking support reaction verifications were carried out prior to the 700mm jacking operation.

Temporary support work

The first challenge we overcame was the design of the temporary support work from which jacking operations would be conducted – the low clearance on the pier and abutments dictated this requirement. H-profile sections, sized 305 x 305mm, were chosen as the main vertical members for the six meter high jacking frames, with eight jacking locations used for each bridge. These members were founded on 600mm thick reinforced concrete bases, which were cast on top of 15MPa mass concrete fill. The foundations were extremely important in avoiding settlement of the temporary supports under jacking, with the design proving to be more than satisfactory and, ultimately, helping to optimize the jack stroke.

1 Chemical anchors were used to fix the plates to the bridge soffit, as well as checkered steel gripper plates.
2 The 700mm jacking operation was completed in four days.

Sloping soffit

The soffit of the bridge was sloped at pier jacking locations at an angle of roughly 10 degrees to the horizontal. To overcome the horizontal jacking component of the vertical jacking force, adaptor plates were designed to be fixed onto the bridge soffit. In addition to the chemical anchors fixing the plates to the soffit, checkered steel gripper plates were also used – these achieve up to a 70% friction coefficient.
The plates at either side of the piers were also connected together with two 26.5mm fully threaded bars to prevent them from slipping apart. The adaptor plates worked as expected and ensured a highly safe and controlled jacking operation.

2

Loading

Differential loading from the inner to outer support on the pier, meant that two separate pumps had to be used to operate the 250t locking collar jacks. This ensured the difference in lifting heights between jacking points was never more than one millimeter. The bridge was typically jacked 40mm to allow a 20mm steel plate to be comfortably inserted on the packing points – the available stroke of each jack was 45mm. Every support had a permanent gauge fixed to the bridge soffit to allow the same final lifting height to be achieved on all eight positions.

The 700mm jacking operation – plus additional jacking for working space – was achieved in four days after the erection of temporary supports and adaptor plates. We encountered a series of challenges during the temporary works design stages, however, a combination of our experience and practical thinking resulted in the successful lifting of two bridges, while minimizing the effect on road and rail traffic. We hope to be involved in further heavy lifting bridge operations as road and rail infrastructure continues to grow in South Africa. ●

TEAM & TECHNOLOGY

Owner – The South African National Roads Agency Limited (SANRAL)
Main contractor – Group Five JV, in consortium with Phambili
Designer – ILISO Consulting & AURECON Cape Town JV (Bridge), NYELETI CONSULTING (Pty) Ltd (Temporary Works)
Technology – Heavy lifting
BBR Network Member – SSL Structural Systems (Africa) Pty Ltd (Africa)

ZLATOLICJE PIPELINE BRIDGE, **NEAR MIKLAVZ, SLOVENIA**

MULTIFUNCTIONAL BRIDGE

Kresimir Bogadi of BBR Adria, the BBR Network Member for Croatia, describes how a new bridge carrying a major gas pipeline was built over the Zlatolicje canal in Slovenia. It sits right next to an old bridge constructed in 1976 with the BBRV wire system.

TEAM & TECHNOLOGY

Owner – Geoplin plinovodi d.o.o.
Main contractor – IMP d.d.
Designer – IMK d.d.
Technology – Stay cables
BBR Network Member – BBR Adria d.o.o. (Croatia)

A distinctive feature of the new bridge is the footbridge – for pedestrians and cyclists – made of rolled profiles and suspended under the pipeline.
Tension bars – galvanized according to BS EN ISO 1461:1999 – have been used for the new bridge and the pipeline is supported, at 11.5m intervals along the deck, by stays connected to two steel pylons.
The pylons have been designed as two-dimensional frames with stabilizing in-plane X-ties and are 14m high and 10m wide at the top. They stand 80.55m apart and are counterbalanced with 2 x 2 backstays from each upper corner and anchored in reinforced concrete foundations at the rear.
A total of 6 x 2 stays were placed symmetrically on both sides, from each upper corner of the pylon frame to the steel structure of the bridge. ●

TWIN RAILWAY BRIDGES, **ANDERLECHT-VOORST, BELGIUM**

Extradosed solution using BBR VT CONA CME tendons

EXTRADOSED CANAL CROSSING

The team from **Spanstaal**, the BBR Network Member in the Netherlands, has used the BBR VT CONA CME post-tensioning system in a special application for construction of an extradosed stay cable bridge over the Brussels-Charleroi canal, south of the Belgian capital city.

This project at Anderlecht-Voorst is for construction of the third and fourth railway lines on the Brussels South to Denderleeuw route which will be carried on two identical bridge decks.

For each of the decks, 13 x 102m long 19-strand BBR VT CONA CMI tendons were installed. In addition, Spanstaal provided detailed design and installation of the external longitudinal post-tensioning which used four 102m long 24-strand BBR VT CONA CME tendons.

The large radius of the strand bundle at the pylon meant that extradosed BBR VT CONA CME tendons could also be used here. The only extra requirement from the client was that the unbonded tendons be supplied with additional corrosion protection. ●

TEAM & TECHNOLOGY

Client – TUC Rail

Main contractor – Antwerpse Bouwwerken NV

Technology – BBR VT CONA CMI internal, BBR VT CONA CME external, Expansion joints, Bearings

BBR Network Member – Spanstaal B.V. (Netherlands)

RETAINING WALL STRENGTHENING, **WELLINGTON, NEW ZEALAND**

IMPROVING ROAD PERFORMANCE

Work has been completed on two retaining walls and adjacent slopes on Churchill Drive, Wellington to improve the performance of a high-priority arterial road in natural hazard events, particularly earthquakes and storms. The aim is to minimize disruption to road users and the wider community, while securing some important utilities which are also routed along this road. ●

TEAM & TECHNOLOGY

Owner – Wellington City Council
Main contractor – BBR Contech
Designer – Opus International Consultants
Technology – PT bar ground anchor
BBR Network Member – BBR Contech (New Zealand)

LEMNHULT WIND PARK, **VETLANDA, SWEDEN**

Ground anchorages for 32 wind towers

ANCHORING FOR WIND

A wind farm is under construction in a wooded area in southern Sweden which will satisfy electricity demand for around 54,000 households. Göran Thunberg of KB Spännteknik, the BBR Network Member in Sweden, offers an insight into the project.

