Dear clients,

business partners and employees,

It is a personal pleasure and an honor for me to be able to present a very special edition of our DSI Info to you this year.

1865-2015 – 150 Years of DYWIDAG

Our parent company was founded in 1865. Today, we are very proud to be able to celebrate our 150th anniversary. The development of modern construction is inseparably connected with the innovations of Dyckerhoff & Widmann AG (DYWIDAG) and therefore also with the extraordinary achievements of well-known DYWIDAG engineers.

Traditional Values – the Basis for Future Innovative Developments

DSI continues to stand for quality, professionalism, innovation, reliability and flexibility. These are values that we embraced then and continue to embrace today and that show our social responsibility – values that are just as up-to-date today as they were 150 years ago.

Change is the only Constant

Global economic conditions were affected by insecurities and transformation processes in 2014. We are very proud to have once more reached our goals in this environment.

Strategic Investments in Underground

We have been supplying high quality ground support products for underground mining to Indonesia for many decades. In order to improve the service for our local customers and to achieve a higher degree of flexibility, we opened a new plant in Gresik, Indonesia in December 2014. At this site, we produce ground support products for underground mining, offering the largest range of products to our customers as an established One-Stop-Shop Supplier.

Furthermore, we successfully acquired the patents and manufacturing facilities of the “OneStep” mining bolt in July 2015. The self-drilling OneStep is an important addition to our product range that targets the premium bolting segment. The bolt sustainably enhances productivity during installation and is already being used successfully in many countries. This acquisition confirms DSI’s continuous interest in technically advanced solutions that make Underground Mining safer and more efficient.

Growth Initiatives for Construction

In the Post-Tensioning market segment, the production of Wire EX Wire Tendons for wind towers has developed especially positively. To ensure the timely production of the continually rising volume of orders, we started up a third production line in Langenfeld, Germany at the beginning of 2015. By now, we are supplying Wire EX Tendons from Germany to South Africa, Brazil and many other countries in the world.

At the end of 2014, we acquired 100 % of the assets of the Prepron Group headquartered in Regente Feijó, Brazil. This acquisition is a long-term, strategic measure to further expand the DSI business in Brazil and to also accelerate growth on the market for Post-Tensioning Systems in the neighboring South American countries. It is an integral part of our target of achieving global growth in Post-Tensioning, and it is an important step for DSI to sustainably strengthen our presence in growth markets.

In July 2015, we were able to successfully establish a strategic joint venture with the company BRIDGECON, which has long-term experience in the design and construction of bridges, viaducts and flyovers in India. The new entity acts as DSI-BRIDGECON on the market. Shortly after its foundation, the joint venture had already successfully acquired five bridge construction projects with a total volume of more than € 13 Million.

Research and Development – the Engine for economic Innovations

Innovations are the key to profitable growth. It is our aim to continuously develop existing products and systems and to bring them to perfection in order to always offer customized and progressive, high quality solutions to you as our customers. Furthermore, we keep engaging in new basic materials and the changing requirements concerning our products and systems. For instance, we have just developed our own fire protection system for the DYNA Grip® Stay Cable System that ensures static safety when exposed to fire.

In Mining, fire protection also plays an important role. Recently, we enlarged our injection resins product range by adding the fast-reacting and super high foaming phenolic DYWI® Mine Fill Resins. To obtain an approval for these special resins in Australia and Turkey, we subjected the products to an external test series that also included a big fire test in the test laboratory of an independent service supplier. Today, we are the only company to have a new fire test for phenolic resins according to recent standards and to have an up-to-date technical approval.

These are just a few examples for a large number of R&D projects that we are realizing around the world in our own units and together with external research facilities.

Customer Focus

You as our customers are always at the center of our activities. We have made it our business to identify your problems and needs and to offer you technically sophisticated and reliable solutions for them. You can profit from our comprehensive service commitment at all times. In accordance with our slogan “Local Presence – Global Competence”, we are there for you with worldwide expertise wherever you need us:

Everyone – Every Day – Everywhere.

Celebrate with us! Allow the following articles to demonstrate to you the many versatile applications of our high quality products and systems in this most recent, 22nd edition of DSI Info.

Sincerely yours,

Patrik Nolåker
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**5**
Reflecting on the extraordinary achievements of DYWIDAG engineers continues to motivate us to develop creative and technically innovative solutions even today. Both then and now, we stand by traditional values such as quality, professionalism, innovation, reliability and flexibility.

We dedicate ourselves to always offer you as our customers and business partners the best possible solutions for your problems today and in the future.

“The arch spans widely” was the title of the anniversary brochure Dyckerhoff & Widmann published on their 100 year anniversary in 1965.

When comparing the construction methods used in the 19th century to modern industrial construction, it becomes apparent how many technological developments have been made since the era of industrialization in Europe.

Now, in the 21st century, more and more daring architectural designs are possible, and we know that this creative power would have been unthinkable had it not been for the development of new concrete construction methods, from reinforced concrete to post-tensioning.

It is difficult to appreciate today how much adventurousness and technical knowledge was needed to begin using non-reinforced concrete that was compacted by pressure surges during pounding (compressed concrete) in structures for which safety had to be of the utmost importance. One of the first concrete bridges in Germany using this technology was built by DYWIDAG in 1880. It was an exhibition bridge with a 12m span that carried a pavilion and stood on the premises of Dusseldorf’s trade and art exhibition. The demolition of the bridge at a later stage was extremely difficult due to the high compression of the concrete. For a quarter century thereafter, DYWIDAG built compressed concrete bridges.
1906 – The first Compressed Concrete Bridges
The largest compressed concrete bridge was built from 1904 to 1906 and crosses the Iller River near Kempten in Germany. It is a double bridge with arch spans that are 64.5m long.

Even today – after more than 109 years – it still performs its purpose and is the world’s largest railway bridge made of compressed concrete.

1922 – A unique, 6cm thick Dome Structure with a 25m Diameter
Still today, the construction material concrete is constantly proving its superiority around the world for shell construction and in post-tensioning. Both construction methods are inseparably connected with the name of Dyckerhoff & Widmann (DYWIDAG).

In 1922, the civil engineer Franz Dischinger and the physician Walther Bauersfeld developed the Zeiss-DYWIDAG shell construction method. One of the first structures to have been built using this method was the planetarium in Jena, Germany. The then newly developed shell construction method helped DYWIDAG to achieve a leading market position in industrial construction.

1927 – First Post-Tensioning using Stress Ribbons – Saale Bridge Alseleben
In 1927, DYWIDAG was awarded the contract for construction of the Saale Bridge Alseleben, having designed an innovative dual pivot arch rib structure with stress ribbons. During construction, the stress ribbons were first connected with one side of the 68m long arches and loosely positioned above a recess in the middle of the longitudinal girders for the bridge deck. Afterwards, the stress ribbons were tensioned using a newly developed puller until they had reached their working load and were then concreted. This project represented the first important step towards post-tensioned concrete.

The post-tensioning construction method developed by DYWIDAG introduced a new period for the construction industry. Thanks to this method, it may be said that concrete triumphed over the laws of gravity for the first time, and it was used in areas in which it had never stood a chance before. Even major bridges could be built using post-tensioning instead of the steel construction method.

1965 – Pioneer Work and a World Record
A convincing example for this development is the Bendorf Bridge, which crosses the Rhine north of Koblenz, Germany. With a span of 208m, it was the world’s widest concrete girder bridge when opened in 1965.

Even today, in 2015, it is still fully functional.
Global

Main Span erected using the Free Cantilever Method

DYWIDAG Know-How for international Projects
In the 1950s, in addition to its traditional business area of construction, DYWIDAG began signing license and consulting contracts for the application of the different, highly developed DYWIDAG construction methods around the world. The success in post-tensioning was especially helpful for DYWIDAG in this process. This mainly applied to the following areas:

- Bridges built using the DYWIDAG Post-Tensioning System
- Construction of large bridges using the patented DYWIDAG Free Cantilever Method
- DYWIDAG Prestressed Concrete Sleepers

In Europe, the DYWIDAG Post-Tensioning System was mainly used in conjunction with the free cantilever method and the use of precast concrete elements.

The first projects were the Freudenau Harbor Bridge and the Au-Leistenau Bridge in Austria. In Sweden, a large number of bridges were built using the free cantilever and precast concrete methods. Examples include the bridge leading over the Kallosund near Skagerrak with a main span of 94m, which was completed in 1957.

Additional license agreements were signed in Denmark, Finland, Norway and the Netherlands.

Strategic Partnership with Sumitomo, Japan
In Japan, the DYWIDAG Post-Tensioning System had been used since the 1950s. The great distance presented a problem, but this was solved by establishing a connection with the company Sumitomo Electric Industries. Sumitomo developed prestressing steel in its plant in Itami and entered a license agreement for the DYWIDAG Post-Tensioning System in Japan and in other Asian countries. Sumitomo then provided sublicenses to large Japanese construction companies. Consequently, in the years from 1959 to 1965, 18 bridges with individual spans of 100m and bridge lengths of up to 800m were built in Japan using the free cantilever method.

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International Infrastructure Work

DYWIDAG not only concentrated on bridge construction, but also significantly contributed to many other types of projects. One of the examples for a major challenge was the construction of the Hardap Dam near Mariental in Namibia. During an international tender in 1959, the owner chose a design, and DYWIDAG participated in its realization. The project included an embankment consisting of gravel and rubble, and the upstream face was sealed using an impermeable bituminous layer. The dam is interrupted by a weir structure for which 90,000m³ of concrete were used. The dam was completed in 1963.

In the following years, DYWIDAG’s international presence continuously increased. For instance, the Randenigala Dam was built in Sri Lanka from 1982 to 1986.

The Beginnings of DYWIDAG-Systems International (DSI)

The license and consulting business was a completely new business idea for a conventional construction company. DYWIDAG had already begun to successively sign license and consulting contracts for the application of the DYWIDAG construction methods in many countries in the 1950s, and the continuous extension of the license business formed a very successful part of DYWIDAG’s international business.

It was, however, only at the beginning of the 1960s that a licensee department was established at DYWIDAG in Munich. This specialist department focused on handling all questions related to the license business and on supporting the licensees with know-how. This license department could be considered the original DSI.

