BBR A Global Network of Experts
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Post-tensioning

A Global Network of Experts™

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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 60 years later, in that same ethos and enterprising style.

From technical headquarters 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

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, DINA, SWIF and CONNAECT – 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 60 years, the BBR Network is focused on constructing the future – with professionalism, innovation and the very latest technology.

Information contained in this brochure is based on original material from the Post-Tensioning Institute (PTI) and the BBR archive.

Everyone's a winner!

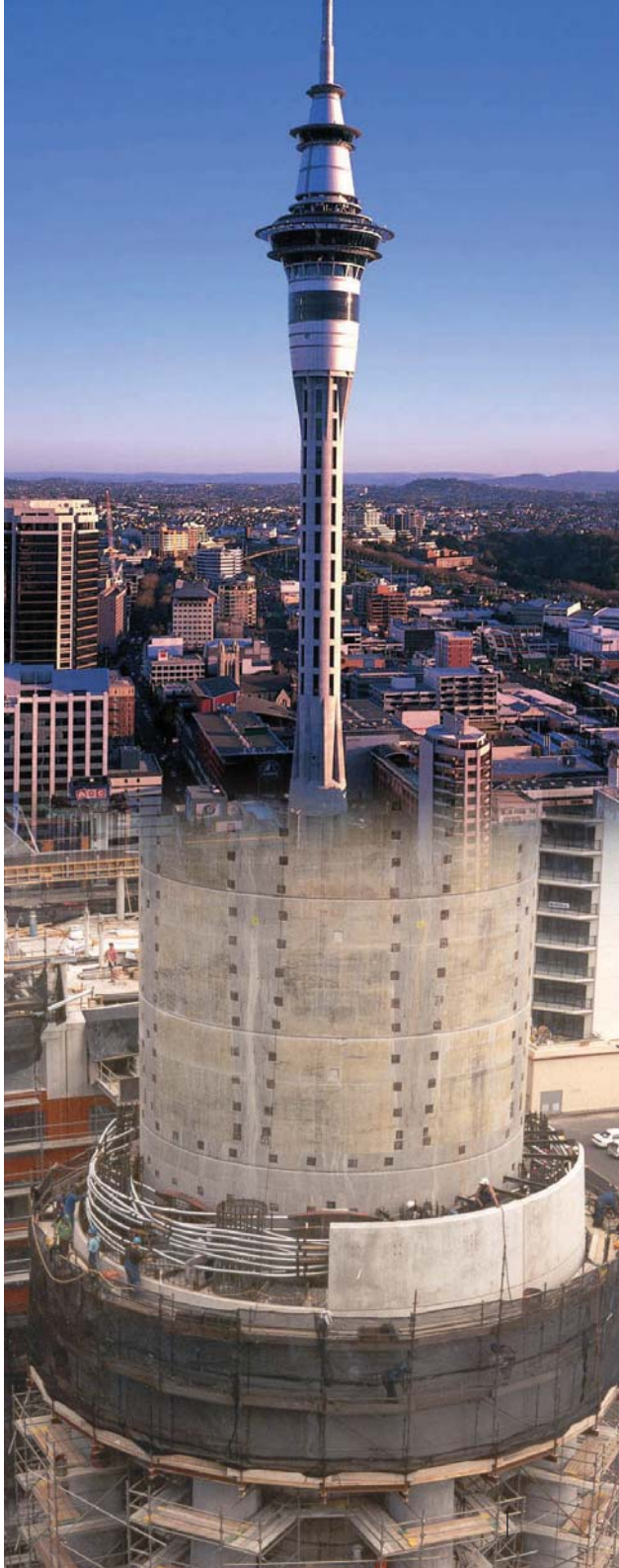
An architect's dream, a delight for developers, a great tool for builders and kind on the environment – post-tensioning allows almost any shape of structure to be constructed, while reducing environmental impacts, construction time, materials and costs. But what is it? And why should you be interested?