FACTS & FIGURES

- Quantity – 32 x 3MW wind turbines
- Wind tower height – 185m
- Estimated production – 270 GWh/year
- Households supplied – 54,000
- BBR VT CONA CMG ground

TEAM & TECHNOLOGY

Owner – Stena Renewable AB
Main contractor – Svevia AB
Designer – VBK Konsulterande Ingenjörer AB
Technology – BBR VT CONA CMG ground
BBR Network Member – Spännteknik AB (Sweden)

The wind farm is located in Vetlanda, Jönköping County – an area dominated by production forestry operations and sparse, scattered settlements. The Lemnhult wind power plant, comprising 32 wind towers, will be southern Sweden's largest onshore wind farm.

Anchoring technology
The foundations were designed with BBR VT CONA CMG – there are 16 ground anchors in each foundation. Each anchor is 15.4m long and we are using 15.7mm, 1,860N/mm² post-tensioning strand – greased and plastic coated on the free length.

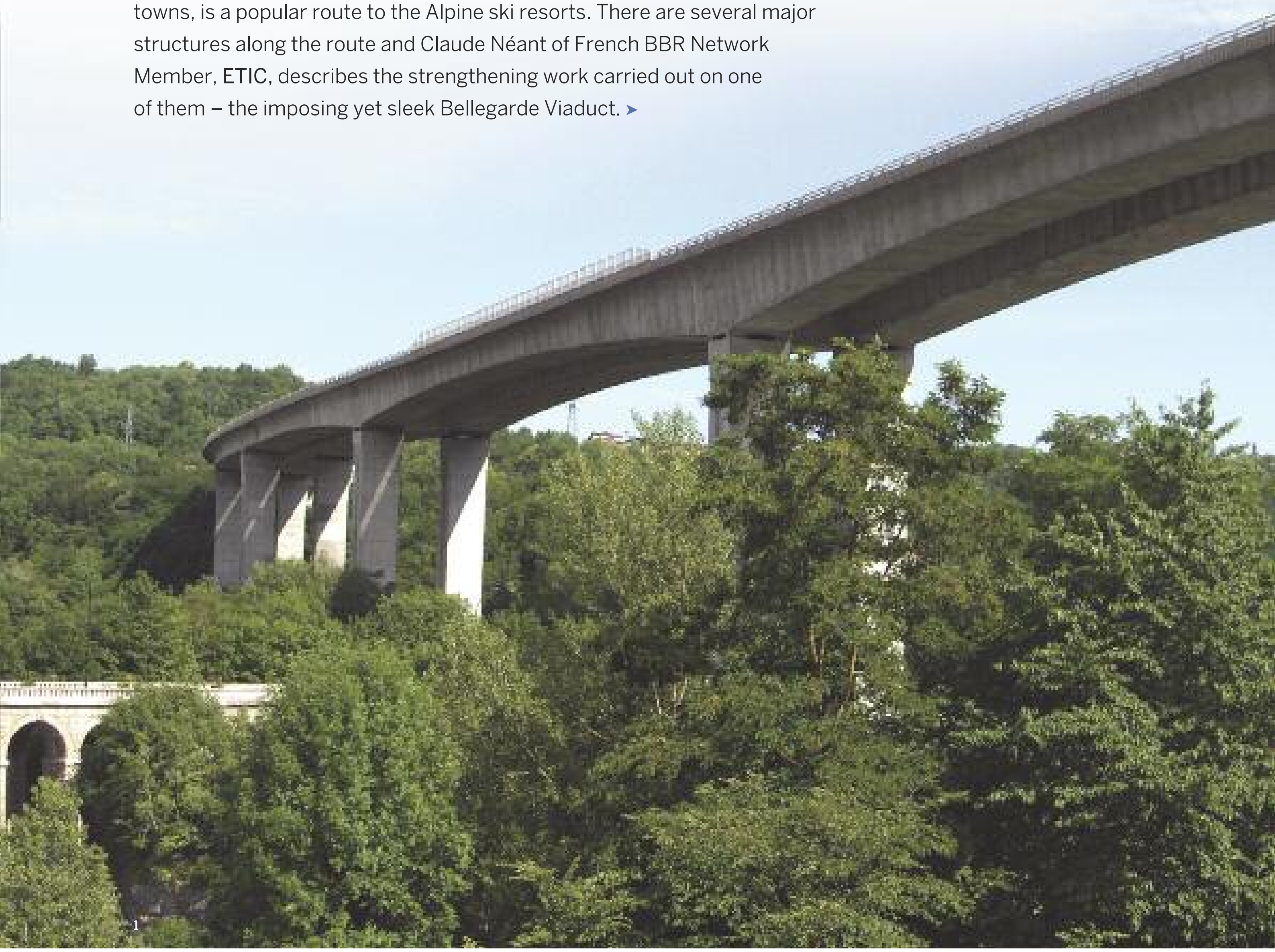
On site methodology
The client performed the drilling works and casting of the foundations. We are installing and grouting the permanent anchors, stressing them and then mounting a protective cover over the anchorage. Included within our contract are all services at the work site – such as lifting assistance, electricity, compressed air and water supplies – so that our work can be carried out independently, without relying on additional support from our client. ●

BELLEGARDE VIADUCT, **A40 LYON-GENEVA, FRANCE**

Strengthening work using BBR VT CONA CME external tendons

HIGHWAY TO THE SNOW

Also known as the Autoroute Blanche, the Bellegarde to Annemasse section of France's A40 motorway terminates close to the famous Mont Blanc tunnel. Completed in the early 1980s, this 110km section of motorway, which carries some 20,000 vehicles per day and connects around 30 towns, is a popular route to the Alpine ski resorts. There are several major structures along the route and Claude Néant of French BBR Network Member, ETIC, describes the strengthening work carried out on one of them – the imposing yet sleek Bellegarde Viaduct. ➤



