CONNECT

THE MAGAZINE OF THE GLOBAL BBR NETWORK OF EXPERTS

Edition 9 | 2015

OVERARCHING EXPERIENCE

Construction of two arch bridges

CULTURE OF SERVICE EXCELLENCE

How BBR shapes exceptional outcomes for customers

CREATING NEW LANDMARKS

BBR Network's stay cable bridge quartet

SKYSCRAPER SUCCESS

Four tower projects rise together

TEST REGIME GOES EXTRA MILE

BBR technology passes additional cryogenic tests

www.bbrnetwork.com

A Global Network of Experts
www.bbrnetwork.com

The BBR Network is recognized as the leading group of specialized engineering contractors in the field of post-tensioning, stay cable and related construction engineering. The innovation and technical excellence, brought together in 1944 by its three Swiss founders – Antonio Brandestini, Max Birkenmaier and Mirko Robin Ros – continues, more than 70 years later, in that same ethos and enterprising style.
From its Technical Headquarters and Business Development Centre in Switzerland, the BBR Network reaches out around the globe and has at its disposal some of the most talented engineers and technicians, as well as the very latest internationally approved technology.

THE GLOBAL BBR NETWORK
Within the Global BBR Network, established traditions and strong local roots are combined with the latest thinking and leading edge technology. BBR grants each local BBR Network Member access to the latest technical knowledge and resources – and facilitates the exchange of information on a broad scale and within international partnering alliances. Such global alliances and co-operations create local competitive advantages in dealing with, for example, efficient tendering, availability of specialists and specialized equipment or transfer of technical know-how.

ACTIVITIES OF THE NETWORK
All BBR Network Members are well-respected within their local business communities and have built strong connections in their respective regions. They are all structured differently to suit the local market and offer a variety of construction services, in addition to the traditional core business of post-tensioning.

BBR TECHNOLOGIES & BRANDS
BBR technologies have been applied to a vast array of different structures – such as bridges, buildings, cryogenic LNG tanks, dams, marine structures, nuclear power stations, retaining walls, tanks, silos, towers, tunnels, wastewater treatment plants, water reservoirs and wind farms. The BBR brands and trademarks – CONA®, BBRV®, HiAm®, HiEx, DINA®, SWIF®, BBR E-Trace and CONNÆCT® – are recognized worldwide.
The BBR Network has a track record of excellence and innovative approaches – with thousands of structures built using BBR technologies. While BBR's history goes back over 70 years, the BBR Network is focused on constructing the future – with professionalism, innovation and the very latest technology.

BBR VT International Ltd is the Technical Headquarters and Business Development Centre of the BBR Network located in Switzerland. The shareholders of BBR VT International Ltd are: BBR Holding Ltd (Switzerland), a subsidiary of the Tectus Group (Switzerland); KB Spennteknikk AS (Norway), BBR Polska z o.o. (Poland) and KB Vorspann-Technik GmbH (Germany) – all three are members of KB Group (Norway); BBR Pretensados y Tecnicas Especiales PTE, S.L. (Spain), a member of the FCC Group (Spain).

FOCUS ON GLOBAL SATISFACTION

Although BBR has now celebrated its 70th anniversary, this is no time for resting on our laurels – after all, there's only another 30 years until our centenary and so much more to achieve before then!

After reading this edition of CONNÆCT, you will realize the entire BBR Network is firmly focused on the future and continuing to provide excellence in every aspect of customer service. In Talking BBR, you can read about how deeply this is embedded in our corporate DNA, as well as news highlights and feature length reports on the Asia-Pacific region and our 70th Anniversary Conference.

Our Portfolio section features more 'headline grabbers' than ever before – two arch bridges, four cable-stayed bridges and no less than four skyscraper projects – all under construction by the BBR Network at the same time. Clearly in the execution of work on site, our global BBR family is delighting customers – many of whom are now regular clients where not only trust, but also enjoyable working relationships have grown, such as in the bridges and commercial buildings sector in Poland and ground slab market in New Zealand. The article on page 66 about wind tower development in Germany is one not to miss – it's a great example of how collaborative inter-industry innovation can help customers meet their aspirations.

Right from the R&D stage, as you will see in the Technology section, our commitment to providing the finest solutions is supported by testing over and above current guidelines as we develop technologies and techniques – based on feedback received – to improve all-round performance, capability and durability.

BBR may indeed be seven decades old, but we still have many dreams to realize and challenges to meet – our mission and vision of providing the finest construction technology and services to satisfy global customers is stronger than ever.

Marcel Poser
Chairman, BBR VT International Ltd

José Manuel Illescas
Vice Chairman, BBR VT International Ltd

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TALKING BBR

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BUSINESS REVIEW

Reflections and outlook from BBR VT's CEO

CULTURE OF SERVICE EXCELLENCE

The BBR heritage is one of achieving excellence for customers – through individual performance, as an international team and also in collaboration with other professionals. BBR VT International Ltd's CEO Antonio Caballero reveals how this is part of BBR's corporate DNA, reviews recent developments and presents an outlook for the future.

Last year saw great celebrations to mark our 70th Anniversary – after all, not many companies can trace their origins back over seven decades these days. However, while it was certainly a time for reflecting on past achievements, it was also an appropriate moment to evaluate exactly why we have been successful for so long.

Innovative solutions

The most obvious success factor has been our ability to consistently provide what customers need, when they need it and how they need it. Our whole business has always been about coming up with solutions to customer challenges – in fact, it is part of our corporate DNA, as the company was founded on innovations designed to meet market needs. Thus, one of our strongest genetic markers is for problem-solving – we like to solve problems, but more than that, where other people see problems, we see new opportunities.

This is essentially what sustains our business – as there will always be problems. If you establish the right communication channels, you will create the right environment and team. Then you can give the right answer. This is actually the main source of innovation – identify the problem, then identify the opportunity. An excellent example of this is the BBR Network itself.

Business model

Our challenge was to find the best way to bring the latest technology to the global market while ensuring quality delivery for customers. The answer was to create a global network of well-established locally based organizations – either major or specialist contractors – who thoroughly understand their own particular market place and share our passion for providing leading edge solutions through construction technology.

BBR HQ has two main goals – developing the finest and most advanced construction technology and supporting BBR Network Members, not only with specialized project support, but also in developing their businesses.

This business model has been very successful. Many BBR Network Members have been with us for 50 or 60 years and this long track record is only achievable because their customers know they are getting all-round quality and support.

Communication channels

Open communication is the vital force – the strength – of the BBR Network. Without it, some of the greatest ideas would never see the light of day and constant improvement of best practice techniques would simply not happen.

Our regular training courses, local country visits and the annual BBR Global Conference are key communication channels for the success of our Network. Our training sessions bring operational staff together and they learn and share with each other how specification, delivery and installation should take place. Meanwhile, visits by BBR HQ to BBR Network Members help promote and grow the local businesses through roadshows, trade exhibitions, local meetings and seminars.

The BBR Network Global Annual Conference, however, is a unique and quite extraordinary vehicle. We bring very diverse people together – BBR VT International shareholders, senior executives of BBR Network Member companies, also key specialists and so on – from all over the world. The initial idea is to share experience, market situation and trends, develop strategic thoughts, joint solutions – in other words, facilitated and enhanced networking. Both regional and global gatherings also facilitate knowledge transfer, networking, exchange and training of best practice – and are a source of joint ventures for large projects. We are progressively seeing more-and-more collaborations among Members with mutual benefits for the parties.

In the past year, there has been some great work between Network Members in Spain and the United Kingdom, as well as between those in Australia and Singapore. Currently, the Swiss Tamina Bridge project (see page 26) is benefitting from the combined experience of KB Vorspann-Technik from Austria and local Member Stahlton and enhanced customer satisfaction has been assured in the commercial ground slab sector through collaboration between New Zealand and Australia (see page 44).

By sharing knowledge, the BBR Network is delivering the best international solutions for customers. ➤

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> "Of course, the best feedback of all is when we learn that BBR Network Members have secured major new contracts for landmark projects."

Research & development
While much of our work happens behind the scenes, our commitment to customer service is usually only experienced or quantifiable at the point of delivery. Of course, it's the BBR Network Members who make use of our technology and have personal contact with customers on a daily basis and so it's their feedback that makes a major contribution to our R&D activities. The new BBR HiAm CONA Viscous Damper, and the new anchorages HiAm CONA Uni Head Short socket, CONA CMO and CONA CMW (see the Technology section, page 81) are, for example, recent developments which originate from market requests made through the BBR Network.
Very often in special projects, the standard approach is not sufficient and fully tailored solutions need to be developed. I can remember, for instance, the water treatment plant in Melbourne where a special pin connector to cope with the movements of methane gas covers had to be developed. We offer this special development facility where it makes commercial sense – and it's also an opportunity to increase our portfolio of products.
Every new development needs to undergo a stringent testing and QA process before it reaches the moment of production and delivery to the client. We simply have to be certain that our technologies meet the highest possible criteria before we make them available in the market place.
Customers like certainty – and so do we. Of course, the best feedback of all is when we learn that BBR Network Members have secured major new contracts for landmark projects – such as Poland's new cable-stayed Rzeszow Bridge, the Sydney North West Rail Link requiring a massive 2,500t of prestressing steel and the new passenger terminal at Zagreb International Airport with its 'levitating' architectural design – where BBR technology will be a competitive, effective and sustainable solution for both customers and end-users.

Staying ahead of the game
Among our key strengths is our global presence all around the world. We would like to strengthen this presence, so are actively promoting the benefits of the BBR Network – and looking towards enlarging our family by incorporating new Members. Even the best technology should have a competitive price. We'll soon be expanding regional production capabilities to increase competitiveness of the local Members, at the same time as securing quality and reducing lead times for delivery.
We will also be extending our technology portfolio to allow us to tackle different types of projects where we don't already have a presence. Our main goal in doing this is to provide our Members with a full package of technologies – allowing them to deliver added value to their clients, as well as diversifying their activities, remaining competitive and increasing the sustainability of their businesses.
Evaluation is also underway on the creation of specialized engineering teams whose mission would be to support Members regionally with special projects. Other work is being undertaken on both the technology development front and on initiatives to further support Members, but these may be something for the next edition of CONNÆCT.

Culture of excellence
Today, BBR's DNA is a blend of international expertize and our original Swiss engineering innovation. It is, in a sense, the culmination of everything the BBR founders strove to achieve – innovation on a global scale to provide the very finest solutions for customers.
The Greek philosopher Aristotle observed: "We are what we repeatedly do. Excellence, then, is not an act, but a habit." Within the BBR Network, excellence is even more than just a habit – over the last 70 years it has become our way of life. ●

Dr. Antonio Caballero

1 Dr. Antonio Caballero, CEO, BBR VT International Ltd.
2 BBR was founded over 70 years ago on innovations designed to meet market needs by Antonio Brandestini, Mirko Robin Roš and Max Birkenmaier.

NEWS HIGHLIGHTS

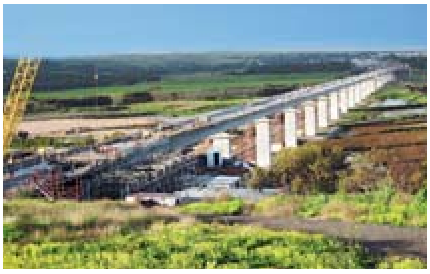
Awards, events and more

INTERNATIONAL INSIGHTS

An exciting year has passed – and there is an even more exciting one ahead. These news items presented here are a selection of the achievements within the BBR Network during 2014 and hint at developments to come.

New BBR HQ under construction
BBR's new HQ is currently under construction and the six storey building will be completed by the end of 2015. BBR's new headquarters – which it will share with sister company Proceq – naturally features floor slabs post-tensioned with BBR VT CONA CMI internal and CMF flat PT tendons, being installed by Swiss BBR Network Member, Stahlton.

Outstanding contribution
BBR Contech MD, Paul Wymer has received an Honorary Membership from the New Zealand Concrete Society for his outstanding industry contributions. Society Past President Andrew Dallas said: "Paul has always pushed for quality and innovation... has certainly played his role in enhancing our industry's place on the New Zealand and international stage."



BBR Network Project of the Year 2014
Seaford Bridge, in Adelaide, Australia was declared the Project of the Year for its demonstration of the BBR Network's major, multi-disciplined project capability and ability to provide innovative solutions protecting the environment – and excellence in customer service delivery. Built for a rail extension scheme, the bridge was incrementally launched across an environmentally sensitive river landscape.

BBR European Project Managers' Workshop
The three day workshop which included a site visit focused on pre-fabricated PT tendons for accelerating on-site activities and high performance characteristics of BBR VT's range of plastic ducts and associated accessories. Content also included latest BBR R&D and testing news, interactive workshops on new BBR technologies and best practice sharing from recent projects.

New BBR brochures launched
Three new brochures are now available from BBR HQ or by download from the BBR Network website:

- **BBR HiAm CONA Strand Stay Cable Damping Systems** – in response to recent competitive tendering bids, BBR VT has developed a viscous strand stay cable damper to complement the existing friction based BBR Square Damper.
- **BBR VT Plastic Duct & Accessories** – covering the full range of BBR VT Plastic Ducts and associated accessories.
- **BBR VT LNG/LPT PT Technology Project References** – outlines BBR capability for cryogenic containment situations and lists the projects completed in over 30 years' experience in this specialist field. ●

SSL becomes SRG Limited
Australian BBR Network Member Structural Systems Limited and associated entities including ROCK Australia have rebranded into one unified company called SRG Limited. This amalgamation brings with it a clearer vision for its customers and means that SRG Limited can bring their combined expertise, skills and technical excellence in an integrated and precise way to all their projects.

ANNUAL BBR GLOBAL CONFERENCE, **INTERLAKEN, SWITZERLAND**

Technical updates, networking and knowledge exchange

CONFERENCE NOTES

The newest addition to the team at BBR HQ in Zurich – Josef Lamprecht, Head of Production and Supply Chain – shares thoughts and experiences from his first Global BBR Conference. Josef joined the company in February 2014, bringing many years of experience in the creation and management of supply chains in new markets.

70th ANNIVERSARY 1944-2014

My first impression was how amazing it was to see everyone – coming in from all over the world – and to meet up together in the same place. The many networking opportunities created were obviously valuable to all delegates – it seemed as though each person had their own 'networking agenda' and methodically worked through it over the three day period. There was a real 'buzz' about the place.

Uplifting welcome

Our pre-conference welcome event set the tone for the conference – we were all treated to an awe-inspiring helicopter flight over the Eiger-Mönch-Jungfrau mountain region. This must be the best kept secret in the history of the BBR Network – even though working at BBR HQ, I had no idea this was planned. It really hit a high spot, in every sense, before our three days of meetings had even begun.

Formal sessions

Our CEO Antonio Caballero welcomed everyone formally and talked about focusing on 'sustaining success' and the importance of working together towards this common objective. Next, Thomas Richli, Chief Business Development Officer, delivered an overview of construction activities within the BBR Network over the past year, along with an informative insight into the latest construction industry trends and some news updates.

Then there was a kind of double act – with Project Leader, Behzad Manshadi giving an excellent briefing on technology and R&D

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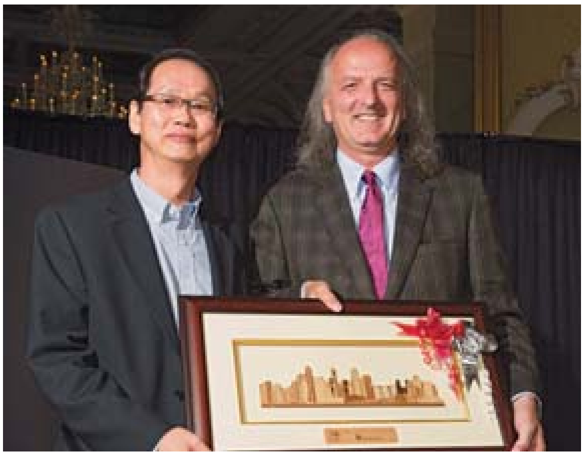
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1 The entire BBR Network team at the Gala Dinner give the thumbs-up to BBR's 70th Anniversary – and the next 70 years.
2 All set for take-off are (LtoR) Zelimir Bodiroga (BBR Adria), Jan Piekarski (BBR Polska), Jelmer van Woesik and Hans Veerman (Spanstaal – Ballast Nedam).
3 Andrew Tan of BBR Construction Systems, Singapore presents Bruno Valsangiacomo with a specially commissioned artwork to commemorate BBR's 70th Anniversary.
4 The best kept secret – the conference began with a helicopter ride over the Eiger-Mönch-Jungfrau mountain range.

highlights, with my updates on production and supply chain developments following on seamlessly. After that, Juan Maier summarized the marketing, business development and franchising activities of the last 12 months.

Interactive workshop

The next day began with something new to the BBR Network – an interactive workshop, moderated by Professor Sean A. Meehan from IMD Business School in Lausanne. Long term organic growth was the key subject and the focus was on how delegates can differentiate their businesses in their own specific markets. This was followed by more networking opportunities and a team building event focused on local Swiss culture.

70th Anniversary Gala Dinner

The greatly anticipated '70th Anniversary Gala Dinner' – to which some special guests had also been invited – took place that evening at our 'base camp', the Victoria Jungfrau Grand Hotel & Spa.
First, came the BBR film premiere – where the new BBR 70th Anniversary video was screened. I will never forget the reaction of one of our guests – the renowned bridge engineer Christian Menn – when he saw the aerial views of Sunniberg Bridge, one of his (and our) finest projects! Everyone enjoyed his amazement and felt a shared sense of pride.
It has always been our tradition at annual BBR Global Conferences to raise money for charity and this year, we thank our kind sponsors – a number of BBR Component Manufacturers. The funds were directed towards SOS-Kinderdorf which helps children directly affected by the conflict in Syria.
This conference will be memorable to many people, but I shall always remember just how good it was to meet face-to-face with BBR Network Members – all successful business people, representing successful companies in their own market places. The discussions we had were extremely useful and will inform the work we undertake, on their behalf, at BBR HQ in coming months. We are now looking forward to our 2015 conference which will be held in Bangkok, Thailand. ●

2014 BBR AWARD WINNERS

BBR NETWORK PROJECT OF THE YEAR

Seaford Bridge, South Australia, executed by SRG (Australia)

BEST ARTICLE AWARD

- **Winner:** BBR Construction Systems (Singapore)
  Title: Unclogging the bottleneck (Keppel Viaduct, Singapore)
- **Runner up:** BBR Polska (Poland)
  Title: Early involvement for best solution (PT slab & beam solutions, Poland)
- **Highly commended:** BBR Contech (New Zealand)
  Title: Going underground (Sewer refurbishment, Auckland, New Zealand)

BEST PHOTOGRAPHY AWARD

- **Winner:** Stahlton (Switzerland)
  Title: Innovative tunnel construction (Cross City Link project, Zurich, Switzerland)
- **Runner up:** ETIC (France)
  Title: Flying entrance for school (Cable-stayed access bridge for school, Luxembourg)
- **Highly commended:** BBR Polska (Poland)
  Title: Symbol of progress (Official opening of Przemysl Bridge, Southern Poland)

SPECIAL REPORT

BBR in the Asia-Pacific region

TECHNOLOGY FOR TIGERS

The BBR relationship with the Asia-Pacific Region began over 50 years ago, with BBR technology being used for a number of major projects. Today, there are BBR Network Members in key locations throughout the southern hemisphere – including some in so-called 'Tiger' economies. Thomas Richli, Chief Business Development Officer, reports on BBR's track record in the region, current initiatives and commitment to further strengthen the Asia-Pacific market in the future with expertise, latest technology and first-class services.

As the wheels of the world economy begin to turn again after the recent economic downturn, commentators have forecast that the largest growth in GDP (Gross Domestic Product) will be experienced in the Asia-Pacific Region. By 2020, Asia is expected to have a 46% share, in terms of construction expenditure, of the global construction market – a rise of 15% compared to 2005.

Construction demand

Burgeoning populations and growing urbanization are the main drivers for new infrastructure provision in many countries. Environmental legislation, as well as whole life costings, are key issues for the approach of some Asian markets. Owners, designers and construction contractors will face challenges over coming years in the delivery of long span and stay cable bridges, energy schemes, LNG containment, water sector projects and high rise buildings.

Specialist BBR expertize

Help is certainly on hand from within the BBR Network. Our expertise in a variety of specialized construction engineering fields – prestressing technology, slab post-tensioning, stay cables, temporary bridge construction works, precast engineering and maintenance, repair and renovation (MRR) services – is available locally to support customer requirements. BBR Network Members, all well-established in the region, include BBR Construction Systems – daughter company of BBR Holdings (S) which is listed on the Singapore Exchange – operating in Singapore, Malaysia, Thailand and Vietnam, with BBR Philippines based in Manila and the newest BBR Network Member, SRG (Hong Kong). Further south, the publicly traded Structural Rock Group (SRG) and BBR Contech provide services for customers in Australia and New Zealand respectively.

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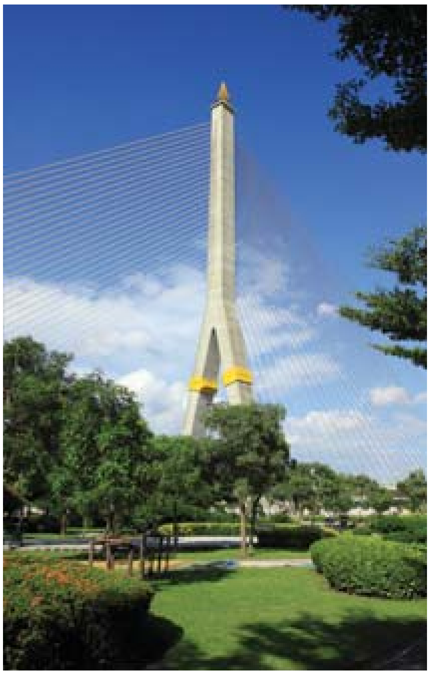

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1 Vidyasagar Setu Bridge, Calcutta, India – a composite box girder bridge with three spans, featuring 148 BBR HiAm stay cables arranged in a double plane around the two pylons. Known for a while as the Second Hooghly Bridge, this was the first cable-stayed bridge in India and still remains the longest cable-stayed bridge in India. Photograph © Swarnasekhar Kumar / Wikimedia Commons / CC-BY-SA 3.0.

2 Genkai Nuclear Plant, Saga Prefecture, Japan – the containment vessels for two of the four nuclear power stations at this plant were post-tensioned with BBR technology.

3 Rama VIII Bridge, Bangkok, Thailand – with a 300m main span, this is one of the world's longest single pylon cable stayed bridges. Opened in 2002, as part of the city's highway infrastructure, the bridge over the Chao Phraya river features 84 wedge-anchored BBR HiAm strand stay cables.

4 Binh Bridge, Hai Phong, Vietnam – featuring BBR technology, this 1,280m long 17-span composite cable-stayed bridge joined the north and south of the country's third largest city.

5 Chientan Station, Taipei, Taiwan – great skill was needed to ensure the stressed BBR stay cables would bear the weight of the 200m long concrete roof. This is the flagship station on the Taipei Rapid Transport System and the architectural vision was to echo Chinese tradition by shaping the roof structure, with its inclined pylons, as a dragon boat.

Sound experience

BBR's relationship with the Asia-Pacific region started in the early 1960s, when Australia's Snowy River Hydro Electric Scheme was under construction. At the same time, a similar story was unfolding in New Zealand – with infrastructure needs in the shape of a dam spillway for a geothermal power development scheme and major motorway system.

In the 1970s, BBR collaboration with leading construction contractor Hutama Karya who saw the pioneering of prestressing technology in Indonesia.

Later, in 1979, the BBR team was gearing up to install BBR HiAm stay cables for the 457m long Second Hooghly River Bridge in Calcutta –the first and still the longest cable-stayed bridge in India. Next came another thrilling bridge project – the Godavari Arch Bridge – India's longest railway bridge and one of the longest span post-tensioned concrete arch bridges in the whole of Asia.

During the 1970s and '80s, BBR technology was applied to various nuclear power plant projects – including one in South Korea and three in Japan. Road infrastructure was also developing rapidly in Japan at that time and, by 1990, BBR stay cable systems had been applied to around 40 of the nation's new bridges.

BBR technology soon found its way into major infrastructure developments in Hong Kong and Taiwan too. Projects included the Tai Wo Hau Station and Tunnels Contract for the MTR, Harbour City, New World Center, the Pok Fu Lam Road / Hill Road Flyover, the Tung Chung section of the North Lantau Expressway and the spectacular roof of Taiwan's new Chientan Station.

New era

BBR post-tensioning, stay cables and specialist services had, by the 1990s, won favor in Singapore, Thailand, Malaysia and the Philippines where today there remain many new and challenging projects for BBR Network Members.

In the early years of the 21st century, BBR technology was also a feature of Vietnam's Binh Bridge, Taiwan's High Speed Rail Project, the Rama VIII Bridge in Bangkok, Thailand and the Seri Saujana Bridge – a stunning stay cable project in Malaysia.

Projects currently underway in the region include the 2nd Penang Crossing, LRT Extension in Kuala Lumpur and the North West Rail Project in Sydney.

BBR Network Members have completed over 260 stay cable projects in Asia and nine LNG tanks in Asia-Pacific. Nearly 50% of BBR's business volume is transacted in the region and we are targeting still further growth.

One of our initiatives includes local and regional customer seminars, such as the collaborations between BBR HQ and Network Members produced in 2014 – with the ASEC conference in Auckland and client meetings in July, visits with customers in Sydney and Melbourne and a road show in Manila. We will also hold the next BBR Global Conference in Asia – further reinforcing our focus on the region.

We recognize that every market place is unique – with different requirements and customs – and that the best people to approach these markets are actually local companies who are well-established and well-versed in the ways of doing business in their home territories. Our role at BBR HQ is to support BBR Network Members with the latest international technology and techniques, so that they can play their part in delivering excellence in customer service locally. ●

PERSPECTIVE

Building the right team for exceptional customer service

ENHANCING CUSTOMER SERVICE

Since 2012, **José Manuel Illescas** has been Vice Chairman of BBR VT International and Vice Chairman of BBR Network Member, BBR Pretensados y Technicas Especiales (BBR PTE), Spain – which is part of the major FCC contracting group. In a career spanning over 25 years, he has developed expertise in bridge technology and other concrete structures. Here, José Manuel talks about the benefits that owning a BBR PT Specialist Company can bring to a construction contractor.

Firstly, I'd like to put things into context by explaining that FCC – originally founded in 1900 – is a massive organization, employing over 70,000 people worldwide. There are three main business streams – Environment, Water and Infrastructure. The latter stream contains the construction contracting part of our business and has many sub-divisions – including BBR PTE – each of which has both the capability and knowledge to deliver a wide range of services.

Added value & competitive strategy

The many specialist companies and divisions within our organization have evolved over the years, in line with our strategy to provide clients with significant added value. Having specialist knowledge and expertise in-house – and therefore always on hand – helps us to do that.

For FCC, this clearly gives us a competitive edge. We can collaborate on the projects from the very beginning – with each of our teams understanding perfectly how they should work with teams from elsewhere in the business to the benefit of the project as a whole. Of course, the knowledge and learning we acquire from each project then also remains in-house and we can use this again for future projects.