Over the next few pages, you will find the answers to both of these questions – and more! However, for now, you need to know that use of a post-tensioning system can offer:

- greater flexibility of design
- faster construction program
- lower construction material costs
- reduced maintenance costs
- potential for increased future loading
- improved whole life costs & durability
- reduced environmental impact

Nowadays, post-tensioning has almost universal application – it is used for bridges, buildings, dams, marine structures, nuclear power stations, parking structures, retaining walls, foundations and excavations, stadiums, slabs-on-ground, silos, cryogenic LNG tanks, towers, tunnels, wastewater treatment plants, reservoirs and wind farms – and for just about any other structure you can think of!

Post-tensioning – where creativity meets strength has been designed to be both an introduction to and a reminder of what post-tensioning is all about and, more importantly, what it – along with the BBR Network – can do for you!



Q: What is post-tensioning?

A: At its most basic level, post-tensioning (PT) is a fiendishly clever way of reinforcing concrete while you are building – occasionally even allowing the construction of something which might otherwise have been impossible!

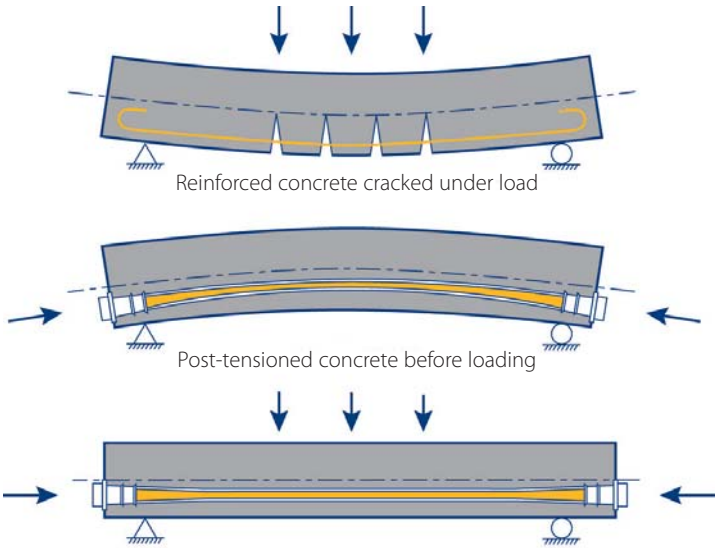
The use of post-tensioning allows thinner concrete sections, longer spans between supports, stiffer walls to resist lateral loads and stiffer foundations to resist the effects of shrinking and swelling soils. First, we need to have a look at concrete.

About concrete

Concrete has what engineers call 'compressive' strength. As soon as you introduce the 'live' loads of everyday usage, such as vehicles in a car park or on a bridge, the concrete deflects or sags which leads to cracking, thus weakening the structure.

Concrete lacks 'tensile' strength. Alone, it does not always offer the flexibility needed. That's why steel reinforcing bars – 'rebar' – are embedded in the concrete to limit the width of cracks. However, rebar provides only passive reinforcement – that is, it does not bear any load or force until the concrete has already cracked.

Typical application of post-tensioned slabs, allowing artistic shaping of the structure and breathtaking long column-free spans.



This is where post-tensioning comes in. PT kits provide active reinforcement. The function of post-tensioning is to place the concrete structure under compression in those regions where load causes tensile stress. Post-tensioning applies a compressive stress on the material, which offsets the tensile stress the concrete might face under loading.

BBR has been developing, testing and installing post-tensioning technology for over 60 years.

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Greater flexibility and efficiency of design

The use of post-tensioning for bridges allows the meeting of very demanding geometry requirements, including complex curves, variable superelevation and significant grade changes. In stadiums, post-tensioning allows long clear spans and a highly creative architectural approach.

PT tendons

PT is applied by the use of post-tensioning 'tendons' – a complete assembly includes a number of individual tensile elements made of very high strength prestressing steel, the sheathing or protective ducting, plus any grout or corrosion-inhibiting filler surrounding the prestressing steel and the anchorages needed at both ends.

Tensile elements

The individual tensile elements are made of 7 mm diameter wires or strands – comprised of 7 wires – in sizes of 12-16 mm diameter. They have a tensile strength around four times higher than an average non-prestressed piece of rebar.

Sheathing & ducting

Sheathing or ducting houses individual tensile elements. This allows them to move as necessary when the tensioning force is applied after the concrete cures. The steel stretches as it is tensioned and it is locked into place using an anchoring component, thus maintaining the force in the tensile element for the life of the structure.