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FACTS & FIGURES

- West viaduct – 5 spans, 39m to 65m long
- Central viaduct – one cantilever support at each extremity – 5 spans, 72m to 135m long
- East viaduct – 4 spans, 39m to 65m long
- Cross-section of the box girder – upper width 11m, height 3m to 6.5 m
- Total post-tensioning steel strand per viaduct – 70t each (x 2)
- BBR VT CONA CME 1206 and 0906 with 124 x 1206 anchors and 8 x 0906 anchors
- Length of 90mm external diameter HDPE ducting – 5,000m

The Bellegarde Viaduct, stretching across the Rhône Valley near Bellegarde-sur-Valserine, was built in the early 1980s by the cantilever construction method – using prefabricated segments. The structure is a 1,060m long, 14 span double box girder bridge with 13 piers per carriageway. ATMB, the owner of the Lyon to Geneva section of the A40, decided to replace the existing 30mm thick asphalt road and the 3mm thick epoxy waterproof layer with a completely new surface to provide greater durability. This might sound straightforward, but the consequence was that loads on the viaduct would be increased by an extra 150kg/m² as a result of the new 80mm thick asphalt layer, plus a new 30mm sheet waterproofing system. So, the decision was taken to reinforce the box girder bridge with additional external post-tensioning tendons. The existing expansion joints have also been replaced by new ones in the abutments and on the cantilever deck.

> "We calculated that it took us just 90 seconds to inject a 100m long tendon with wax heated to 100°C..."

PT methodology

The additional post-tensioning was calculated based on two tendons per web for the East and West viaducts and three tendons per web for the Central viaduct, all the additional tendons are anchored on either side of the corresponding span.

The existing viaduct was designed with a trumpet system allowing for additional post-tensioning. The trumpets and tubes had been concreted during construction, with diaphragms located above each pier.

It was this arrangement which led us to recommend the use of a special device in our tender to ATMB. This special device – essentially a circular tube – acts as an adaptor to connect the BBR VT CONA CME anchor head onto the existing trumpet, as well as allowing a final deviation of the strand in accordance with the technical requirements of the BBR VT CONA CME system.

Another special device – a circular molded elastomeric collar – was installed at the other end of the diaphragm to assure the continuity between the 90mm diameter HDPE pipe and the existing steel ducting.

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PT installation

All the HDPE tubes were introduced into the box girder from ground level – lifted by electric winch through the special service opening created in the box girder. The strands were pulled through a recess created in the upper slab, from strand coils resting on the upper slab. Then installation of each HDPE tube was carried out by means of a temporary support until the stressing operation and the continuity of the HDPE tube was assured by welding the joints.

The deviation of the tendons – two units per span – was concreted with a special mortar from the outside through a recess.

Corrosion protection

After stressing, the tendons were protected by injecting a special type of wax. This operation was performed with the help of a specially adapted truck – fitted with a tank, a power pump and a system to warm the wax and inject it at 100° Celsius. The truck was placed on the viaduct and the tube for the wax was fed through a temporary 160mm diameter recess created in the lower slab of the box girder. A team of nine staff carried out the injection – two in the special truck, five in the box girder and two in between those locations.

Wax injection of all the tendons for the first viaduct took only 2.5 days – including half-a-day to prepare the operation. We calculated that it took us just 90 seconds to inject a 100m long tendon with wax heated to 100°C – and that we used 15t of wax to inject the whole 5,000m length which was encased in 90mm external diameter HDPE ducting. ●

1 The Bellegarde Viaduct stretches across the Rhône Valley (page 81).
2 New loads from viaduct resurfacing and waterproofing meant that additional PT was needed for structural reinforcement.
3 Two special adapters allow connection of the BBR VT CONA CME anchor head onto the existing trumpet.
4 The new PT tendons running inside the box girder.
5 Built in the 1980s from prefabricated segments, the viaduct is a 1,060m long, 14 span double box girder bridge.

TEAM & TECHNOLOGY

Owner – ATMB
Main contractor – JV Demathieu et Bard + ETIC
Consultant – INEXIA
Designer – Lux OA – Luxembourg
Technology – BBR VT CONA CME external
BBR Network Member – ETIC S.A. (France)

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KINGFISHER BRIDGE, **KOTA KINABALU, MALAYSIA**

Urgent remedial work following bridge pile movement

BBR TO THE RESCUE

> "...we outlined a plan to underpin the existing foundation with micropiles and replace the damaged bearings."

A second link bridge was under construction to improve access to the Women & Children's Hospital at Kingfisher Park. Meanwhile, the pile cap at Pier 2 of the existing Kingfisher Bridge – with its span configuration of 28m + 56m + 28m – had moved 150mm in a transverse direction from its original position, explains Yan Man Chung of **BBR Construction Systems**, the Malaysian-based BBR Network Member.

This movement was a result of on-going piling for spun piles for the new bridge which was only 1.5m away. Due to the lateral movement on the existing spun piles, the piles had cracked and their structural capacity reduced, while the displaced bearings were not functioning properly. The situation was very alarming.

As we were working on the new bridge, we outlined a plan to underpin the foundation of the existing bridge with micropiles and replace the damaged bearings. Shear keys were installed on the top, sides and soffit of the pilecap when water levels in the river were at their lowest.

After pilecap enlargement, the multiple cell box girder bridge was jacked up at six jacking points to enable replacement of the five pot bearings – total capacity 2,000t.

After epoxy curing, the flat jacks were lowered simultaneously to transfer the bridge weight onto the new bearings.

The Client and Public Works Department benefited from our quick action and experience in providing an effective solution to this critical problem. ●

TEAM & TECHNOLOGY

Owner – Public Works Department, Malaysia

Main contractor – Kumpulan Kalasahan Sdn Bhd

Prestressing contractor – BBR Construction Systems

Technology – Bearings, Heavy lifting

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

1 Shear keys were installed on the top, sides and soffit of the pilecaps at low water.
2 The bridge was jacked up at six points to enable bearing replacement.

EDITH RIVER BRIDGE, **AUSTRALIA**

Repairs and refurbishment of flood-damaged railway bridge

BACK ON TRACK

Flooding caused by heavy rainfall from Cyclone Grant in December 2011 washed away part of the Edith River Bridge in the Northern Territory of Australia. There was an urgent requirement to get trains back up and running on the busy Alice Springs to Darwin rail line. Richard O'Connor from Australian BBR Network Member **Structural Systems**, presents a pictorial overview of the project.