By having in-house specialist companies and divisions we shift the mind-set away from the traditional specialist subcontractor approach – potentially adversarial – to one which is of mutual collaboration between the main contractor and specialists for the benefit of the overall project and ultimately the client.

Without doubt, specialist support from an in-house partner is most useful for major projects – such as high speed railway lines or aerial metro lines and special structures or bridges – where a well-coordinated approach between the main contractor and specialist partners is needed from tender stage, through design and onto construction.

There are many examples which demonstrate that this way of working is successful for us. Maybe the best example is our approach for precast segmental bridges where we have in-house resources for design, equipment, segment manufacture, deck erection and, of course, BBR PT and stay cable technology – and heavy lifting, if needed.

The New Europe Bridge over the River Danube at Vidin, Bulgaria and the Rio Navia Bridge in Spain are good examples of where in-house collaboration has delivered excellent results. In fact, these two bridges have won several international awards – perhaps that is no coincidence.

Innovating for an internal client

In many ways, working for an internal client is not so different from working with external clients. You always have to do your best. You have to be ready for collaboration at any stage of the project – and you have to be competitive on quality, price and delivery time.

With a range of in-house specialists, FCC is able to take a more holistic approach to problem solving, dealing with project constraints and developing solutions that otherwise may not have been possible under the traditional approach to project procurement. Consequently FCC is better positioned to integrate the complexities of the design, procurement, installation and operative phases of a project in order to bring significant value to the client through a better quality output in a shorter delivery period and at a more cost effective price.

A further example here is the Almonte Bridge project where, currently, BBR PTE is installing the temporary stays for the arch of the new bridge – and where the success of the project will be a direct result of a special collaborative effort between BBR PTE and parent company FCC.

An in-house PT Specialist can help a parent contracting organization in many ways and there are a lot of synergies to be considered and on which to capitalize.

As much as we have helped our parent company to win work and realize some massive projects, they have also opened the door for us to show our most innovative capabilities on a broad scale – together we are providing some really exceptional results for our customers. ●

PORTFOLIO

IN THE SPOTLIGHT

BBR Polska celebrates 20th Anniversary

WINNING HEARTS & MINDS

BBR Polska's two decade-long journey has been about more than delivering technology, first the team had to convince organizations, engineers and contractors of the benefits of the BBR approach, while the country grappled with transition to a free-market economy. BBR Polska – the BBR Network Member in Poland – has just celebrated the 20th Anniversary of its founding and CEO Jan Piekarski shares with CONNÆCT readers his own thoughts and the story of the company's evolution.

Older colleagues recall that the relative surge in the use of post-tensioned concrete in Poland – despite the permanent lack of prestressing steel – dates back to the 1960s. Within the former Comecon (Council of Mutual Economic Assistance) structure, post-tensioning steel was produced only in Czechoslovakia, but quotas and quality were poor.

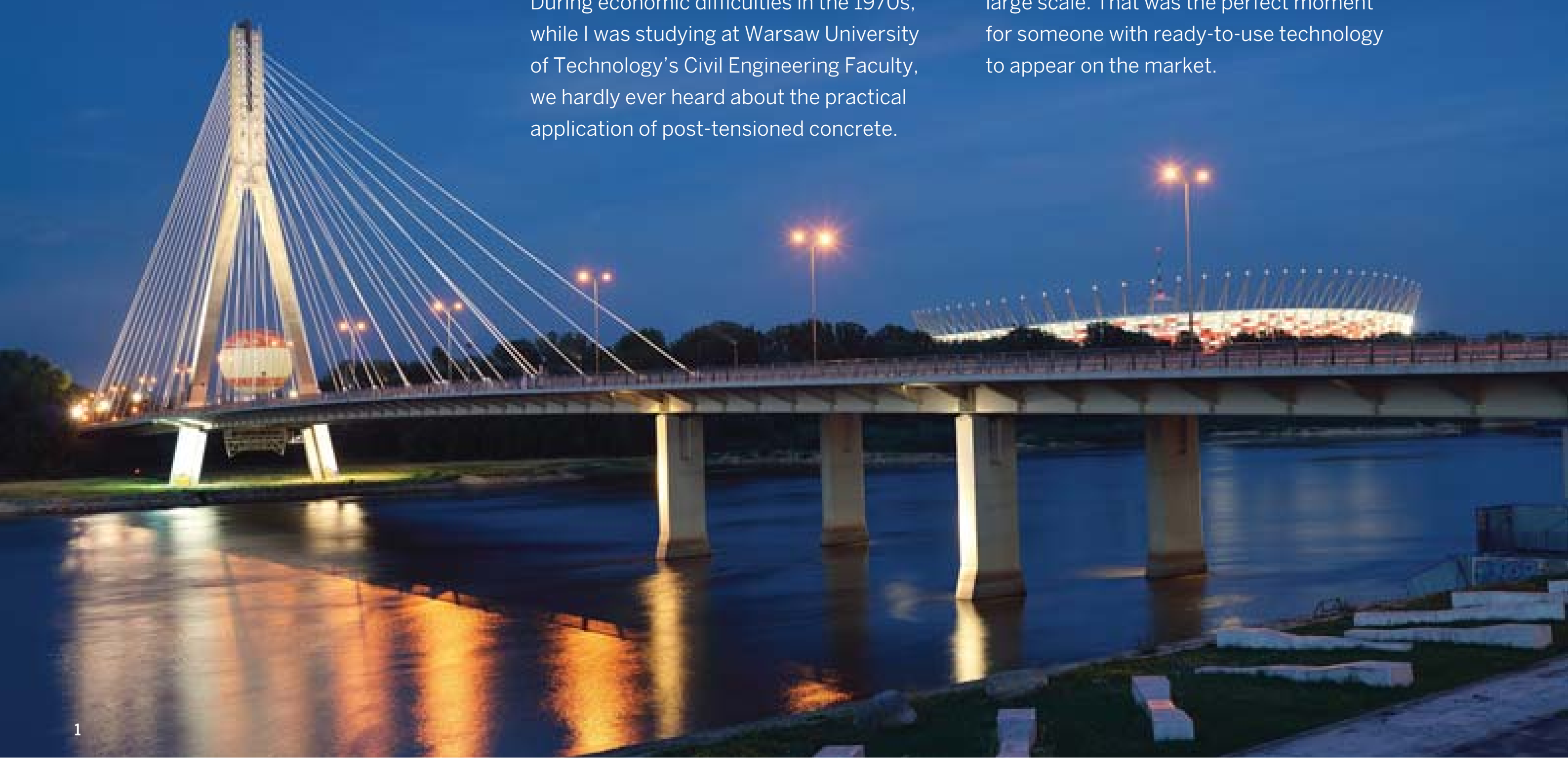
Sometimes, lack of acceptance for a prestressed structure resulted not from economic, but political issues. Strategic structures, such as bridges over major rivers, were built according to the military doctrine – of steel, rather than concrete. Yet still, designers created interesting projects and contractors managed to construct them – often by means of improvised technologies, which was a speciality back then.

During economic difficulties in the 1970s, while I was studying at Warsaw University of Technology's Civil Engineering Faculty, we hardly ever heard about the practical application of post-tensioned concrete.

General economic decline engulfed the beginnings of modern technologies. However, the idea survived with several Universities of Technology continuing to search for solutions.

Some time later, the Road and Bridge Research Institute tried to create their own system and two river bridges were constructed in segments, using incremental launching technology. These were pioneering structures which did not much resemble the current day application of post-tensioned concrete.

In the field of prestressing technology, seven-wire strands were then dominating the globe – as were wedge anchorages. Yet, there was still a gap here in Poland between copying individual components and applying complete technologies on a large scale. That was the perfect moment for someone with ready-to-use technology to appear on the market.



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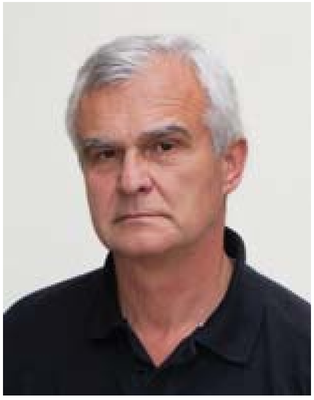


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Birth of BBR Polska

In the early 1990s, BBR shareholders decided to expand activities into our part of Europe. The idea originated from Bruno Valsangiacomo, an experienced strategist who had anticipated the opportunities of the emerging market. Being an expert on the Polish business environment, Bruno later became the driving force behind the greenfield operation in Poland. Back then, while working in Switzerland, I had an ideal opportunity to meet the key players in BBR. Soon I met the management board to discuss the possibility of opening a Polish BBR Branch. A few days later, I was appointed project coordinator.
The meeting was attended by Zurich Office Director, Fritz Ernst Speck – an outstanding engineer and an excellent source of the technical know-how for the young company, actually the most significant person for the development of BBR Polska. Through his patient instruction, counseling and support with customers, we were able to improve our skills.
BBR Polska was founded on 8th March 1994 in Warsaw as a limited liability company – thereby, with its legal status and solid financial backing, distinguishing itself in the Polish market which was then cluttered with numerous sales representatives and marketeers.

Early days

Even after obtaining an acceptance certificate for this prestressing system, one would be mistaken for thinking this ground-breaking product – accepted worldwide – would be welcomed into the Polish market. Although an incrementally launched prestressed viaduct, motorway bridge and a steel trussed bridge with a composite prestressed concrete slab were under construction here, the broadly defined industry was not yet ready to accept the innovation of post-tensioned concrete. We kept hearing: 'That new technology of yours...' so we kept on explaining that it was not 'new', it had been around for years – just not applied in our country. Thus, the first years of our existence were more about education than construction! However, an arch bridge over the Narew in Ostroleka gave us the opportunity to enter the market, as well as to present stay cable technologies, bearings and expansion joints. It was these products which enabled us to survive the years when we were only re-promoting post-tensioned concrete – effectively, refreshing the memory of our engineers who had been familiar with the product before the 20-year long period of technological hibernation.

First PT bridge projects

Opening our roadways to Europe resulted in traffic congestion, with consequent load increases on bridges and, ultimately, an urgent need for bridge strengthening. Strengthening the old bridges required a static system change – from simply supported beams into a continuous beam. We applied PT bars and prestressed the bridges with external tendons. As we did not yet have a strand-pushing machine, we pulled the cables into ducts with a tractor! The first post-tensioned structures that were really ours – right from the design stage – were the viaducts and footbridge over the A4 motorway in Katowice. The project delivered the mental breakthrough which was unforgettably summed up by a customer – 'why didn't you tell us it was so simple?'
In the following years, we worked on many similarly 'simple' structures. ➤

1 Swietokrzyski Bridge – construction involved prestressed abutments carried out with PT bars, incremental launching, bearings, suspension with the BBR HiAm stay cable system and, finally, expansion joints.
2 Father Laetus Bernatek Bridge, Krakow – this 172m long arch bridge was constructed on the riverbank and, after partial tensioning, was launched on barges and rotated into its final position. It features two curved decks – one for pedestrians and one for cyclists – supported on steel crossbeams suspended with fully locked coil cables from a steel arch. The arch is tied with BBR VT CONA CME external tendons.
3 Madalinski Bridge – this arch bridge over the Narew River in Ostroleka features 10 pairs of BBR DINA stay cables. It gave BBR Polska an entry into the market and remained our flagship project for some time. Photograph courtesy of Briho, CC-BY-SA-2.5, 2.0,1.0, accessed at en.wikipedia.com, August 2014.
4 Jan Piekarski – CEO and co-founder of BBR Polska (top). Fritz Ernst Speck – the BBR Director and later member of the BBR Polska Supervisory Board, who guided the new Swiss-Polish business to success (bottom).

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5 Swinna Poreba – this incremental launching project, involving a viaduct curved on plan, earned the trust of civil engineering contractor KPRM and has led to many further projects together.
6 Milenijny Bridge, Wroclaw – Poland's first post-tensioned cable-stayed bridge and for over ten years was the nation's only cable-stayed concrete cantilevered structure. The project was executed under a design-build arrangement, a fairly innovative approach in those days.
7 Grudziadz Bridge – the high-water mark of BBR Polska's achievements in cantilever technology. The company operated eight form travelers concurrently and carried out the prestressing of the entire superstructure, as well as supplying and installing huge modular expansion joints.
8 Hall of Champions, Wloclawek – this parabolic hyperboloid structure was the first cable supported structure of its kind in Poland. The two-direction layout of cables is made up of load-bearing and tensioning cables. Photograph courtesy of Mariochom, accessed at commons.wikimedia.org, August 2014.
9 Siekierkowski Bridge, Warsaw – the BBR Polska team applied the then new BBR CONA Stay system to this 500m long three lane road bridge, with pedestrian walkways and cycle tracks.

Growing trust & milestone

In the mid-1990s, Kielce Civil Engineering Company (KPRM) invited us to work with them on a project in Swinna Poreba. The circumstances allowed us to modify the methodology to incremental launching. Our successful work here secured the trust of KPRM, which soon resulted in another collaborative project for the River Oder bridge at Opole.

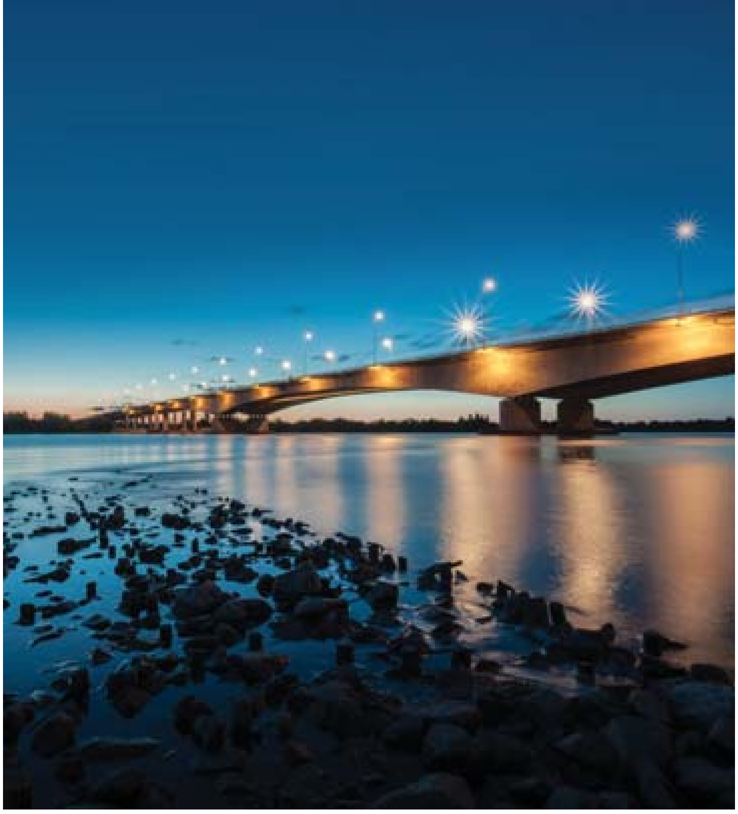
The Opole project was a real milestone – extremely important to us as a company and to the development of post-tensioning technology in Poland. We priced an alternative PT option – realized with cantilever methodology – for KPRM and together we won the tender. All the bids for a concrete alternative were cheaper than the cheapest steel bridge – an iconoclastic event which generated a wave of disbelief, suspicion and predictions that one day the chickens would come home to roost.

After a comparatively small bridge project in Krzyzanowice, came the construction of Zwierzyniecki Bridge in Krakow, another successful team effort with KPRM. Earlier learning enabled us to complete this challenging project within 12 months – cantilever construction methodology allowed us to continue working despite bad weather and flooding! Ten years later, the same technology worked in even more harsh conditions, during construction of a river bridge in Sandomierz.

We were moving forward with a method of balanced development – focusing on building a reputation for first-class engineering services and technology, rather than spectacular projects. We only suggested solutions we truly believed in and our aim was to become the leaders in our field. However, we were searching for a flagship project – and in 2004, the Milenijny Bridge in Wroclaw came along. It required a design-build formula – a fairly innovative approach in those days. The project was the crowning glory of our so far really positive working relationship with KPRM. Meanwhile, ownership changes at the Kielce company meant that we actually completed the project with a contractor, by then, called Skanska.

The Milenijny Bridge, with its post-tensioning and stay cables, was considerably larger than any of our previous projects. The idea that had been born in Opole now became the company's mission – our challenge is to solve complex problems in an innovative manner.

Of the many bridge challenges which have followed, the high-water mark of our achievements in cantilever technology has to be the crossing over the Vistula river near Grudziadz, on the A1 motorway. It is a record-breaking structure – with a total length of nearly 2km and a main river span of 180m. During this project, we operated eight form travelers concurrently. We carried out the prestressing of the entire superstructure, as well as supplying and installing huge modular expansion joints. Realization of this bridge, constructed in difficult conditions during two extremely harsh winters and flooding, tapped into all our previous experience – and a significant part of our potential!



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"The idea that had been born in Opole now became the company's mission – our challenge is to solve complex problems in an innovative manner."

Suspended and cable-stayed structures
As mentioned, our first suspension project was a bridge over the River Narew in Ostroleka – an arch structure resting on four concrete supports on the river banks and a deck suspended with ten pairs of BBR DINA stay cables. The structure, designed by Marek Lagoda, was our flagship project for a long time – and still remains a landmark of Ostroleka city.
Warsaw was destined to welcome the third millennium with the first cable-stayed bridge in Poland – construction of the Swietokrzyski Bridge started in 1999 and was another milestone for BBR Polska.

The success of the project anchored the reputation of BBR Polska and paved the way for another cable-stayed crossing project – the Siekierkowski Bridge. This time, we applied another new technology – the BBR CONA Stay system which has been setting world standards ever since. Next, using a unique combination of our skills and experience, came Poland's first post-tensioned cable-stayed bridge and only cable-stayed concrete cantilevered structure – the Milenijny Bridge.
Many more bridges – including numerous structures for pedestrians and cyclists – have followed, each with its own particular character and challenges to our growing experience.
Meanwhile, at the turn of the century, we had the privilege of working on an interesting and unusual project – assembly and tensioning of a cable roof structure for the sports arena in Wloclawek, today called the Hall of Champions. It was the first cable supported structure of its kind in Poland – a parabolic hyperboloid structure. The two-direction layout of cables is made up of load-bearing and tensioning cables.
This project was a springboard for further schemes at Plock Amphitheater, the Dialog Arena Stadium and a further project in Plock – the Orlen Arena. ➤

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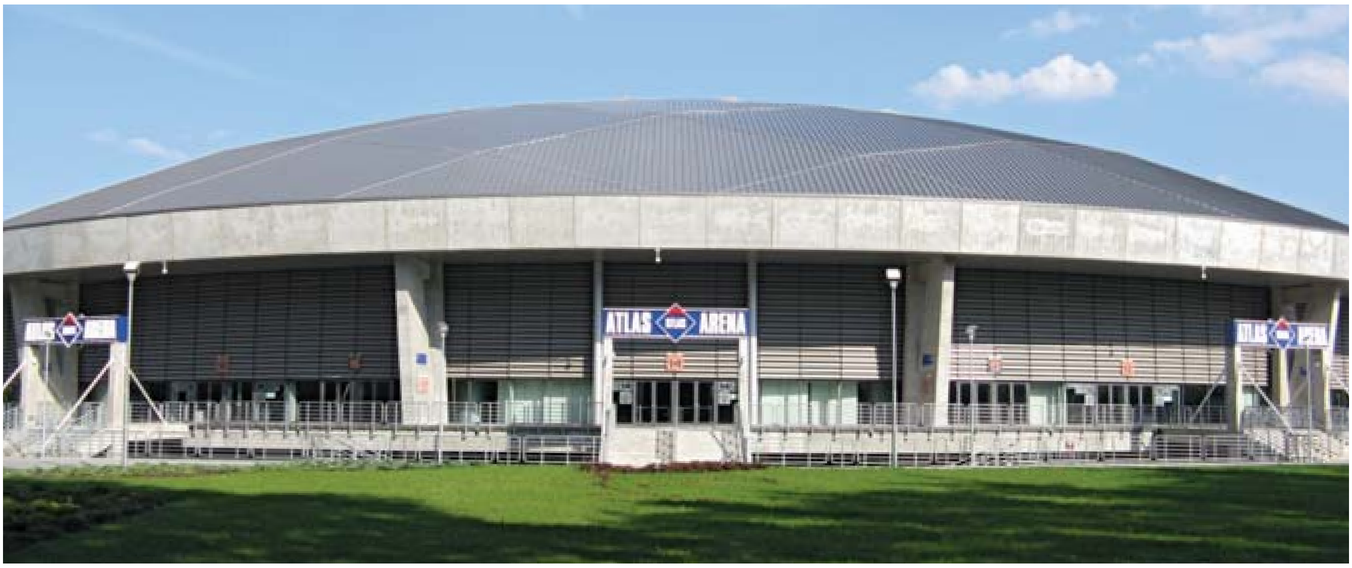

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PT Technology for buildings

As the new century dawned, we also witnessed and participated in a breakthrough in slab construction. Although we had already carried out some slab or girder strengthening with post-tensioning – usually during building conversion projects – we had still not managed to persuade project teams to embrace PT slabs for buildings. Meanwhile, the fashion for open plan offices brought a need for large column-free spaces and opened the market to PT slabs. Liberty Corner – a smart office building in Warsaw designed by Buro Happold became one of the first commercial building in Poland to have a column-free office space, thanks to BBR flat tendons.

Flat PT slabs in buildings are no longer a novelty in Poland. We are successful in providing post-tensioning as an alternative solution for reinforced concrete or precast concrete slabs. Quite often, as a result of previous successful cooperation, a contractor or a designer working on a new project turns to us to elaborate a PT solution – it happened, for instance, in the case of a parking lot next to the Centennial Hall in Wroclaw.

Post-tensioning has also been welcomed for the construction of sporting facilities and PT technology has helped to create some distinctive shapes, such as for the Atlas Arena in Lodz.

The BBR Polska portfolio also includes post-tensioning of numerous huge circular symmetrical tanks and silos – for storage of foodstuffs and materials.

PT ground slabs

BBR Contech in New Zealand helped us immensely in getting to grips with the technology for producing monolithic floors. Since our pioneering project, supervised by NZ-based Jeff Marchant, we have, among others, provided ground slabs for apple purée silos, an airport technical hangar and – to prove that it is not always true that the shoemaker's children are ill-shod – the manufacturing hall in our own steel structures plant has a monolithic post-tensioned slab-on-ground floor, which is tested every day!

10 Atlas Arena, Lodz – this structure is covered with a dome supported on a huge concrete ring, a box in cross-section, resting on 16 columns. We provided external and internal post-tensioning of the ring. We also suggested and implemented a dedicated bearing system for the ring – allowing radial movement while blocking tangential forces. Photograph © Zorro 2012 / Wikimedia Commons / CC-BY-SA-3.0.

11 Business Garden, Warsaw – BBR Polska continues to deliver large spans for office buildings using BBR post-tensioning. Here, there were spans of up to 11.4m, difficult shapes – most slabs were unique – and low material consumption rates, as well as a requirement for fast design and construction. In total 52,000m^2 of post-tensioned slabs were executed for this project.

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12 Copernicus Science Centre, Warsaw – a really interesting non-standard application of a post-tensioned platform which sits above the Wislostrada expressway tunnel, resting on 45m span post-tensioned beams, supported on both sides of the tunnel. Photograph © Wistula / Wikimedia Commons / CC-BY-SA-3.0.

13 John Paul II Bridge, Gdansk – this is the longest cable-stayed bridge in Poland supported by a single pylon. It was BBR Polska's sixth heavy lifting project and catalyst for further expansion and modernization of their equipment.

14 Euro 2012 Transport Junction, Wroclaw – an atypical structure where a railway and tram transfer node is integrated into a viaduct. It is a light sculpture-like structure reflecting all that is best in architectural concrete. Collaboration with the designer enabled the BBR VT CONA CMX system to be used to best advantage – it was applied to nearly all structural elements.

Heavy lifting

In the early days, we had three jacks – two for launching, one for prestressing. For five bridge launching operations, our jacks worked hard for us. When our sixth project – the John Paul II Bridge in Gdansk – came onto the horizon, we expanded and modernized our machinery stock. European Union projects and the preparations for hosting the Euro 2012 Football Tournament were catalysts for intensive expansion of the Polish road network. We were running on all cylinders and enjoying a real logistics challenge – managing detailed schedules for teams and machines consisting of 12 jacks, 150 slide bearings and 400 pads at a time... on four major construction sites in four different locations.

And sometimes the thing is not about bridges at all – we have lifted gas turbine set elements, a 40t drilling tower structure and, in 2009, we were given a special task which prompted us to invest in yet more new equipment. Construction of the Temple of Divine Providence in Warsaw saw us lifting a record-breaking 800t load to a height of 26m. It was a really breathtaking operation!

Special applications

We eagerly get involved in unusual projects with unique structural forms which often require non-standard work procedures or working under unusual conditions.

One of our most bizarre projects was for the construction of an eight storey 'catwalk' connecting the SAS Radisson Hotel in Warsaw with an adjacent office building. Other unusual projects have included repairing a hot water pipeline bridge and saving factory roofs which were in a perilous state.

Renovating historic structures is always satisfying – although, we often feel we are working in miniature, as was the case with the Church of Friars Minor in Opole. Here, we devised and implemented reinforcement, using high-resistance steel stressing ties, for the cracked side chapel vault and walls. Paradoxically, a larger scale process – such as bridge launching – needs the same precision.

While the Olivia Arena in Gdansk is probably not an architectural treasure yet, it is certainly historic. We strengthened the roof girders there by installing external stressing tendons. A few months later, as part of a seminar on post-tensioning technology, we presented a paper on that topic... under that very same reinforced roof.

Along with the logo of our Swiss parent company, we also adopted the motto 'Innovative Engineering' and we now continue to live up to that ideal with our partners who, since 2008, are the Norwegian group Spennteknikk International.

During the past 20 years, we have introduced many innovations into the Polish civil engineering market – and more importantly than this – as well as the built environment, we have also improved ourselves! ●

CONCRETE ARCH BRIDGES

Two new projects underway within the BBR Network

OVERARCHING EXPERIENCE

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Today, the construction of arch bridges provides practical infrastructure with minimal environmental impact – while delivering an aesthetically pleasing end result. We delve into the past to examine the BBR track record in arch bridge construction, before looking at the progress of two new arch bridges being realized with BBR technology. BBR PTE in Spain is working on the Almonte Bridge, while fellow BBR Network Members KB Vorspann-Technik and Stahlton are providing BBR technology and know-how for the Tamina Bridge in Switzerland, BBR's home territory.

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Arch bridges have evolved as a specialist structure category within the bridge genre and have presented challenges to engineers down the centuries. In modern times, the arch bridge regained popularity in the 1930s with structural engineer Robert Maillart's Salignatobel and Schwandbach bridges. Here, his innovation in aesthetic concrete design – with his post-tensioned decks, hollow box girder and three hinged arch approach – was to set the scene for the current generation of structures.