Types of PT

Post-tensioning tendons come in a number of varieties and cover a wide range of applications.

Internal bonded tendons – where one or more tensile elements are inserted into a metal or plastic duct that is embedded in the concrete. By filling the duct with special grout, the tendon is 'bonded' with the surrounding concrete. This approach is often used for bridges, tanks and silos, as well as heavily loaded beams in buildings.

Internal unbonded tendons – where the prestressing steel is not actually bonded to the concrete that surrounds it, except at the anchorages. They are used in slabs and slabs-on-ground for buildings and parking structures, as well as structures where inspection and replacement of the tendons is required.

External unbonded tendons – these are installed on the outer surface of concrete structures. This type of post-tensioning allows access for maintenance and replacement, this is therefore the solution of choice for bridge enhancements and refurbishments.

Rock & soil anchors – these are used to stabilize sides of excavations, hillsides and tunnel walls. They are also used for resisting uplift for towers or seismic strengthening.

Q: What is a post-tensioning kit?

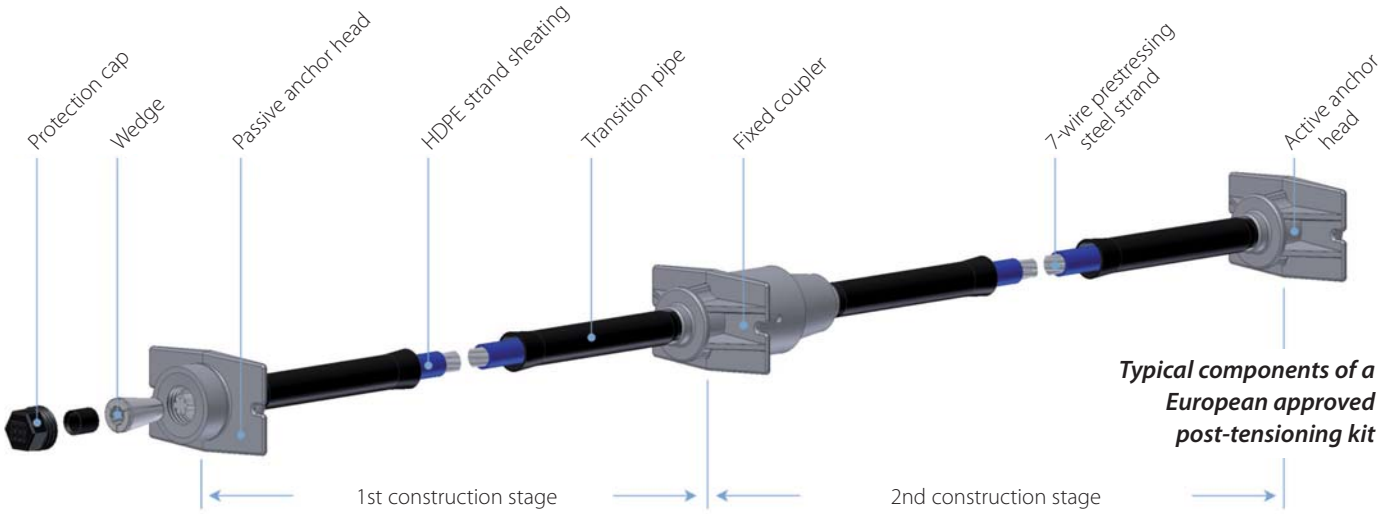
A: A post-tensioning kit comprises all elements that make up the complete PT tendon. PT kits are sold by a post-tensioning specialist company, who – if the kits are European approved and CE marked – takes the full responsibility for all components and conforming installation on the construction site.

Assuring quality

In the past, there were a lot of national standards – for example, British or DIN standards – and guidelines for testing provisions to which post-tensioning systems had to be subjected. Some of these specifications were very detailed, as a result of local experience – others were not. Some countries adapted and adopted specifications for the acceptance of PT systems running in other countries, others did not have any acceptance criteria at all.

Today, post-tensioning technology has a clear international passport if it bears the CE mark and has secured the European Technical Approval (ETA) for post-tensioning kits.

The BBR VT CONA CMI kit has passed all prescribed ETA tests with flying colors – and withstood even harsher voluntary testing, commissioned by BBR engineers.