1 A freight train was derailed during the flood which washed away the Edith River Bridge. This caused a great disruption to all freight and passenger services between Darwin and Katherine, including the iconic 'Ghan' – on which passengers can enjoy one of Australia's 'Great Railway Journeys'.

2 Carbon fiber strengthening work was carried out. Cracks were repaired by full depth epoxy injection.

3 Two weeks of continuous operations ensured speedy bridge re-opening.

4 All the girders needed to be realigned, both laterally and longitudinally.

5 The southern abutment with the remnants of the train wreck.

6 Following the completion of the works, the bridge was load tested before being reopened.

TEAM & TECHNOLOGY

Owner – Genesee & Wyoming Australia Pty Ltd
Main contractor – BJB Joint Venture
Designer – Kellogg Brown & Root (KBR)
Technology – Heavy lifting, MRR
BBR Network Member – Structural Systems Limited (Australia)


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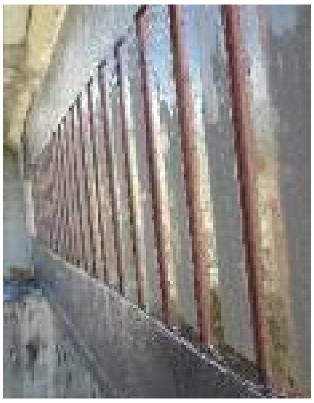
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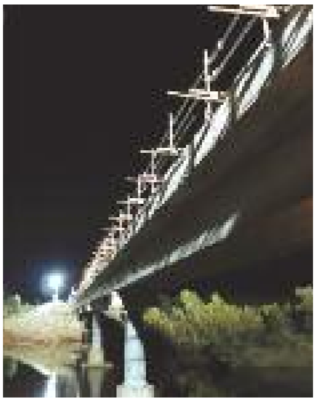
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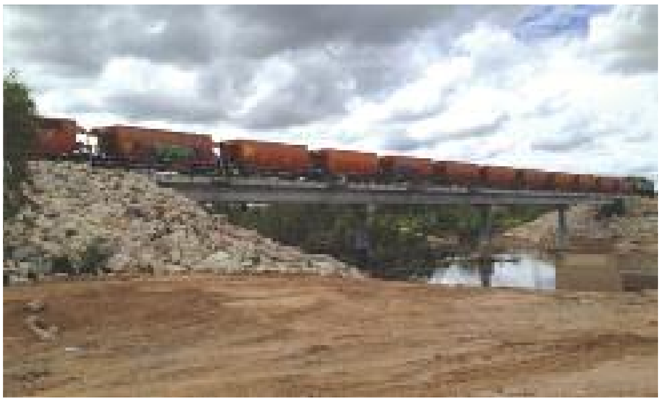
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PROJECT HIGHLIGHTS

Brief overview of three BBR Network MRR projects

IMPROVING INFRASTRUCTURE

These three projects demonstrate just some of the special techniques and skills for improving existing infrastructure applied by BBR Network Members throughout the world.

1 Bridge refurbishment, Salzburg, Austria

For refurbishing Kenlachbrücken I and II – two bridges on the B311 national road in Salzburg, Austria – BBR Network Member KB Vorspann-Technik used BBR VT CONA CMB external 2 x 0206 for prestressing the newly enlarged pier heads as well as flat jacks for bearing replacement. Flat jacks for supporting the new bearings were first pumped up with hydraulic oil, then finally the media was changed to grout.

TEAM & TECHNOLOGY

1 **Owner** – Bridge Department; Federal Government of Salzburg
Main contractor – STRABAG SE
Designer – SPP, Spirk&Partner ZT GmbH
Technology – BBR VT CONA CMB band, Flat jacks
BBR Network Member – KB Vorspann-Technik (Austria)

2 **Owner** – Infrastructure Department, Federal Government of Styria, Austria
Main contractor – HTL-Bau GmbH
Designer – Daninger & Partner Ziviltechniker KG
Technology – BBR VT CONA CMB band
BBR Network Member – KB Vorspann-Technik GmbH (Austria)

3 **Owner** – Dunedin City Council
Main contractor – BBR Contech
Designer – MWH New Zealand Ltd
Technology – MRR
BBR Network Member – BBR Contech (New Zealand)

2 Bridge strengthening, Styria, Austria

A country road bridge, about 50km from the Austrian town of Graz, has been strengthened by BBR Network Member, KT Vorspann-Technik using BBR VT CONA CMB 4 x 0406 and 3 x 0406 external band tendons. As one lane had to be kept open at all times, the tendons were installed in two operations, but stressed together to avoid asymmetric loading.

3 Bridge cathodic protection, Dunedin, New Zealand

BBR Contech has installed an impressed current cathodic protection (CP) system on Dunedin's Kaikorai estuary bridge – a vital link between the city and the suburb of Brighton. The CP system is connected to a computer, enabling remote monitoring and adjustments as necessary. Strict operational specifications apply during the repair and installation work to protect the estuary's wetlands ecosystem.

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exploring various ways in which BBR technology has set new competitive benchmarks, literally passing the test of time

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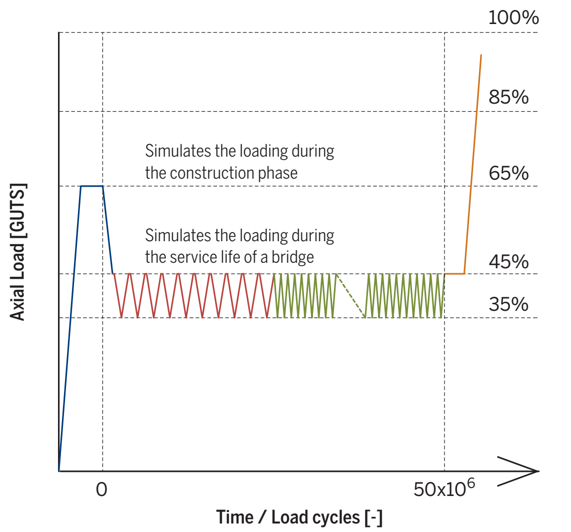
RESEARCH & DEVELOPMENT

BBR HiAm CONA and DINA stay cable systems prove their ability to perform

SETTING NEW COMPETITIVE BENCHMARKS

In day-to-day operational conditions and in the laboratory, BBR HiAm CONA and DINA stay cable systems have set new benchmarks for BBR technology.