The construction of the Brenner Motorway and additional motorways in the middle of the 1960s also opened the Italian construction market to the license business. The rapid growth of this market resulted in the foundation of the affiliated company DYWIT, headquartered in Milan, in 1970. In the following years, it became one of the most successful representations of the license business abroad. The positive results in the license business also caused DYWIDAG to venture the leap over the ocean to the United States and Canada. Consequently, DYWIDAG Inc. was founded in the USA in 1969, and a representative office was opened in Canada.
Following the successful establishment of agencies in Europe, the Americas and Asia, DYWIDAG engaged in an extension and renewal of its product range. Already at the beginning of the 1970s, it became apparent that the strong concentration of the license business on prestressed concrete and the use of prestressed bars no longer met market requirements. DYWIDAG reacted by developing an enhanced, grade 110/125 bar prestressing system with accessories.

In the middle of the 1970s, DYWIDAG also decided to develop a strand post-tensioning system. In addition to this revolutionary expansion of Post-Tensioning, Geotechnics became increasingly important. It quickly turned into a second key market segment next to Post-Tensioning.

The DYWIDAG Threadbar was especially predestined for geotechnical applications, and DYWIDAG’s research and development department worked on the development of additional high-quality geotechnical systems at full speed. An important key product was the new DYWIDAG Soil Nail with double corrosion protection.

In the following years, the Geotechnical product range was increasingly expanded, and at the same time, the Strand and Bar Post-Tensioning System portfolio was continuously widened in accordance with the dynamic market development. Sales were carried out both via the international network of licensees and via affiliated companies. These measures opened completely new competitive opportunities to the license department of the international business and therefore provided opportunities for ongoing, strong growth.

The DYWIDAG management recognized that the growth was no longer manageable through a licensee department that was incorporated in DYWIDAG and that the foundation of a specialized subsidiary was required.

1979 – Foundation of DYWIDAG-Systems International
Thus, the DYWIDAG license department became the independent company DYWIDAG-Systems International (DSI) in 1979. The new DSI changed very quickly and increasingly acted as a global company. At the beginning of 1979, DSI already had more than 450 employees.
DSI continuously strengthened its international business, and the products and systems were further adapted and optimized to suit the requirements and needs of local markets. The two pillar model consisting of DYWIDAG Geotechnical Systems and DYWIDAG Post-Tensioning Systems was continuously developed over the course of time, and the know-how in Post-Tensioning was used to develop additional systems with different anchorage types for stay cable bridges.

A unique example for this special know-how was the construction of the Kap Shui Mun Bridge in Hong Kong, China in 1995.

At the end of the 1990s, the company reexamined its strategy in order to open additional growth opportunities to the DSI Group. The decision was made in the year 2000.

**2000 – Market Entry into Mining**

In September 2000, DSI acquired the former ANI Arnall in Australia. The company specialized and continues to specialize in the production of ground support products for Underground Mining. Following the successful acquisition, the company operated as DYWIDAG-Systems International Pty. Ltd. As a result of the Mining activities in Australia, additional plants were established in South Africa and North America in 2002. The new manufacturing sites are located in mining centers so that logistical and infrastructural advantages enable an optimum supply of DSI products to local customers.

Through this diversification, DSI became less dependent on the economic cycles in construction.

**2005 – The End of Dyckerhoff & Widmann AG**

Already in 2001, Dyckerhoff & Widmann AG had been merged with Walter Bau AG, forming “Walter Bau AG vereinigt mit DYWIDAG”. On February 1st 2005, the company fell into insolvency – a hard blow for its several thousand employees in Germany and around the world.

DSI, however, had already worked successfully and largely independently for many years. In 2004, the company on its own employed more than 1,100 employees worldwide.

Following the insolvency of its parent company, DSI was acquired by the financial investor Industri Kapital.

Thanks to the excellent cooperation between management and investor, the future continued to be set for growth – a growth that was a combination of strong organic growth and growth by acquisitions.

In 2005, DSI created another global business unit in Tunneling through the acquisition of two market leading companies in Austria and the USA. In 2006, DSI entered the market for “Concrete Accessories” and acquired three leading producers and suppliers in France as well as a German company.

In the second half of 2007, DSI was sold by Industri Kapital to another financial investor, CVC Capital Partners. At that time, the DSI network was active in 90 countries around the world with wholly-owned subsidiaries, participations, licensees and agents. Due to the financial crisis in 2008/2009, a consolidation phase and a phase of reorganization of the DSI Group followed.

In 2010, DSI was taken over by BAML (Bank of America Merrill Lynch) and Barclays Capital and sold to Triton Advisers on April 1st 2011.

Today, in 2015, the DSI network is stronger than ever. Our success is based on a clear strategy. In Construction, we are successful in the business segments Post-Tensioning, Geotechnics and Concrete Accessories. In Underground, we are active in the business segments Mining and Tunneling. Today, approx. 2,300 dedicated employees around the world work for the DSI Group.

We uphold the awareness and the values derived from our 150 year long history – and keep working for a safer today and tomorrow. This is what we stand for; each and every one of our experienced and dedicated employees.

Our activities support increased safety in Underground, and we are continuously developing new and innovative systems for exciting, challenging construction projects around the globe. We want to inspire you each and every day anew with our philosophy:

**Everyone – Every Day – Everywhere.**
The North West Rail Link in Sydney:
DSI supplies Quality Products for fully-automated Rapid Transit Rail System

The North West Rail Link in Sydney is currently Australia’s largest public transportation infrastructure project. When completed, the light rail system will be the first fully-automated rapid transit rail system in Australia. The railway track runs to the city’s North West and includes a total of 8 railway stations, thus relieving the rapidly growing districts from increasingly heavy road traffic. The joint venture Thiess John Holland Dragados is the General Contractor for this project.

The project also includes the construction of 15km long twin tunnels from Epping to Bella Vista – Australia’s longest rail tunnels. Four tunnel boring machines (TBMs) with internal diameters of 6m are used for driving the tunnels. Tunnel advancement is mainly through sandstone and shale at an average cut rate of 120m per week.

DSI supplied 300 complete semi-permanent DYWIDAG Strand Anchors to both KPS and the Rix Group for the Epping and Castle Hill stations. A special 15.2mm strand wedge block was approved for use on all project sites. Already at the beginning of the project, DSI Australia supplied more than 1,000 wedge blocks and associated wedges to the 5 subcontractors for the more than 1,800 semi-permanent anchors that are required for the job.

In addition, DSI supplied one Type 55-0.6” DYWIDAG Strand Anchor with a total length of 35m to the subcontractor KPS.

DSI also supplied DCP Rock Bolts, chemical bolts and GEWI® and GEWI® Plus Soil Nails and Rock Bolts to various sites throughout the project. Furthermore, in 2014, a supply of the new Kinloc Bolt with 30t load bearing capacity was carried out with a trial impending. The Kinloc Bolt System is a mechanically operated, point anchored friction bolt. The new rock bolt not only permits single pass bolting; it can also endure constantly shifting ground conditions and has optimum performance in shear loading.

The new North West Rail Link in Sydney is scheduled for completion at the end of 2019.
The DSI-PEAK Resin Bolting System is a new development by DSI Australia that ensures more efficient and productive working cycles underground. Furthermore, it is a major step in moving the mining industry away from excessive bolting practices towards high quality, lower total cost solutions. The bolting system is an optimization of long-term mining industry experience and customer feedback from site and lab testing.

The DSI-PEAK System captures the various advantages of both point-anchored and fully encapsulated bolts, while eliminating disadvantages and hidden technical deficits that have crept into current industry practice, hindering efficient mining.

The system also makes for easier and optimized ground control through less strata damage during bolting than during the installation of conventional rock bolts. Thanks to the shorter anchor and resin cartridge lengths as well as the reduction in bolting patterns, tangible cost savings are created for primary support, and the need for secondary support is reduced.

The rock bolt system is based on the newly developed, high-impact “AK” steel grade and features a unique bar profile to optimize localized micro-mixing and reduce longitudinal pressures during the mixing sequence. In comparison to similar 30t rock bolts, the DSI-PEAK Bolt is shorter and uses a larger hole size to reduce back pressure on bolt thrust. The system’s 2:1 FASLOC® resin provides effective mixing in up to 30mm bore holes and reliable top anchoring with reduced bolt lengths.

Greater load bearing capacity at the hole collar and plate, along with improved pre-tensioning, are achieved through increased nut length. A greater load bearing area into the strata is achieved by a larger surface area plate. The correct tightening sequence and bolt tensioning provide an effective 0.5m beam. The DSI-PEAK System is available now from DSI Australia.
The Koralm Tunnel in Austria is the core part of the Baltic-Adriatic Corridor, a planned railway link between the cities of Gdansk in Poland and Ravenna in Italy. Once completed, the tunnel will have a length of 32.9km and cross the Koralpe Massif at a depth of up to 1,200m. The center distance between the two parallel, single-track tunnel tubes measures approx. 40m, and the tubes are connected via crossways every 500m.

12km of the double-tube tunnel are advanced from the western portal in the Lavant Valley in Carinthia towards the East – the northern tube is primarily advanced by a Tunnel Boring Machine (TBM), and the southern tube is being excavated using the cyclical method.

First, the existing Paiersdorf exploratory tunnel is being widened over a length of 7.6km. DSI Austria had already supplied high quality ground support products that stabilized advancement during the construction of the exploratory tunnel.

The northern tube is being excavated using a TBM over a 2.6km long section. At the western portal in Carinthia, which is located in alternating layers of claystone and sandstone, the northern tube only has a minimal cover. For protecting the tunnel advancement, 15m long, Type AT – 114 Pipe Umbrellas with a tube wall thickness of 6.3mm are used in this area. DSI Austria supplied the AT – Pipe Umbrella System in individual lengths of 3m together with hardened solid drill bits, an AT – 114 Starter Unit and additional system accessories. The pipe umbrella system was installed using conventional drilling equipment.

To connect individual tubes, DSI Austria’s newly developed squeezed connection system is used instead of conventional threaded couplers. In this method, a tapered end is inserted into the already installed tube, and both tubes are force-fitted within
a few seconds using a hydraulic jack. The squeezed connection is more robust
than the conventional threaded coupling
and permits a faster connection of the
individual pipe umbrella tubes. Furthermore,
the elastic load bearing capacity of the
connection is approximately twice as
high as that of the threaded coupling.