Typical components of a European approved post-tensioning kit

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Improved whole life costs and durability

Post-tensioned structures attract lower maintenance costs in the longer term. Take a warehouse floor slab, for example. A PT solution will be almost joint-free, thus reducing joint maintenance and delivering long-term durability. Looking at tanks and silos, post-tensioning can provide virtually crack-free concrete.

Real comparisons

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

Beware of imitations!

There are counterfeit components out there in the market place – and these cheap copies of real construction products ultimately risk lives. Despite some of them carrying seemingly bona fide trademarks, they actually bear no relation to the original, genuine technology. Genuine PT products are constantly under surveillance to ensure they continue to fulfil all requirements of their European Technical Approval (ETA). If you are in any doubt about a product which is offered, seek advice from the BBR Network!

Green credentials

The one-size-fits-all concept is no longer a viable one – optimization is needed to achieve the most environment friendly structure. Opting to use post-tensioning means that a wider product range is available.

At BBR, we have now grouped our tendons so that you only use what you actually need. For example, we offer the widest range of multi-strand anchorages – ranging from 1 to 73 strands. All the size groups can be handled and stressed with just one piece of gear – the kit has been rationalized. In this way, we are helping to ensure that only the amount of anchoring material which is really needed goes into the structure, whilst minimizing additional transportation impacts for construction gear.

BBR technologies remain the benchmark for compactness in the anchor zone – reducing materials and environmental impact.

Q: How is PT installed?

A: The short answer is 'easily' – that is, by a post-tensioning specialist company whose staff has completed the relevant training and has the backing of a major international organisation.

Post-tensioned systems should only be designed and installed by PT specialist companies, such as those within the BBR Network.

Designing a PT system

Designing the shape of the PT layout and specifying the right system is a vital stage in the process and requires sound engineering consideration in order to maximize the benefits for all the stakeholders in a project.

For example, in the case of slabs-on-ground, design of the post-tensioning involves the careful analysis of the loads applied to the slab, the interaction between the slab and the ground that supports it, restraint forces and temperature effects.

The techniques can be extended to deal with weak ground where the ground acts as permanent formwork for the slab between piles and/or ground beams. This avoids expensive ground improvement work.

On site

Work on applying the post-tensioning kits can begin after any formwork or bottom reinforcement has been installed. The ducting will be laid out and the anchorages partially installed. Pushing of the tensile element into the duct can be performed before or after the concrete has been placed. Concrete placement follows next. When the concrete has attained its minimum strength, the tendons are stressed with hydraulic jacks and anchored. The anchor maintains the applied force in the tendon and transfers it to the surrounding concrete. The duct is then filled with a cementitious grout or flexible corrosion inhibitor. Installation can also be performed with fully or partially prefabricated tendons.

Rock & soil anchors

Typically, a cased hole is drilled into the side of an excavation, hillside or tunnel wall. A tendon is inserted into the casing and then the casing is grouted. Once the grout has reached sufficient strength, the tendon is stressed. Anchors in excavations tie back the piles into the ground and also stabilize the loose soil or rock.

Stressing with a large hydraulic jack and anchoring in a common BBR anchor device.

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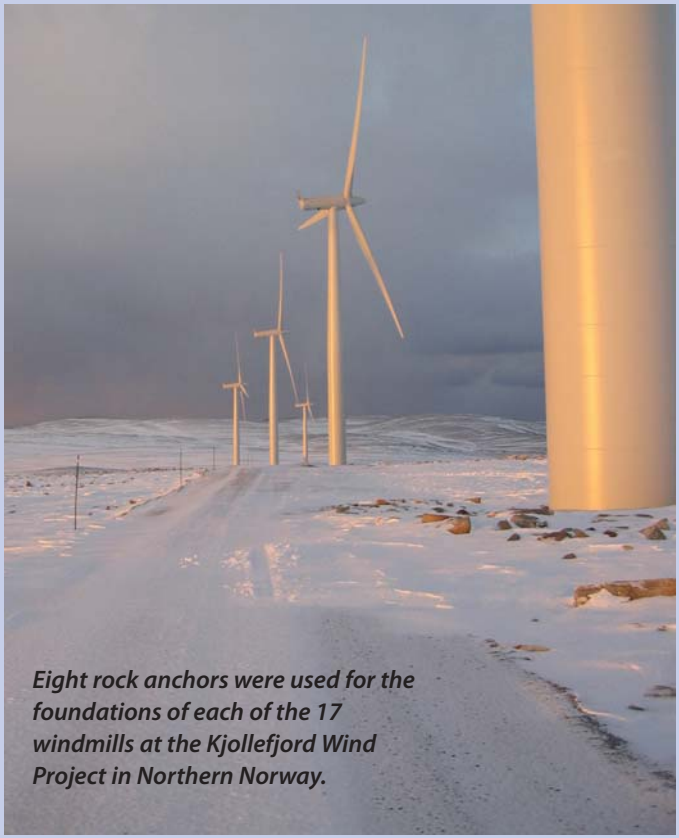
Lower construction costs, faster program