Recent proof loading tests of DINA wire cables supporting Australia's iconic Sydney Tower and long term fatigue lab tests on HiAm CONA stay and extradosed cables have proved their durability and, quite literally, their staying power.



Test procedure to simulate the loading during construction and service phase for stay cables.

Three decades in harness

The cables in the 309m high Sydney Tower are now reaching their 30-year design life and to provide certainty as to their structural integrity and future service capacity, Australian BBR Network Member Structural Systems recently performed proof loading – using purpose-designed stressing equipment – to the stay cables' full design ultimate load.

While observation and analysis showed that there had been some minor losses, the cable net was meeting anticipated performance criteria. Regular monitoring and detailed inspections will ensure confidence in continued cable performance.

Staying power

BBR VT International's Head of Technology, Dr. Antonio Caballero and Wolfgang Träger, PhD student at the Institute for Structural Engineering of Vienna University of Technology (TUW), describe how, in the course of a research project, two long-term fatigue tests were carried out on one BBR HiAm CONA stay cable and one extradosed cable, subjecting them both to up to 50 million load cycles.

The tests were carried out in the light of current debate about whether the initial approval testing of stay cable systems to two million load cycles, as specified by approval bodies such as *fib*, PTI and CIP, is sufficient – as many bridges will experience greater load cycles over their lifetime.

BBR CARBON FIBER TECHNOLOGY

First long term testing of carbon fiber reinforced polymer PT tendons

PASSING THE TEST OF TIME

BBR began testing carbon fiber reinforced polymer (CFRP) technology back in the early 1980s and a patent, covering both post-tensioning and stay cable anchorages, was granted in 1995. A report has recently been published on the results of long term monitoring carried out on test tendons placed inside Dintelhaven Bridge in the Netherlands, which provides evidence of the strength and stability of CFRP post-tensioning.

Serving the Port of Rotterdam, Dintelhaven Bridge was constructed in 1999 using the free cantilever method and has a main span of 185m. Rijkswaterstaat – the government body responsible for major infrastructure in The Netherlands – saw an opportunity here to trial CFRP tendons. The four 75m long CFRP external tendons, installed over the bridge piers, were made of 91 x 5mm diameter CFRP wires, encapsulated in a polyethylene tube. Before installation, two prototype tendons were tested and stressed at the first stage to the same load as intended for the bridge tendons. After that, the stressing load was increased step-by-step by 15%. One tendon was stressed beyond its limits during third stage stressing and failed after 19 days because of slippage in the anchorage. However, the other was stressed only to the second stage and continues to perform well, having retained its full stress load with little or no slippage of wires at the anchors over a 10-year period. The same performance is demonstrated by the tendons installed on the bridge.

One of the report's authors, Senior Bridge Specialist, Cor Kuilboer of Rijkswaterstaat, commented: "Generally, the CFRP external tendons performed well over the 10-year monitoring period. This is a most interesting material, with great stiffness and strength, and I can see applications for it particularly in long span or cable-stayed bridges where weight is an issue." As well as being relatively lightweight construction – making longer spans possible for suspension bridges, for example – use of CFRP cables or tendons also offers reduced long term maintenance even in the harshest environments. ●

Testing

The testing procedure followed during the long-term fatigue tests featured:

- Anchorages at both sides inclined 0.6° for both, the stay and the extradosed cable, and oriented such as to create an S-shaped cable profile.
- Specimen initially loaded up to >60% GUTS to simulate overloading during construction and cable replacement. Although service loads for stay and extradosed cables do not exceed 50% GUTS and 60% GUTS respectively, that load level can in fact be exceeded during cable replacement or during the construction phase using installation methods such as strand-by-strand. Although that initial higher load might increase wedge biting, stress concentration and damage in the strands, it is not considered in current standards. BBR VT International has included this effect to more realistically reproduce current loading and installation methods.
- For stay cable, upper load 45% GUTS and stress range equal to 200MPa, or for extradosed cable, upper load 55% GUTS and stress range equal to 140MPa.
- Fatigue loading for up to 50 million load cycles. Real structures are subjected to a number of load cycles, which is much higher than the number of cycles at which systems are tested according to the current standards. Although real structures are designed to undergo smaller fatigue stress, current tests are not enough to predict whether the progress of wire failures with load cycles, in a particular stay cable system, follows a 'stable' or 'unstable' progression. Testing the system up to 50 million load cycles can answer this question.
- Subsequent static load test to failure.

Results

Both HiAm CONA specimens showed a very high fatigue resistance with minimal number of wire failures. Wire failures also appeared in a 'stable' manner demonstrating the long term reliability of the HiAm CONA system. Subsequent static load tests also showed excellent results with ultimate breaking loads that exceeded the ultimate limit state (ULS) specified by *fib* – demonstrating the superior performance of the HiAm CONA system under long term fatigue conditions. ●

TECHNICAL UPDATE

BBR VT CONA CMI is the most economical – and environment friendly – PT system on the market

SAFER AND GREENER CONSTRUCTION

With the implementation of European standards for construction products, you might be forgiven for thinking that all products in one category were exactly the same. Dr. Antonio Caballero, Head of Technology for **BBR VT International**, explains why the BBR VT CONA CMI post-tensioning system remains the best available.