Other than the AT-Pipe Umbrella System,
DSI Austria also supplied 25mm Ø, 3, 4 and
6m long SN Anchors with ultimate tensile
loads of 260kN including accessories.
Additionally, R32-250 and R38-500 Ø,
2, 3, 4 and 6m long DYWI® Drill Hollow
Bars are used as self-drilling anchors to
stabilize tunnel advancement. The ground
support products produced and supplied by
DSI Austria also include 51 x 3.2mm Ø, 3 and
4m long POWER SET Self-Drilling Anchors;
51mm Ø self-drilling spiles; 38 x 4mm Ø steel
tube spiles and Types 50/20/30, 70/20/30
and 95/25/36 PANTEX Lattice Girders.
The A 9 Pyhrn Motorway in Austria is an important North South link. One of its sections is the Klaus Tunnel Chain. The approx. 8km long section of the A 9 is located around 130km east of Salzburg and was originally built with one lane in each direction. At the end of 2013, the completion of the section began with the construction of new bridges that also served as access roads for the construction of the second tunnel tubes.

Section 4 included the eastern tube of the 2.2km long Klaus Tunnel as well as the eastern tube of the 0.4km long Traunfried Tunnel. The Klaus Tunnel is being excavated from an intermediate heading, with a 28 and a 70m long section in the North being built using the open cut method and a 36m long section being built using the cut-and-cover method. The actual excavation work of the 1,857m long tunnel started in May 2015 and is being realized using the mining construction method.

The crown of the eastern tube was driven in advance because it served as an escape route for the existing western tube. Bench and invert heading were used for driving the tunnel. The excavation of the Traunfried tunnel was carried out successively in crown, bench and invert.

For stabilizing the tunnel driving work in both tunnels, DSI supplied the following high quality ground support products:

- OMEGA-BOLT® Expandable Friction Bolts with anchor plates
- 25mm Ø SN Anchors in lengths of 2, 3, 4 and 6m
- R32-250 Ø and R 32-280 DYWI® Drill Hollow Bar Anchor System in lengths of 2, 3 and 4m
- R32-250 Ø DYWI® Drill Self-Drilling Spiles
- 25 mm Ø steel spiles in lengths of 3 and 4m
- Type AT – 114 Pipe Umbrella System with threaded connections including drilling unit and accessories

The 2.9km long Spering Tunnel as well as the 0.8km long Falkenstein Tunnel are located in section 5. Carbonate rock with gravel, limestone and clay marl prevail in this part of the northern Tyrolean limestone Alps. The Eastern tube of the Spering Tunnel was excavated using bench and invert heading along the complete tunnel length. In two locations, the tunnel tube was widened.
to accommodate cutouts. The new and the existing tunnel tube are connected via 8 walkable and 2 drivable crosscuts. At the eastern tube of the Falkenstein Tunnel, excavation and stabilization are carried out in the total cross section. Here, both tunnel tubes are connected via 2 walkable crosscuts.

In both of these tunnels, the following ground support products were used for safe excavation in partly brittle rock:

- OMEGA-BOLT® Expandable Friction Bolts with anchor plates
- 25mm Ø SN Anchors in lengths of 2, 3, 4 and 6m
- R32-250 Ø and R 32-280 DYWI® Drill Hollow Bar Anchor System in lengths of 4, 6 and 12m
- 25 mm Ø steel spiles in lengths of 3 and 4m
- R32-210 Ø, 3m long IBO Self-Drilling Spiles
- Lattice girders incl. angle connections and accessories
- Arches
- Type AT – 114 Pipe Umbrella System with threaded connections including drilling unit and accessories

With the help of the ground support products supplied by DSI, all of the tunnel tubes were excavated safely and within the planned schedule.
The Inn Joint Venture Hydroelectric Power Plant (GKI): More than 400GWh of Energy from Water in Tyrol

The GKI at the upper Inn River in the area of the Swiss-Austrian border is the largest run-of-river installation that is being built in the Alps in this millennium. Once the construction phase of approx. 4 years from 2014 to 2018 is over, the new plant will generate more than 400GWh of energy from the renewable resource water every year. Basically, the plant consists of a retaining area, a weir system, a head race tunnel and a power house.

The 15m high weir system for water retention is being built in the border area between Martina and Nauders. Up to 75m³/s of the retained water will be diverted into the 23.2km long headrace tunnel. This tunnel discharges into the pressure tunnel which, in turn, leads toward the turbines in the powerhouse in Prutz/Ried. Here, two powerful hydroelectric generating sets consisting of a Francis turbine and a generator each produce environmentally-friendly electricity.

Below Martina near Inn, at km 413.84, near the Ovella farm building, a two-section weir is being built for the power plant.

By retaining the Inn River via this weir system, an approx. 2.6km long retention area is being created. The beginning of the retention area backwater reaches back as far as the Inn Bridge in Martina.

The water that is drawn through the intake near the weir system reaches the GKI power house in Prutz via the intake waterway. The intake waterway consists of an approx. 23km long underground head race tunnel and a power descent that is being built as an inclined chute. The outflow towards the surge shaft is located in front of the transition from the head race tunnel to the inclined chute.

Due to its long length and in order to permit high rates of advancement, the intake waterway was excavated using Tunnel Boring Machines (TBMs). In addition, several access galleries, access tunnels and starting ranges are being cyclically excavated by blasting. The northernmost part of the head race tunnel is also being advanced using the cyclical full-circle tunnel heading method and will be stabilized by a double lining. The outer lining consists of reinforced shotcrete with rock bolts and steel arches. The inner lining is a cast-in-place concrete ring that is partly fitted with a sealing sheet.
Before the head race tunnel could be excavated, an access gallery had to be built using the blasting method. The gallery, which features a 17 degree incline, will transport the water from the head race tunnel to the powerhouse.

For advancing the different tunnels and access galleries as well as the inclined chute, DSI Austria supplied the complete range of ground support products that were needed. This mainly included 120kN, 3 and 4m long OMEGA-BOLT® Expandable Friction Bolts with anchor plates and sleeve tubes as well as Type SN25-250 Anchors in lengths of 4 and 6m with special ALWAGRIP rib geometry including 200/200/10mm anchor plates, nuts and washers.

Furthermore, DSI supplied the R32-250 and R32-280 Ø DYWI® Drill Hollow Bar System in lengths of 2, 3 and 4m; 25mm Ø BST 550 steel spiles; R32 self-drilling spiles in lengths of 3 and 4m including hardened drill bits as well as Types 130/20/30 and 70/20/30 PANTEX Lattice Girders with welded-on nut pairs and spacers.
Underground—EMEA—Austria—Tunneling

The Brenner Base Tunnel: DSI supplies Ground Support Products for safe Advancement in highly converging Rock Mass

At 1,371m above sea level, the Brenner Pass is the most important connection between Central Europe and Italy, carrying more than a third of all transalpine traffic. The existing railway line from Innsbruck, Austria to Bolzano, Italy, was built in the 1860s. Due to grades of up to 25 ‰, freight trains often have to be pulled by two locomotives.

The new Brenner Base Tunnel (BBT) runs from Innsbruck, Austria to Fortezza, Italy over a length of 55km and will be the world’s second largest tunnel after the Gotthard Base Tunnel in Switzerland. As a base tunnel, the railway tunnel passes unusually deep underneath the main ridge of the Alps. With a cover of 1,800m, the tunnel will reach an elevation of 795m at its highest point. Since the grade in the tunnel is limited to a maximum of 6.7 ‰, trains will be able to use the BBT at higher speeds in the future. The transit time from Innsbruck to Bolzano will be cut in half from currently more than 2 hours to below one hour once the tunnel is completed.

The BBT consists of two single track tunnel tubes with interior diameters of 8.1m separated from each other at a distance of 70m. Both tubes are connected via crosscuts every 333m that will also serve as escape routes.

The STRABAG/Salini Impregilo Joint Venture has been awarded two contract sections of the BBT: The main contract section Tulfes-Pfons in Tyrol, Austria at the northern end of the project and the underground Eisack Crossing in the southern part of the tunnel in the province of Bolzano, Italy.

The main section includes the construction of 38km of tunnel. Due to the highly converging rock mass conditions, ground support products in this area have to be used on a large scale, which makes progress slow. Consequently, advancement in this area is simultaneously carried out from several places at once.

The development includes the first sections of the tubes for the main tunnel as well as a 15km long part of the Ahrental exploratory tunnel to Steinach, which is being excavated using a Tunnel Boring Machine (TBM).

A new emergency tunnel for the Innsbruck bypass and two connecting tubes between the bypass and the BBT are also being built. The 9km long emergency tunnel is being built using the drill and blast method and runs parallel to the bypass. Within the scope of construction work, the exploratory tunnels that have already been built towards the south are being widened. DSI has already supplied ground support products for stabilizing advancement in the Innsbruck quartz phyllite.

Due to the high cover, the ground is highly converging in many areas. The portal area in Tulfes was stabilized using the AT – 139 Pipe Umbrella System because of the soft ground that is prone to settlements. For this purpose, DSI supplied the complete pipe umbrella system including starter unit, threaded connections, drill bits and drill rods. This way, stability in the portal area was considerably
enhanced which, in turn, increased safety in the advancement area. During advancement, 120kN OMEGA-BOLT® Expandable Friction Bolts in lengths of 3m with 150/150/8mm anchor plates are installed for immediate support. The principal characteristics of OMEGA-BOLT® Anchors include their safe and easy installation and their insensitivity to blasting works because the load-bearing capacity is ensured over the entire installed anchor length. Furthermore, 3, 4, 5 and 6m long, Type SN20-180 and SN25-250 Anchors with different anchor plates are installed in accordance with construction progress. The anchors are installed in highly converging rock mass. Therefore, DSI produced and supplied the SN Anchors with special ALWAGRIP rib geometry in order to enhance their load-bearing capacity.