As well as reducing the quantities of concrete and steel for the superstructure, post-tensioning can significantly reduce the amount of groundwork required. In addition, thinner PT slabs and early strength stressing promote a faster floor cycle time, allowing the structure to progress more rapidly.



Eight rock anchors were used for the foundations of each of the 17 windmills at the Kjollefjord Wind Project in Northern Norway.

Earliest strength stressing

BBR products continue to promote faster construction programs through early strength concrete stressing which reduces the construction cycle time – the earlier you can stress, the earlier you can build. Alternatively, a lower quality, cheaper or possibly recycled concrete can be used.

The BBR VT CONA CMI system requires significantly lower concrete strength prior to stressing – other approved systems need a 20% higher concrete strength. Also, other systems demand 30 to 70% more space for the anchorages to be placed than the BBR VT CONA CMI system.

Multilayer protection

Protection against corrosion is provided by waterproofing, dense impermeable concrete, sealed ducts and good quality grouts – a multilayer protection strategy.

Post-tensioning has been provided with a first protective barrier against corrosion – namely grout. The second protective barrier is provided by the ducting.

The quality of grout and grouting application are important factors in ensuring the reliability of a post-tensioning system. For unbonded systems, soft filling materials such as grease and wax or plastic sheathing fulfil this function.

For bonded systems, cementitious grout provides excellent protection for prestressing steel – the highly alkaline environment passivates it against corrosion.

Every BBR Network member is able to give technical advice – from the design stage right through to project completion.

Q: Is PT a recent invention?

A: No, it's been around for a long time! In fact, prestressed concrete has become the most widely used construction material for today's bridges and a growing number of residential, commercial and public buildings. BBR has led in this development and today thousands of projects worldwide contain BBR post-tensioning technology.

Max Birkenmaier, Antonio Brandestini and Mirko Robin Ros

Almost as soon as reinforced concrete had been developed, at the end of the 19th Century, engineers recognized that its performance could be improved if the bars could be placed in tension – and keep the concrete in compression. However, it was not until much later that the use of post-tensioning for structures really became widespread.

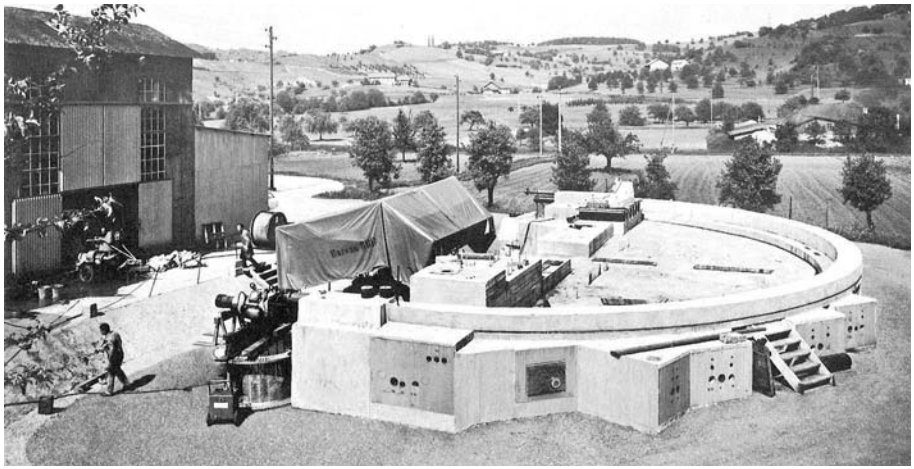
Wartime

The BBR story began during the Second World War, when materials were in short supply – the import of steel was difficult and, with reduced energy availability, cement was a precious commodity.