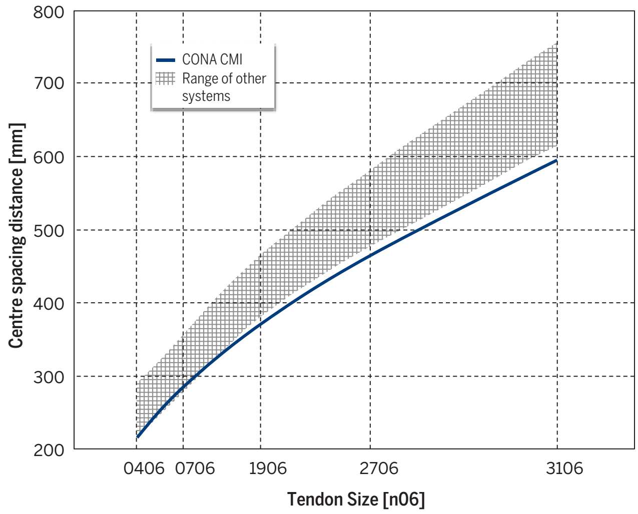
Following the introduction of the European Construction Product Directive (CPD) – Council Directive 89/106/EEC – all construction products used within the European Union must carry CE (Conformité Européenne – European Conformity) marking. Post-tensioning kits can only carry the CE marking if a European Technical Approval, in accordance with ETAG 013-2002, has been obtained from an eligible approved or notified body.
Since the CPD came into force, all suppliers of post-tensioning kits have been working with great diligence to secure approval for their systems.
Despite the assessment criteria specified in ETAG 013 being common to all post-tensioning kits, the advantages of the CONA CMI system are clearly evident when compared to other competing systems.
These advantages are a direct result of the multi-million dollar investment in R&D by BBR VT International Ltd, made with the sole intention of making the best Swiss technology available – at the best price and to all clients.

Two key benefits, in particular, of the CONA CMI system must be highlighted:

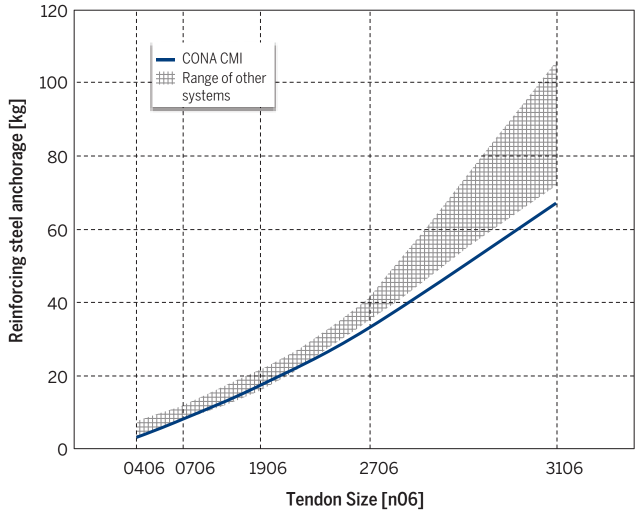
Reduced center-distance between tendons
The CONA CMI system undoubtedly offers the smallest center-distance for all tendon sizes and at the lowest mean compressive concrete strength – $f_{cm,0} \geq 19/23$ MPa – thus allowing for very slender concrete elements, without compromising the construction program.

Optimized use of reinforcing steel
The use of reinforcing steel in the anchorage zone is also optimized, leading to savings of up to 120% when compared with other systems in the marketplace.

Apart from the obvious and clear economical benefits – in terms of reduced material and labor costs – these material savings also make the CONA CMI system the most environmentally friendly CE marked post-tensioning kit on the market. ●

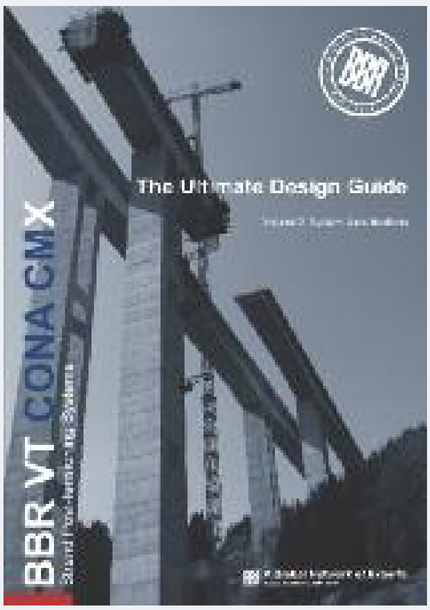


Graph showing that the BBR VT CONA CMI BT system offers the smallest center-distance for all tendon sizes.



Graph showing how use of the BBR VT CONA CMI BT system promotes optimized use of reinforcing steel in the anchorage zone – leading to savings of up to 120%.

ESSENTIAL CONA CMX ENGINEERING GUIDE



Within the BBR Network, we have a long history of innovation founded on listening to what our customers want and then going the extra mile to deliver it. The CONA CMX System Specification is the ultimate 'must-have' guide for engineers for quickly and efficiently finding all the technical data they need to design post-tensioned concrete structures.
You will see that we have focused on creating a 'user-friendly' technical guide aimed at assisting engineers to select and specify PT systems correctly, offering design and detailing recommendations, advising on appropriate corrosion protection and guidance on calculating prestress loss, eccentricity and minimum radii of curvature. We have also made the engineer's life even easier by pre-calculating and building easy-to-read tables showing bursting reinforcement requirements and the minimum edge and centre spacing distance for the entire CONA CMX range of PT systems at various concrete strengths.
This amazing technical guide will be available in the first quarter of 2013.
Contact your local BBR Network Member for a copy or download it directly from the BBR website – www.bbrnetwork.com.
Also download our latest CAD files here for the complete engineer's guide to designing post-tensioning! ●

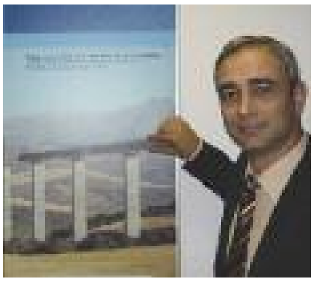
TECHNIQUES

Incremental launching of bridges can save time, money, space and disruption while easing access and delivering a high quality finish

SLIDING INTO PLACE

Juan Linero of BBR PTE, the BBR Network Member in Spain, outlines the incremental launching method and highlights the benefits of adopting this approach to bridge construction.

1



1 The incremental launching method was chosen for construction of the 1,176m long, 18-span Barbantiño Viaduct in Galicia, Spain because of the rough terrain and great height of the piers.
2 During construction of Spain's 1,444m long Arenteiro Viaduct, 65 bridge segments with a combined weight of over 50,000t were launched.
3 Duplication of the existing Mount Henry Bridge connecting Perth to Mandurah, Western Australia involved the incremental launching – to provide least disruption and quickest construction – of large 76m spans across the Canning River.
4 The 107m long deck of the Eix de Llobregat motorway bridge in Cataluña, Spain, was launched on a downhill gradient of 1% in one phase.