Additionally, DSI Austria also continuously supplied the self-drilling R32-250 and R32-280 Ø DYWID® Drill Hollow Bar System in lengths of 2, 3 and 4m with accessories. The product range that was produced and supplied by DSI to the jobsite just in time also included BST 550, 25mm Ø, 3m long steel spiles, R32 self-drilling spiles in lengths of 3 and 4m as well as 38mm Ø steel tube spiles in lengths of 3 and 4m.

As a recognized and leading system supplier of ground support products for tunneling, DSI Austria is very proud to be supplying high-quality, certificated products and systems to the BBT and to be supporting the jobsite with technical know-how at all times.
The single tube Arlberg Tunnel is the only east-west connection between Tyrol and Vorarlberg that can be used year-round. At a length of 13,972m, it is Austria’s longest road tunnel and crosses the Arlberg Mountain at a maximum depth of 850m.

Opened in 1978, the tunnel will now have to be adapted to the requirements of the road tunnel safety law (STSG) before the end of 2019 with regards to escape routes and lay-bys. The new safety concept includes the posterior construction of 8 lay-bys, a new crosscut to the existing escape and rescue route and escape routes at maximum distances of 500m to each other. In addition to the existing escape and rescue routes, 37 new galleries in lengths of 42 to 134m will have to be advanced. Most of these will lead from the drivable part of the tunnel into the inlet air canal in a semicircle that can be used as a staircase.

Furthermore, within the scope of the comprehensive repair program, aquiferous cracks will be sealed, the sealing of the interior lining will be renewed and the exposed concrete in the galleries will be comprehensively repaired. In addition, three service rooms for the electrical equipment and the transformers in the tunnel will have to be built, and a sprayer system will be installed in order to reduce the temperature at possible fire sources even before the arrival of the fire department.

The road tunnel was fully closed for several months during rehabilitation.

The Arlberg Tunnel is located in a phyllite gneiss zone at the northern rim of the Silvretta Massif. The rock strata near the planned escape galleries are characterized by strong tektonization with several fault zones so that ground support products were necessary for excavation.

To advance the new escape routes and the additional crosscut, DSI Austria produced and supplied 240kN, 3, 4 and 6m long OMEGA-BOLT® Expandable Friction Bolts with anchor plates and sleeve tubes; Type SN25-250 Anchors with special ALWAGRIP rib geometry in lengths of 3, 4 and 6m with anchor plates as well as the R32-250 Ø DYWI® Drill Hollow Bar System in lengths of 2, 3 and 4m with couplers, cross drill bits and button drill bits. In addition, DSI Austria also supplied the necessary BST 550, 25mm Ø steel spiles in lengths of 3m; R32, 3m long self-drilling spiles and Types 70/20/30 and 50/20/30 PANTEX Lattice Girders.
The Prenner Pedestrian Tunnel in Ischgl: DSI produces and supplies Ground Support Products for Safe Tunnel Excavation

The Prenner Pedestrian Tunnel is located in the center of Ischgl, Austria and when finished, will ensure a direct connection of the parking garage in Ischgl’s center with the 3-S Pardatschgrat gondola. The mined part of the tunnel included in this contract is 130m long and has a cross section of approx. 26m².

The owner, Silvrettaseilbahn AG, awarded the contract for the tunneling work to ÖSTU-STETTIN Hoch- und Tiefbau GmbH, Austria. Due to the fact that the tunnel is located directly underneath the densely developed town center of Ischgl, tunnel work has to be carried out very carefully.

The tunnel portal had to be elaborately stabilized in advance using R32-250 Ø DYWI® Drill Hollow Bar Anchors and shotcrete. The moraine material in the area of the jobsite is loose and partly contains blocks the size of houses. To stabilize the tunnel advancement, 95/20/30 PANTEX 3-bar Lattice Girders and P230-36 4-bar Lattice Girders were installed. The goal is to complete structural work before the 2015/16 winter season so that the tunnel can be opened for pedestrians. Once completed, the tunnel will also be equipped with 2 escalators for providing additional comfort to ski-tourists.

Owner
Silvrettaseilbahn AG, Austria

Contractor
ÖSTU-STETTIN Hoch- und Tiefbau GmbH, Austria

DSI Unit
DYWIDAG-Systems International GmbH, Austria

DSI Scope
Production, supply, technical support

DSI Products
R32-250 Ø DYWI® Drill Hollow Bar Anchors; 95/20/30 PANTEX 3-bar Lattice Girders and P230-36 4-bar Lattice Girders
Successful Use of Ground Support Products for the Rehabilitation of a Shaft in the Altaussee Salt Mine, Austria

Salinen Austria AG is a leading producer and supplier of evaporated salt derived from brine for a large number of different applications. The company attaches great importance to offering high quality products and services.

One of the traditional mines of Salinen Austria AG is located in Altaussee, Austria. Even today, salt is economically extracted from this mine in the Hasel Mountains, a hybrid geology consisting of sandstone, anhydrite, clay minerals, rock salt and companion salts.

The salt is extracted using solution mining – the most modern and economic method in the world. In the drill probe method, a vertical, 30cm Ø bore is drilled to a depth of several hundred meters from a gallery or an exchanger field. Afterwards, two tube systems are installed into the borehole. Alkaline water is flushed through one of the tubes to the bottom of the borehole in order to dissolve the hydrogenetic rock. In this method, the borehole is widened to form a base cavity. The saturated brine flows upwards in the second tube. Additionally, compressed air is pumped into the borehole, protecting the borehole itself from uncontrolled erosion. Furthermore, the shape and size of the created base cavern can be controlled via the compressed air buffer.

In addition to electricity, compressed air and suitable ventilation, this technique requires pipelines for the alkaline water and the brine. At the Altaussee Mine, these supply lines run through a central gallery that is currently undergoing a total rehabilitation.

Currently, rehabilitation work is being carried out in the second section over a length of 26m. In this area, the extraction and supply shaft has to be partly demolished and comprehensively stabilized. First, a concrete gallery wall that had been built a long time ago and that has since deteriorated had to be removed and restabilized. The rehabilitation was carried out while the mine was in operation, and the supply lines in the central shaft had to remain operational during the work.

The inner shaft walls were stabilized using Nirosta mesh with an aperture size of 30 x 30mm. The mesh was installed over the load-bearing rock and anchored in place using...
800mm long DSI Expansion Head Anchors consisting of mine support steel, 16.2mm Ø, grade 450/700N/mm², 145kN maximum load. For this purpose, 33-36mm Ø boreholes were drilled and the anchors were installed including anchor nuts and 100 x 100 x 6mm perforated plates.

To stabilize the trusses for the supply lines, DSI Austria produced and supplied 800mm long DSI Resin Anchors consisting of GEWI® Steel in nominal diameters of 20mm and steel grades of 500/550 N/mm² with ultimate loads of 173kN. The anchors have a yield strength of 157kN. The resin anchors were installed together with 28 x 500mm long resin cartridges with a reaction time of 120 seconds and placed together with domed nuts and 100 x 100 x 6mm solid plates with hole diameters of 35mm.

Although the repair work was much more comprehensive than originally planned, the work is being carried out according to the schedule. Once the second section is completed, the most complex 30m of the 200m deep shaft will be comprehensively stabilized. DSI Austria would like to wish “Glück Auf” to all miners involved in the work.
Recently, DSI completed its range of injection resins with the addition of fast reacting and super high foaming phenolic DYWI® Mine Fill Resins. DYWI® Mine Fill Resins A and B feature low viscosity, thus enhancing pumping performance and, as a result, are an efficient means for sealing gas dams or surfaces. Furthermore, they serve well for filling cavities in order to prevent gas accumulation and are especially suitable for erecting firewalls.

In order to obtain an approval for marketing these special phenolic resins especially in Australia as well as in Turkey, the DYWI® Mine Fill Resins had to pass several critical tests. These also included a major fire test jointly carried out by DSI and Polychem at the test facility of the independent service provider DMT in Dortmund, Germany in May 2015. In addition, the test program included further tests concerning the curing temperature as well as a 90l test with and without carbon dust, a filter test, an electrostatic test and several hygiene tests.

It took DMT several days to prepare the fire tests in a special gallery at the facility. A very specific design protocol had to be followed for the mine related tests. Once a 13m long section of the gallery had been prepared, DSI and DMT installed tubular films and pumped the Mine Fill foams into the cavities between the gallery walls and the lining. The pumping operation required the best part of 3 days. After the foam was installed, time was needed to remove the reinforcement mesh and foil material, install the required measurement instrumentation and to allow the resin material to dry completely.

In preparation for the fire test, a fuel source was installed to very specific detail and probes were installed in the tunnel to monitor both temperatures and gas emissions.
During the fire, two highly trained fire wardens remained in the tunnel. The entire fire test was monitored at a control center on the surface. The fire, which was monitored overnight, produced temperatures above 800°C. During the complete test, the highest temperature measured in the middle of the DYWI® Mine Fill body was 99.47°C and thus considerably below the stipulated maximum temperature of 150°C. After the test setup had been allowed to cool for 24 hours, the foamed DYWI® Mine Fill body was cut open and revealed a fine-pored, homogenous structure. The foamed body did not show any signs of carbonization. Consequently, DMT confirmed that DYWI® Mine Fill Resin had fully complied with the relevant regulations and therefore passed all tests. DSI is currently the only company to have a new fire test for phenolic resins that meets recent standards and to have an up-to-date technical approval.
The Ceneri Base Tunnel: DYWIT supplies Ground Support Products for Switzerland’s third largest Tunnel

The Ceneri Base Tunnel (CBT) in the canton of Ticino is the third longest railway tunnel in Switzerland. It is the continuation of the Gotthard Base Tunnel along a new transalpine railway line that has a total length of more than 70km.

The modern and flat route will allow speeds between 200 and 250km/h. In contrast to the existing section, where additional locomotives are required to push the trains in order to cope with a slope of up to 26 ‰, the trains will no longer have to be pushed on the new section, which is also 40km shorter than the existing section.

The 15.4km long Ceneri Base Tunnel is being built as a double tube tunnel with a cover of 10 to 850m. The parallel tubes are single track tubes separated by a space of 40m. Every 325m, the tubes are connected via crosscuts.

Via a 2.5km long approach adit, an intermediate heading was driven near Sigirino from which the main tunnel is being simultaneously excavated at four different locations. The main section – Lot 852 – consists of two 8km long drifts towards the North and of 2 approx. 6km long drifts towards the South.