Prelude to the modern era

Back in the mid-1960s, BBR founding father Mirko Robin Roš was working alongside renowned architect and artist Max Bill on the design of the Lavoitobel arch bridge in Tamins, Switzerland. The bridge has a 105.7m span, with a post-tensioned deck and a 60m clearance above the ravine below. In those days, a large timber scaffold was created in the valley below to support the construction work. This practice was often very difficult from a topographical and geological perspective, but was certainly costly and time-consuming – as well as having a significant impact on the environment during construction. Ultimately, these concerns led to the development of the now well-known methods of free cantilevering, suspended cantilevering and cable-stayed construction, as well as incremental launching and construction with various systems using launching girders. These methods allow bridges to be built without supports from below. ➤

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"At the same time as Maslenica bridge was taking shape, the BBR team set about constructing a staggering total of 28 twin arches for the third Godavari Railway Bridge, near Rajahmundry close to the east coast of India."

Implementing new methods

With the latest expertise and technology, in 1980 the BBR team began construction of the Bloukrans Bridge with its 272m long span. It sits 216m above a gorge on South Africa's Garden Route between Cape Town and Port Elizabeth. The arch was constructed simultaneously from both banks in stages, involving segments of around 6m long and using the suspended cantilevering system with temporary suspension and tie-back cables.

A few years later, came the bridge over the Crotta Valley in southern Switzerland. This was a quite slender twin arch with a 90m span which was also erected by the suspended cantilever method. The first seven segments on each side were suspended by temporary stay cables, while the top elements were cantilevered. Formwork carriers, weighing around 15t each, were tailor-made for this project.

Croatia's 380m long Maslenica Bridge has a span of 200m and was constructed in the early 1990s, step-by-step from both banks by the suspended cantilevering method and using form travelers. The deck structure is supported by 11 twin columns spaced at 30m. The deck consists of prefabricated, prestressed T-beams – eight per span – with a cast in situ deck slab on top. The arch was constructed from both banks simultaneously in stages of 5.25m using temporary stay and tie-back cables.

In order to minimise the bending moments in the arch and at the same time to ensure that the required final arch profile was achieved, the suspension and tie-back cables had to be precisely adjusted at each construction stage.

At the same time as Maslenica bridge was taking shape, the BBR team set about constructing a staggering total of 28 twin arches for the third Godavari Railway Bridge, near Rajahmundry close to the east coast of India. Each set of twin concrete arches was erected by the balanced suspended cantilever construction method using temporary stay cables which were fixed to a temporary steel tower erected on top of the pier. The bridge was completed in 1996.

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1 Almonte Viaduct, Spain – artist's impression of bridge currently under construction with the help of BBR HiAm stay cables and heavy lifting techniques. Image courtesy of ADIF.
2 Lavoitobel Bridge, Tamins, Switzerland – in the 1960s, one of BBR's founders worked on the design of this arch bridge. Photograph courtesy of and copyright Fotostiftung Graubünden (www.fotoGR.ch)
3 Lavoitobel Bridge, Tamins – showing the timber scaffolding required to construct arch bridges in bygone days.
4 Bloukrans Bridge, South Africa – constructed in 1980 using the suspended cantilever method 217m above a gorge.
5 Third Godavari Railway Bridge, India – 28 twin arches were erected using the balanced suspended cantilever method.
6 Maslenica Bridge, Croatia – constructed in the early 1990s by the suspended cantilever method and using form travelers.
7 Crotta Valley Bridge, Switzerland – constructed in 1965 using the suspended cantilever method.
8/9 Almonte Viaduct, Spain – the arch, of what will be the world's widest single span arched high speed railway bridge, is being erected with the use of temporary BBR HiAm stay cables.

1 World's widest single span arched high speed railway bridge

Bringing the story right up to date is work to build Spain's Almonte Viaduct – where high speed railway infrastructure meets the latest BBR technology. BBR PTE's Andrés Soriano explains that the Almonte Viaduct is situated over the Alcantara-Garrovillas reservoir and will carry the AVE high speed railway from Madrid to Extremadura. The use of a concrete arch bridge here was dictated by the width of river to be bridged, the requirement that there should be no piles in the river bed and environmental constraints.

The 996m long Almonte Viaduct is the most prominent structure on this section of high speed railway. It has been designed with a 384m long central span arch sitting over 100m above the Alcantara reservoir. When completed it will be the widest single span arched high speed railway bridge in the world.

For the construction of the arch, it is necessary to install a provisional system of HiAm CONA 5506 and 3706 stay cables during the concreting of the segments and to establish a sequence to build it.

During the project, we will install a total of 208 temporary stay cables comprising a variable number of strands. The stay cables are arranged in two sections, North and South, and there are eight groups of stay cables – four for pulling and four for retaining operations. The HiAm CONA stay cables are divided into 26 'families' which are assembled on the ground, then installed in position using cranes. Before the segments of the arch are concreted, we stress the stay cables in a synchronised sequence, applying force to the pulling and retaining cables at the same time.

The pulling stay cables are anchored to the arch and the retaining ones to the concrete footings.

For cable families 9 to 26, steel tightening towers over piles 6 and 15 had to be installed to allow construction of the arch to continue. We are also using heavy lifting techniques to raise the tightening towers which are assembled horizontally in the access span.

Once completed, the high speed railway line will significantly reduce journey times for passengers – with trains traveling at speeds of up to 200km/h. The same line will serve freight trains and it is hoped to achieve a more balanced distribution of transportation which will also reduce road traffic. ➤


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2 Growing over the gorge

Another large concrete arch bridge is currently under construction amid the stunning alpine landscape of Switzerland's canton of St Gallen – with technology and expertize from KB Vorspann-Technik and Stahlton, the BBR Network Members for Austria and Switzerland respectively.
The Tamina Bridge with its 265m span is a key structure within an overall scheme to improve road links between Pfäfers and Valens, two small villages on either side of the scenic 200m deep Tamina Gorge, near Bad Ragaz and the Rhine Valley.
The bridge is a shallow asymmetrical post-tensioned concrete arch with a span of 265m, total deck length of 417m and up to 55m high piers. The free cantilever method was chosen for the erection of the arch, with temporary pylons and stay cables to support construction.
The arch consists of 55 concreted segments – starting from massive 50m high abutments either side of the gorge, where 32 segments will 'grow' from the Pfäfers side and 23 from the Valens side. The first segments have been designed as a box girder, while the last 10 to 12 segments on each side are fully concreted.

After detailed post-tender discussions about alternative construction concepts with the main contractor, KB Vorspann-Technik has been working with the construction team on the erection of the arch segments using temporary stay cables. Norbert Bogensperger outlines the process.
The segments are carried by 31 sets of temporary stay cables, anchored on both sides of the gorge at temporary steel pylons which are around 100m high. Close to the abutments, every second segment has a pair of stay cables and each of the last five to seven segments on each side also has a pair of cables.
To the rear of the pylons, a corresponding set of cables is guided to auxiliary foundation blocks which are secured by rock anchors to transmit the cable loads into the ground. We designed the temporary stay cables to meet the specific requirements of this bridge.
Cables on the arch side consist of up to 24 white PE-coated monostrands, while back span cables are mainly designed with 19 strands each.

"The segments are carried by 31 sets of temporary stay cables, anchored on both sides of the gorge at temporary steel pylons which are around 100m high."

10 Tamina Bridge, Switzerland – the arch is 'growing' from both sides of the gorge.
11 Tamina Bridge, Switzerland – the stay cables are anchored at and stressed from 100m high temporary steel pylons.
12 Tamina Bridge, Switzerland – segments are supported by temporary stay cables at both back and front edges.

Photographs 11-12 courtesy of Tiefbauamt Kanton St.Gallen.

11

Anchorages concreted within the arch are based on BBR internal anchorages and were preassembled at KB Vorspann-Technik's building yard in Austria. Due to the shallow web thickness, the larger anchorages – with 22-24 strands – are made of two 12-strand BBR internal anchorages, brought together with a Y-pipe and terminating in mono-couplers, graded in length to connect the strands up to the pylon.

Stressing operations have to be carried out simultaneously on the right and left sides of the bridge axis, ensuring also that the differences in horizontal forces affecting the pylon remain within limits between the arch-side and back-span cables. This procedure requires the use of up to 10 large jacks (3,500kN) at the same time on the back-span cables of one pylon and two jacks (7,000kN) on the arch-side cables. The same procedure is replicated on both sides of the gorge.

During the whole stressing operation, the pylon is controlled by geodetic survey, registering every millimeter of movement and confirming the vertical pylon position after stressing is finished.

After gaining access to the abutments, slope reinforcement and anchoring foundation blocks – mainly in autumn 2013 – arch construction started in April 2014. The arch has been growing in five meter sections over the Tamina throughout the year, with closure of the arch anticipated in spring 2015.

Once the arch is closed and the pylons dismantled, the superstructure will be constructed on traditional formwork.

Stahlton AG will carry out the post-tensioning works, using the BBR VT CONA CMI 1906 system, for the superstructure and the approach bridges consisting in total of 190t of prestressing strand and about 8km of BBR VT Plastic Duct for extra durability and robustness. Subject to continued good progress – and suitable weather conditions – the bridge along with its connecting roads, is due to open for traffic in 2017. ●

12

TEAM & TECHNOLOGY

1 **Owner** – ADIF
Main contractor – FCC Construcción S.A + Conduril.
Technology – BBR HiAm CONA stay
BBR Network Member – BBR PTE, S.L. (Spain)

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

IZERON VIADUCT, **ISÈRE, FRANCE**

Izeron Viaduct

STRENGTH FOR CANTILEVERED CROSSING

1

Following the deconstruction of a single-lane suspension bridge, a new two-lane viaduct has been constructed over the River Isère linking the communes of Izeron and Saint Saveur, in south east France. Claude Néant of French BBR Network Member, ETIC, describes the project.

The Izeron Viaduct is an important crossing point in the Isère Valley, both for local traffic and as a crossing of the River Isère. Originally built in 1858 and reconstructed in 1943, the bridge had long been closed to vehicles of over 19t because of structural decay. As well as this, the single lane bridge itself was no longer adequate for the needs of modern traffic, often there were long waits at peak times to cross the river.

New bridge

The new viaduct has been built in exactly the same location as the old one. It has two three meter lanes for traffic – one in each direction – and features two one meter cycle lanes and a 1.5m footpath, improving safety for pedestrians and cyclists.

The main 176m span of the viaduct comprises two 53m long concrete box girder cantilevers supporting a central 70m steel span. The viaduct is supported on two 33m long concrete abutment piers to balance each cantilever – there are no intermediate piers in the river.

Seismic construction

Built in an earthquake area, the link between abutment pier and box girder is realized by four 1100 x 1100 x 200mm elastomeric bearings each side, in order to decrease the general stiffness of the structure. The central steel beam, with free sliding pot bearings on each cantilever for the vertical load, is linked to the cantilever by seismic resistant lock up devices which create a single horizontal link so that differential movement between cantilever and steel span is prevented during any seismic activity. We also supplied and installed the elastomeric bearings, lock up devices and shock transmission units. Special steel expansion joints have been installed on each abutment to allow lateral displacement during any seismic movements.

The main dimensions of a typical cross-section of the cantilever's box girder is 11.2m wide, with a constant height of 9m between abutment and abutment pier – the height tapers to 3.5m at the cantilever end to support the central steel beam.

1 Central steel beam of the new Izeron Viaduct is being positioned.
2 The viaduct is supported on two 33m long concrete abutment piers to balance each cantilever.
3 The main 176m span of the viaduct will comprise two 53m long concrete box girder cantilevers supporting a central span of 70m.
4 Four 60m long BBR VT CONA CME external tendons within HDPE ducts were installed horizontally in each cantilever after construction.

Post-tensioning
We installed BBR VT CONA CMI internal post-tensioning tendons using the step-by-step method appropriate for cantilever construction. After stressing, the tendons were grouted with special grout. There were two 86m long tendons each side of the box girder between the abutment and cantilever end, plus a further four 40m tendons between the abutment and abutment pier on each side of the bridge. After construction of each cantilever, we installed four 60m long BBR VT CONA CME external tendons within HDPE ducts between each abutment pier and cantilever end. Following stressing of the tendons, we injected the HDPE ducts with wax for additional corrosion protection. In total, 154t of prestressing steel was installed – 45t per cantilever for the BBR VT CONA CMI tendons and 32t per cantilever for the BBR VT CONA CME tendons. At a total cost of €16.5 million and after just two years for demolition and construction work, the new viaduct will soon be open to traffic – and waiting in queues to cross the river will be a thing of the past. ●


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TEAM & TECHNOLOGY

Owner – Conseil général de l'Isère – Direction des mobilités
Main contractor – GTM (subsidiary of Vinci Group)
Designer – Quadric and Tonello (Tonello, Bonnard et Gardel Group)
Technology – BBR VT CONA CMI internal, BBR VT CONA CME external, Bearings, Expansion joints
BBR Network Member – ETIC S.A. (France)

MRT STATIONS, PACKAGE S2, **MALAYSIA**

Precast crosshead construction

PLATFORMS FOR STATIONS

Construction of the first MRT line from Sungai Buloh to Kajang is currently making good progress. Chang Chee Cheong from BBR Construction Systems (Malaysia) offers a detailed account of how, over a busy main road, post-tensioned precast segmental crossheads are being constructed and installed for three stations on the new line.

We were appointed by Naim Engineering – the nominated subcontractor for the stations on the route – to provide our specialist post-tensioning expertise for constructing the 27 precast crossheads for the three stations within Package S2. The piers supporting the light rail viaduct also provide the main supports – crossheads – for the stations. While work on the viaduct continues by launching gantry above, the stations below are being constructed concurrently to ensure readiness for track and equipment installation.

1

Structure configuration
Each station comprises nine crossheads, located in the center of the road over which the rail line is being constructed. Five crossheads are being created from the viaduct piers while the other four are being built between two viaduct crossheads. There is a 6m long cast in-situ pier segment and from this, three pairs of cantilevering precast segments are erected using the balanced cantilever method. The segment lengths of 2.48 + 4.05 + 4.13m give a total crosshead length of 27.3m. We are match casting the segments off-site.

Construction of in-situ pier & first segment pair
Post-tensioning tendon ducts are fixed on profiling bar supports in the pier segment. After casting, construction of the pier above continues to completion and erection of the viaduct spans by launching gantry follows, while station works are in progress below. At night, the first pair of precast segments is erected on heavy duty scaffolds using a mobile crane. Each segment weighing 40t is supported by four levelling and alignment jacks. A stitching gap of 175mm is allowed to handle the difference in shear keys between the cast in-situ segment and the precast segment. After stitching concrete has gained transfer strength, the tendons in the first pair of segments are stressed – then the heavy duty scaffolds are removed. ➤

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"Some hanging work platforms have been manufactured to allow strand threading to take place during the day over live traffic."

Erection of second & third pair segments
We aim to erect a second pair of segments within the limited working hours at night. After the road closure at 11.30pm, a 300t mobile crane begins setting up with a counter-weight. A spreader beam is installed to lift the segment off the low-loader. The segment is lifted for a trial fit against the first segment to check accuracy of fit. The challenge is that the concrete shear keys have been designed with a long protrusion of 100mm and angled upwards, making it difficult to fit the shear keys during segment erection without damaging them. We overcame the problem by designing a spreader beam which enables minute vertical and horizontal adjustment with lever blocks. After checking for a correct joint fit, the segment is lowered to the ground for epoxy to be applied. Upon lifting the segment again and closing the shear key joint, four 36mm diameter prestress bars are stressed to compress the epoxy and provide structural support from the cantilevering first segment. As the temporary prestressing is a critical structure element, the prestress bars have been designed with greater structural redundancy against accidental breakage of bar.

Strands are threaded into the empty ducts. The duct sizes are increased by 5mm to enable threading of strands through the cast ducts. Some hanging work platforms have been manufactured to allow strand threading to take place during the day over live traffic. The BBR CONA internal 3106 and 2206 tendons are stressed at night from one end only. Stressing is carried out simultaneously with a 750t jack for the top 3106 tendon and a 500t jack for the diagonally opposite bottom 2206 tendon. This is to prevent unbalanced stresses being induced into the crosshead, as precast station beams will only be erected after completion of the entire crosshead. After tendon cropping, the hanging work platforms can be rolled towards the pier to clear the space for launching the third pair of segments.

Key benefits
This project demonstrates the market need for services of specialist contractors like BBR with the benefits of our post-tensioning technology, equipment and construction experience. As well as providing the permanent tendon installation, we are also providing temporary works services including temporary prestressing and segment launching works.

1 Each of the three new MRT stations comprises nine post-tensioned precast segmental crossheads, located in the center of the road over which the rail line is being constructed.
2 While work on the viaduct above continues by launching gantry, the stations below are being constructed concurrently.
3 Hanging work platforms have been manufactured to allow strand threading to take place during the day over live traffic.
4 Five crossheads are being created from the viaduct piers while the other four are being built between two viaduct crossheads.

TEAM & TECHNOLOGY

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

RAIL BRIDGE, OTAIO RIVER, **CANTERBURY, NEW ZEALAND**

BBR VT CONA CMX for replacement bridge

ON TRACK WITH BBR NETWORK TECHNOLOGY

Always keen to apply smart technology to post-tensioning solutions, New Zealand's BBR Contech is working on a bridge construction project using the latest European approved CONA CMX post-tensioning range.

The 120m concrete railway bridge is being built over the Otaio River in southern Canterbury, replacing a 169m steel and timber structure built more than 100 years ago. While the original 24 steel-plate girders are still in maintainable condition, the rail infrastructure manager, KiwiRail, concluded that it was uneconomical to repair the bridge's deteriorating timber piers to a safe and reliable standard.
The new bridge will feature nine spans of 14m long precast concrete deck units. Working with main contractor McConnell Dowell Constructors and engineering specialist Novare Design, BBR Contech will supply, install, stress and grout 12 post-tensioned BBR VT CONA CMI 0906 tendons into each one.

The CONA CMX post-tensioning range is designed to optimise the structural form and speed up the construction program because of the compact anchorage design and ability to stress at relatively low concrete strength. ●

TEAM & TECHNOLOGY

Owner – KiwiRail
Main contractor – McConnell Dowell Constructors
Structural engineer – Novare Design
Technology – BBR VT CONA CMI internal
BBR Network Member – BBR Contech (New Zealand)

LRT KELANA JAYA EXTENSION, **KUALA LUMPUR, MALAYSIA**

Vertical tendons and bars in balanced cantilever bridge pier

POST-TENSIONED PIER FOR CURVED BRIDGE

Development of the latest LRT Extension has been welcomed by urban residents, says Tie King Bang of local BBR Network Member, BBR Construction Systems Malaysia, as it will be one of the most convenient public transport systems, integrating local bus services and other train networks. With high public demand, the light railway will extend to connect local residential districts and business hubs. Meanwhile, there are unavoidable intersections with major highways and, here, there will be long span elevated bridges – known as 'special crossing bridges'.

The longest special crossing bridge has a span configuration of 65m + 100m + 65m with a tight 122m radius curvature. During construction, the top of the pier head will experience high tensile stresses – created by the weight of precast box girder segments, construction live load and segment lifters. The curved geometry of the cantilever arms means that the pier section at the outer curve will experience high tensile stresses while the inner curve will be subjected to high compressive stresses. In compliance with the design code, the pier must be post-tensioned to balance and reduce the stresses to an acceptable level.

Application of PT tendons & bars

The post-tensioned pier consists of permanent and temporary vertical tendons – the BBR CONA internal bonded system was chosen for the permanent tendons and a 50mm diameter bar system was selected for temporary prestressing.

All the tendon dead ends are anchored mid-depth in the pile cap. The top stressing ends terminate at four different casting stages inside the pier section. The arrangement of stressing ends was detailed to avoid congestion of bearing plates and pier reinforcement.

Permanent tendons are stressed according to the designed stressing sequence, ensuring that the pier section is always in compression. As well as PT tendons, six 50mm diameter prestress bars accommodate temporary stresses and are placed at the outer curve of the bridge which is subject to tension stress during cantilever construction.

After construction of the mid-span closure segment, the structural behavior of the curved bridge will be changed from overturning toward inner curve to overturning toward outer curve of bridge. Therefore, temporary prestress bars can be detensioned, removed and the ducts grouted.

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1 Vertical post-tensioning tendons for the bridge pier were lifted into place by mobile crane.

2 The post-tensioned pier consists of permanent and temporary vertical tendons to handle the high tensile stresses created by the weight of precast box girder segments, construction live load and segment lifters.

Installation

Installation of permanent vertical tendons is a challenging task as the duct containing precut strands will be heavier and more awkward to install vertically. First, we placed temporary steel beams leaning away from the pier, ensuring there was sufficient height for the tendons to rest horizontally and bend vertically towards the pile cap. Pile cap top reinforcement had to be partially installed before tendon dead end preparation could be carried out. Installation of tendon dead ends was staggered to avoid a honeycomb effect being created by congestion of strand bulb ends.

Upon completion of pile cap construction, a scaffold was erected on top of the pile cap to the designed pier height and pier perimeter, leaving sufficient space for pier formwork. A mobile crane was used to lift all tendons vertically and place them onto the perimeter scaffold for temporary support. At least three grout vents are needed for each tendon and are installed at dead ends, intermediate and stressing ends of tendons.

A 750t multistrand jack was lifted vertically into the pier to stress the 3106 tendons and a 480t jack for the 2206 tendons.

At the top of the pier, a 150t jack was used to stress the 50mm PT bar to 140t.

Key benefits

A bridge pier constructed using post-tensioning can have smaller dimensions compared to a conventional reinforced pier, thus contributing to the overall aesthetic appearance of the bridge. The combination of permanent prestressed tendons and temporary PT bars controls the changes and reversal of tensile and compressive stresses during and after construction. ●

TEAM & TECHNOLOGY

Owner – Prasarana, Government of Malaysia

Main contractor – Trans Resources Corporation Sdn Bhd

Designer – Minconsult Sdn. Bhd.

Technology – BBR CONA internal, PT bar

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

2

BRIDGE PROJECTS, **MIDDLE EAST**

BBR VT CONA CMI applied for three new bridges

BRIDGES FOR REASONS & SEASONS

Having introduced the very latest BBR VT CONA CMI internal post-tensioning to the Middle Eastern market, BBR Network Members NASA Structural Systems and Structural Systems have had a lively and challenging time installing the system for many new bridges and buildings throughout the region. Warwick Ironmonger shares brief insights into three of their recent bridge construction projects.

1 Mina Salman Interchange Project

The Mina Salman Interchange is one of the strategic interchange projects in the Kingdom Of Bahrain and, upon completion, is expected to ease a traffic bottleneck at the main access to the largest industrial belt in the kingdom. The Mina Salman Industrial Area is spread along the Shaikh Isa Bin Salman Highway and connected to the capital Manama, through Fatih Highway.

The project involves construction of a flyover and underpass at the intersection of Shaikh Isa Bin Salman Highway and Al Fatih Highway. The flyover facilitates signal-free movement of traffic from Shaikh Isa Bin Salman Highway towards Al Fatih Highway connecting the capital Manama with the Industrial Area on the other side.

The 266m long flyover carries two traffic lanes and consists of seven spans – ranging from 32m to 47m long. The single cell box girder deck of the flyover is constructed by cast in-situ concrete supported by conventional formwork.

As there was limited space available for traffic diversion during building work, construction of the flyover was divided into five stages. Anchorage couplers were used to connect the tendons from one stage to another. BBR VT CONA CMI 3706 anchorages were used here and H-couplers were used for the first time in the Middle East region. Thus, it was a challenging task for our technicians and engineers to install the H-couplers as they were to be assembled on site.

The underpass was constructed along the Shaikh Isa Bin Salman Highway below the junction with Al Fatih Highway. The underpass roof slab was prestressed using BBR VT CONA CMI 1906 / 1206 internal tendons.

A special feature of the project was a full scale grout mock-up. A tailor-made 83m long beam with complete BBR VT CONA CMI 3706 tendons – including anchors, strands and ducts – was made for this purpose. The tendon was stressed to 5% of the stressing force specified for the actual bridge construction and then grouted. After hardening of the grout, the tendon was cut at five locations to check for any voids. It's always good to refresh our own knowledge and techniques – but also useful to reassure other members of the professional team that we really do know what we're doing!

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1 Mina Salman Interchange, Bahrain – this 266m long seven span flyover project featured the use of BBR VT CONA CMI and, for the first time in the Middle East, CONA CMI Type H sleeve couplers to connect the tendons from one stage to another.
2 Wadi Al Qor Road Project, Hatta, UAE – a total of 285t of prestressing strand was used for the post-tensioning of this 270m long six span bridge.
3 Oman Convention & Exhibition Centre Bridge – two 100m long cast in-situ twin cell post-tensioned box girder bridges were constructed to serve the international venue.

3

2 Wadi Al Qor Road Project, Hatta, UAE

This road project connects a remote settlement along the Oman borders with the historically and archeologically important tourist town of Hatta. The area borders the Sultanate of Oman and is surrounded by mountains, hence is of military importance too. The existing road passes through the Al Qor Wadi which is subject to flash floods cutting off the area from the rest of the country. Hence the authorities decided to construct new roads suitable for all weather with a series of small bridges and culverts, plus one major bridge across Wadi Al Qor. The 270m Wadi Al Qor Bridge has six spans – 2 x 40m + 2 x 45m + 2 x 50m. The bridge superstructure deck consists of five cell box girders (six webs) with each web of the box having eight BBR VT CONA CMI 1906 tendons. Due to substantial moments at the intermediate pier locations, additional BBR VT CONA CMI 1206 / 1306 tendons were provided in the top slab. The bridge deck was cast in-situ, in two stages, on conventional staging. Continuity of the tendons was achieved by application of BBR VT CMI 1906 K couplers. Grouting was the most challenging task as it was done in high summer when temperatures often exceed 45°C. In total we used 285t of prestressing strand for this project.

3 Oman Convention and Exhibition Centre Bridge

This bridge project for Oman Tourism Development Company is located in Ghala about 5km from Muscat (Omran) International Airport and is to serve the Oman Convention and Exhibition Centre, which is currently under construction. It consists of two cast in-situ twin cell post-tensioned box girder bridges – westbound and eastbound structures. Each of the girders' three webs contained three BBR VT CONA CMI 3106 tendons for which the jacking force per tendon was 6,450kN. The total length of each bridge was 100m, consisting of a central span of 50m and two side spans of 25m each. The total tonnage of prestressing steel involved was 67t and the project was completed well within the stipulated five month construction programme. ●

TEAM & TECHNOLOGY

1
Owner – Ministry of Work, Kingdom of Bahrain
Design & Supervision Consultant – Parsons Global Services Limited
Main contractor – AFCONS Infrastructures Limited
Technology – BBR VT CONA CMI internal
BBR Network Member – NASA Structural Systems LLC (Dubai)

2
Owner – Command of Military Works
Consultant – Cardno
Main contractor – Catalyst Viva Das General Contracting LLC
Technology – BBR VT CONA CMI internal
BBR Network Member – Structural Systems Middle East (Abu Dhabi)

3
Client – Oman Tourism Development Company (S.A.O.C.)
Consultant – Parsons International & Company LLC
Main contractor – Khalid Bin Ahmed & Sons LLC
Technology – BBR VT CONA CMI internal
BBR Network Member – Structural Systems Limited (Oman Branch)

RAILWAY FLYOVER, **BELTINCI, SLOVENIA**

BBR technology & expertise speeds up program

BRIDGE TO ECONOMIC & SOCIAL GOALS

The €330m upgrade of the rail link between Slovenia's Pragersko junction and the Hodos border crossing with Hungary is due for completion by the end of 2015. The team from BBR Adria has helped the project along with speedy installation of post-tensioning for a railway viaduct.