Determined to use their ingenuity to overcome these limitations, three engineers – Max Birkenmaier, Antonio Brandestini and Mirko Robin Ros – explored the savings to be made by using pretensioned reinforcement for concrete support girders.

First product

In 1945, BBR's first product – the pretensioned small beam – was brought to the market. Meanwhile, the trio had recognized and fulfilled the need for proper design, machinery and tools to allow easy handling of post-tensioning work, as well as for the efficient manufacture of prestressing elements.



As early as the 1960s, BBR engineers were testing high capacity PT tendons for nuclear applications.

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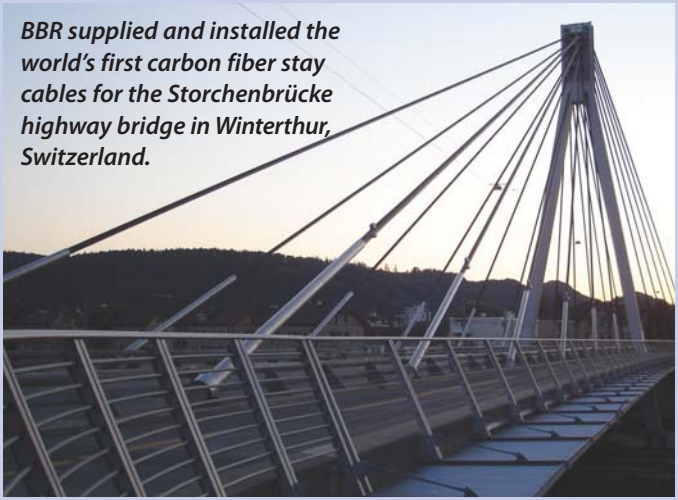
Reduced environmental impact

In the first place, post-tensioned structures feature less construction materials – such as steel reinforcement, concrete – and thus create fewer carbon emissions in terms of production and transportation.
By using a PT solution, extremely long span bridges can be constructed without the use of temporary intermediate supports, thus minimizing environmental impacts.



BBR supplied and installed the world's first carbon fiber stay cables for the Storchenbrücke highway bridge in Winterthur, Switzerland.

Post-tensioning tendons

BBR's long history of innovative development began in 1948, when the partnership patented the BBRV 'button head' post-tensioning system.

At home and in Europe, there was a demand for prestressing concrete with anchored tendons. Whilst some methods to anchor prestressing steel were known and had been tried, the accuracy of the anchorages was insufficient.

BBR developed and produced a button heading from cold drawn high tensile wire. This anchoring method was named BBRV. In the 1950s, the Swiss BBRV kit was the only reliable PT system available on the construction market.

Rapid development

Subsequently, BBR developed a complete range of prestressing and post-tensioning systems, ground anchors and stay cable anchorages, covering all structural engineering applications. This work mainly took place during the 1950s and 1960s – during the phase of rapid development in prestressing technology. BBR's first major bridge project was for the Swiss Federal Railways – the Andelfingen Viaduct – built in 1952. The first cable stayed bridge was constructed in around 1960 in Stuttgart, Germany, while the contract for BBR's first major high-rise building was awarded in 1959.

Success stories

Since those early applications there have been many more stories to tell of BBR successes and innovations. BBR technologies have been used in thousands of structures on all continents. BBR's commitment to major technological innovation has been continuous. In 1996, BBR installed the world's first carbon fiber stay cables for the Storchenbrücke highway bridge in Winterthur, Switzerland and then, in 2005, the BBR VT CONA CMX series was launched.

Global BBR Network

From the very early days, construction engineering firms around the world were keen to participate in the success of BBR's designs and technologies. It was recognized that not only a license to use the designs and sell the specialist equipment was necessary, but also that an effective process for knowledge transfer was needed to support best practice in the use, particularly installation, of BBR technologies. Thus the BBR Network was born and, today, it operates in over 50 different countries.

Find your local BBR Network representative by visiting www.bbrnetwork.com – and let them help you to explore what post-tensioning can do for you!

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