The new tunnel is located in the crystalline rock of the Southern Alps in heterogeneous rock strata. Due to the fault zones that are expected in this area, tunnel advancement is primarily carried out using the conventional blasting method. In order to cope with the very different geological conditions, the project is divided into 10 different excavation sections.

The areas located in the most stable rock formations required flat inverts, few short rock bolts and a thin shotcrete lining. The sections where intermediate fault zones are prevalent were advanced using curved inverts, steel ribs in the crown, rock bolts in the tunnel walls.
Underground—EMEA—Italy—Tunneling

and thick shotcrete lining. The areas located in the strongest fault zones were excavated using circular invert, steel ribs in the crown and invert, many long rock bolts and a thick shotcrete lining.

For all 10 excavation sections, DYWIT Italy supplied R 32 and R 38 Ø DYWI® Drill Rock Bolts with a total length of approx. 149,500m, all of which were flexibly adapted to on-site conditions. The self-drilling DYWI® Drill Hollow Bar System proved to be ideal in these difficult ground conditions because it can also be installed trouble-free and safely in a single step in unstable boreholes.

In addition, DYWIT supplied a total of 93,000 Type EFB-160 and EFB-240 OMEGA-BOLT® Rock Bolts. The expandable friction bolts achieve immediate full load bearing capacity over the entire installed bolt length and are therefore very suitable for advancing the Ceneri Base Tunnel in the prevailing fault zones.
Fast Emergency Reaction: DSI Steel Ribs ensure Safe Advancement of the Drumanard Tunnel

North-east of Louisville, Kentucky, USA, the Ohio River Bridges - East End Crossing Project is underway. This project will close the last remaining gap in the I – 265 freeway. The first part of the construction project includes the construction of a stay cable bridge spanning the Ohio River. Further along, the highway then continues into a tunnel in order to preserve a historical building and gardens that are located on the new route. The 518m long Drumanard Tunnel is located in the town of Prospect and is being built as a twin drive with two lanes per tunnel tube.

The original excavation plan of the north and south drives was to create approx. 16.8m (55ft) wide and 9.5m (31ft) high horseshoe shaped tunnels. The jobsite is primarily located within a large dolomite formation which is just below a uniform shale formation. In the beginning, the excavation sequence was carried out using the drill and blast method. The initial support system included various DSI bolts consisting of DYWIDAG THREADBAR® as well as shotcrete.

In September 2014, DSI received an urgent call from the contractor: A portion of the tunnel crown had collapsed at the north end. Presumably, the rock strata had developed some separation due to heavy rainfall. The estimated rock fall was approx. 91m (300ft) long, 15m (50ft) wide and 3m (10ft) deep. Fortunately, no one was in the tunnel at the time of the fall.

Immediately, a DSI delivery of additional bolts, resins and hardware were on their way to the jobsite to stabilize the site conditions. As the days unfolded, DSI committed itself completely to supporting the contractor’s efforts with an array of alternative analyses. Ultimately, a revised excavation plan was jointly determined for which DSI supplied high-quality underground support products.

The new ground support products used were steel horseshoe sets consisting of W8 x 67 beams, fabricated in seven segments to ensure easy installation. As the excavation
consisted of a heading and bench sequence, wall beams were included on each side of the tunnel, allowing for bench excavation and successive post installation, thus completing the full set. Each set is spaced at 1.5m (5ft) center to center utilizing DYWIDAG THREADBAR® as spacers. The new excavation sequence continued to employ drill and blast, but limited the advance to 6m (20ft), or four steel sets per day. Once the rib sets were installed, steel lagging was installed above the sets, and all voids above the interim support structure were filled with concrete.

Thanks to the steel rib sets, work advanced regularly and ahead of schedule without any interruption. DSI continued to produce steel sets at a pace matching the contractor’s advance. The contractor was very satisfied with the solution proposed by DSI for the challenging tunnel advancement. The resulting excellent relationships will surely last beyond the completion of the Drumanard Tunnel.
Underground — North America — USA — Mining

The Leeville Mine: DYWIDAG GRP Rock Bolts and DYWI® Inject Systems ensure Safety in Aggressive Environments

The Newmont Mining Corporation was founded in 1921 in the USA and is a globally leading producer of gold and copper. Approx. 16km north-west of the town of Carlin in Nevada, the company operates the Leeville Underground Mining Complex. As of 2014, the Leeville Mine reserves amount to an estimated 1.291 million ounces of gold.

Within the scope of planned rehabilitation work, the owner was looking for suitable ground control products. The main challenge was the very high corrosion potential in this area of the mine; for example, mine water samples showed a pH value in the range of 3, indicating a highly acidic and thus corrosive environment.

DSI Underground Systems had previously supplied a variety of high quality ground support products to the mine. Consequently, the owner asked DSI to develop a corrosion resistant ground control system that was going to be installed in the mine within the scope of a large-scale trial and tested with regards to its suitability. The highly corrosive environment in which default, steel-based ground support systems corrode within a very short period of time was not the only topic that was problematic: high temperatures underground posed an additional challenge.

In view of these circumstances, DSI proposed a combined ground control system consisting of DYWIDAG GRP Rock Bolts and DYWI® Inject Resins. Glass fiber reinforced tendons feature excellent corrosion protection and low weight, have a high tensile load-bearing capacity, and can be easily cut by mechanical excavators or shearsers if necessary.

For the comprehensive test, more than 200 CH25-250 DYWIDAG GRP hollow bars as well as self-drilling, CR32-340, DYWIDAG GRP hollow bar rock bolts were used. Trial installation tests were carried out using two different types of injection resins plus accelerator. The first injection resin was DYWI® Inject SILO 8044, a 2-component silicate resin with excellent adhesive properties that cures quickly. Due to the prevailing characteristics of the surrounding rock mass, some DYWIDAG GRP Rock Bolts were also
injected with the 2-component polyurethane injection resin DYWI® Inject PURE 8034 plus accelerator DYWI® Inject PURE X 8034. In contrast to cement grout, this injection resin ensures fast curing for immediate support even in areas that are subject to mine water inflow.

The installation procedure was optimized with the help of DSI’s technical personnel in order to ensure a fast, easy and safe installation and to optimize cycle times. DSI also provided the owner with the necessary accessories as well as a high-pressure pump for injecting the resins.

In order to permit a direct comparison, 8 pcs. of R32 DYWI® Drill Hollow Bars were installed and also injected with DYWI® Inject Systems.

Based on the trial test results, DSI provided detailed recommendations for the rehabilitation work in the mine. In addition to the optimum ground control system, DSI also proposed suitable installation methods and training for on-site personnel. The tests showed that the use of DYWIDAG GRP Hollow Bars together with DYWI® Inject Resin was the best solution for the prevailing conditions at the Leeville Mine.
DSI Underground Systems USA supplies Solution for Excavation in Thin Seams

A team of technical experts – including several employees of DSI Underground Systems USA – conducted an underground ground control inspection and assessment of the GCC National King Coal Mine II in Hesperus, Colorado, USA.

The mine operator anticipates that the coal seam will become thinner as excavation progress and therefore requested recommendations from DSI, their ground support supplier, on effective roof support solutions.

The mine currently uses a combination of fully grouted headed DSI Rebar Rock Bolts in combination with a pattern of DSI’s 30T capacity EZ Trusses. As the mined coal seam gets thinner, finally reaching the precalculated thickness of 1.37m (4.5ft), the reduced mining height will not allow the current, fully grouted rebar bolt and EZ Truss System to be effectively installed.

The mine is considering using a 1.83m (6ft) long roof bolt system and asked DSI to carry out an analytical examination beforehand. In order to find a suitable ground support design solution, an on-site inspection of the current conditions had to be undertaken.

At the mine, the group of DSI experts toured current development works directly after the mine visit, the technical team of DSI Underground Systems supplied a detailed report to the mine that included efficient technical solutions for future ground support in thinner seam conditions.
Owner
Grupo Cementos de Chihuahua, S.A. de C.V. ("GCC"), USA

DSI Unit
DSI Underground Systems Inc., USA

DSI Scope
Production, supply, technical support

DSI Products
Fully grouted DSI Rebar Rock Bolts, EZ Truss System
BULLFLEX® Hoses ensure the safe and flexible Rehabilitation of a Conveyor Tunnel at the Bingham Canyon Mine

Kennecott Utah Copper (KUC) is a mining subsidiary of the global company Rio Tinto. At the Bingham Canyon Mine near Salt Lake City, Utah, KUC has been extracting gold, silver, copper and molybdenum in an open pit mine that will soon be expanded to include underground operations.

The approx. 4.6km (15,000ft) long and 6.4m (21ft) high C6 conveyor tunnel was constructed in 1959 and includes a belt conveyor for transporting extracted ore. A portion of the tunnel leads through a fault zone, the Fortuna fault, where numerous rehabilitation efforts were undertaken prior to 2014.

At the beginning of 2014, progressive damage to the tunnel support was observed that was caused by overstressing due to movements in the surrounding rock mass. Spalled concrete and shotcrete was observed in the steel sets embedded in concrete lining that had been installed as initial support for the tunnel. Since a portion of the conveyor tunnel could no longer be inspected and maintained, access between the pit portal and the Fortuna fault zone area had to be restricted. This resulted in a critical economic and safety-related risk to the operation of the entire mine.

Under enormous time pressure, the companies involved in the project developed a design concept for the sustainable rehabilitation and strengthening of the tunnel in the fault zone area with the support of DSI Underground Systems. The concept had to take the limited space conditions into account and ensure the uninterrupted operation of the conveyor belt. Furthermore, ongoing movements of the tunnel in the fault area due to mining-induced deformations required a yielding roof support system that was simple and easy to install.

For this purpose, a yielding support system consisting of TH Steel Sets was used in combination with a prefabricated Type BULLFLEX® Roof Support Backfilling System. The single sections of the TH Sets were bent to the corresponding profiles at DSI’s plant in Louisville on the shortest possible notice. The single sections were connected by yielding locks to accommodate consecutive deformation and yielding in the fault zone area.
Installation in the tunnel was accomplished using a monorail based, elevated work deck to minimize the impact of the installation procedure on the conveyor belt operation. The Type TH-25 and TH-29 profiles and locks were assembled outside the tunnel and transported underground using a jig crane developed especially for this project. Following the installation of the complete TH rings, the 320mm Ø BULLFLEX® Hoses were placed in the gap between the TH profile ring and the excavation surface and were injected with a ready-mix grout.