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The overall scheme, which has already been in progress for several years, involves the reconstruction, electrification and upgrading of a 109 km section of railway line, as well as modernization of level crossings and stations. When the works are completed on this last remaining non-electrified section on the trans-European transport corridor between Lyons and Ukraine, trains will be able to travel at speeds of up to 160km/h.

The Beltinci Flyover will take the railway line over a complex road junction and its superstructure has been designed as a flat 'T' shaped girder 12.86m wide and 1.1m high. The structure is 95m long and has five spans (15 + 20 + 25 + 20 + 15m).

The project was originally designed to be executed in three phases – one 40m long with nine tendons, another 24m with 11 tendons and the last phase, 31m long with nine tendons. Also, passive anchorages in the original plan had been designed as onion anchors.

The need for faster delivery meant that the project was redesigned to be executed in a single phase over its full 95m length. As a result of this, the number of tendons in the cross-section also changed to 11 tendons throughout. Stressing of the tendons was done from both sides of the structure, with a stressing force of 2,907kN per tendon.

When the revitalized rail link opens for business, it will bring the overarching European objective of creating sustainable transport and improving competitiveness of shipping cargo by rail – as well as reducing travel times for passengers and improving social cohesion – a further step closer. ●

1 Instead of the originally planned three phase execution, the PT was redesigned so that the whole 95m long rail structure could be completed in a single phase to speed up the program.

2 Stressing of the BBR VT CONA CMI internal tendons was carried out from both sides of the structure.

TEAM & TECHNOLOGY

Owner – Republic of Slovenia, Ministry for Transportation

Main contractor – SGP Pomgrad gradnje d.o.o.

Designer – Gravitas d.o.o.

Technology – BBR VT CONA CMI internal

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

SKYSCRAPERS, **AUSTRALIA, POLAND & SINGAPORE**

Achieving new heights in architectural design with PT

SKYSCRAPER SUCCESS

BBR Network Members have been working on an amazing total of four skyscraper developments on three continents. This may even be a record for the largest number of such buildings under construction by BBR engineers at any one time. We take a journey around the world to explore these new structures and examine what they mean for the communities in which they are growing. ➤

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Skyscrapers quite literally create new horizons – not just for the city skyline, but also for the people who use them and look upon them. They are bold structures, symbolizing positivity and people's aspirations for the future and exude confidence in their distinctive architectural lines.

1 Guoco Tower, Singapore
Since early 2014, BBR Construction Systems has been busy with the construction of Guoco Tower, located on top of Singapore's Tanjong Pagar MRT station.

Once completed in 2016, the 64-storey mixed-use development will stand at 290m, narrowly overtaking the current tallest buildings in Singapore – UOB Plaza, Republic Plaza and One Raffles Place – which are all 280m tall.

The development will consist 100,000ft^2 of retail space, 850,000ft^2 of Grade A office space – occupying 38 floors – and 181 luxury residential units, the Clermont Residences, which will take up the 39th – 64th storeys, starting from 180m above ground. This will be linked to a smart business hotel – the Clermont Singapore – which will have around 200 rooms.

A detailed account of the construction of this inspirational new building will follow in the 2016 edition of CONNÆCT.


2

1 Q22 office building, Warsaw, Poland – construction of this 155m high office building is underway and will feature floor slabs post-tensioned using the BBR VT CONA CMF flat system.
2 Guoco Tower, Singapore – once completed in 2016, this 64-storey mixed-use development will stand at 290m, narrowly overtaking the current tallest buildings in Singapore.
3 South Beach, Singapore – the two towers of this mixed-use development will rise to 35 and 45 storeys.
4 South Beach, Singapore – inclination of some of the columns created an interesting challenge for the BBR team, this was resolved by installing additional horizontal BBR CONA tendons at selected storeys to tie the inclined columns back to the vertical core.
5 International Towers Sydney – SRG will be using almost 2,500t of prestressing strand for post-tensioning works in the construction of these three multi-storey buildings at Barangaroo.
6/7 Q22 office building, Warsaw, Poland – as well as fulfilling top international standards for high-rise buildings, the team has focused on meeting stringent sustainability targets.


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2 South Beach, Singapore

South Beach is a mixed-use development, strategically located on Beach Road and bordering Singapore's Central Business District. Four historic buildings already on the site will blend with these two new towers which will contain offices, luxury residences, a designer hotel, retail spaces and a members-only arts club.

With a distinctive design including a state-of-the-art environmental canopy, South Beach has already won two Green Mark Platinum Awards and is set to be the new defining structure in Singapore's vibrant skyline when completed in 2015.

The project involves a total gross floor area of 146,827m^2 in two towers reaching 182m into the sky. The 35-storey North Tower will contain office space, while in the 45 storeys of the South Tower hotel and residential accommodation will be created.

In general, the 265-375mm thick post-tensioned floor slabs were produced using BBR CONA flat tendons, with post-tensioned banded beams at the perimeter.

The slabs for the North Tower's 'Sky Garden' were 600mm thick and, for the hotel floor in the South Tower, there was a reinforced concrete floor slab with a post-tensioned banded beam and transfer beam. The six storey podium also featured a post-tensioned beam and slab scheme.

There are some interesting challenges for the BBR Construction Systems team in Singapore. For example, the inclination of some of the columns means that the vertical load from upper floors create a 'kick-out' force when columns change direction of incline. Thus, additional horizontal BBR CONA tendons are being installed at the 10th to 12th storeys of the North Tower and 14th to 16th, 22nd and 32nd floors of the South Tower to tie these inclined columns back to the vertical core.

Formwork also required special considerations during design, as well as additional precautions and supervision during the erection stage to ensure capacity and safety. Part of the formwork was designed to be freestanding – because after the 11th storey, the building edge extends outwards before inclining inwards again. ➤

"It is the city's largest redevelopment project this century and, over the next five years, this former container port will be transformed..."

3 International Towers, Barangaroo, Sydney, Australia

Barangaroo is a 22-hectare harbor front urban redevelopment project underway on the north-western edge of the Sydney central business district. It is the city's largest redevelopment project this century and, over the next five years, this former container port will be transformed into public waterfront walks and parks along with commercial office towers, retail spaces and apartments. Australian BBR Network Member, SRG (formerly Structural Systems), has been involved in a variety of works associated with this colossal project. The site is divided into three main development areas – Headland Park, Central Barangaroo and Barangaroo South.

Working alongside Lend Lease, the developer of Barangaroo South and main contractor for both Barangaroo South and Headland Park, the SRG post-tensioning and remedial teams have been focused on the commercial office towers and apartments at Barangaroo South. The post-tensioning works include three multi-storey towers and additional slabs, entailing close to 2,500t of 15.2mm prestressing strand. Construction of the three commercial towers – known as International Towers Sydney – is underway and they are rapidly rising to join the Sydney skyline. Tower 2, the middle of the three towers, is the most advanced in its construction and is expected to reach its full height of 42 storeys in mid-2015. The remedial works involved grouting and associated compressive strength testing to the Tower 2 lift overrun walls.

SRG has also been working on the Barangaroo Headland Park Cultural project which is being built by Lend Lease subsidiary, Baulderstone. This project involves the construction of a land bridge, supporting a park – complete with bicycle paths, walking tracks, retaining walls, water mains, trees and grassed areas – over the top of a large 17m high 18,000m^2 open floor space. SRG is supplying and installing the post-tensioning works for holding down the beams to the 17m high supporting concrete columns.

Separately, the team is working on the Wynyard Walk project too. This Transport for NSW project is connected with the Barangaroo redevelopment and requires construction of a fully accessible pedestrian tunnel and footbridge linking Wynyard Station and the Barangaroo waterfront in approximately six minutes, avoiding steep inclines and road crossings. To construct the 110m long, 3.5m high and 9m wide pedestrian tunnel, SRG worked with Thiess Contractors and their subcontractor Ward Civil to supply, install and stress post-tensioning tendons to new concrete beams. They also provided, installed and operated 47 flat jacks to support the heritage listed Transport House during the tunnel's construction and to provide permanent support upon completion. Construction of the footbridge is also underway and involves supply, installation and stressing of PT bars within the western abutment and its connection to precast T-beams spanning Sussex Street.

5

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TEAM & TECHNOLOGY

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

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

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

4 **Developer & general contractor** – Echo Investment S.A.
Architect – Kurylowicz & Associates Sp. z o.o
Structural design – Buro Happold Polska Sp. z o.o
Frame contractor – Modzelewski & Rodek Sp. z o.o
Technology – BBR VT CONA CMF flat
BBR Network Member – BBR Polska Sp. z o.o (Poland)

4 Q22 office building, Warsaw, Poland

Another project recently underway on site is the 155m high Q22 office building in Warsaw, Poland. The 41-storey structure is being developed on the site of a former hotel, located in the business heart of the city. When completed, the PLN500m development will offer almost 50,000m^2 of office space and feature many amenities for its users – including a restaurant, fitness area, car park and locker rooms for cyclists. As well as fulfilling the top international standards for high-rise buildings, the team has focused on meeting stringent sustainability targets on the project.

On site since autumn 2014, BBR Polska has been tasked with the delivery and execution of 58,830m^2 of floor slabs, post-tensioned using the BBR VT CONA CMF flat system. By the time their work is complete, the team will have installed some 153t of stressing steel. Again, you can expect to hear more about this project in the next edition.

All of these projects will owe their creation to teamwork – the close collaboration between client, architect, main contractor and specialists such as the BBR Network. The BBR brand of technology, experience and know-how gives designers greater scope and ensures that the new structure is as economic and environmentally friendly as possible to construct.

7

RETAIL, DISTRIBUTION & DAIRY INDUSTRY FLOOR SLABS, **NEW ZEALAND**

BBR technology, experience, expertise combine for first class results

GROUND FLOOR ACHIEVEMENTS

2

The growth in 'mega' stores, online shopping and high-tech warehousing systems is seeing some of New Zealand's well-known brands invest in new and extended retail, distribution and storage facilities. When it comes to the floors BBR Contech is ready to help, offering decades of experience, innovative solutions and, when required, access to the intellect and expertise of colleagues in the global BBR Network.

1

1 When two heads are better than one

Collaboration was the name of the game when Bunnings Warehouse, one of Australasia's largest household hardware chains, decided to build its biggest yet New Zealand store – a multi-level, 1.2 hectare giant in the Auckland suburb of New Lynn. Terry Palmer describes how this project was realized.

We successfully tendered for the design / build contract for the store's main floor – an 11,000m² elevated expanse located above a 300-bay underground car park. Recognizing the complexities of the project – and the similarities of similar Bunnings projects in Australia – we called on the expertise of Australia's Structural Systems, a fellow member of the global BBR Network.

We knew that they had installed a number of suspended slabs for Bunnings and that the store layouts were similar in both countries. They were happy to meet us and our preferred designer, MSC Consulting, to show us the stores where they had worked and share their ideas and expertise.

Work on the floor is now underway, using the BBR CONA flat post-tensioning system and following a carefully planned schedule that responds to the layout specifications and the physical and logistical challenges of installation. With very limited access – there's even a roadside railway line to consider – and different floor surface requirements for the 2,000m² timber yard, 6,500m² retail area and 2,500m² garden center. It has been an interesting and absorbing project.

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2 Getting goods on the move

Founded in 1909, the Farmers Trading Company has proven its ability to adapt and change with the times and, with 55 stores nationwide, it is now firmly established in the mid-range shopping market. Its online shopping initiative is so successful that it has extended its warehouse to include a purpose-designed distribution center, reports Terry Palmer.

Located in Auckland's East Tamaki, the new 25,000m^2 building services a growing business providing a vast storage space for goods – all accessible via a state-of the-art VNA (very narrow aisle) racking system. With a 16m top beam height, this is about as high as cutting edge technology world-wide allows. The warehouse floor is designed to be incredibly robust, both to handle high racking loads and the constant traffic from delivery trucks. A total of 14 pours were required to construct the heavy-duty, 240mm thick floor, which was post-tensioned using five-strand, 15.2mm tendons.

Conslab General Manager Tim Walker said "Traditionally this would have been a conventional floor poured in 5 – 12m wide strips to allow the very narrow aisle flatness specification to be achieved. With Conslab's confidence in pouring large PT slabs to tight tolerances we were still able to use a PT floor, and meet the rigorous flatness standard with minimal grinding along the VNA aisles. So the client got the operational surface they needed, but without having to compromise from the durability of a large joint free PT slab."

3 Supermarket goods storage

Talking of distribution centers, Peter Higgins relates that BBR Contech has also installed a post-tensioned slab in a new, NZ$45 million distribution center for Foodstuffs – New Zealand's largest grocery distributor. The 30,000m^2 building is located in Hornby, a community southwest of Christchurch which has experienced rapid growth in population and land development since the 2010/11 earthquakes. As an extension to an existing 13,000m^2 facility – incidentally featuring a floor installed by BBR Contech in 2004 – it provides the company with a South Island distribution hub close to key transport routes. It also enables it to introduce energy-efficient heating and lighting systems, increase rack heights and offer employees improved working conditions. Working once again with main contractor Calder Stewart, the floor was constructed in 11 individual, 180mm thick concrete slabs for both the warehouse and canopy, ranging in size from 1,260m^2 to 3,600m^2, each post-tensioned with four-strand, 12.7mm BBR CONA flat tendons. ➤

2015 Milestone

BBR Contech will pass a major milestone during 2015 – the company will have constructed 2,000,000m^2 of post-tensioned slabs in around 300 separate building projects.

1 Bunnings Warehouse, New Lynn, Auckland – design and construction of the store's complex 11,000m^2 main floor benefited from collaboration with SSL, a fellow BBR Network Member, to capitalize on their similar experience in Australia.
2 Farmers Trading Company, East Tamaki, Auckland – the new 25,000m^2 post-tensioned warehouse floor is designed to handle high level VNA racking systems.
3 Foodstuffs, Hornby, Christchurch – NZ's largest grocery distributor now has a 30,000m^2 post-tensioned floor at its South Island distribution hub.
4 Fonterra Co-operative Group, Whareroa – the latest in a long line of warehouse slabs for this client, this 22,000m^2 floor for a new warehouse was installed in 12 concrete pours and using BBR CONA flat PT tendons.

> "Having worked with BBR Contech on around 25 projects in the past 12 years – about 250,000m² of floor – we had every confidence that they'd deliver another outstanding result. We have a very strong relationship, and the Contech team are always the first people we call on for large, business-critical projects like this."
>
> Peter Stewart, Joint Managing Director, Calder Stewart

4

TEAM & TECHNOLOGY

1 **Owner** – Bunnings
Main contractor – Dominion Constructors
Designer – MSC Consulting
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

2 **Owner** – Farmers Trading Company
Building frame – Concrete Structures
Flooring contractor – Conslab Ltd
Designer – BGT Structures
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

3 **Owner** – Foodstuffs South Island Ltd
Main contractor – Calder Stewart Industries
Designer – Engenium Ltd
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

4 **Owner** – Fonterra Co-operative Group
Main contractor – Calder Stewart Industries
Designer – Kirk Roberts (Drystore), BBR Contech (PT slabs)
Technology – BBR CONA flat
BBR Network Member – BBR Contech (New Zealand)

4 Supporting the dairy industry

Our long-standing relationship with Calder Stewart extended in June 2014 to another project for the Fonterra Co-operative Group, a multinational dairy co-operative owned by 10,600 New Zealand farmers. Bojan Radosavljevic explains that the three companies have worked together for more than a decade, on some of the largest post-tensioned floor slabs in New Zealand. The latest was a 22,000m² floor for Fonterra's Whareroa site in the heart of Taranaki, which collects up to 14 million liters of milk every day and makes enough milk powder, cheese, cream and other dairy products to fill more than three Olympic-sized swimming pools every week!

In this six-month project, we installed six 175mm thick slabs in 12 pours, using 4-strand, 12.7mm diameter BBR CONA flat tendons. Fortunately we had the resources to get the job done well and the Christchurch and Wellington teams of BBR Contech worked closely to deliver this project, drawing on their experience from other similar jobs. This achievement is most recently reflected in our latest appointment – to another Calder Stewart / Fonterra project. This will be a 20,000m², 175mm thick slab for a storage area and railway siding at Fonterra's Pahiatua milk-processing plant, about two hours' drive from Wellington. ●

HOTEL EXTENSIONS, **WESTERN CROATIA**

Extending facilities with BBR technology & expertise speeds up program

COMFORT IN CROATIA

Two hotels with frontage on the crystal blue Adriatic Sea have recently improved and extended their facilities, reports Goran Tomisic from local BBR Network Member, BBR Adria.

1 The new 50m swimming pool at the Vitality Hotel Punta, Losinj Island, Croatia.
2 The car park under construction on top of the conference hall at the Hotel Royal, Opatija, Croatia.

1 Pool & underground garage

Near the beautiful and historic town of Veli Losinj, on Losinj Island in Western Croatia, the Vitality Hotel Punta needed a new 50m swimming pool and two level underground garage.

Both structures were post-tensioned using the BBR VT CONA CMM monostrand system. The total slab area was around 4,500m^2. Spans in the garage were 11 x 7.9m and 8.1 x 7.9m with a constant slab thickness of 300mm. Spans for the pool were 6.6 x 7.9m and the slab thickness varied.

Each slab was concreted in two pours, with a four meter pouring strip in between each pour. Around 21.5t of prestressing steel was used for the project.

2 Rooftop car park

Meanwhile, back on the coast of mainland Croatia, about 120km north of Veli Losinj, the BBR Adria team has been creating a car park at the Hotel Royal, in Opatija.

The hotel was built without post-tensioned slabs, however its conference hall – which sits between the Hotel Royal and a sister hotel – now has a post-tensioned roof slab. It is designed with two-way spanning large span grids. There are 600mm high beams of widths of 1,600, 2,100 and 2,400mm and slab thicknesses of 220mm and 300mm. The largest span in the 840m^2 roof slab is 21m. Around 10.5t of prestressing steel was used to create the BBR VT CONA CMM monostrand tendons which help the new roof slab carry its own weight and the heavy loading which will include cars, coaches and trucks. ●

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TEAM & TECHNOLOGY

1 **Owner** – Vitality Hotels
Main contractor – Medimurje Graditeljstvo d.o.o.
Designer – K.A. Biro d.o.o.
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o. (Croatia)

2 **Owner** – Milenij Hoteli Opatija
Main contractor – Kamgrad d.o.o.
Designer – Smagra d.o.o.
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o. (Croatia)

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HIGH RISE BUILDINGS, **CROATIA, ESTONIA, NETHERLANDS, OMAN, SINGAPORE & UK**

Spacious, flexible buildings created with post-tensioning

HIGH-RISE HIGHLIGHTS

While skyscrapers might grab the headlines, BBR technology also offers just as much freedom of scope for designers, as well as savings in materials, time and cost in the construction of high and mid-rise buildings

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1 VMD Quart Strojarska, Croatia

In an attractive city center location, two tower buildings in Zagreb have come to represent the vision of Croatia in Europe. Just as the architects were finalizing their designs, the nation became the 28th member state of the European Union.
The VMD Quart towers – 14 and 25 floors high – are part of a large €100m residential and business development in the Strojarska district of the city. At 96m high, the largest tower is the second tallest structure in Zagreb – after the cathedral whose 108m high spires are visible for miles around.
As the development has sustainability at its heart, it was natural that BBR technology should be incorporated into these landmark structures. While the spans of only seven or eight meters were not as large as we would normally expect for a post-tensioned structure, the fast floor-cycle time was key to winning this project.
With the BBR VT CONA CMM system, BBR Adria was able to achieve a one week cycle time for each of the 850m^2 floors – at least three days faster than using traditional reinforcement. Some 40 different subcontractors were working on site, with between 500 to 1,000 staff, over a construction period of around two years. In total, 130t of prestressing steel was used to create the post-tensioned floor slabs for the project which was fully opened in January 2015.

2 Innovation in Estonia

An innovative 14-storey residential and commercial development, with vistas over the Gulf of Finland, is nearing completion with the help of BBR Network Member KB Spännteknik.
The Kentmanni 6 scheme involves a number of integral units which together make up the entire development. Part of the structure stands on columns which, as well as allowing traffic to pass beneath the building, also permit uninterrupted views right along the tree-lined Ravala Avenue and daylight to reach the adjacent building. The main volume of the building has thus been raised to fifth floor level. Office space is on two lower levels, while 91 apartments are situated on the other storeys.
All floor slabs – covering around 19,758m^2 – were post-tensioned with BBR VT CONA CMM single tendons, while the CONA CMM 0406 system was used for the beams.

3 Development for fast growing capital

The ground and first floors of this mixed use development in Muscat, Oman feature commercial space, while on the upper floors there are 44 office spaces in Wing A and Wing B has 66 residential apartments.
The post-tensioning solution offered by BBR Network Member NASA Structural Systems was ultimately chosen as it provided an economical approach for each of the different floor usages, whilst minimizing self-weight, requiring simple formwork and permitting swift floor construction cycle times.
Structural Systems undertook the specialist design, supply and site supervision works for the post-tensioned floor slabs associated with the 11 suspended levels.
The total post-tensioning works using the BBR CONA flat post-tensioning system, covered an area of nearly 34,000m^2 and were completed within a year.

4 Food for thought

Taking shape in Amsterdam – opposite 'The Pretzel' and next to 'Cookie Bridge' is 'The Macaroon'. It will house 134 rental apartments designed to offer elderly people various service levels – ranging from those who would like a little assistance, to others who may require more support and care. Ruud Steeman of Spanstaal – Ballast Nedam, the BBR Network Member for the Netherlands, talks us through the project.
With a total floor area of about 28,000m², the building contains six floors and a single level basement car park. By using the BBR VT CONA CMM monostrand unbonded system, beam thickness can be kept to a minimum which will create more space for necessary mechanical installations.
The CONA CMM system is further enhanced by the use of the newly developed pocket formers which facilitate the tensioning process. ➤


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"With the BBR VT CONA CMM system, BBR Adria was able to achieve a one week cycle time for each of the 850m² floors – at least three days faster than using traditional reinforcement."

5 Europe's largest regeneration program

Part of Nine Elms London – Europe's largest regeneration program – Embassy Gardens is a scheme to provide 605 residential units. Diego Dellatorre reports that Structural Systems UK Limited has designed, supplied and installed post-tensioning for structures ranging in height from 7 to 19 storeys on three of the scheme's plots.

The BBR VT CONA CMF flat system was the most appropriate system for both the slabs and the beams, which totalled nearly 71,000m² in a variety of slab depths.

The largest of the three sites covers 35,392m² and contains six blocks up to 19 storeys high. The floor plates of each block are built around a structural core with the numerous pours connected by a series of temporary movement joints (TMJ) to allow shrinkage to occur between the slabs as a result of the concrete curing process and post-tensioning forces. In several locations on the mezzanine and podium, pour strips were substituted due to buildability issues.

The podium was particularly challenging as it included large post-tensioned transfer beams up to 2,500mm wide by 1,200mm deep and deep slabs up to 1,200mm thick – carrying not only the loads from the transfer beam above, but also from hanging columns as well as transfer core walls.

6 Integrated health facilities

Lee Chong Whey of Singapore-based BBR Construction Systems offers an insight into the company's work on the 700-bed Ng Teng Fong General Hospital (NTFGH), 400-bed Jurong Community Hospital (JCH) and Specialist Outpatient Clinics (SOC) with 120 consulting rooms – on a site of 53,844m².

The unique building form – including a 16-storey ward tower, eight storey SOC tower and 12-storey JCH – posed challenges for the structural design, coupled with the fast track construction timeline, thus post-tensioning was explored for the project.

Part of the project team since 2012, we have provided post-tensioned beams, flat slab and drop panels for the podium levels 2-4 at NTFGH and levels 2-8 at SOC. It was important that the construction form, technology and method should have the flexibility to accommodate not only changes and expansion in healthcare requirements, but also flexibility for M&E services.

To maximize the capacity / self-weight ratio, all beams, slabs and drop panels have been designed individually, based on their requirements such as applied load, as well as the optimum sizes from within the BBR CONA anchorage range. ●

1 VMD Quart Strojarska, Croatia.
2 Kentmanni 6, Tallinn, Estonia.
3 Jasmine Tower, Muscat, Oman.
4 The Macaroon, Amsterdam, Netherlands.
5 Embassy Gardens, London, UK.
6 Ng Teng Fong General Hospital & Jurong Community Hospital, Singapore.

NEW FOOTBALL STADIUM, **MADRID, SPAIN**

Flat post-tensioning technology for new grandstands

NEW TECHNOLOGIES FOR STADIUM

Atlético de Madrid is one of the biggest clubs on the European football scene and the team at Spanish BBR Network Member BBR PTE is helping them grow still further, as the club replaces its old stadium.

The old stadium, located near the Manzanares river and Madrid-Rio park, will be demolished to make way for construction of new apartments, service areas and the expansion of Madrid-Rio park. The new stadium is being built in northwest Madrid, near the airport and one of the fastest growing areas in recent years. The new stadium, with a capacity of around 70,000, has been designed with new stadium technologies and meets all guidelines for hosting high profile sports events – including the final of the Champions League. Furthermore, it will be equipped with better access for the disabled, a large number of parking spaces, shopping areas and restaurants. The stadium is divided into five levels to support the grandstand seating. The prestressing technology selected for this project is the BBR VT CONA CMF flat 406 system with a nominal strand diameter of 15.7mm and cross-sectional area of 150mm^2. All tendons are formed with corrugated galvanized oval ducts.