At its most basic, incremental launching involves the progressive assembling or casting of the superstructure on one side of its final location – on an abutment – and subsequently longitudinally pushing or 'launching' it into its final position.

How is it carried out?

While the whole superstructure can be assembled before the pushing operation, usually the launching operation takes place after each segment is completed, providing enough room to add the subsequent segment and repeating the process until the structure is completely finished and in its final position. Where there are long or heavy elements, or minimum execution time requirements, the superstructure is divided in two parts and they are launched from both abutments at either side – and finally joined somewhere in the middle after their simultaneous or alternate launching.

The superstructure is supported and guided along its travel by sliding supports and lateral guides located in abutments and piers.

To overpass the piers with a minimum of flexural forces being induced into the structure, usually a 'launching nose' is used. The launching nose, light in weight, facilitates the structure – still in a cantilevered situation – to reach the next pier where it will be supported. Sometimes, lifting jacks or other lifting elements are used in conjunction with the launching nose to provide the height needed to clear the pier or abutment. Temporary piers or supports can be required too.

This technique applies to both steel and concrete structures and is virtually unlimited by length or by weight. However, it can only be used on structures with a constant geometry – that is, with almost straight or circular structures in plan and in elevation – and a constant height.

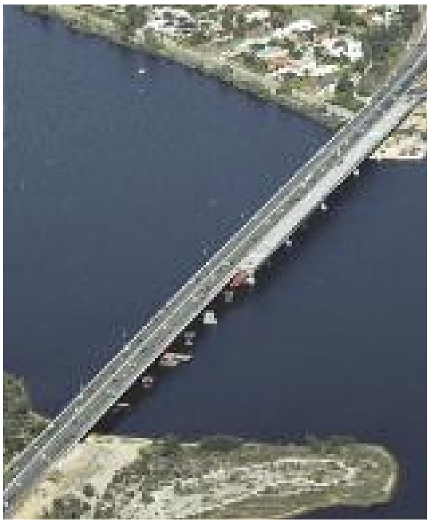
2

"Although its significant advantages make using this technique a highly attractive option, certain aspects require a high level of expertise – both in terms of people and equipment."

Why is it carried out?

The main reasons and advantages for using this construction methodology, rather than other traditional methods, are:

- Minimal disturbance to environmentally sensitive areas.
- Smaller assembly zone required.
- Greater safety during construction which is mainly carried out at ground level.
- Economy of transportation and general reduction in construction elements.
- Higher quality finish and performance derived from easier working conditions and repeatability of tasks.
- Ease of access to restricted or limited sites – such as over rivers, deep valleys, road or train lines, in poor soil conditions or environmentally protected areas.



3

Who is it performed by?

Although its significant advantages make using this technique a highly attractive option, certain aspects require a high level of expertise – both in terms of people and equipment.

The full structure itself must be carefully designed to support maximum flexural forces along any part of its length during the launching phase. Launching parameters – launching force, retaining force, emergency brakes, launching speed, pier tilting, wind and so on – must be controlled and balanced at all times, together with the friction forces at sliding supports and guiding elements. Demanding construction tolerances and working procedures must be adopted to avoid any unforeseen events which might introduce higher forces capable of permanently damaging the piers. Members of the BBR Network have much experience, acquired over many years, in the techniques of incremental launching and a track record for successful delivery of launched structures all over the world. ●

4

1

2

INSIGHT

Description of technique for making new openings in an existing unbonded post-tensioned slab

CREATING NEW OPENINGS

The need for architectural modifications in post-tensioned concrete slabs can sometimes arise – whether in newly-built structures or buildings undergoing refurbishment. Kresimir Bogadi from BBR Adria in Croatia, guides us through the technique which is used when a modification to an unbonded post-tensioned slab is needed, but the length of strand protruding beyond the anchorage is not sufficient for a jack to grip it and mechanically de-stress the strand.

In these days where the focus is on sustainable practices, this technique can help to extend the life of a structure and further endorses the flexibility of post-tensioned slab construction. Before any work is carried out, it is important that qualified engineering personnel analyze and check the stresses in the slab – both during the temporary operational phase and in the final condition with permanent and live loading. In addition, they should also ensure that all safety measures are in place during the operational phase.

1 The Mepas Mall shopping center in Mostar, Bosnia & Herzegovina was approaching structural completion when a new opening was required in a post-tensioned floor.
2 The new opening in the PT floor slab created space for additional escalators.


1


2


3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6


7


8

STEP-BY-STEP GUIDE

1 The slab is marked out, carefully locating positions of the strands. A cover meter could be used if necessary.

2 Next the slab is back-propped to release the gravity load stresses in the slab and provide vertical support to it during the slab modification works.

3 Concrete is carefully removed around the post-tensioning tendons to expose the strands. Meanwhile, a solid protection barrier is installed at the anchorages at both ends of the slab. Once all safety measures have been observed, the strands are carefully cut using the application of heat, so that there is a slow and controlled release of the tension in the strands.

4 The full opening in the slab is created. The cut strands are then shortened to their new correct lengths, carefully removing the heat affected portion of the strands from the earlier heat cutting.

5/6 New anchorages are installed along with new wedges and protection caps. Reinforcement is placed in the slab as required by the engineer.

7 New slab edge formwork is installed around the new opening, followed by concreting of the area around the slab opening and at the anchorages.

8 The final shape of the opening is formed and the tendons are ready for re-stressing. Finally the slab can be de-propped, before handing back to the client. ●

Thomas Heubel, CEO, KB Vorspann-Technik – and a member of the board of directors of BBR VT International Ltd – reflects on recent international sporting events and the message they carry

IGNITING INTERNATIONAL EXCELLENCE

During the past year, many major sporting events have taken our breath away – a particular highlight was, of course, the London 2012 Olympic Games. Although for us, as engineers, the newly created stadium complex and associated infrastructure had been a focal point for much longer, it seemed as though the sparks from the lighting of the magnificent Olympic cauldron ignited interest in excellence and success everywhere around the world.

Experiencing such highpoints often makes us think that the limits must surely have been reached – yet time-and-time again, these boundaries are broken.