The BULLFLEX® fabric permits the induction of an active, pre-defined load into the excavation perimeter while maintaining a controlled residual load. The combination of TH profiles and BULLFLEX® Hoses provided a flexible and incremental ground support rehabilitation of the fault zone in the C6 conveyor tunnel with a minimum impact on critical operations. Furthermore, DSI supplied Type FS Friction Bolts, OMEGA-BOLT® Expandable Friction Bolts and mesh.
Development and Application of a flexible Combined Support System for Tunnel Rehabilitation

A rehabilitation concept for tunnels consisting of a combination of yielding steel arch sections and BULLFLEX® Roof Support Backfill Hoses was developed and successfully implemented in the course of the rehabilitation of a conveyor tunnel in operation at the Rio Tinto Kennecott Utah Copper (RTKC) Bingham Canyon Mine (Utah, USA).

The focus of the rehabilitation was the approx. 4.5km long C6 conveyor tunnel, which was originally excavated in 1959 as a 5.5 x 7.5m cross section railroad tunnel, and which is currently being used as the main conveyor tunnel. At the time, horseshoe shaped steel sets with a spacing of 1m to 2m were installed as ground support. Furthermore, roof bolts and a timber lagging (200m per tunnel meter) were installed and subsequently backfilled. In addition, load distribution structural elements were selectively used as support for the steel sets in the tunnel invert. Finally, a 25cm to 30cm thick cast in place concrete lining was installed which has since been repeatedly repaired on a provisional basis in the course of time using rock bolts, mesh and shotcrete.

At the beginning of 2014, as a result of nearby open pit mining activities, considerable damage was detected in the C6 conveyor tunnel especially near fault zones. This included severe damage of the concrete lining as well as a clear increase in displacement of the tunnel tube. The damage led to a partial closure of the tunnel so that the urgently required inspection and maintenance work at the main conveyor belt could no longer be carried out. Therefore, a short-term rehabilitation of the affected sections was required without hindering the operation of the conveyor belt.

DSI Underground Systems, Inc. (DSI) and their cooperating partner BuM Beton- und Monierbau GmbH (BuM) were asked to provide technical planning criteria by the engineers Gall Zeidler Consultants LLC (GZ), who had been awarded the contract for developing the rehabilitation concept. In the shortest possible time, DSI and BuM supplied the required information needed to design an efficient and safe rehabilitation concept. Important aspects during the dimensioning of the rehabilitation elements included the fact that the installed support measures had to ensure sufficient clearance, while the impact on the operation of the conveyor belt during the rehabilitation had to be minimized.
Furthermore, a system with immediate load-bearing capacity was needed that ensured a high degree of flexibility in case of increasing convergence. Within a few days, GZ proposed a rehabilitation concept to the customer RTKC and the rehabilitation project was immediately commissioned by the client.

Upon the recommendation of GZ, BuM and DSI, the following stabilization concept was chosen:

- TH steel sets with yielding locks in areas of overlapping segments, Types TH-25 and TH-29
- BULLFLEX® Groutable Hoses functioning as a roof support backfill, 3,200mm Ø

The TH system was developed in the 1930s in Germany for application in highly converging ground conditions in coal mining. The single, interleaved TH sections are connected by lock systems. Depending on number and type, these locks can accommodate a defined load until a controlled slippage of the segments into each other occurs, thus ensuring the yielding ability of the system. For dimensioning of the yielding support system for the C6 Rehabilitation project, in-situ measurements carried out in German coal mining were used as references.

The BULLFLEX® System, which is filled with grout at a pressure of up to 4 bar, ensures a stable and safe form fit between the steel support and the rock. Furthermore, point loads are avoided and premature relaxation movements are minimized. Thanks to the special filter effect of the BULLFLEX® fabric, any surplus water is immediately drained, thus maintaining the induced pre-load, i.e. the active support.

The main characteristics and advantages of this combined support system can be summarized as follows:

- Steel arch support with yielding lock systems
- Easy adaptation of the steel support to uneven excavation surfaces
- Controlled slippage in converging ground conditions
- Immediate, full face load bearing capacity and introduction of an active pre-load thanks to the installation of BULLFLEX® System

The TH steel arch support sections were manufactured at DSI’s plant in Louisville including the load distribution profiles and flexible footings (also known as Dutchmen) in accordance with the design specifications. The steel arch segments and locks were assembled outside of the tunnel and then transported to the underground jobsite using a support manipulator. The installation was carried out from an elevated work deck using a second support manipulator. The BULLFLEX® Groutable Hoses were filled on site using a grout mix (portland cement and fly ash) supplied by mobile mixing units. In addition to this support system, wire mesh and rock bolts were installed.

The described rehabilitation concept including the combined support system was implemented quickly and successfully. Consequently, the C6 conveyor tunnel is now once again fully accessible and can be considered as stable for the medium term. In cooperation with the customer, Rio Tinto, the mining service provider Cementation and the responsible engineers GZ, DSI and BuM have made an important contribution to restoring the functionality of a drift that is critical for mine operation.

Sources


DSI Rock Bolts stabilize Excavation in historic Mine: Rehabilitation of the Rayas Shaft

The historic town of Guanajuato is a four hours’ drive north-west of Mexico City in an area in which silver and gold have been extracted from underground mines for more than four centuries.

This is also where the Guanajuato mine complex, operated by Minera Mexicana el Rosario, is located. Here, more than 1 million ounces of silver and 10,350 ounces of gold were mined in 2012 alone. The precious metal deposits are located at a depth of up to 400m in a complex that forms part of the world’s deepest mines.

At the Rayas Mine, which is also part of the Guanajuato complex, an octagonal, 11.31m Ø main shaft that was established in 1833 leads to the excavation galleries.

Recently, the Rayas Shaft was comprehensively rehabilitated in order to substantially improve safety and efficiency. The rehabilitation measures will enhance the transportation of miners underground and shorten transport times, which will, in turn, improve overall operational efficiency.

Work at the vertical, 300m long shaft had to be executed from a platform. To stabilize the shaft walls, DSI Mexico supplied THREADBAR® Rock Bolts that were installed together with resin cartridges. All test anchors successfully passed the pull test carried out by DSI experts in advance. Thanks to the comprehensive repair, the shaft will ensure a continuing safe extraction of gold and silver for many years to come.
Systematic Safety: DSI supplies Complete Ground Control Solutions for the Pencaligue Hydroelectric Power Plant in Honduras

The Pencaligue hydroelectric power station in the district of Santa Barbara in Honduras is one of several projects that will sustainably enhance power supply in that country. The new power plant has a planned service life of 30 years, and an installed power of 20MW.

The construction of a new head race tunnel with a cross section of approx. 4m x 4m and a length of 3km was necessary for the Pencaligue power plant. The tunnel partly leads through a tectonic fault zone; further along, excavation is carried out in relatively good, but highly fractured rock mass.

DSI provided the customer with a complete solution including on-site technical support. The products were successfully supplied to the jobsite just in time, thus ensuring that construction proceeded smoothly and on schedule.

Owner
Hidroeléctricas de Occidente S. de R.L de C.V. HIDROCCI, Honduras

DSI Unit
DS International S.A. de C.V., Mexico

DSI Scope
Supply, technical support, test installation

DSI Products
19mm Ø rock bolts, 1.5 x 2.7m mesh, Type FS-39 Friction Stabilizers
The Transolímpica Tunnel: Easy and Fast Stabilization using DYWIDAG GRP Rock Bolts

The Transolímpica Bus System is currently under construction in Rio de Janeiro in preparation for the 2016 Olympic Games. The new route is one of three mass transit routes in Rio. Adjacent to the bus lanes, there will be two toll lanes each for vehicular traffic. After its completion, the 23km long Transolímpica will connect the districts of Deodoro and Barra, the two most important venues for the 2016 Olympic Games.

A double tube tunnel is being built in the western section of the route. This Transolímpica Tunnel, designed for 55,000 vehicles per day, will run through the Engenho Velho Mountain Massif.

The tunnel portal is located in a strongly fissured and unstable slope that had to be comprehensively stabilized in advance. The required slope stabilization measures were carried out using shotcrete and temporary rock bolts.

To stabilize the tunnel portal, DSI Underground Brasil recommended the use of glass fiber reinforced rock bolts (GRP Anchors) to the owner. DYWIDAG GRP Systems, characterized by their light weight, can be installed quickly and have a high tensile load bearing capacity. Another essential advantage of the GRP system for conventional tunnel driving by blasting and excavation is that they can be cut and removed easily and quickly so that they do not obstruct tunnel driving.

For the quick and efficient stabilization of the portal area, DSI Underground Brasil supplied the Type CS-20 and CS-25 DYWIDAG GRP System.
Extension of the BR 101 Motorway:
DYWIDAG Rock Bolts stabilize the Formigão Tunnel

A new road tunnel was recently opened in southern Brazil near Tubarão, a town that is located near the Atlantic coast. The Formigão Tunnel is the last of four new tunnels built during the widening of the BR 101 Motorway.

At km 338 of the road widening project, the tunnel leads through Formigão Hill, thus doubling the capacity of the BR 101 motorway. With a total length of 900m, the section included the construction of a 530m long double tube tunnel as well as a 210m long northern and a 160m long southern access road. Both tunnel tubes accommodate two lanes and a pedestrian walkway.

The tunnels were driven using the drill- and blast method at an average advance rate of 4-5m per day.

To stabilize the tunnels during excavation, DSI Underground Brasil supplied 4m long DYWIDAG Rock Bolts that were tightly anchored in the load-bearing rock using resin cartridges. Additionally, DSI employees carried out comprehensive performance and pull tests and supported the joint venture with their technical know-how.

Thanks to the excellent co-operation of all companies involved, tunnel advancement was efficiently completed within a short time period.
The Mandacarú Tunnel in Bahia: 
DYWIDAG Rock Bolts secure Brazil's Future as an Exporter

Brazil, the world’s second largest producer and exporter of soy beans after the USA, plans to increase both production and exportation in the years to come.