The new stadium will be constructed using more than 300t of prestressing steel, distributed across 2,700 tendons, with radial placement and with an average length of 35m. Corrosion protection for the stressed tendons will be provided by grouting which is being carried out according the latest European EN standards. The grout is made with Portland cement I-42.5 (w/c=0.34) and it is tested every two weeks – excellent results have been obtained in terms of bleeding, change of volume, workability and low exudation of water. ●

TEAM & TECHNOLOGY

Owner – Club Atlético de Madrid
Main contractor – FCC Construction
Technology – BBR VT CONA CMF flat
BBR Network Member – BBR PTE, S.L. (Spain)

TEAM & TECHNOLOGY

1 **Owner** – VMD PROMET d.o.o.
Main contractor – TEAM d.d., Mursko Sredisce, Croatia
Designer – Predrag Presecki, Croatia
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o. (Croatia)

2 **Developer** – Merko Ehitus Eesti AS
Architect – Arhitektuuriburoo Pluss
Main contractor – Merko Ehitus Eesti AS
Technology – BBR VT CONA CMM monostrand
BBR Network Member – KB Spännteknik (Sweden)

3 **Client** – Tameer Investment Co. LLC
Consultant – Arab Engineering Bureau
Main contractor – United Golden Construction Company (INSHAA)
Technology – BBR CONA flat
BBR Network Member – NASA Structural Systems LLC (United Arab Emirates)

4 **Owner** – Syntrus Achmea Real Estate & Finance
Main contractor – M.J. De Nijs En Zonen BV
Designer – De Architekten Cie
Technology – BBR VT CONA CMM monostrand
BBR Network Member – Spanstaal – Ballast Nedam Infra Specialiteiten B.V. (Netherlands)

5 **Client / Developer** – Ballymore Group
Structural Engineer – Walsh Associates
Technology – BBR VT CONA CMF flat
BBR Network Member – Structural Systems UK Limited (UK)

6 **Client** – Jurong Health Services
C&S Consultant – CPG Consultants Pte. Ltd
Main contractor – GS Engineering & Construction
Technology – BBR CONA internal, BBR CONA flat
BBR Network Member – BBR Construction Systems Pte. Ltd. (Singapore)

SHOPPING CENTERS, **AUSTRIA & MALAYSIA**

Post-tensioning of floor slabs and car parks becomes a national standard

FAST TURNAROUND FOR RETAIL CUSTOMERS

BBR post-tensioned flat slab technology has become a firm favorite for large retail developments. Its appeal lies in the flexibility it offers – allowing aesthetically pleasing design along with strength – and in the advantages offered within often tight construction programs. Norbert Bogensperger of KB Vorspann-Technik reports on three shopping center developments in Austria and HM Goh and CL Lee of **BBR Construction Systems Malaysia** describe a major retail mall project in an upcoming business hotspot.

Austrian market insight

Building new shopping centers and expanding or upgrading existing ones, seems to be a growth business in Austria. The use of post-tensioning for slabs in malls and car parks has become a standard feature of these schemes.

Within a 15-month period, we secured deals for three shopping center projects and all feature BBR VT CONA CMM Two/Four monostrand post-tensioning. This particular post-tensioning system uses a four strand band configuration which makes it easier and faster to install on site. We love the system because we can carry out tendon cutting and mounting, as well as prelocking of the fixed anchorages off-site, in our factory. This saves time in the overall construction program and it clearly delights customers who keep coming back for more!

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1 Fischapark, Wiener Neustadt

The Fischapark-Center in Wiener Neustadt, 40km south of Vienna, was built and is operated by SES-Spar European Shopping Centers within their portfolio of 26 shopping centers in five European countries. Among them, is the Europark in Salzburg which was recognized with the 'Best Shopping Center Worldwide' award in 2007 – and also features post-tensioned slabs designed with the BBR VT CONA CMM Two/Four monostrand system.

The great success that SES is enjoying means that they now wish to double the sales area and refurbish parts of existing stores. In March 2013, construction of the first part of the new section of the Wiener Neustadt store began. As a design alternative, the slabs were designed with unbonded CONA CMM Two/Four post-tensioning. This new part of the shopping Center opened in April 2014. After this, demolition of the old structure and erection of phase two began. We delivered and stressed about 125t of tendons in the first phase and are now working on another 100t for the second phase which should be finished in autumn 2015. By then, there will be a sales area of more than 42,000m² waiting for customers.

2 SCA-Shopping Center Alpenstrasse, Salzburg

The new SCA replaces the western part of the old one, which is over 20 years old and situated to the south of Salzburg.

With spectacular architecture it looks like a gift – ready to be unwrapped and discovered. With silver stripes covering the joints of a sun-whitened glass-membrane façade. Inside it is a classic mall concept combined with a market place with two floors for shopping and a total of five parking floors, beneath and above.

About 300t of BBR VT CONA CMM Two/Four monostrand post-tensioning tendons were used in five slabs of around 24,000m². ➤

"So within less than two years, we have carried out all the major post-tensioned slab jobs for shopping centers in Austria..."

1 Fischapark-Center, Wiener Neustadt – an alternative slab design for this new store uses around 225t of unbonded CONA CMM Two/Four PT tendons.
2 SCA Shopping Center, Salzburg – 300t of CONA CMM PT tendons were used for the classic mall, contained within this strikingly designed building.
3 SC Weberzeile, Ried im Innkreis – a further opportunity for BBR Network Member KB Vorspann-Technik to work with the same contractor as at the Fischapark-Center.
4 IOI City Mall, Selangor, Malaysia – BBR PT solutions helped to achieve the desired aesthetic effect for structure of this shopping mall.

3 SC Weberzeile, Ried im Innkreis

SES is also developing a site in Weberzeile in the center of Ried im Innkreis, a district town and regional center about 60km north-east of Salzburg in Upper Austria, where a 22,000m² shopping center is under construction. Work started in late 2013 and the center will be finished and opened in mid-2015.

We are also working with GRANIT again here, the same main contractor as at Fischapark. Based on the good working relationship and trust which developed between us earlier, they opted for an alternative design with post-tensioned slabs for this new project – and to negotiate a contract with us, over just a few days, rather than enter into a lengthy competitive tendering process.

We delivered and stressed 370t of CONA CMM Two/Four tendons from end of February until early October. These covered three floors – two parking levels underground and one mall floor.

So within less than two years, we have carried out all the major post-tensioned slab jobs for shopping centers in Austria – in total, delivering and stressing about 900t of BBR VT CONA CMM Two/Four monostrand tendons.

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4 IOI City Mall, Selangor, Malaysia

The massive new IOI City Mall will soon become another iconic business hot spot in the southern part of Selangor. The construction program is short and stringent quality standards are in place for this mega-project, thus a well-planned, flexible and effective construction methodology is vital. Our alternative technical solutions were based on using the BBR CONA flat post-tensioning system.

The new development is over 550m long and has a footprint which covers more than 110,000m². There are four levels of basement car-park, five levels of shopping mall, two 30-storey office towers and one 27-storey 5 star hotel.

There were mainly three types of structural post-tensioning, designed according to the intended usage of that part of the structure:

- PT flat slab with drop panel system for car park areas
- PT long beams and conventional slab system for mall areas
- PT band beam with PT slab system for office tower.

Expansion joints are not permitted by the client, thus, to minimize the risk of cracks – from early shrinkage, elastic shortening and creep effect of the concrete – pour-strips were introduced between the construction zones in the car park. Each floor was divided into 66 construction zones. Casting of the pour-strips was carried out 14 days after stressing had been completed. The post-tensioned flat slab with drop panels was designed with BBR CONA flat tendons – providing savings in material costs compared with a traditional reinforced beam and slab approach. Another advantage was the improvement of the soffit floor aesthetics offered by the shallow drop panel depth. We worked together with the client to incorporate the use of modular formwork within the flat slab system to provide a hassle-free, fast and highly effective construction method. This allowed the contractor to complete four zones per week.

Aesthetics were crucial here in the structural design of the shopping mall area. The walkway was designed with shallow cantilevering beams to give a visually floating effect. Post-tensioning provided the construction solution by inducing an uplift force to counter the heavy slab and beam weight, thereby controlling deflection.

The depth of the post-tensioned beams was shallower than that achievable with reinforced concrete. The BBR CONA tendons were stressed with a 170t multistrand jack. The two 30-storey office towers were designed to have an elegant sloping outlook. In order to give a more flexible and efficient structural design, a post-tensioned band beam and slab system was adopted here. Due to the relatively small floor area, construction joints with overlapping tendons were designed to enable a construction cycle time of seven days per floor. Tendon stressing was carried out with a light 25t monojack to avoid the need for craneage to handle multistrand jacks in this high-rise tower construction situation. The project started in early 2014 and the shopping center opened at the end of 2014, while the hotel will be open in the middle of 2015. Within a three year period, the BBR CONA internal post-tensioning system will have successfully achieved the goal of providing a thinner slab, longer span, lighter floor, time savings – and, of course, a structurally sound solution. ●

TEAM & TECHNOLOGY

1 **Owner** – SES Spar European Shopping Centers
Main contractor – Granit Baugesellschaft m.b.H
PT designer – Herbrich ZT GmbH
Technology – BBR VT CONA CMM Two/Four
BBR Network Member – KB Vorspann-Technik GmbH (Austria)

2 **Owner** – Convergenta
Main contractor – ALPINE / Ing. Hans Bodner Baugesellschaft m.b.H
PT designer – Herbrich ZT GmbH
Technology – BBR VT CONA CMM Two/Four
BBR Network Member – KB Vorspann-Technik GmbH (Austria)

3 **Owner** – SES Spar European Shopping Centers
Main contractor – Granit Baugesellschaft m.b.H
PT designer – Fuchs ZT GmbH
Technology – BBR VT CONA CMM Two/Four
BBR Network Member – KB Vorspann-Technik GmbH (Austria)

4 **Owner** – IOI City Mall Sdn Bhd
Main contractor – HAB Construction Sdn Bhd & Al-Ambia Sdn Bhd
Technology – BBR CONA flat
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

ATLANTIC GROUP FACTORY, **NOVA GRADISKA, CROATIA**

BBR technology delivers economic, low maintenance factory slab solution

PERSUASIVE BBR POST-TENSIONING

The benefits to be gained from using BBR technology for ground slabs proved persuasive in winning the contract for Atlantic Grupa's new factory. Goran Tomisic of BBR Adria, the Croatia-based BBR Network Member, reports that it is a project worth €16m which will also create many new jobs.

Atlantic Grupa is the leading European producer of sports and functional food under the Multipower brand – and most of the product range is made in the company's own facilities. Construction of the new factory at the Nova Gradiska Industrial Park began in April 2014 and the first products from the new lines are expected to be on the market in early 2015.

Design for highest standards

The new production facilities have been designed to meet the highest food industry standards, and represent an investment in further development of Atlantic's sports nutrition segment, along with similar areas of their product range in the South-East European region.

Persuasive benefits

We participated in the design and construction of 6,000m^2 post-tensioned slabs on ground. The advantages offered by the BBR VT CONA CMM system were fundamental to us winning the work. The client was persuaded by the thinner slab – slab thickness was 180mm, less reinforcement, absence of costly internal jointing, cost savings from speed of construction, crack-free performance, enhanced water resistance properties and reduced future maintenance costs. The slab was designed with only one expansion joint in the middle of the slab. Each column and wall was separated from the slab by polystyrene. Tendon stressing was done from box-outs which were created before pouring. The entire slab was constructed in four cycles and around 22t of prestressing steel was used in the creation of the CONA CMM tendons. ●

TEAM & TECHNOLOGY

Owner – Atlantic Multipower d.o.o.
Main contractor – Projektgradnja d.o.o.
Designer – Zoinvest d.o.o.
Technology – BBR VT CONA CMM monostrand
BBR Network Member – BBR Adria d.o.o. (Croatia)

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CAR PARK, **MASSY, FRANCE**

Post-tensioned basement slabs

INNOVATION IN PARTNERSHIP

In Massy, a south-western suburb of Paris, near to Orly Airport and South TGV Station, a new business and residential community is being created – Quartier Atlantis. Claude Néant describes how the team from Paris-based BBR Network Member ETIC has provided the very latest technology and know-how to overcome a challenge during construction of a new town center office building.

1 Temporary support structures meant the developer could not use precast elements as planned, so ETIC provided an alternative post-tensioned slab solution for the underground parking levels.
2 Artist's impression of the completed Massy Helios building to the south west of Paris, adjacent to the TGV railway station and close to Orly Airport.

TEAM & TECHNOLOGY

Owner – Amundi Immobilier Helios Massy
Developer – Investissement Hertel
Main contractor – Leon Grosse
Technology – BBR VT CONA CMM monostrand
BBR Network Member – ETIC S.A. (France)

This sensitive and well-planned redevelopment of the previously densely industrialized zone in Massy will see the creation of some 14,000 new jobs, as well as bringing residential accommodation into the new neighborhood. The excellent transportation links enjoyed by the town offer easy access to Paris, other areas of France – and beyond.

Project overview

The Massy Helios development stands right in front of the southern entrance to the high-speed TGV railway station. The six storey office building has two basement levels of car parking. The challenge arose when temporary horizontal steel supports were installed to maintain stability of the lateral walls during excavation of these two underground levels.

The temporary supports would have made slab construction with precast elements – as normally used for this type of structure – very complicated. So, when ETIC proposed a post-tensioned solution, it was accepted by both the developer and main contractor.

Parking slabs

The two slabs measure 88 x 45m and 72 x 52m long and wide. Each slab was 250mm thick and had four rows of columns spaced at 9.5m in one direction and 5.5m in the other. The live load of the structure was 250N/m^2.

Post-tensioning activity

We used the BBR VT CONA CMM monostrand unbonded system for the post-tensioning of both slabs.

In the longer, longitudinal direction we installed eight CONA CMM monostrand tendons to create an internal beam, within the slab, on the axis of the columns. There were four columns per length in the longitudinal slab direction. These beams were stressed after construction. The longitudinal post-tensioning allowed us to preserve a constant 250mm thickness over the whole surface of the slabs and avoid the punching effect between column and slab.

For the shorter, transverse direction we installed four CONA CMM monostrand tendons per meter of slab concreted, in pour strips of 10m. Concrete pouring took around a day-and-a-half to two days each. At each extremity, we placed one passive anchor and one active anchor and we stressed the tendons two days after concreting.

When concreting of the whole slab and stressing of all the longitudinal and transversal tendons had been completed, we used traditionally reinforced concrete to construct a 1.5m wide lateral band between the wall and the ends of the transverse tendons to link the peripheral walls with the slabs. ●

CABLE-STAYED BRIDGES, **POLAND, MALAYSIA & CANADA**

BBR HiAm CONA stay cables become international system-of-choice

CREATING NEW LANDMARKS

As one major cable-stayed bridge project is completed and three others are gearing up to begin, it is clear that BBR HiAm CONA stay cables have become the system of choice internationally. The University Bridge, in the Polish city of Bydgoszcz, has opened – meanwhile the BBR Network will soon start installing BBR HiAm CONA stay cables for Rzeszow Bridge, also in Poland, along with the St Jacques Bridge in Montréal, Canada and the Pulau Poh Bridge in Terengganu, Malaysia during 2015. ➤

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"Many of the most dramatically beautiful architectural designs and technically excellent feats of engineering have been realized with the use of state-of-the-art Swiss BBR stay cable technology."

Today, the creation of a bridge is not just about creating a new piece of infrastructure – it's very much more than this. We live in an age where caring for the environment in which we live has become recognized as a priority, thus we look for maximum value from all our construction activities. We demand purpose, aesthetics, time and cost-effectiveness and low environmental impact. Choosing to build a cable-stayed bridge can often minimize intrusion in sensitive, protected environments and, when combined with the advantages of the BBR HiAm CONA stay cable system, this choice becomes sustainable from every perspective. BBR HiAm CONA has the highest capacity, most compact and widest range of anchorages – combined with superior fatigue resistance, advanced water tightness, high corrosion protection, simple installation and easy, low maintenance.

Track record of world firsts

Over 420 stay cable projects have been carried out by the BBR Network in almost 55 years. During this time, pioneering BBR technology has enabled construction teams to be the first to use wire stay cables (1958), first to use strand stay cables (1968) and first to use carbon stay cables (1994). Today, the BBR HiAm CONA stay cable system – introduced in 2008 – is simply the finest product on the market place – from just about every perspective. Many of the most dramatically beautiful architectural designs and technically excellent feats of engineering have been realized with the use of state-of-the-art Swiss BBR stay cable technology. The BBR HiAm CONA strand stay cable system, BBR HiEx CONA saddle technology for extradosed applications and the BBR HiAm / DINA wire stay system are unrivalled anywhere on the planet.

BBR HiAm CONA strand stay cable system

HiAm CONA fulfills the latest international standards and recommendations deemed approved and compliant with *fib* Bulletin 30, as well as the corresponding PTI and Setra recommendations. Its wide range up to 217 strands, tendon capacity from 200 to 60,000kN, advanced water tightness, high corrosion protection, simple installation and superior fatigue resistance makes it attractive for the most challenging of projects. Designers and architects have particularly welcomed the compactness of the anchorage system which allows them greater scope to produce a sleeker and more striking structure. HiAm CONA is subject to BBR Factory Production Control and must be installed by certified BBR PT Specialist Companies only. The system can be used for cable-stayed bridges, arch bridges, roofs and also special applications like towers.

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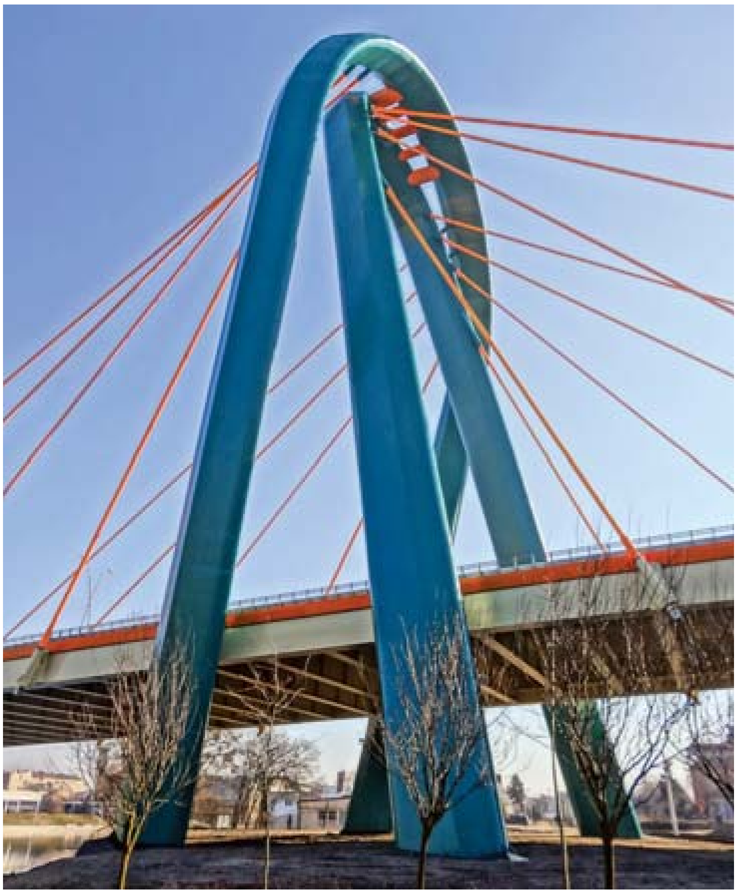

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Complementary technology
Complementary technology includes the BBR HiEx CONA saddle system which represents the newest and most modern saddle for stayed and extradosed bridges. The HiEx CONA saddle system completely eliminates the problems associated with standard friction saddles and, at the same time, allows for a compact and slender pylon. The technical solution results from the combination of the CONA CMI internal PT system with the BBR HiAm CONA strand stay cable system.
The BBR HiAm CONA Pin Connector is the perfect blend of strength and beauty, while at the same time it extends the inherent benefits of the BBR HiAm CONA family. The BBR HiAm CONA Pin Connector is a beneficial solution for stay cable structures where it is necessary to simplify the end connection detail or to have a certain rotational capability along a specific axis.
Due to its simple design, high efficiency, easy adjustability and low maintenance requirements, the BBR Square Damper is simply the most superior damping device available on the international market. The BBR Square Damper incorporates a new generation of materials, together with a ventilation / insulation system to enhance the durability of the components and to extend maintenance intervals.
Complimenting the friction based BBR Square Damper, the latest addition to the range is the BBR Viscous Damper suitable for internal and external applications.
There is more information about these dampers on Page 86 and the BBR HiAm Strand Stay Cable Damping Systems technical brochure can be downloaded from the BBR Network website.

1 Largest road investment
With the opening of University Bridge, the town of Bydgoszcz began to reap the rewards of its largest ever road investment – and of BBR technology and know-how. The new 200m long bridge is part of a four-lane 'University Route' which stretches 1.58km and links the northern and southern suburbs of the city. Realization of the three year scheme was made possible by co-funding from the European Union.
BBR Polska was responsible for installing the stay cables, as well as executing the post-tensioning of the side flyovers and delivery of expansion joints.
University Bridge is a composite structure – with a steel frame and a concrete deck. It is suspended from pylons using 16 BBR HiAm CONA stay cables – four pairs on each side – encased in HDPE pipe. The longest stay cables are almost 49m long. The steel pylons are almost 70m high and form the shape of two intersecting horseshoes – one symbolizing the shape of Greek letter 'Omega', the other 'Alpha'. This was a unique type of structure for Poland and its distinctive form presented many challenges to the construction team. ➤

1 The new 200m long University Bridge in Bydgoszcz, Poland.
2 Cross-section of a BBR HiAm CONA stay cable.
3 The University Bridge, Bydgoszcz under construction, with the intersecting horseshoe pylons taking shape.
4 The distinctive pylons of the University Bridge create a dramatic new panorama, as construction work in Bydgoszcz draws to a close. Photograph courtesy of Pitt1233, Wikimedia Commons, CC0 1.0 Universal.
5 BBR Polska installed the stay cables for the University Bridge, as well as executing PT for the side flyovers.

"The creation of a stay cable bridge was greeted as an opportunity to create a landmark structure."

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6 The new 480m long bridge in Rzeszow, Poland will feature 64 BBR HiAm CONA stay cables – and become a new landmark for the city.

7 Artist's impression of the new 133m long cable-stayed bridge which will link Pulau Poh island to the shores of Lake Kenyir, Malaysia.

8 Montréal's elegant new Saint Jacques Bridge is being constructed using the BBR HiAm CONA stay cable system and forms part of a massive infrastructure replacement scheme in this Canadian city.

2 Landmark opportunity

Meanwhile, the BBR Polska team has won a further contract for a cable-stayed bridge – in an open and very competitive bidding process. They will be installing 64 BBR HiAm CONA stay cables on the new Rzeszow Bridge over the Wislok river.

For over 30 years, the municipality of Rzeszow has been planning to build a bypass running through the town's north-western industrial zone – the northern section of the inner city ring road. Construction of this new infrastructure, made possible by co-funding from the European Union, will relieve traffic congestion and act as an economic stimulus to the area.

The new 1.8km road will connect Zaleska and Lubelska streets and a key element of the scheme is the 29m wide bridge. The creation of a stay cable bridge was greeted as an opportunity to create a landmark structure. The new road bridge over the river and adjacent power station reservoir will be 480m long, with a main span of 240m and four side spans of 150 + 30 + 30 + 30m. Stay cables will be anchored at a single 108m tall A-shaped pylon located on the west bank of the river and the top will proudly bear the Rzeszow coat of arms, a knight's cross. The asymmetrical position of the pylon minimizes the number of supports and environmental impact – a particularly important factor, as the reservoir, river and floodplains are in a Natura 2000 site.

The composite bridge deck will have four traffic lanes plus pedestrian walkways on both sides. The bridge will be equipped with 128 BBR HiAm CONA anchorages with sizes ranging from 17-114 strands – and the longest cable will stretch 230m.

The stay cables will also be fitted with the latest BBR Viscous Dampers – there is more information about these dampers on Page 86 and the full technical brochure can be downloaded from the BBR Network website.

Installation of the stay cables is expected to start around May 2015 with completion by September 2015.

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3 Connection for eco-tourism

Exciting developments are underway at Lake Kenyir, in Malaysia's eastern province of Terengganu, and these involve the construction of another cable-stayed landmark bridge.

The new bridge will have a 133m long main span and, when completed in 2016, will link the new Pengkalan Gawi marina center development with the island of Pulau Poh which sits within South East Asia's largest manmade lake.

The lake was created when the Kenyir river was dammed in 1985 as part of a hydroelectric power scheme. Since then, the lake has been developed for eco-tourism and now has many resorts around its shores. Pulau Poh is one of 340 small islands created by former hilltops or highlands during the formation of the artificial lake.

The Pulau Poh Bridge will carry two lanes of traffic in each direction and there will be a 2.5m wide pedestrian walkway on both sides of the deck. Its striking 60m high inclined curved A-pylon will become a landmark for the area. BBR Construction Systems (Malaysia) will install 20 pairs of HiAm CONA stay cables to support the deck and these will be counter-balanced by seven pairs of massive 12706 HiAm back stays. Stay cable works are scheduled to start in late 2015.

4 Environmental integration

Having opened in time to serve visitors attending Expo '67 – over 45 years ago – the 21km of roads making up Montréal's Turcot Interchange are now being reconstructed. This important intersection, which carries around 300,000 vehicles each day, is showing signs of aging. Set for completion in 2020, the $3.7bn scheme will see the replacement of some 128 lane kilometers of elevated highways that are, in some places, stacked three high.

In this scheme, Transports Québec is seeking to integrate the project into the urban environment while incorporating a number of green and significant architectural elements. The Saint Jacques Bridge – a new cable stayed bridge over the A15 highway – is certainly destined to add a sense of space and elegance to the cityscape.

The bridge will have a two span superstructure – with spans of 55m and 65m – and a steel pylon. ETIC, the BBR Network Member for France has been appointed to install ten 3106 BBR HiAm CONA stay cables with the longest cable being 68m in length.

The use of the HiAm CONA stay cable system here is particularly appropriate – as this will be Transports Québec's first carbon-neutral project. ●

TEAM & TECHNOLOGY

1 **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 z o.o. (Poland)

2 **Owner** – City of Rzeszow
Main contractor – Bilfinger Infrastructure S.A.
Designer – Promost Consulting / Mosty Gdansk
Technology – BBR HiAm CONA stay, BBR Viscous Damper
BBR Network Member – BBR Polska z o.o. (Poland)

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

4 **Owner** – Transports Québec
Main contractor – DB-Aecon JV
Designer – Transports Québec with CIMA / SNC-Lavalin
Technology – BBR HiAm CONA stay
BBR Network Member – ETIC S.A. (France)

DE MOLENBRUG BRIDGE, **NETHERLANDS**

BBR HiAm wire stay cables inspection

THIRTY YEARS YOUNG

De Molenbrug is still commonly known as the 'new bridge' although it has been spanning the River Ijssel, near the town of Kampen, for just over 30 years. Ruud Steeman from Spanstaal – Ballast Nedam, the BBR Network member for the Netherlands, reports on a recent inspection of the stay cables.

The ultimate goal of the project was, by means of inspection, to determine what measures would need to be taken to create a 10 to 15-year maintenance free period for the 48 BBR HiAm parallel wire stay cables and their anchorages.

In 1983, BBR Network Member Stahlton had provided Spanstaal with the stay cables needed for the original installation. So, it was fitting that this inspection project should also have been carried out jointly by Coos Boon of Spanstaal and Jürg Däniker of Stahlton who were both involved with the project some three decades earlier. The investigation concluded that, even after all these years, the cables were still intact and functioning well – only anticipated minor maintenance tasks needed to be performed. Once again, BBR technology has proven that it can stand the test of time.