We want to break records too!

While 80% of our work involves dealing with and managing everyday projects, our customers are always looking for reliable partners to solve difficult tasks with reliability, high quality and value for money.

So what can we learn from a spectacle such as the Olympic Games which is clearly more than just a sporting competition about heights, lengths and hundredths of seconds?

Sports people from the whole world come together to compete in a peaceful environment – regardless of race, creed or culture – not only to discover who is the best, but also to represent their country and make many new personal contacts.

The experience of being part of a team – making an individual contribution to the success of the team and, at the same time, benefiting from the strength of the team – is something quite special. Establishing a place in the team, finding and being given opportunities to interact with many others with similar experiences is especially important for young people and also helps them to find their place in life – and in society generally. The exchange of information across borders opens up possibilities and opportunities on an unimaginable scale, lending special value to the Olympic ideal that 'being there is everything'.

Well, what does this mean within the context of this magazine about the BBR Network and post-tensioning technology?

The answer is quite simple.

If you browse through the pages of CONNÆCT 2013 again, you will notice how numerous and diverse the reports and features on worldwide construction projects are. Yet the basis is the same for all. All authors and their organizations have become part of a global team in which they bring their strengths and likewise benefit from the strengths of other members. In this spirit of international teamwork within the global BBR Network, many local challenges have been solved. Our interest, however, goes far beyond just wanting to be there.

Let yourself be inspired and harness the strengths and advantages of this globally operating team to provide answers to your problems in an increasingly competitive market.

You can also find your place with us! ●

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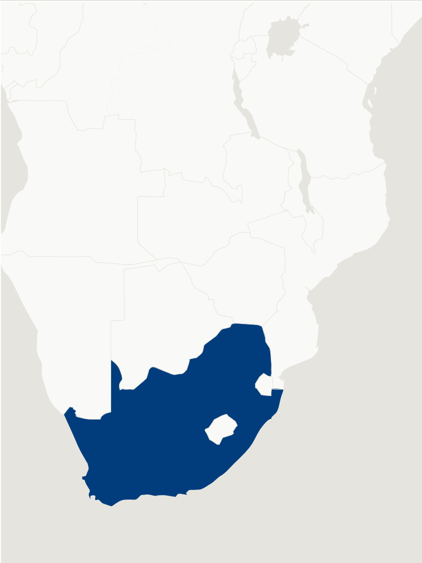

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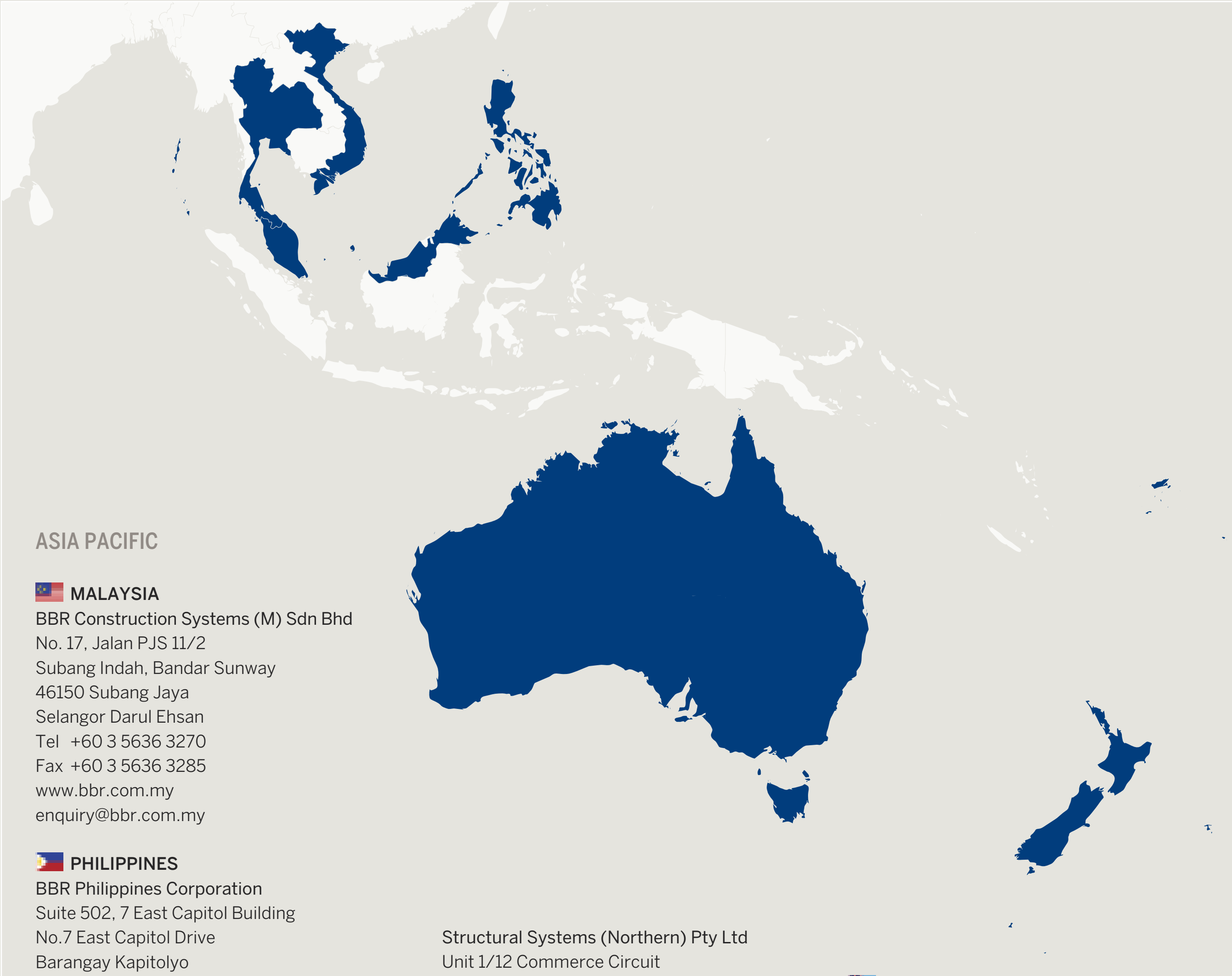

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