One factor that has a decisive influence on this development is the high cost of transportation in Brazil in comparison to the US: Soy beans in Brazil have to be transported over long distances on an infrastructure network that is not yet well developed.

In order to increase its competitiveness, Brazil is planning to expand its railway network by adding 10,000km of tracks. This project also includes the Mandacarú Rail Tunnel near the town of Jequié in the federal state of Bahia. As part of a new railway route, it will permit transportation of soy beans and iron ore to a new harbor on the coast.

The single tube, 780m long Mandacarú Tunnel runs through highly weathered and fractured rock formations. Due to these difficult ground conditions, the general contractor required a high performance, high quality, and flexible ground support solution to ensure that tunnel excavation could be undertaken safely.

DSI Underground Brasil supported the owner and consulting engineers during the selection of a rock bolt system suitable for use in these conditions. To stabilize the tunnel excavation, DSI produced the necessary DYWIDAG THREADBAR® Rock Bolts as well as resin cartridges and supplied them to the jobsite just in time. The use of these high quality ground control products ensured the safe and efficient excavation of the tunnel.
New Tunnels in Brazil: 
More Safety with DYWIDAG Rock Bolts

The BR 381 motorway, which links the federal states of Minas Gerais and São Paulo, is one of the most dangerous roads in Brazil. Furthermore, the motorway is heavily congested by truck traffic coming from the mines and steel mills in Minas Gerais.

In order to improve safety on this mountainous road and to stimulate the region’s economy, the capacity of BR 381 is being significantly increased on a 303km long section.

Within the scope of this major project, 5 new tunnels are being built in addition to 34 bridges and 66 viaducts. The project is divided into 11 sections. DSI Underground Brasil contributed to Lots 3.2 and 3.3. This is where the Piracicaba, Antônio Dias and Prainha tunnels are being built.

The new tunnels will make the BR 381 motorway considerably safer.

Construction work proved to be difficult due to the mountainous terrain and the limited space in the portal areas. Furthermore, the road located nearby had to remain in service, and work had to be carried out within a very limited time frame.

To stabilize the excavation in all three tunnels, DSI Underground Brasil supplied DYWIDAG Rock Bolts as well as resin cartridges and steel fibers. The high quality ground support products were supplied just in time to the respective tunnel sites in accordance with construction progress.
Customized Products for Alto Maipo, Chile’s largest Hydroelectric Power Plant Project

The construction of the Alto Maipo Hydroelectric Power Plant is currently being carried out in the foothills of the Chilean Andes in the Maipo valley, approx. 50km south-east of Santiago de Chile. In 2012, the Chilean tunneling division of STRABAG SE was awarded the planning and construction contract for one of the two sections of tunneling and engineering work for this project by Alto Maipo S.p.A.

Alto Maipo is one of the largest private construction projects in South America. It includes the construction of tunnels and shafts with a total length of 46.5km that will be excavated using the New Austrian Tunneling Method (NATM) as well as Tunnel Boring Machines (TBMs). The two underground power houses Alfalfal II and Las Lajas in the northern part of the project also form part of this contract. Once completed, the hydropower plant will have an estimated total output of 531MW.

DSI Chile has been supplying a comprehensive range of ground support products and systems since construction work started. In addition to Type FS-47 Friction Stabilizers and Forepoling Boards, the products also included Type CP-95 and CP-130 PANTEX Lattice Girders. The Lattice Girders were custom-tailored and produced at DSI Chile’s plant in Santiago de Chile.

At the tunnel portal areas, the AT – 114 Pipe Umbrella Support System was used for pre-support. The system’s pipes decrease excavation induced deformations and increase the stability in the working area by transferring loads in the longitudinal direction. In addition, DSI Chile supplied the self-drilling Type R32-280 DYWI® Drill Hollow Bar System.

DSI supplied all products and systems to the job site just-in-time and optimized the ground support supply chain in close cooperation with the client STRABAG. The general contractor was very pleased with the high quality DSI products which have been delivered so far.
The Loboguerrero Tunnel Chain: DYWI® Drill Hollow Bar System ensures fast Construction Progress in difficult Ground

In the province of Valle del Cauca in western Colombia, a new 32km long federal road is being built between the towns of Mulaló and Loboguerrero.

This new corridor will connect the region to the cities of the province and create a faster route for freight traffic to Buenaventura, Colombia’s most important Pacific harbor.

The section runs through steep terrain that is prone to landslides and includes 9 12km long tunnels as well as 32 bridges.

Varying and difficult ground with many fault zones required the use of reliable ground support in the tunnels. For stabilization of the excavation work, DSI Colombia supplied the Type R32-280 DYWI® Drill Hollow Bar System.

The hollow bars were used cost-effectively as supplementary rock bolts in the area of the tunnel walls to repair unstable sections.

Thanks to the fast, safe and flexible application of the DYWI® Drill Hollow Bar System, the work in difficult ground was efficiently completed.
Complete System Solution for Application in highly weathered Rock Mass: DYWI® Drill Hollow Bar System for the Alejandría Hydropower Plant

In Alejandría near Medellin, Colombia, the new Alejandría hydroelectric power station is being built. The power plant will include two turbines with a maximum output of 7.7MW each. After its completion, it will produce 94.5GWh of energy per year on average.

In the summer of 2014, construction work began at the slope as well as the exit portal of the future 2km long headrace tunnel. During all stages of constriction, the DYWI® Drill Hollow Bar System was used for four different applications.

First of all, the foundation of a 20m long bridge for the access road was stabilized using 12m long Type R38-550 DYWI® Drill Micropiles. Additional DYWI® Drill Hollow Bars were used near the river bank for slope stabilization purposes. Furthermore, DYWI® Drill Soil Nails were installed for stabilizing the tunnel exit portal. For an efficient stabilization in highly weathered rock mass, up to 20m long Type R32-280 DYWI® Drill Soil Nails were used.

Finally, Type R51-660 DYWI® Drill Hollow Bar Spiles were used as pre-support for stabilizing the tunnel portal. The DYWI® Drill Hollow Bars, installed in difficult ground, were 9m long.

All hollow bars including accessories were produced by DSI Austria and temporarily stored at DSI Colombia in Medellin so that the products could be supplied to the job site just in time whenever needed.

Work was made difficult by Columbia’s frequent and heavy precipitation during the country’s rainy season. Furthermore, conventional ground support could not be used in the highly weathered rock at the jobsite. Ground conditions were too unstable to carry out drilling and installation of rock bolts, spiles and micropiles in two separate steps. DSI’s competence in self-drilling technology was of decisive importance, and the DYWI® Drill Hollow Bar System, which can be installed in a single operational step, proved to be the ideal solution.

DSI Colombia supplied a complete solution to the client and provided competent technical support for all four applications of the DYWI® Drill Hollow Bar System. The general contractor was very satisfied with the DYWI® Drill Hollow Bar System, which was used for the first time in Colombia in this extended application.

Owner
Generadora Alejandria S.A.S. E.S.P., Colombia

General Contractor
Consorcio ACM, consisting of AIA - Arquitectos e Ingenieros Asociados and CONSTRUCTORA MORICHAL Ltda., both Colombia

Subcontractor
GEODIG and PERFOREX S.A.S., both Colombia

Consulting Engineers
Integral S.A. Ingenieros Consultores, Colombia

DSI Units
DSI Colombia S.A.S., Colombia
DYWIDAG-Systems International GmbH, Austria

DSI Scope
Design, development, production, supply, installation, engineering services, technical support, supervision, test installation

DSI Products
Type R38-550, R32-280, R51-660
DYWI® Drill Hollow Bar System
The Santa Rosa Tunnel: AT – Pipe Umbrella Support System permits Continuation of Excavation following Tunnel Collapse

In Lima, a Tunneling project is currently under construction that will efficiently connect the northern suburb of San Juan de Lurigancho with the suburb of Rímac located further towards the South-West. The project includes two parallel, 300m long road tunnels – the San Martín and Santa Rosa tunnels that will lead through the Santa Rosa Hill. The tunnel tubes are 8m high and 14.2m wide and accommodate two 3.5m wide lanes per direction.

Excavation of the Santa Rosa Tunnel had to be interrupted in February 2011 when a part of the tunnel collapsed as work was progressing. Following the collapse, a new technical study was carried out that would ensure that the tunnel could be advanced safely. In contrast to the first design, the tunnel will now be lined with reinforced concrete instead of conventional concrete nearly along its total length. The new design requires approx. 10x as much reinforcing steel as originally planned.

For the technically demanding task of excavating the collapsed part of the tunnel a second time, DSI Peru supplied the Type AT – 139/NC Pipe Umbrella Support System with Threaded Nipple Couplings. This system is a special development of DSI: Additional steel nipples with a threaded connection are pressed into and welded onto both ends of the extension tubes. This threaded nipple connection provides an elastic design load over the entire pipe umbrella length which is equal to the one of a standard pipe. Thereby, the AT – Pipe Umbrella Support System increases the stability in the working area by transferring loads in the longitudinal direction and decreasing excavation induced deformations.

Thanks to the high stability and safety provided by the AT – Pipe Umbrella Support System in unstable ground conditions, work could be continued quickly and efficiently. DSI also provided design-related and on-site support during the entire construction phase.
Static Safety during Fire Exposure:
DSI develops Fire Protection for the DYNA Grip® Stay Cable System

Fires caused by accidents or lightning quickly turn into a problem if the structural components of a bridge are not sufficiently protected from the impact of heat. Fires that occurred on bridges in the past have increased the requirements for fire protection in some new bridge projects as well as for the reinforcement of existing structures. DSI has developed and tested a fire protection system that protects stay cable and steel parts such as anchorages reliably from this threat.

The aim was to protect the complete stay cable system against a 30 minute long hydrocarbon fire with a temperature of 1,100°C. During this time, all of the protected parts had to remain below a temperature of 300°C. The fire protection system is divided into two different areas. The protection in the free stay cable length and in the transition areas up to the anchorage is a highly fire resistant hydrophobic mat that is wrapped around the stay cable bundle and covered by an outer tube such as a weather resistant PE tube. An intumescent epoxy coating is used to protect the anchorage and the anti-vandalism tube. This coating can either be brushed or sprayed on. At high temperatures, this coating increases its volume by foaming, thus isolating the anchorage material from high temperatures.