TEAM & TECHNOLOGY

Owner – Rijkswaterstaat
Designer – Rijkswaterstaat
Main contractor – Spanstaal
Technology – BBR HiAm stay
BBR Network Member – Spanstaal – Ballast Nedam Infra Specialiteiten BV (Netherlands)

SILOS & TANKS, **AUSTRALIA, OMAN & UNITED ARAB EMIRATES**

BBR VT CONA CMI hoop tendons for slipform silo and tank construction

FROM INDUSTRIAL INGREDIENTS TO WATER STORAGE

BBR Network Members have again been demonstrating their skill in the creation of post-tensioned concrete silos and tanks for a variety of uses. The projects – in Australia, Oman and the United Arab Emirates – were all constructed by the slipform method and all used BBR hoop tendons. ➤

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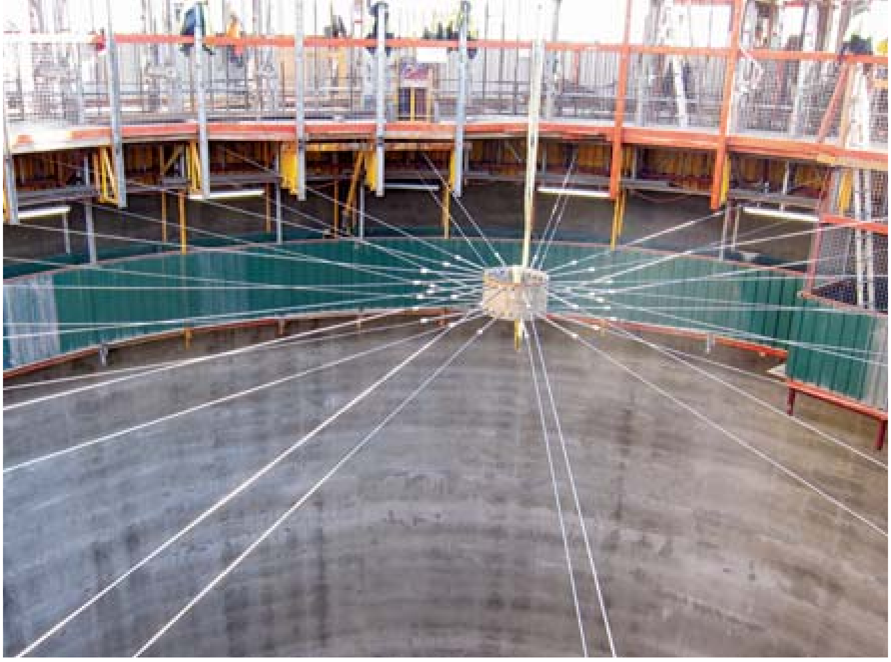

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1 Cement silo, Perth, Australia

SRG's unique ability to provide a slipform and post-tensioning package solution, combined with a track record of reliable service, have been at the heart of a strong relationship with BGC Cement. Mahesh Nayak reports that this excellent working relationship has brought the Australian BBR Network Member repeat business in the shape of their fourth silo construction project for this client since 2005.

We were contracted for the post-tensioning and slipforming design and construction of the new 10,000t BGC cement silo at the Perth Naval Base. The silo stands 43.1m high and has an internal diameter of 18m, with wall thicknesses varying from 700mm to 300mm.

Slipforming operations continued around-the-clock, generally progressing at around 250mm per hour. There were two stops in the slipforming process – the first, at 3.2m, for connecting a trailing deck and secondly, at 10.35m, to make adjustments for the reduction in wall thickness.

We used 50 five strand BBR VT CONA CMI 0706 hoop tendons, anchored at buttresses where we installed mast climbers to enable the post-tensioning works. Tendons were stressed simultaneously in pairs from opposing buttresses.

Special attention was paid to grouting works. After running rigorous tests with different additives, we came up with a grout mix design that met the stringent specification requirements and delivered compressive strengths in excess of 60MPa.

One of our key challenges and successes was close co-ordination with other trades. This was especially important as embedment of mechanical devices was taking place alongside PT ducting installation during slipforming. We completed the contract in just 12 weeks and our commitment to health and safety was recognized by our client.

2 Alumina silo, Sohar, Oman

This new alumina silo was constructed as part of an expansion plan for Sohar Aluminium – one of the region's leading factories – which produces a variety of aluminum products, mainly for the building industry. Warwick Ironmonger of BBR Network Member NASA Structural Systems, reports that his company was selected, by the main contractor for the expansion project, as specialized post-tensioning subcontractor.

We were proud to be associated with this project as it was our first silo project in Oman. Our scope involved the supply and detailing of the post-tensioning systems and supervision of post-tensioning duct installation during slipforming, strand pushing post-slipforming, stressing and grouting works – all with our specialist plant and equipment.

The height and inner diameter of the silo were 37.38m and 24m respectively and there were four stressing pilasters set at 90° from each other. The BBR VT CONA CMI internal 0706 and 1206 hoop tendons, each divided into two halves, were anchored at opposing pilasters.

The silo was constructed using slipform construction methodology and the post-tensioning ducts were installed during slipforming operations which progressed continually around-the-clock.

Strand pushing was carried out after completion of slipforming and dismantling of formwork. We used a hydraulic powered strand pusher for pushing the strands. Coil dispensers were kept on the ground near to the stressing pilasters and mast climbers were used for pushing, stressing and grouting works.

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3 Water tanks, Umm Al Quwain, United Arab Emirates

To meet this Emirate's water demands, the Federal Electricity and Water Authority (FEWA) extended the Fujairah-Al Ain water transmission line – owned by the Abu Dhabi water and electricity authority – to Umm Al Quwain, then constructed a four million gallon capacity reservoir at the existing Umm Al Quwain distribution center and a one million gallon reservoir in Falaj Mualla.

NASA Structural Systems was appointed by the main contractor to perform the specialist post tensioning works, including supply of BBR post-tensioning kits, shop drawings related to the post-tensioning works, designing the antiburst reinforcement, installation, stressing and grouting works.

For the larger of the two reservoir tanks, there were 20 layers of post-tensioning hoop tendons. Each layer was comprised of four tendons which extended between two adjacent buttresses.

The tank height and diameter were 10m and 52m respectively. The walls were typically 350mm thick and locally thickened to form eight equally spaced 2,500mm long x 800mm wide buttresses. These accommodated anchorages and stressing of the BBR VT CONA CMI internal 0706 tendons.

Meanwhile, the one million gallon reservoir featured 15 layers of hoop tendons. Here, each layer consisted of three CONA CMI tendons which, again, extended between two adjacent buttresses. The tank height and diameter were 10m and 13m respectively. Walls were typically 350mm thick, but locally thickened to form six equally spaced buttresses, of the same dimensions as above, to allow space for anchorages and tendon stressing activities. ●

1 BGC cement silo, Perth, Australia – 50 five strand BBR VT CONA CMI 0706 hoop tendons were anchored at buttresses, where mast climbers facilitated the post-tensioning works.
2 BGC cement silo, Perth, Australia – close co-ordination was required with other trades, especially as embedment of mechanical devices took place alongside PT ducting installation during the continuous slipforming operation.
3 Alumina silo, Sohar, Oman – this 37.38m high slipformed silo was NASA Structural Systems first post-tensioned silo project in Oman.
4 Water tanks, Umm Al Quwain, United Arab Emirates – two water tanks were post-tensioned using CONA CMI hoop tendons.

TEAM & TECHNOLOGY

1 **Owner** – BGC Cement
Main contractor – BGC (Australia) Pty Ltd
Design – Structural Systems Limited (Slipform & PT Works)
Technology – BBR VT CONA CMI internal, slipforming
BBR Network Member – SRG Limited (Australia)

2 **Owner** – Sohar Aluminium
Design consultant – RTA Alesa Ltd
Main contractor – Petron Gulf LLC
Technology – BBR VT CONA CMI internal
BBR Network Member – NASA Structural Systems LLC (United Arab Emirates)

3 **Owner** – Transco, Abu Dhabi Transmission and Despatch Company
Main contractor – Al Nasr Contracting Co. LLC
Consultant – AECOM Middle East
Technology – BBR VT CONA CMI internal
BBR Network Member – NASA Structural Systems LLC (United Arab Emirates)


4

WIND TOWER DEVELOPMENTS, **GERMANY**

Innovation in wind tower construction

SOWING INNOVATIVE SEEDS TO REAP THE WIND

While the new demands created by the intensification of interest in wind power generation – following the Japanese nuclear disaster in 2011 – are relatively recent, BBR technology and expertize has long been applied to satisfying customer requirements in this sector. Thomas Heubel of German BBR Network Member KB-VT, examines what has been happening in the market place and shares news of his company's innovative work underway in Germany.

When invited to write an article for CONNÆCT about wind power, I immediately agreed – based on the many years of experience we have here at KB Vorspann-Technik in this area. However, when thinking about this carefully, doubts crept in – what actually should a supplier of post-tensioning systems say about wind power?

The creation of wind power has brought about the collision of two industries that could not be more different. The classic conservative construction industry – which is not exactly known for its short innovation cycles – and the young, modern rapidly developing wind industry, which is essentially driven by the keenly innovative equipment manufacturers.

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Understanding roles

The towers, which carry the generators and facilitate energy production from wind, were long regarded as merely a secondary element of a wind turbine – and, as such, deserved no special attention. Thus, initially people simply used whatever was to hand to elevate the blades of the wind turbines to the desired height. Lattice masts were well-known from the building of electricity pylons, while steel pipes were also quickly crafted into tower construction, since both of these items were readily available. It was almost like ordering from a catalog – and, thanks to the sharp decline in transportation costs, they could pretty much be obtained from anywhere in the world.

Initially, the suitability of the well-proven structural steel and steel construction methods for dealing with the compressive, tensile and vibrational stresses that occur in a wind tower were not questioned – because, as mentioned above, the tower was deemed only to play a minor role in the wind industry. Logistics and construction did not present any special challenges, so focus was concentrated on the critical systems engineering. Generators were quickly developed into high-performance engines – in a similar way to developments which have progressively increased the performance of personal computers – meanwhile, the construction technology was completely neglected.

This omission, however, should be laid squarely at the door of the construction industry, rather than the installation developers themselves. Vehicle manufacturers also prefer to rely on their suppliers to develop tires rather than doing it themselves. For lack of better deals, developers grabbed whatever equipment was easily available – having never seen themselves as instigators for the development of tower construction.

In principle, they do not care whether the equipment is on a tower made of wood, steel or concrete, as long as the loads arising from the plant can be safely and permanently transferred to the subsoil – and, above all, as long as the costs are reasonable.

Optimizing performance

The very rapidly developing wind machine industry – which experienced a huge surge after the disaster at Japan's Fukushima nuclear plant – is now suddenly demanding taller towers, as larger generators require higher and more consistent wind flow to optimize their performance on land.

Just a few years ago, the hub height of generators was in the range of 70-100m, today heights of around 150m are already standard – and the trend is towards even greater heights. Like the tower heights, rotor diameters have also grown to 130m – a dimension that would, a few years ago, have been unimaginable.

At this point, we return to the first question asked… what, from the viewpoint of a post-tensioning company, is interesting about the wind industry – apart from admiring the strength of innovation that this intrinsically new industry possesses and how it always manages, time-and-time-again, to raise the necessary development funds despite higher risks.

Traditional approaches

At the heights currently required, the simple tubular steel tower is reaching its technically and logistically sensible limits – and thus also its economic feasibility. The continuing high demand for on-shore tower structures has led to the current round of testing of new systems – such as wooden-framed towers, steel lattice masts, towers of folded sheet steel bolted together and other construction methods which, essentially, attempt to apply existing principles of construction to the new requirement.

So far, only one of these – the so-called hybrid construction method – has been taken up. This method combines concrete and steel construction in a way which plays to the materials' individual strengths. While concrete is used for its good compressive properties for the first 70-100m lower part of the tower, steel shines through for construction of the tower's upper 50-80m due to its light weight and speed of installation.

Concrete without prestressing should simply no longer exist for engineering structures – this is where we come in! Even if the application of post-tensioning systems were to be 100% in the building sector, PT companies would still not be builders – certainly not as far as their capacity for innovation is concerned, although not quite all construction firms are the same. ➤

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Strategic innovation

Since the late 1990s, KB Vorspann-Technik has been working together with a construction company on the development of a concrete tower with external prestressing for the wind industry – and this has now become the standard design for high towers. Modern hybrid towers use external post-tensioning for the concrete shaft, making this approach economical when compared to steel towers.

Today, due to time constraints, most towers are constructed of precast concrete components – but it is the post-tensioning on the inside of the towers which holds them together and makes them viable in the first place.

Those contractors who have moved to modern manufacturing processes and building methodology tailored to the specific application – rather than requiring the application to adapt to their existing or old technology – have become established in the market for wind towers.

Meeting customer needs

Following the Fukushima incident, Germany – our home base – has decided to phase out nuclear energy and has therefore turned to renewable forms of energy generation. Benefiting from our location, we have now worked on over 350 projects with various tower designs.

Meeting the needs and stipulations of the wind industry constantly requires us to maximize effort in terms of production, logistics and application development to achieve the required technical – and particularly the economic – outcomes.

At the beginning, we should have concentrated on the development of our own assembly platforms – rather on the application system – and directed our focus towards the highest possible factory prefabrication of our products and services. Today, increasingly attention is on application-oriented product development as a means of continuing to meet the increasingly stringent requirements of our customers in relation to cost-effectiveness, durability and assembly logistics.

1 BBR technology and expertize has long been applied to satisfying customer requirements in the wind power sector and innovative work is underway in Germany. Photograph courtesy of Nordex SE.
2 Since the late 1990s, KB Vorspann-Technik has been working together with a construction company on the development of a concrete tower with external prestressing for the wind industry – and this has now become the standard design for high towers.
3 Like the tower heights, rotor diameters have also grown to 130m – a dimension that would, a few years ago, have been unimaginable.
4 Today, due to time constraints, most towers are constructed of precast concrete components – but it is the post-tensioning on the inside of the towers which holds them together and makes them viable in the first place.
5 KB Vorspann-Technik has now worked on over 350 wind projects with various tower designs.

"Just a few years ago, the hub height of generators was in the range of 70-100m, today heights of around 150m are already standard – and the trend is towards even greater heights."

ARJANG & TANUM WIND FARMS, **SWEDEN**

Installation of ground anchors for wind tower bases

STRONG ROOTS

Constructing strong foundations for wind towers has become a regular feature of Swedish BBR Network Member Spännteknik's work. Their latest project involves 33 bases at two different wind farms – Tanum and Arjang – in south west Sweden. Göran Thunberg provides a brief insight into the project.

1 The rock anchors were manufactured at our plant in Kongsvinger, Norway and, at these remote sites, we were required to be self-sufficient for craneage during installation and stressing, as well as for power and compressed air. We also performed all the drilling and testing of the boreholes to the rock anchors.

2 The anchors were stressed, 7-10 days after grouting, to a test load of 70% of specified breaking load with a hold period to measure any load losses. Anchors were then locked at 60% of breaking load as specified by the designer. After checking that all results were as required, the strand lengths used for stressing were cut and protective caps mounted.

3 Anchor plates and protective caps had been galvanized prior to delivery. Our final job was to fill the roughly one meter space beneath the anchor plate and protective cap with grout. We injected the approved grout through a horizontal hole in the anchor plate and when the grout emerged through the hose on the protective cap, the hose was sealed. Our work was thus completed and the foundation was ready for a wind tower to be installed.

For the 94m high wind towers at the Tanum Wind Farm, we installed 11 foundations with eight 12m long BBR VT CONA CMG 1906 ground anchors each. Meanwhile, at Arjang – where the wind towers were 124m high – we used 16 CONA CMG 1506 ground anchors, which were 14.5m long, for each of the 22 foundations. ●

TEAM & TECHNOLOGY

Owner – Rabbaldshede Kraft AB
Main contractor – Svevia AB
Designer – VBK
Technology – BBR VT CONA CMG ground
BBR Network Member – Spännteknik AB (Sweden)

New generation

Despite ongoing political discussion about the intrusiveness of wind towers on landscapes, making the change from conventional energy production to renewables is not possible without the wind industry. Thus, a ready market for us as suppliers of prestressing systems has been created which, as well as needing our full attention and much commitment, will also be a source for innovation – from which classical construction techniques will also profit.

In many countries of the world, energy production is still dependent on government investment. The desire to transform these investments into local value-added, is often easier to implement with concrete that can be produced almost anywhere, than with steel – which must, in many cases, be imported and thus shifts the value creation into other countries.

Inspired by our wind tower construction experience and with an eye to a future of ever-rising tower heights, for some time now we have been working with architects and other construction specialists on a tower building concept – a third generation, made only of concrete which, more than ever before, plays to our strengths in the field of post-tensioning and stay cable technology. Central to this work, is finding a solution for the logistical challenges posed by increasing tower heights, as well as environmental issues.

The development of our tower concept is largely completed and a pilot installation is being planned. You can expect to read more about this in forthcoming editions of CONNÆCT – meanwhile, never doubt the role that a supplier of post-tensioning systems can play when innovation is needed! ●

MHLOTI BRIDGES, N2 UPGRADE, **DURBAN, SOUTH AFRICA**

Incremental launching on a curve

TRADEMARK TECHNIQUES

Having been applied on so many projects by their team, incremental launching methodology has become something of a 'trademark' for BBR Network Member Structural Systems Africa. Shane Coll, Operations Manager, describes their most recent project for the N2 upgrade scheme in Durban.

TEAM & TECHNOLOGY

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

Main contractor – Group 5 Coastal / 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

When completed, the N2 upgrade scheme will accommodate the increase in traffic flow between Durban City Centre and the newly-built King Shaka International Airport, north of the city. A key feature of the scheme is the widening of the Mhloti bridges, by constructing two incrementally launched bridges alongside the existing carriageways, to increase the capacity of each bridge to three lanes.

Incremental launching methodology was chosen for the new bridges as it would cause only minimal disturbance to the area beneath and also avoid any disruption to progress which may otherwise be caused by heavy rains during the spring and summer.

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Structural overview

The new bridges are identical in both geometry and design. A hollow box girder design has been utilized which contains both concentric and draped BBR VT CONA CMI post-tensioning tendons. Each bridge consists of 17 segments of 16.67m in length and each has four 50m and two 40m spans. The bridges were launched downhill on a vertical curve and then longitudinally stitched together to the two existing bridges.

Restraint system

Due to the downhill slope, two restraining jacks were used in combination with PT bars cast into each individual bridge section. The restraint force on these jacks was adjustable. Using the latest structural analysis software, we calculated the restraint force required once each segment was cast. Based on this, we set the restraint force of the restraint jacks using a 110t hollow ram jack. Once the launch began, the restraint force in the restraint jacks was overcome and the jacks began to retract. Then, once the bridge was placed back on the brake saddles, the restraint jacks held the dead load of the bridge.

Once the launching was complete, all of the draped tendons were installed in the bridges and then stressed. After stressing the draped tendons, all of the temporary bearings were replaced with permanent bearings. As part of the works, we will also be replacing the bearings on the old bridges – under live traffic conditions.

This bridge marks another successful incremental launching project for Structural Systems Africa. Since 2009, the same crew has travelled from one incremental launching project to another – and has become extremely skilled in applying the methodology and overcoming the challenges of incrementally launched bridges. ●

1 The highway widening was achieved by constructing two incrementally launched bridges alongside existing carriageways.

WHARF REPAIRS, **AUCKLAND & WELLINGTON, NEW ZEALAND**

Innovative maritime solutions

SEASIDE SAVIORS

As a small island nation with more than 15,000km of coastline, New Zealand is home to hundreds of seaside communities and a number of stop-off points for import-export shipping and international cruise liners. However, these locations come at a cost, with the harsh marine environments corroding concrete and metal structures and shortening service lives in the process. **BBR Contech**'s Mark Kurtovich and Dean Latham report on two recent projects involving communities and businesses affected by the unfortunate consequences of coastal occupation.

1 Transforming a waterfront gateway

A NZ$24 million transformation underway in one of Auckland's most popular harbor-side suburbs includes a major redevelopment of its marine gateway. Built in 1929 in the days of car ferries and cargo ships, the 150m long Victoria Wharf has become a popular walking and fishing spot. However, in September 2012 it was closed to the public, owing to an increasingly serious decline in its condition. While the piles were in generally good shape, chloride-induced corrosion had damaged the reinforcing steel in many of the structural elements, the cover concrete suffered from splitting and spalling – and the deck slab soffits were in extremely poor condition. Recognizing the wharf's historic role and archaeological significance, Auckland Council sought a design-build solution that retained its heritage elements, footprint and harbor views. ➤

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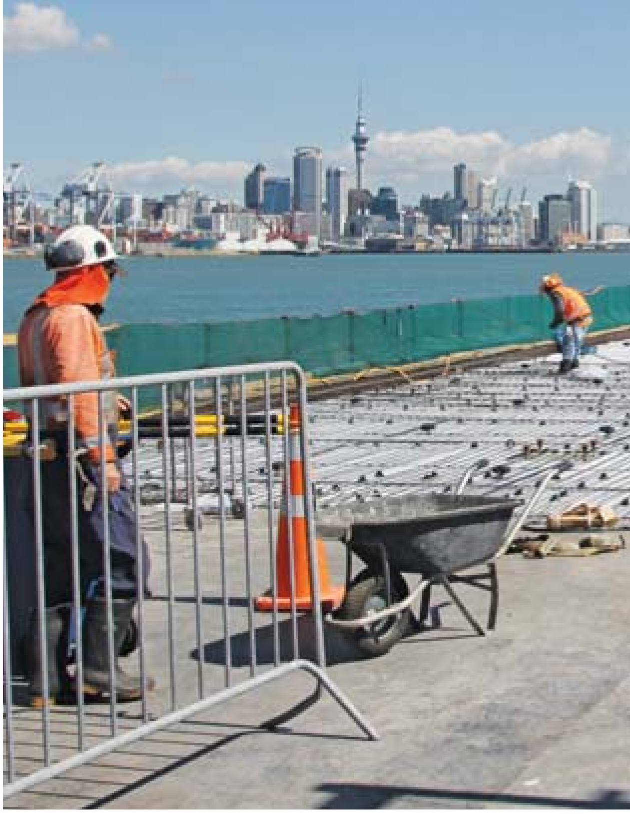
> "BBR Contech brought to the team a fantastic combination of technical knowledge, smart technology and on-site physical capabilities.
> They were also brilliant as part of the team, in supporting us to produce the winning bid, working with the client throughout the project and handling the occasional road block with dignity.
> The collaboration worked really well – and you can't ask for more than that."
>
> Murray Ford, Project Manager, Downer NZ



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Tripartite approach

A design-build partnership comprising BBR Contech, engineering and infrastructure management specialist Downer and design engineering firm Novare Design successfully tendered to repair the wharf. Their appointment to this high-profile project reflected both their extensive experience with this kind of work and their innovative approach to the design solution, which meant they could achieve two important council requirements – commit to the tight timeframe of just 12 months for completion and meet a strict budget limit of NZ$6m. What's more, they could eliminate the need to transport around 3,000t of wharf demolition material through the tiny Devonport township and beyond.

This unusual design solution was remarkably simple – keep and reuse as much of the existing wharf as possible by constructing a new deck on top of the old, supporting it only on the wharf piles and bypassing the badly corroded deck slab and beam.

While it had its challenges, the project was delivered on time and within budget, with the team removing deteriorated concrete from the piles and braces underneath the wharf, installing new reinforcing bars, extending the pile reinforcing and constructing a new decking slab on top of the existing concrete surface. They also installed a grid of hangers to connect the old deck to the new – to prevent large pieces of the now-redundant old deck from falling and damaging the wharf's substructure during a seismic event.

Successful collaboration

The project demonstrated the team's ability to repair, strengthen and upgrade a modern, mixed-use facility in a busy urban environment with minimal disruption to the surrounding community and business network. They also succeeded in designing a solution that integrated the historic fabric of the original structure with the new, enhancing the wharf's purpose and long-term sustainability.

The wharf reopened to the public in November 2014 and will now continue to be a significant commercial and recreational asset for the village, surrounding community and thousands of people who visit each year.

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1 Auckland's historic Victoria Wharf has now reopened to the public after specialist structural repairs. Photograph courtesy of Incredible Images.
2 The design solution for reviving Victoria Wharf involved constructing a new deck on top of the old, supporting it on the wharf piles and bypassing the badly corroded deck slab and beams.
3 The design-build partnership succeeded in designing a solution that integrated the historic fabric of Victoria Wharf's original structure with the new.
4 The team removed deteriorated concrete from the piles and braces underneath Victoria Wharf, installing new reinforcing bars, extending the pile reinforcing and constructing a new decking slab on top of the existing concrete surface.
5 Thorndon Wharf, CentrePort, Wellington – this main container wharf, damaged in the July 2013 earthquakes, has now been repaired and the compromised cathodic protection system has been reinstated.

2 Enabling wharf operations

With help from the team at BBR Contech, Wellington's main container wharf received some emergency repairs following a significant earthquake.

Following the 'Seddon' earthquakes that hit central New Zealand in July 2013, a number of Thorndon Wharf's supporting piles were found to have suffered damage. CentrePort, Wellington's Port facility owner, arranged for Holmes Consulting to undertake a survey of the wharf structure following the sequence of earthquakes. BBR Contech was also consulted due to its long association with CentrePort – and involvement in New Zealand's largest cathodic protection installation on the wharf, completed in 2011.

The team worked together to establish the extent of repairs, formulate suitable repair methodologies, prepare budgets and plan for the work to be carried out around existing port operations. Unfortunately, the earthquake damage had impacted on some of the new cathodic protection system and any repair had to ensure this was also restored.

The scope of work included repair – of varying sizes and extent – to the cracked piles. This included 'hand-patch' techniques and injection of epoxy resins to fill cracks and return structural integrity to the broken piles. Several of the damaged piles received a new reinforced collar for the top meter of the pile.

A total of 120 piles were repaired on this 600m long wharf – with work being carried out urgently and completed in June 2014, so that the wharf could be returned to full operating capacity. ●

TEAM & TECHNOLOGY

1 Owner – Auckland Council
Design-Build Partnership – Downer, Novare Design & BBR Contech
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

2 Client – CentrePort
Main contractor – BBR Contech
Designer – Holmes Consulting
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

DUBAI HEALTH CARE CITY, **DUBAI, UNITED ARAB EMIRATES**

Remedial works for Hyatt Regency Dubai Creek Heights

SPECIALIST KNOW-HOW FOR STRUCTURAL CHANGE

BBR Network Member NASA Structural Systems was originally appointed to undertake the specialist design and construct post-tensioning works associated with the suspended tower floors of the hotel and apartment towers for the Dubai Health Care City project. These PT works were successfully completed in November 2008, but the financial crisis saw the completion of the overall project delayed for a period of almost five years, a change in ownership of the towers and, eventually, a change in architectural demands for the hotel tower.

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Revised architectural layouts demanded changes in service penetrations throughout the already constructed hotel tower floors. NASA Structural Systems was appointed to review the proposed changes and coordinate these with the contractor, to arrive at a solution that was workable without compromising the structural integrity of the floor systems. Ultimately, we arrived at a layout that could be accommodated with the least possible modifications to the existing post-tensioned floor system and this was agreed upon for implementation, for each of Levels 01 through 32.

New service penetrations of sizes up to 1,400 x 775mm and 2,150 x 650mm needed to be introduced to the existing floor system. As these would result in a loss of concrete section and also cut as-constructed post-tensioning tendons and conventional reinforcement, Structural Systems provided a remedial solution whereby:

- existing, stressed, bonded post-tensioning tendons of sizes up to 0505 were anchored adjacent to the proposed penetrations through the implementation of epoxy 'plugs' prior to them being cut
- existing slab concrete, PT tendons, and conventional reinforcement were cut with diamond saws at newly required penetration locations
- carbon fiber (CFRP) laminates were utilized at the top and bottom of the slabs to strengthen the PT slab as required to accommodate the service openings
- carbon fiber sheets were used to wrap the edges of the newly created penetrations, offering protection to the cut steel and trimming of the void
- the carbon fiber laminates and sheets were typically epoxied along their lengths to the top and bottom of the slabs and mechanical anchorages, formed of steel plates with hold-down bolts, were employed in instances where it was required to achieve full development of the laminates at their ends.

Structural Systems not only provided the concept design for the CFRP solution, but also prepared the detailed design, shop drawings and method statements as required, obtained the approval of the approval body (TECOM) for the specialist repair works to proceed, supplied the CFRP materials, and supervised the complete MRR works.

All-in-all, over 120 new penetrations over 32 floors were introduced necessitating use of around 1,600m of carbon fiber laminates, 800m^2 of carbon fiber sheets, 85 epoxy 'plugs' and 10 or so mechanical anchorages to existing PT tendons. The bulk of the MRR work was completed over a three month period.

This is a classic example of a project where BBR Network Members assist in the development of original structural schemes, while also providing specialist knowledge and support to allow significant structural changes to be realized to accommodate changed architectural demands.

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1 When construction, under new ownership, of the part-built hotel and apartment towers for the Dubai Health Care City project resumed, changes in service penetrations were accommodated with specialist solutions from the BBR Network.

2 The remedial solution provided by NASA Structural Systems included CFRP laminates being applied, top and bottom, to strengthen the PT slabs.

TEAM & TECHNOLOGY

Owner – Wasl Asset Management Group
Consultant – RMJM
Main contractor – Al Basti & Muktha LLC
Technology – MRR range
BBR Network Member – NASA Structural Systems LLC (Dubai)

PLAZA 33, **PETALING JAYA, SELANGOR, MALAYSIA**

Strengthening of PT transfer beam

SALVAGING LOW STRENGTH BEAM

When a large concrete transfer beam in a 14-storey office tower development failed to achieve the minimum compressive concrete strength required for stressing, BBR Construction Systems Malaysia was called in to salvage the understrength beam. Mohd Yusri Yahaya talks us through the situation and solution.

The consultant had designed two post-tensioned transfer beams of Grade 45 concrete at Level 9 to carry loads of the tower. A combination of factors meant that one beam failed to achieved the required stressing strength. We proposed widening of beams on both sides and installing additional post-tensioned tendons. The PT sequence was revised to allow the existing transfer beam to be partially post-tensioned to enable construction of floors above while the beam was being strengthened.

Structural strengthening

The original beam was cast with 28 BBR CONA internal 1905 tendons. Strengthening involved widening of the beam by one meter and adding a further nine tendons on each side. Widening increased the cross-section modulus and thus its ability to handle the heavy loads from the tower. Additional tendons were installed to support the weight of the additional concrete – and to increase beneficial stresses due to post-tensioning to compensate for reduced concrete compressive strength. T20 reinforcement bar was anchored into the existing roughened face of the beam to enhance interfacing shear between the concrete of the existing beam and new concrete used for widening.

Four stage stressing

Stage one stressing of the existing section enabled prop removal and allowed construction of floors above to continue. After widening had been completed, the second stage stressing of the strengthened beam took place after completion of Level 16. The hogging deflection was at midspan and within allowable limits – so would not cause differential movements to columns supported by the transfer beam.

Stage 3 stressing was carried out after construction of Level 20 and Stage 4 stressing after completion of Level 23. The strengthened beam was checked and complied with the Service Limit State and Ultimate Limit State as set out in BS 8110. By using our BBR post-tensioning technology and stage stressing experience, we were able to help the client to salvage the beam while enabling construction works above to continue while strengthening the beam – saving program and potential overrun costs.

TEAM & TECHNOLOGY

Owner – Plaza 33 Sdn Bhd
Main contractor – SIAB (M) Sdn Bhd
Technology – BBR CONA internal
BBR Network Member – BBR Construction Systems (M) Sdn Bhd (Malaysia)

PARADISE DAM, **QUEENSLAND, AUSTRALIA**

Dam spillway repairs

HITTING THE GROUND RUNNING

The ability to mobilize a specialist crew immediately was crucial after major flooding caused damage to Queensland's Paradise Dam. Australian BBR Network Member, **SRG** (formerly Structural Systems), rose to the challenge and, within just one week, hit the ground running with a range of technology, variety of techniques – and team of highly skilled professionals.

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FACTS & FIGURES

- 10,522m^3 N32 concrete (batched on site)
- 730t reinforcement
- 25,000m N32 Passive Anchors
- 2,700 anchors installed
- 12m maximum anchor length
- 1,450m stainless steel vertical waterstop (300mm x 1.6mm)

A major flood event in early 2013 significantly damaged the dam's spillway dissipator and immediate repair work was needed. Dam owner and manager, SunWater Limited, began the works and then engaged SRG (formerly Structural Systems) as main contractor for the interim repairs. Paradise Dam, near Bundaberg, is a 52m high roller compacted concrete (RCC) gravity dam on the Burnett River, housing a mini-hydro generator and turbine to produce electricity. After a short tender process, SRG were awarded the contract for completion of flood repairs – and were on site within a week.

Dissipater sill reinstatement

After mobilizing a full specialized dam crew to site within a matter of days, the team assembled a group of subcontractors, including SRG's mining division. The initial scope of work for the project included reinforcing, forming and pouring 69 major pours to reinstate the dissipator sill and steps, which sit on the downstream edge of the apron. The steps were some 1.5m high x 1.5m long and were formed and poured to restore the flood scoured rock. The original work scope ensured armor to the dam's toe was repaired so that it was not susceptible to any similar flood events. During the six month construction period, there were two notable variations which further strengthened the dissipator and were completed, whilst ensuring the program for the initial scope was met. The first variation was for the construction of reinforced concrete capping slabs downstream of the sill and steps, which ensured that any damaged rock was removed and capped by a concrete layer at least 600mm thick.

1 Queensland's Paradise Dam was damaged by major flooding in 2013 and local BBR Network Member, SRG, mobilized a team in just days to begin urgent repairs of the spillway dissipator.

TEAM & TECHNOLOGY

Owner – SunWater Limited
Technology – MRR
BBR Network Member – SRG Limited (Australia)

Further reinforcement

During October 2013, it was determined that the dam apron was to be further reinforced. The works entailed installation of further capping slabs, but this time they were anchored on top of the existing concrete apron slabs.

SRG's input on the project was invaluable, with the professional installation of 12,900m of galvanised passive anchors and 12,100m of ungalvanised passive anchors. Anchors with a length of up to 12m were installed, with over 2,700 individual anchors in total. SRG also drilled drainage holes through both the new and existing concrete structures, as well as facilitating shotcrete works to a portion of damaged rock adjacent to the dam's primary spillway.

Timely completion

After the successful completion of the repair works, SRG were then called upon to facilitate the recommissioning of the mini-hydro which had been damaged in the 2011 floods.

The works included the use of a 200t crane to remove the roof for the mini-hydro installation, along with the installation of a reconditioned hydraulic power unit and electrical control panel. The mini-hydro works were completed in June 2014 allowing the 11kV, 2.6MW turbine driven generating set to release water for downstream demands.

The original contract works were finished 23 days ahead of schedule. The 6,000m^2 of apron capping slabs were successfully concluded by 18 December 2013 – two days before completion of the downstream capping slabs.

The completion of these works before the end of December meant that the dam was adequately strengthened against floods which might have occurred during the 2014 wet season – as well as any flooding in years to come. ●

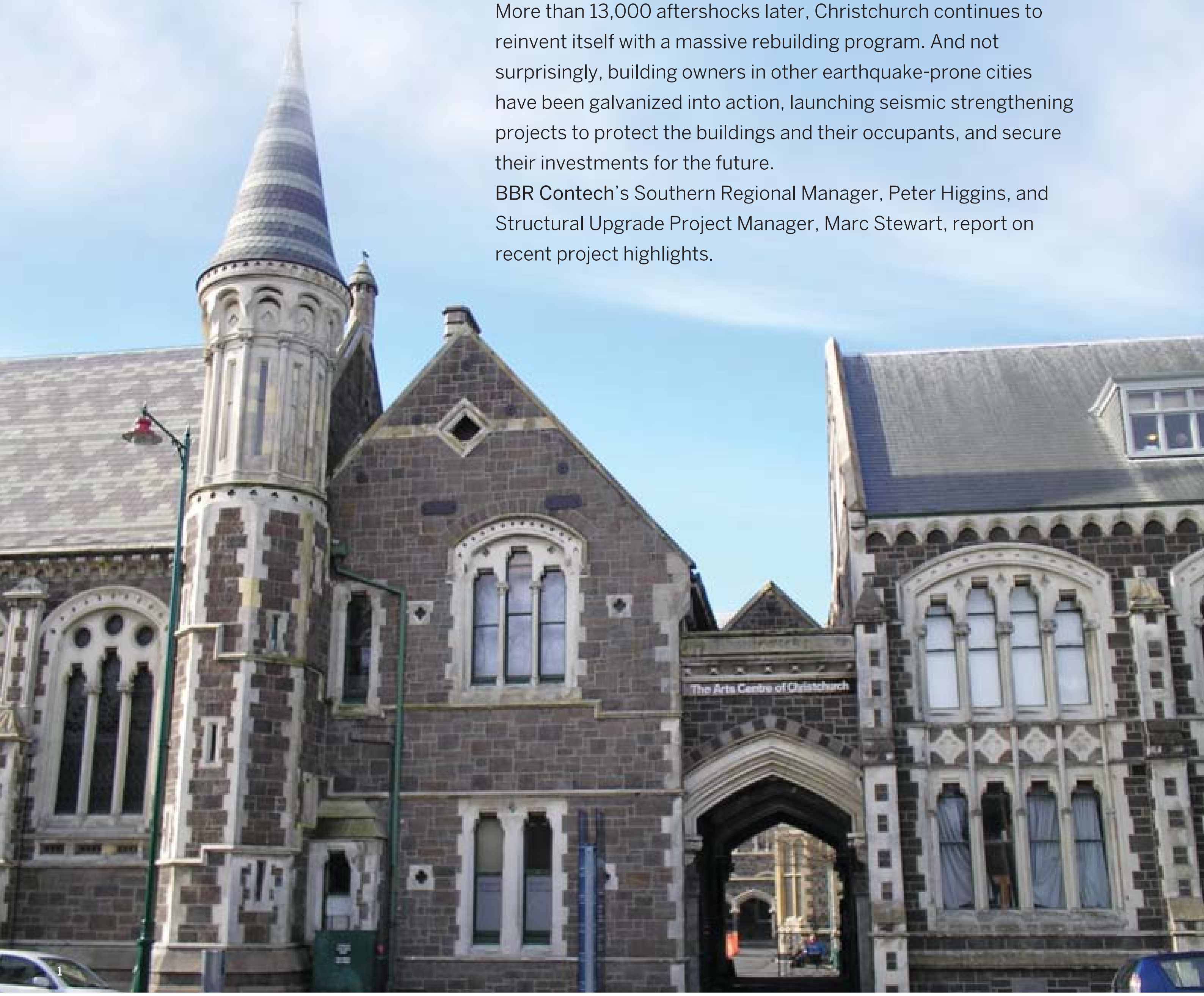
SEISMIC MRR, **CHRISTCHURCH & WELLINGTON, NEW ZEALAND**

Repair & strengthening of historic & modern buildings

STANDING ON SHAKY GROUND

It's now almost five years since a magnitude 7.1 earthquake jolted Christchurch's citizens from their beds – a calamitous event that, combined with a series of devastating aftershocks, resulted in the deaths of 185 people and left much of the central city in ruins. More than 13,000 aftershocks later, Christchurch continues to reinvent itself with a massive rebuilding program. And not surprisingly, building owners in other earthquake-prone cities have been galvanized into action, launching seismic strengthening projects to protect the buildings and their occupants, and secure their investments for the future.

BBR Contech's Southern Regional Manager, Peter Higgins, and Structural Upgrade Project Manager, Marc Stewart, report on recent project highlights.



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> "I've long been aware of BBR Contech's capabilities, their very high performance standards and their commitment to making the most of world-leading technology. It's great to have them on board."
>
> André Lovatt, Chief Executive, Christchurch Arts Centre

1/2 BBR Contech provided urgent structural repair services for the historic Christchurch Arts Centre after the 2010/11 earthquakes, now they have been awarded a new five year contract for the rebuild and restoration project.

3/4 Registry Building, University of Canterbury – the latest repair and strengthening project here has involved completely enveloping over 100 underfloor beams with FRP and installing 'through anchors'.

5 On four levels of a building, on Wellington's Golden Mile, columns have been strengthened with FRP and given vertical support by installing PT bar, anchored into new foundation blocks in the basement, right next to them.

1 World's largest heritage restoration project

We have recently been appointed as nominated contractor for all specialist civil and upgrading work at the 19th century Christchurch Arts Centre.

This 23-building complex is considered one of New Zealand's most significant heritage sites – and a cultural treasure for the people of this ravaged city.

The earthquakes caused significant damage to all but one of the Arts Centre buildings, forcing its closure and the launch of a NZ$290m rebuild and restoration project – the largest heritage restoration project in the world. BBR Contech has been involved right from the start, providing services such as exterior post-tensioning, structural repairs and FRP strengthening.

The new five-year contract will see our team work directly with the client and their appointed building teams – offering them all the benefits of a long-term, close working relationship, as well as opportunities to design, plan and procure more efficiently.

The formal partnership has evolved from a prior professional association, as the Arts Centre's Chief Executive, André Lovatt, formerly worked in Singapore with Juan Maier, now Head of International Projects and Senior Business Development Manager at BBR VT International in Switzerland.

Among the many projects underway at the Arts Centre, the NZ$36m restoration of the Great Hall is a major highlight. We first became involved with this stunning heritage building in 2011, installing strand and bar tendons on the exterior walls to stabilize it until the strengthening work could begin. Now well underway, the project should be complete by 2015, with other buildings re-opening according to a planned schedule by 2019.

2 Adding academically

Just a few kilometers from the Arts Centre, the University of Canterbury has been keeping our team busy with an extensive range of post-earthquake repair and seismic strengthening projects, managed by main contractor Hawkins Construction.

The projects have included the University's Registry building – a seven storey, 1970s structure that suffered damage to its shear walls, concrete frames, concrete floors and masonry partition walls. The repair and strengthening work began in February 2013, when we were tasked with repairing cracks and concrete spalling and undertaking an extensive seismic strengthening program.

This last project involved completely enveloping more than 100 under-floor beams with two layers of FRP – a complex task that also required drilling up through the floors and installing FRP 'through anchors' to complete the confinement.

Adding to the challenge, one end of the building was open to the chilly winter air and, as FRP can only be installed in very specific temperature ranges, the target areas had to be encapsulated with tent-like structures to contain the heat.

The Registry re-opened in August 2014, providing a new hub for frontline services to all students and housing the University Council and the Vice-Chancellor's office.

It also has a new name, Matariki – 'new beginnings' – which was gifted to the University by Ngāi Tahu, the principal Māori iwi tribe of New Zealand's southern region.

This was one of several projects at the University which have also included external concrete repair work at the 11-storey James Hight Central Library building – one of the largest post-earthquake remedial projects being undertaken in the city. ➤


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3 Protecting for the future

Further north, building owners in New Zealand's capital city are taking action on the seismic strengthening front – both to protect their buildings from disaster and to ensure that they continue to attract and retain tenants in a market that is more earthquake-aware than ever before. We have stepped in to help, with about ten projects currently underway and a number of others in the pipeline. Most recently we have completed a strengthening project on a 13-storey building at a prime location in the Wellington CBD.

We worked on four levels of the building, strengthening the columns with FRP and providing vertical support by installing PT bar right next to them. The bars were anchored into new foundation blocks in the basement, then passed through the upper levels before being re-anchored into structurally enhanced spandrel beams. In addition, the suspended ground-level and third-floor slabs received two layers of FRP on their upper surfaces to improve the diaphragm action of the floor. ●

TEAM & TECHNOLOGY

1 **Owner** – Arts Centre of Christchurch
Main contractors – Fletcher Construction, Simon Construction, C Lund & Son
Designer – Holmes Consulting
Technology – BBR VT CONA CME external, MRR range, PT bar
BBR Network Member – BBR Contech (New Zealand)

2 **Owner** – University of Canterbury
Main contractor – Hawkins Construction
Designer – Holmes Consulting
Technology – MRR range
BBR Network Member – BBR Contech (New Zealand)

3 **Owner** – ANZ Bank Property Group
Main contractor – LT McGuinness
Designer – Beca
Technology – MRR range, PT bar
BBR Network Member – BBR Contech (New Zealand)

TECHNOLOGY

RESEARCH & DEVELOPMENT

Cryogenic testing of BBR VT CONA CMI PT system

TEST REGIME GOES EXTRA MILE

The R&D team at BBR HQ has recently put a BBR VT CONA CMI tendon successfully through cryogenic testing to specifications exceeding those currently required to meet industry standards. Head of R&D at BBR VT International, Dr. Behzad Manshadi, talks us through the thinking and process behind this additional test.

With some 60 projects completed worldwide over the past 35 years, the BBR Network has amassed significant expertize in the construction of post-tensioned concrete tanks for cryogenic containment of liquefied gases such as LNG and LPG. These natural and petroleum gases are both condensed to liquid form by super-cooling them to around -162°C and -42°C respectively – which reduces them to about 1/600th and 1/300th of their previously gaseous volumes, with obvious benefits for transportation and storage.

At these temperatures, the requirements for containment structures are very stringent and post-tensioned concrete tanks are ideally suited to the task. The use of post tensioning in such structures offers demonstrable benefits in terms of performance, particularly with respect to leak-tightness, and long-term durability – both aspects are acknowledged by designers and clients throughout the industry. Superior corrosion protection measures are applied to the post-tensioning tendons for such tanks – which can be constructed in many shapes to suit project needs, there are no practical limitations.

With market analysts currently forecasting that worldwide demand for LNG will grow at 5% annually up to 2020 – and, for LPG, at 4% to 2018 – construction of cryogenic containment facilities continues to be an important market for BBR technologies.

1 BBR PTE's fourth LNG tank in Cartagena, Spain – post-tensioned with some 600tn of prestressing strand.
2 Simulation showing how an entire BBR VT CONA CMI post-tensioning tendon was tested in a liquid nitrogen bath to verify its ductility performance under cryogenic conditions.
3 Graph comparing the static tensile test results of two post-tensioning strands – one under cryogenic conditions, the other at ambient temperature – and clearly showing their different performance characteristics.

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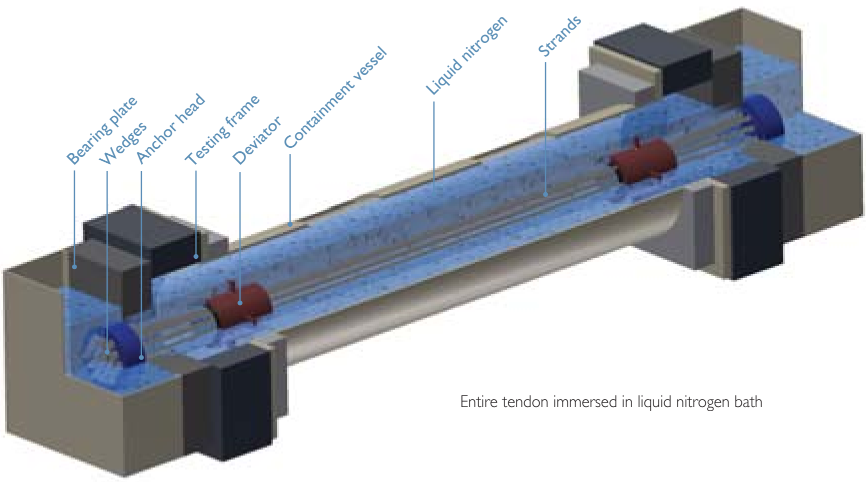
Importance of ductility

The Guidelines for European Technical Approval of Post-Tensioning Kits, ETAG 013, outline supplementary technical requirements for special optional use categories, for instance tendons subjected to cryogenic conditions.

However, we wanted to fully examine all parameters to ensure our technology also met our own stringent standards for performance and durability. We wanted to go beyond the test setup commonly used to verify a post-tensioning system's performance under cryogenic conditions and prove its ductility.

Ductility is an important factor as, in some circumstances – such as when considering dynamic loads – it becomes an important resistance characteristic. Without ductility – or the ability to deform under tensile stress – structures would be vulnerable to brittle failure.



Entire tendon immersed in liquid nitrogen bath

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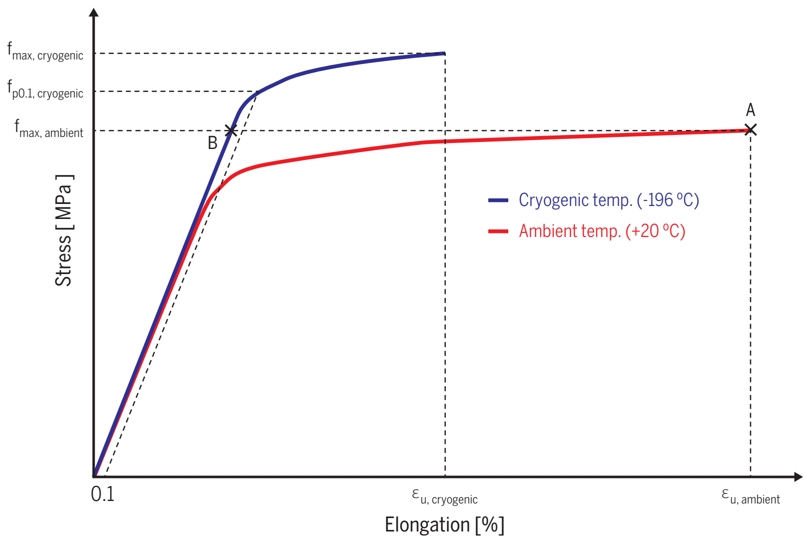

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Rationale for extending testing parameters

The commonly used test setup subjects only one anchorage to cryogenic conditions to verify the performance of post-tensioning systems. The reason that this test setup is unable to verify the ductility of post-tensioning systems under cryogenic conditions is that, when only one anchorage is immersed into a liquid nitrogen bath, the tensile elements (strands) at both ends of the tested tendon will be under two different thermal conditions.

The part of the tendon close to the immersed anchorage will be subjected to a cryogenic temperature (-196°C), while the remainder of the test tendon – which is fairly far from the cooling zone – will be at room temperature (+20°C). As is well-known, prestressing steel is significantly strengthened when subjected to cryogenic temperatures – the adjacent graph compares the static tensile test results of two strands under different temperature conditions.

The ultimate failure of the entire tendon with only one anchorage under cryogenic conditions will always occur on the tendon side under ambient temperature (see point A on graph). Meanwhile at this load level, the tendon part immersed into the liquid nitrogen bath will still be in the linear elastic zone (see point B on graph). This means that the ultimate failure force ($f_{max,ambient}$) obtained never reaches the yield point of the strand subjected to the cryogenic temperature ($f_{p0.1,cryogenic}$).

Thus, the outcome of this test is unable to verify the ductile performance of a post-tensioning system under cryogenic conditions. Therefore, we instigated our own test setup.

Verifying full compliance and ductility

Our R&D department carried out testing of single and multi strand tendons in which the entire tendon length, including both anchorages, was completely submerged into a liquid nitrogen bath. This new test procedure allowed assessment of the ultimate failure force ($f_{max,cryogenic}$) and the ductility of the post-tensioning system under cryogenic conditions.

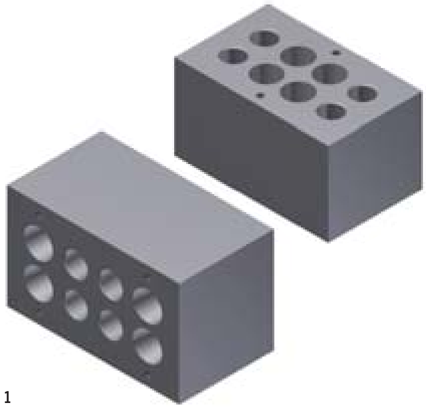
The successful test results obtained confirmed the ductile performance of the BBR VT CONA CMI post-tensioning system and proved that it is in full compliance with – and even exceeds the requirements of – the ETAG 013 testing regime under cryogenic conditions. ●

RESEARCH & DEVELOPMENT

Introducing the new BBR VT CONA CMW anchorage

DURABILITY AND ECONOMY

The newly developed BBR VT CONA CMW anchorage offers an economical solution for certain types of tank or silo. It requires no buttresses, no extra reinforcement and both the number of anchorages required and, thus, stressing operations is reduced.



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Post-tensioning is used in the construction of tanks and silos to increase concentric confinement in the structural wall and thus optimize the design in terms of concrete and steel reinforcement. Aside from the economic benefits, the usage of post-tensioning also enhances durability – confined concrete is free of cracks – and safety.

Continuous improvement

The BBR post-tensioning systems, usually CONA CMI BT/SP, have been continuously improved over recent years to deliver the right solution for this kind of application. These systems are stressed from the buttresses placed in the outer side of the tank.

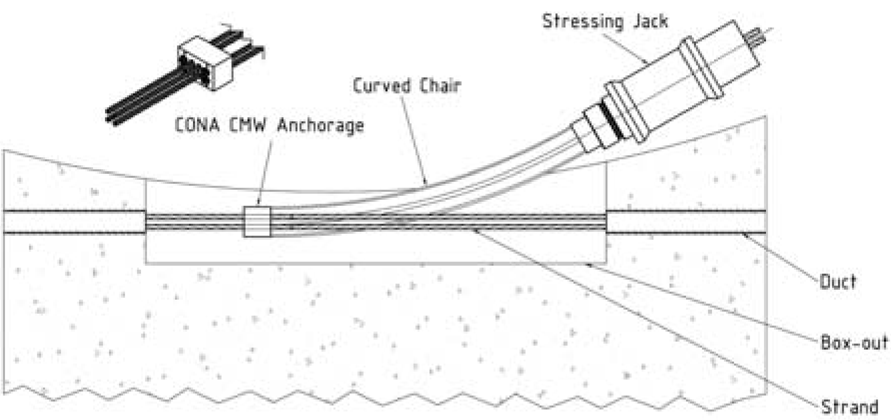
New CONA CMW system

The new CONA CMW system, see Figure 1, designed and tested according to ETAG 013, see Figure 2, has been developed for special tank and silo applications in which the buttresses are eliminated. In the new system, the tendon is directly stressed inside a box-out which, depending upon the access facilities, may be located on the inside or the outside of the concrete wall. The stressing operations require a curved chair to be inserted between the anchor body and the jack. Figure 3 illustrates how the special curved chair enables the strands to be bent out from the box-out. After stressing, the box-outs are filled with concrete.

Economical solution

In summary, use of the newly developed BBR VT CONA CMW anchorage provides an economical solution for the following reasons:

- No buttresses are required
- Number of anchorages per tendon is reduced
- Stressing operation per tendon is decreased
- No local zone reinforcement around the box-out is required. ●



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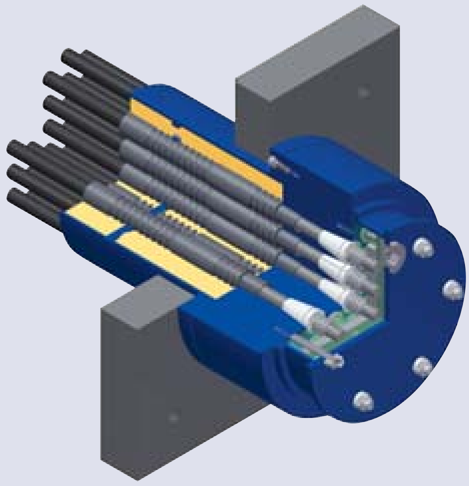
1 New BBR VT CONA CMW anchorage system.
2 ETAG 013 testing of CONA CMW anchorage.
3 Special curved chair enables strands to be bent out from the box-out.

RESEARCH & DEVELOPMENT

New Uni Head Short Socket Anchorage for BBR HiAm Stay Cable System

INCREASED PRODUCTIVITY



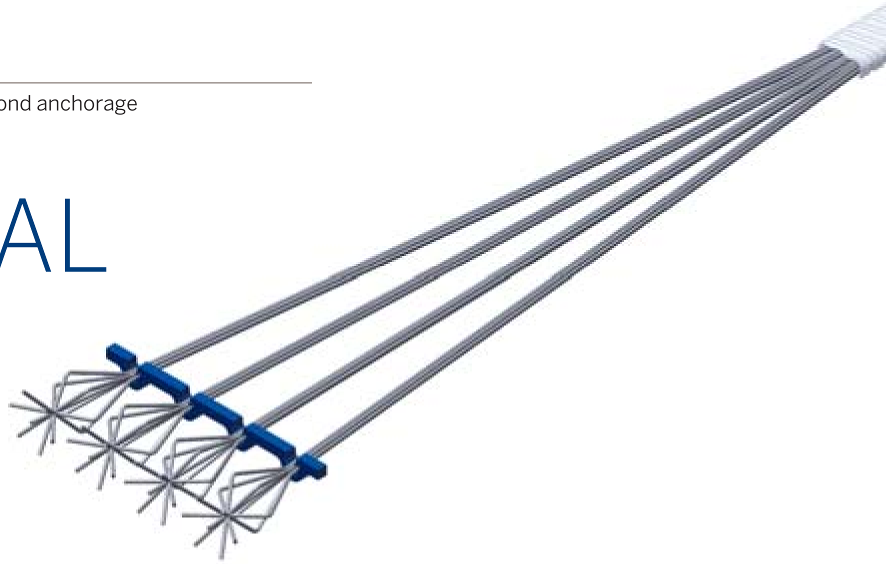
The BBR HQ R&D Department has developed a new HiAm CONA Uni Head anchorage which will increase productivity.

This new anchorage exhibits an optimized design with a shorter socket, optimized anchor head and other changes foreseen increasing the productivity during the anchorage preassembly and anchorage installation.
The new anchorage has been tested and, like the rest of the HiAm CONA system, is fully in compliance with *fib*, PTI and CIP Setra recommendations. ●

RESEARCH & DEVELOPMENT

Focus on BBR VT CONA CMO cast-in and inaccessible bond anchorage

ECONOMICAL SOLUTION



The BBR VT CONA CMO anchorage is an economical fixed-end anchorage which can reduce material usage and enhance productivity on site.

The CONA CMO post-tensioning kit with a flat array of bulb-strand ends is a multi-strand system for internally post-tensioned applications and very thin concrete cross-sections such as slabs.

Standard sizes
The standard tendon sizes range from 2 to 6 seven-wire prestressing strands. Both 0.62” (15.7mm) strands with a cross sectional area of 150mm^2 and 0.5” (12.9mm) strands with a cross-sectional area of 100mm^2 are commonly used, whereas the characteristic tensile strength for both strands is 1,860MPa.

Operation & advantages
The CONA CMO bond anchorage is cast in the concrete before stressing. The tendon force is transferred to the concrete by bond of the strands in the concrete and the mechanical resistance of the bulb-strand ends.
This type of anchorage, rather than transferring tendon force only in a concentrated zone, provides a smooth force transition into the concrete over the bonding zone. In this situation, the in-plan resistance of the concrete, with low concrete strength $f_{cm,0}$ 20/25 MPa, can contribute more to deal with the deviation forces and thereby the need for spiral reinforcement will be significantly reduced or eliminated.

Anchorage configuration
The main components in the anchor zone of the CONA CMO system are the bulb-strand spacer and the duct sealing filler. The innovative clip-lock design of the bulb-strand spacer has significantly increased the productivity during the anchorage installation, while the fixed distance between the bulb-strand ends is assured.
Our CONA CMO bond anchorage can save valuable program time and material, while reducing impact on budgets and environment. But there’s even more – the system has been independently tested in accordance with testing procedures specified by European Technical Approval Guideline (ETAG 013). ●

RESEARCH & DEVELOPMENT

New BBR Viscous Damper & Damping System

NEW STAY CABLE DAMPING TECHNOLOGY

In response to market demands, BBR VT International has developed a viscous strand stay cable damper to compliment the existing friction based BBR Square Damper.

The BBR Viscous Dampers in this new range are capable of damping a wide range of stay cable sizes and lengths with various damping forces and hydraulic piston configurations. It is also available in both an internal and external configuration depending upon architectural requirements.

Operation & components

The BBR Viscous Damper, specially developed to counteract vibrations on stay cables, works based on the resistance induced by the rapid passage of a viscous fluid through a narrow opening. The resistance can dissipate a large amount of energy leading to the damping of the cable. This principle of energy dissipation allows an independent and real-time reaction of the damping device to the occurring vibrations.

The BBR Viscous Damper consists of twin hydraulic telescopic cylinders. The inner cylinder contains the piston working chambers and the outer cylinder works as a housing and reservoir. The BBR Viscous Damper can be installed in either an internal or external damper configuration.

External viscous damper

The external viscous damper connects the stay cable directly to the deck without a damper housing. The BBR Viscous Damper (external) has a superior surface protective coating which protects it from the environment. The standard external damper is a double acting device – extension and compression – and is available for a maximum damping force of up to 70kN. Larger damping force resistance is available upon request.

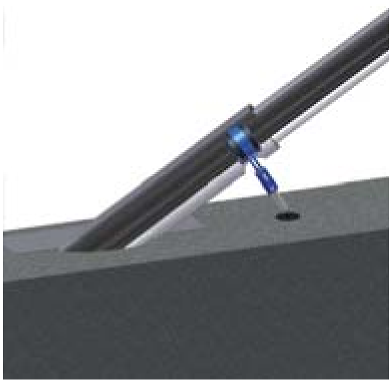
Internal viscous damper

The internal viscous damper is mounted inside a steel housing which gives support and protects against the environment. This compact solution is often preferred because it has a more pleasing design from an aesthetical point of view.

The standard BBR Viscous Damper (internal) is a double acting device and available for a maximum damping force of up to 50kN. Larger damping force resistance is available upon request.

Brochure

A new BBR HiAm CONA Strand Stay Cable Damping Systems brochure has also been produced to provide further technical data on cable damping, as well as to showcase BBR's full range of strand stay cable dampers. This brochure may be downloaded from the BBR Network website. For further technical support on cable damping, including the selection of the correct damper for your project, please contact BBR VT International directly. ●



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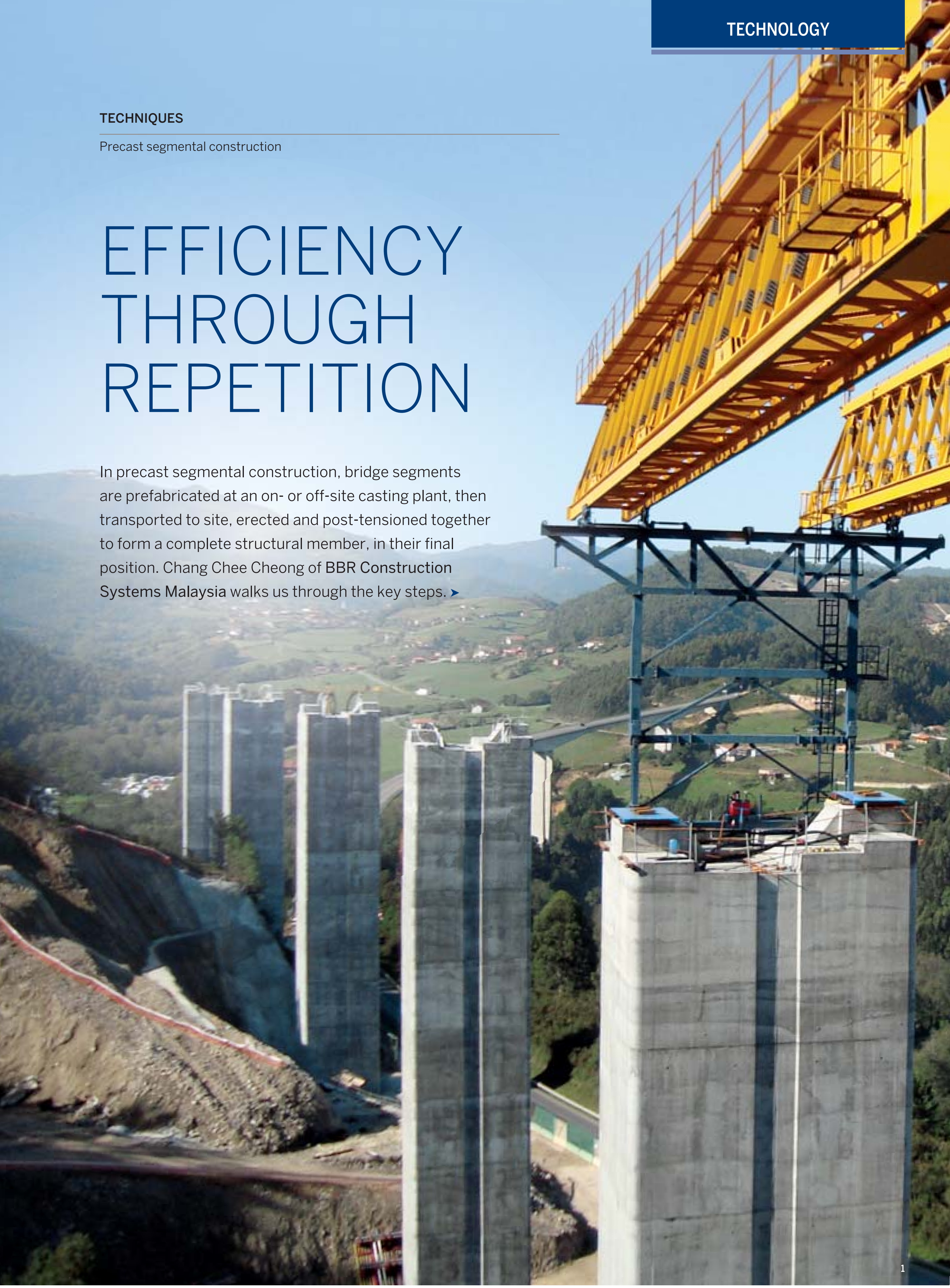
1 External damper configuration.
2 Internal damper configuration.

TECHNIQUES

Precast segmental construction

EFFICIENCY THROUGH REPETITION

In precast segmental construction, bridge segments are prefabricated at an on- or off-site casting plant, then transported to site, erected and post-tensioned together to form a complete structural member, in their final position. Chang Chee Cheong of BBR Construction Systems Malaysia walks us through the key steps. ➤



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1 Concha Artedo Viaduct, A8 Highway, Spain – a self-launching gantry was used to install 560 precast segments, creating a 1,200m long, 17-span bridge.

2 LRT Extension, Kuala Lumpur, Malaysia – precast viaduct segments were manufactured in a yard and delivered by low loaders to be stacked under the span to be launched by launching gantry.

3 Romeral Viaduct, Spain – balanced cantilever method used, in conjunction with a self-launching gantry, to erect precast segments for this 570m long bridge.

4 Penang Second Crossing Bridge, Malaysia – segments for the new 24km bridge were produced off site and loaded by gantry crane onto barges for delivery to site.

5 New Europe Bridge, Bulgaria / Romania – each span of the 180m long Main Navigation Channel bridge has 42 precast concrete segments. These were loaded in pairs onto a barge and brought to the piers 3km away, then lifted by a mobile crane.

6 New Europe Bridge, Bulgaria / Romania – front stressing of the main Navigation Channel Viaduct. More than 250t of PT tendons were threaded, stressed and grouted in just one month. In total, 79 precast concrete segments weighing up to 230t were installed for this project.

6

Step 1: Rationale for precast

Often, the approach is dictated by the location of the new bridge – such as above existing highway infrastructure which must remain open to traffic, across a valley where scaffolding would be expensive or topographically impossible to install and also in environmentally sensitive landscapes where impact on the ground or water beneath must be limited. Speed of construction may also be a factor, precast segmental construction can achieve faster cycle-times than in-situ techniques. As each steel mold can be repeatedly used to cast successive segments, the formwork cost is low when there is a large quantity of segments. Another benefit is greater control over quality assurance when compared with the cast in-situ method – the working environment and facilities in a casting yard are better.

Step 2: Erection techniques

Once manufactured, two main techniques may be used to erect the precast segments – span-by-span or balanced cantilever. Span-by-span construction focuses on erecting one span at a time and is a very fast construction method. The segment launching operation is carried out using an overhead or underslung launching gantry. Alternatively, full-span precast beams can be delivered by motorized transporter to the erection front.

Since there is only one cycle of tendon stressing per span, the span-by-span method can be significantly faster than precast balanced cantilever construction which requires stressing one pair of segments per cycle.

Balanced cantilever construction involves a similar erection system, without the need for scaffolding or formwork at ground level. Cantilevering spans are constructed, working outwards from a pier – in the same way as cast in-situ balanced cantilever construction.

Step 3: In the casting yard

The casting yard is usually located near, or within, the project site and the standard box girder (SBG) segments are cast on a just-in-time basis. This saves on both transportation and space requirements, as well as allowing for a stringent quality control process before each segment leaves the yard.

Several precasting lines are set up to produce the SBGs in a casting yard. The match-casting technique is frequently used. This involves casting each segment against the previous one to ensure correct fitting of shear keys at the joints during segment erection.

The segments themselves are of hollow box girder construction and stressed together by post-tensioning tendons. External tendons, rather than internal tendons, are normally used. These are located outside the concrete sections and run through preformed deviator holes inside each hollow segment. Where tight curves are necessary, bent steel pipes are cast into the concrete to deflect external post-tensioning tendons.

Step 4: Handling, lifting & positioning

The rebar for each segment is preassembled into a steel cage. It is lifted and placed on top of the casting bed mold. After fixing of anchorages and reusable deviator hole formers, the formwork is closed. Concrete compaction is usually carried out with external vibrators. The next day, the internal and external formworks are opened and lowered by hydraulic jacks. Then the segment is rolled out onto the rails into position for preparing the next segment.

Step 5: Stressing stages

After all the SBGs within one span have been assembled with vertical bars and temporary horizontal ties on the launching gantry, the HDPE ducts are threaded through the deviator holes. This is followed by strand installation carried out manually or by strand pushers. Unlike for internal tendons, no epoxy paste is required at segment joints.

Two hydraulic jacks hung from the front of the launching gantry are fixed onto the anchor heads. All the tendons are stressed in one stage. During the stressing operation, the weight of the SBGs is transferred gradually to the hydraulic flat jacks on top of the two piers. Then, the launching gantry can move forward to the next pier for erection of the next span. ●

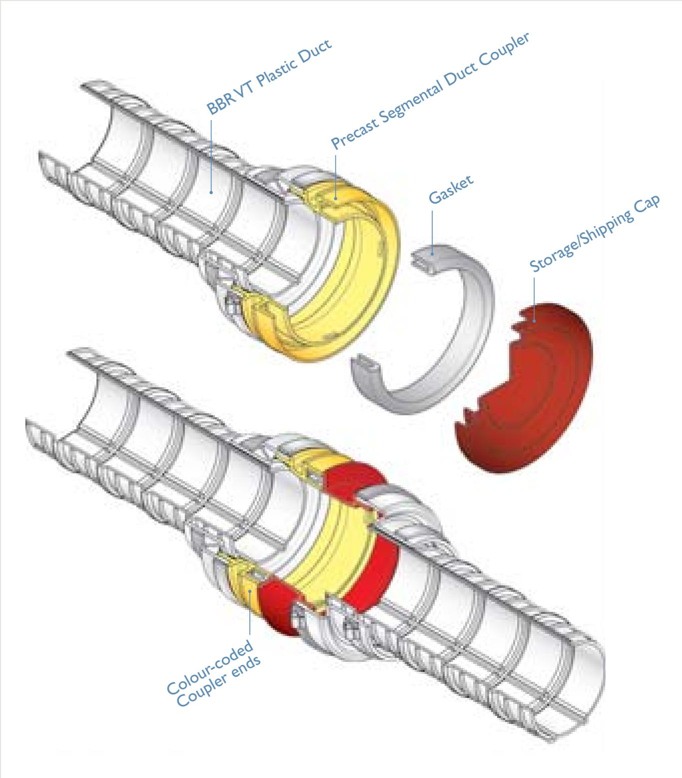
TECHNICAL INSIGHT

PRECAST SEGMENTAL DUCT COUPLER

This is a state-of-the-art coupler for post-tensioned ducts at precast segment connections. Designed specifically for the precast segmental bridge construction industry in mind, it incorporates strong, rugged, high performance materials together with user-friendliness and easy color-coded installation in the field. The Precast Segmental Duct Coupler complies with *fib* and the Florida Department of Transportation (FDOT) specifications.

Benefits and features include:

- Creates air and water tight connection at the most vulnerable location in the tendon, the segment joint – providing the best corrosion protection available
- Maintains the integrity of the post-tensioning tendon duct for grouting purposes – no crossovers and epoxy does not leak through segmental couplers or attachments
- Accepts angles up to 15° in any direction at the segment joint to maintain tendon alignment – far greater than required on most projects
- Allows for misalignment of the segments by up to 6mm on any axis – meaning field tolerances are achievable
- The boot design provides tolerance – permitting prefabrication of duct lengths and enhancing field productivity
- Robust and user friendly components – easing installation and improving overall project efficiency and quality. ●



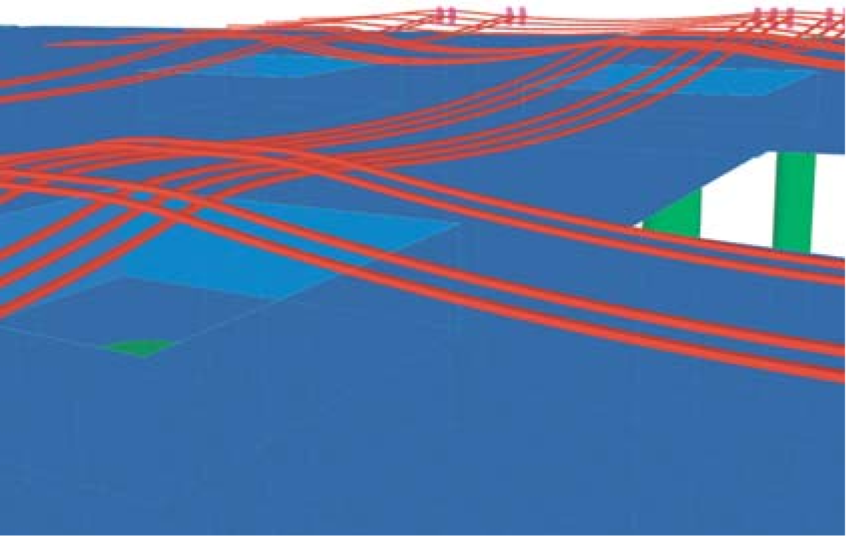
INSIGHT

Optimizing buildings with PT solutions

DESIGNED TO MAXIMIZE POTENTIAL

We hear so much about how there are great benefits to be gained by 'optimizing' buildings through the use of post-tensioning. But, what does this really mean? Bartosz Lukijaniuk of BBR Polska explores how their innovation focused, design-led approach combined with the BBR VT CONA CMX post-tensioning range is delivering maximum advantage for their clients.

First of all, let's face facts – price will always be a major decisive factor in whether a client awards a contract. It's not enough to just say that a building needs post-tensioning, the possible benefits and savings need to be clearly demonstrated through innovative design work. An effective design, combined with the inherent flexibility of BBR VT CONA CMX post-tensioning technology is proving to be a winning solution for us and our customers. We have found that, with the unique features of CONA CMX range – such as having the smallest center spacings and edge distances – and great design solutions, we can consistently differentiate our services and are enjoying much repeat business as a result.



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Our technique for delivering the best possible service to our customers is to become involved at the earliest possible stage of the project. It is at this point that our design engineers can gain a complete understanding of the client's goals and contribute innovation and real enhancements to the design while, at the same time, delivering savings on both program and costs.

Greater flexibility & efficiency of design

Recently, the main contractor for the new Film School building in Gdynia asked us to provide a post-tensioned solution alternative for part of this traditionally designed structure.

As a matter of course, we examined the whole project – and found another area that could be optimized too. By eliminating around 30% of the columns in the underground car park, we not only saved costs, but also improved sight-lines within the structure. Our optimization won us the project.

Later, the same contractor asked us to review designs for their office building contract at Warsaw University of Technology. This was another structure where traditional reinforced concrete had been specified and, by then, the contractor already knew that post-tensioning combined with our design skills would provide a cost-effective solution. Also, the wide range of anchorages within the BBR VT CONA CMX post-tensioning range allowed us to use exactly what was needed to deliver the best solution for the client.

2

3

1 An effective design, combined with the inherent flexibility of BBR VT CONA CMX post-tensioning technology is proving to be a winning solution for BBR Polska and their customers .Tendon layout drawing by gp-projekt.

2 Underground Car Park, Wroclaw – reliable slab performance was required and whole PT design helped to save 12% of construction costs, shorten program time and reduce environment impact.

3 Centrum Bankowo Finansowe, Warsaw – the BBR Polska design team engineered a post-tensioned solution for complex architectural shapes while delivering efficiencies.

Lower maintenance, faster construction program

In the case of an underground car park project next to the Centennial Hall in Wroclaw, a low maintenance solution was key for the design and build contractor, as they would be maintaining the structure for several years.
Here, our post-tensioned slab approach promotes reliable slab performance with reduced cracking – and saved 12% of the construction costs compared with traditional reinforced concrete construction. Our whole design solution actually reduced the height of the structure by 700mm too and thus reduced excavation needs by about 5,000m^3 – another cost-saving feature of our optimization which also saved valuable program time and reduced environmental impact.

Freedom of design

Hard on the heels of our completion of the challenging Business Garden office building (see page 20), a project to construct new offices for Centrum Bankowo Finansowe came onto the horizon.
The main contractor needed to meet the requirement for complex architectural shapes while retaining control over building costs. Although the structural designer had already included post-tensioning in the initial specification, detailed design had not been completed. Our design team approached this in their usual thorough way and not only did our solution meet the very specific architectural needs, but it was also the least expensive.

Reduced materials consumption

Reduced construction material consumption – and, therefore, costs – is a regular feature of our post-tensioning design. Our work has repeatedly contributed towards lowering the rates of materials consumption on site. For example, at an office building project in Szczecin, we reduced the reinforced concrete consumption by 17.5kg/m^2 – and, in doing so, the contractor saved around €5 per square meter on slab construction. The value-added environmental effect here is that precious natural resources were saved, along with the impacts associated with transporting those now superfluous materials to site.

Customer care & more

In taking a 'whole project' view of the service we provide, we are also building relationships with customers – and tailoring our approach to suit the way they work. While savings on budget may initially be a key deliverable for customers, in the end what we are actually supplying is far more than this – our high quality construction engineering solutions ensure that building owners, developers and users will benefit from practical, sustainable and economical structures. With innovative design and BBR technology, the BBR Network holds the key which unlocks real added value and excellent customer service. ●

Cornelia Bodmer-Roš, Chairwoman of BBR Network Member, Stahlton AG explores the effect of the digital revolution on businesses and identifies our key differentiating factor

KEY TO COMPETITIVE ADVANTAGE

The internet, allied technologies and associated networking has revolutionized our lives in the last 20 years – like nothing before – and is going to continue to change them at an ever increasing speed. What should we make of this and where does it leave us?

Currently, 39% of the world's population is using the internet, the volume of data generated or processed in 2014 exceeded six zettabytes – and will increase to 40 zettabytes by 2020. More than 140,000 new websites go live every day, half of all users bank online and social networking users averagely hang out on sites for 3.2 hours a day.

The internet has become the new world in which we live, communicate, network, distribute what we know, find out new things and generally use to manage the whole of our professional and family lives. In his book "Turing's Cathedral" (2012) George Dyson, a historian among futurists, writes: "Facebook defines who we are, Amazon what we want, and Google defines what we think."

As fundamental socioeconomic and cultural changes take place, we realize that the internet revolution is, in fact, The Industrial Revolution of our time – establishing the infrastructure for a new level of civilisation. It brings not only new inventions and advances, but also revolutionizes the methods of work and the conditions under which companies operate.

Many thus far successful business models change or disappear and the relationships between producers, suppliers and customers are redefined – offering a huge chance to define and learn about needs and wishes, as well as opportunities to comply with these. The amount of data collected and stored grows exponentially and the reasonable use of Big Data, its handling and the protection of sensitive business secrets has therefore become a big issue for every company. The CEO of Google recently observed: "The internet is the first thing that humanity has built that humanity doesn't understand, the largest experiment in anarchy that we ever had."

Through the internet, information spreads widely and new discoveries become known immediately. As a consequence, new market players arise, competitive pressure intensifies and distinction between competitors is hard to achieve. In this situation, human capital turns out to be the most important – if not the only – distinguishing characteristic of a company.

The best use of human capital is not only significantly essential, but it becomes an important key to competitive advantage. Products and technologies can quickly be copied, but never the potential of human beings. It is the individuality of people – their vital strength, their creativity and their determination to use both – that gives every company a face, an identification and most importantly the unique specific distinction. From the very beginning, BBR was formed by outstanding personalities – people from different backgrounds with unusual ideas, using their individual talents to make ideas and dreams become reality and, thus, laying the foundations of the BBR family spirit.

Thanks to the possibilities created by internet communication, the distance between our family members, scattered all over the world, has become less – experiences can easily be exchanged and problems jointly solved. It remains, however, the task of each family participant to identify and promote the potential of their own team members and establish a culture which enables entrepreneurship and curiosity, courage and tenacity for innovation.

As Albert-László Barabási, the renowned researcher on networks, remarked: "In spite of all digitizing we will never be able to exist without human relations". Let's all renew our vow of continuing to exploit the amazing opportunity which has been laid at our door and continue to work together to maximise our unique advantage, both locally and globally. ●

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