Two tests were conducted to qualify the system. The first test was to prove the efficiency of the fire resistance design, and the second test was to show that the cable force can be reliably maintained by the DYNA Grip® Anchorage at 300°C for a minimum of 30 minutes.

In the first test, a Type DG-P12 DYNA Grip® Stay Cable bundle was mounted on a steel frame for this purpose. The stay cable bundle was covered with the fire resistant mat, and the steel components were covered with the intumescent epoxy coating.
In order to measure the temperature, several sensors were mounted on the strands underneath the mat and on the bare steel components underneath the coating. This test frame was placed in a furnace chamber and exposed to a 1,100°C hydrocarbon fire for 30 minutes. After half an hour, the measured temperature of all sensors stayed below 300°C; in fact, in some areas, the temperature only reached 200°C.

In the second test, a Type DG-P12 DYNA Grip® Stay Cable bundle without any fire protection was mounted on a steel frame that was also placed inside the furnace chamber. Outside of the furnace, a hydraulic jack was placed in front of the steel frame to stress the complete specimen to a force of 45% of the cable’s guaranteed ultimate tensile strength (GUTS). At a temperature of 300°C, the system did not show any failure or strand slippage even after one hour.

The fire protected DYNA Grip® Stay Cable bundle is the first – and so far the only – system that has been successfully tested according to the new PTI guide line for stay cables.

The fire protection concept for the free stay cable length is currently in service on the DYNA Grip® Stay Cables of the Trois Bassins Extradosed Bridge on La Reunion and has served as a reinforcement measure for protecting the stay cables of the Galecopper Bridge in the Netherlands since 2014.
The Tsubasa Bridge:
DYNA Grip® Stay Cables support Cambodia’s longest Bridge

With a length of approx. 167km, National Highway 1 in Cambodia connects the capital of Phnom Penh with the Bavet border crossing to Vietnam. Due to the increasing congestion on this important route, a decision was made to construct the Tsubasa Bridge in Neak Loeung 60km south-east of Phnom Penh. The structure is a three span stay cable bridge crossing the Mekong River.

The project also included the construction of two 900m and 675m long approach bridges. Both structures consist of 35 spans, each of which is 45m long. The precast concrete girders were fabricated in a construction yard and installed using two sets of erection girders. The precast girders were post-tensioned using Type 12S 15.2 DYWIDAG Strand Tendons, and Type 3S 15.2 DYWIDAG Strand Tendons were used for transverse post-tensioning.

The main bridge is 640m long and divided into three spans with lengths of 155m, 330m and 155m. The two pylons are 121m high measured from the pile cap and consist of two individual pillars on the outside of the bridge that are connected by several cross beams. The pylons rest on cast-in-place, 2.5m Ø concrete piles. The main girder has a cross-section of 17m and a height of 1.8m. The bridge segments adjacent to the pylons were built first so that the stay cables could be installed at both pylons and anchored at the bridge deck. This way, the stay cables supported the weight of the form traveler during the construction of the bridge sections between the pylons. These were constructed using an underslung form traveler in a 10 day construction cycle. In total, 930t of Type DG-P61, 55, 37, 31 and 22 DYNA Grip® Stay Cables were installed.
The stay cables are galvanized, waxed and inserted in HDPE ducts. In the main span area, transverse post-tensioning was carried out using 170t of 32mm Ø DYWIDAG Bar Tendons. The individual cross beams were stressed using 510t of Type 12S 15.2 horizontal DYWIDAG Strand Tendons.

Furthermore, 140t of Type 19S15.2 DYWIDAG Strand Post-Tensioning Systems and 200t of Types 5S 15.2, 7S 15.2 and 9S 15.2 DYWIDAG Strand Post-Tensioning Systems were used in the pylons. Additionally, 180t of 36mm Ø DYWIDAG Bar Tendons were installed in the pylons.

The Tsubasa Bridge is not only a new landmark of the region, but also the longest bridge in Cambodia.
The Tanjung Priok Access Toll Road in Jakarta: Large Scale Use of DYWIDAG Tendons

The project includes the construction of a 12.1km long and 26.5m wide 6 lane toll road that will significantly improve traffic flow in metropolitan Jakarta and ensure a good connection to the country’s most important international commercial harbor. The project also includes the construction of 10 viaducts and consists of 5 sections. The DSI licensee PT Delta Systech Indonesia participated in the realization of phase 2 in the 1.9km long section E2A Jampea - Simpang Jampea.

PT Delta Systech Indonesia was awarded a contract to supply and install DYWIDAG Post-Tensioning Tendons for the 691 precast concrete segments that were needed for the viaduct girders in this section.

In addition, PT Delta Systech Indonesia supplied and installed DYWIDAG Tendons for 56 pier heads. Bonded DYWIDAG Strand Tendons with Type MA5919, MA5912 and MA5907 Anchorages were used for post-tensioning the precast concrete girders. In total, 1,450t of Type 0.5” strand were required for post-tensioning the 691 precast concrete segments for the bridge girders.

For the 56 cast in place pier heads, PT Delta Systech Indonesia supplied DYWIDAG Post-Tensioning Systems with 907t of Type 0.6” strand as well as Type MA6819 Anchorages. In addition, DYWIDAG Bar Tendons were used as temporary tendons for placing the segments during erection work.
The Brantas Bridge: DYWIDAG Systems secure the Soker Toll Road in Indonesia

The 177.12km long Solo-Kertosono also known as the Soker Toll Road is a major project that is currently under construction on the Indonesian island of Java. Once completed, this road will be the longest toll road in Indonesia and lead through eight different provinces. As the eastern component of the Trans Java Toll Road, this section will connect the provinces of Jombang and Mojokerto with Surabaya, the country’s second largest city on the eastern coast of Java, considerably simplifying the transportation of goods and passenger traffic in this part of the island.

The bridges were built using the balanced cantilever method with 4 sets of DYWIDAG Form Travelers supplied by DYWITECH Taiwan. One form traveler was used per side on each structure, and the form travelers were simultaneously operated from both sides. This method ensured fast construction progress even at high water levels and did not obstruct shipping traffic underneath the bridge.

PT Delta Systech Indonesia and DYWITECH Taiwan supplied DYWIDAG Systems for the construction of the Brantas Bridge, which is part of a 40.5km long section of the Solo-Kertosono Toll Road from Mojokerto to Kertosono. The bridge is located in the 19.9km long Section II.

The structure consists of two parallel box girders crossing the Brantas River. Each of the main spans is 145m long, with the total length of the bridges measuring 300m. The box girders have a width of 16m. PT Delta Systech Indonesia supplied and installed 522t of longitudinal prestressing tendons for the box girders. The post-tensioning systems that were used were DYWIDAG Strand Tendons with Type MA 6819 Anchorages.

PT Delta Systech Indonesia and DYWITECH Taiwan cooperated closely during the operation of the form travelers and supported Wiecon Consultants, Taiwan, in developing the technical design.
The 3,228m long Okegawa viaduct is a prestressed concrete, multi-span continuous box girder bridge in Saitama Prefecture in the metropolitan area of Tokyo in Japan. In order to keep construction time for the bridge as short as possible, a span-by-span construction method using precast concrete segments was employed for the two parallel bridge structures.

In order to reduce the total number of segments and facilitate production, transport and assembly, the segments were designed as light-weight, ribbed U-shaped core segments. Thanks to the special form of the segments, both upper decks could be cast in place following assembly. To further reduce the weight, the webs were designed as butterfly webs, i.e., laterally cantilevering, butterfly-shaped concrete panels.

In a butterfly web bridge, the butterfly-shaped webs form a structure that exhibits behavior similar to that of a double Warren Truss. Precast, 150mm thick concrete panels consisting of 80MPa concrete material were used for the butterfly webs. Instead of untensioned reinforcing bars, these special concrete panels contain pre-tensioned tendons to induce prestressing forces against tensile loads.

The use of butterfly shaped panels for the webs of the bridge results in the resolution and transmission of shear forces into tensile and compressive forces within the panels.

The concrete resists compressive forces and the prestressing force induced into the panels resists tensile forces.

Furthermore, the 150mm thick panels are reinforced only by steel fibers. The high quality butterfly web panels were produced at a factory without any reinforcement bars. They are therefore highly durable and can be maintained better because they do not contain any untensioned reinforcement that could experience corrosion caused by salt air and concrete carbonation.
The bridge segments were fabricated at two concrete plants and transported up to 100km to the erection site. On site, the U-shaped segments were erected first and tensioned with external and internal tendons to create an independent structure. Afterwards, the deck slabs were constructed using cast-in-place concrete, and the remaining external tendons running through the complete hollow box girder of both bridge structures were tensioned.

For post-tensioning the viaduct, Sumitomo supplied external 19S 15.7 MC and 12S 12.7 MA DYWIDAG Strand Tendons with epoxy coated and filled ultra-high strength strand. In order to protect the external tendons from ultra-violet rays coming in from the web panels’ openings, the strands are covered with PE ducts.

The new viaduct was completed within just 18 months, including detailed design. It took only one year of construction to build the 35,000m² bridge decks, which were built span-by-span.
Of the 5 MRT (Mass Rapid Transit) Lines in Singapore, the East-West Line is by far the longest: It is approx. 50km long and serves 35 stations. Currently, the green line of the city railway is being lengthened by 7.5km within the scope of the Tuas West Extension project. The new line will provide better connections between Tuas Industrial Park in western Singapore and other districts. For the 100,000 commuters who travel to the industrial park daily, travel times will be shortened by up to 35 minutes thanks to the MRT extension.

The extension of the East-West Line is being built in four sections. In one of these sections, awarded under Contract C1688, a 2.8km long viaduct is being built that will accommodate the rails for the new route. Utracon Singapore was awarded the contract for post-tensioning and erecting the precast concrete segments needed for the viaduct in this section.

The majority of the spans for the viaduct are 40m long, and the precast segments are typically 2.4m deep. Near the station, the spans are generally smaller at a length of 25m with 1.6m deep segments. The viaduct is constructed using the span by span precast segmental construction method with launching girders.

However, one section of the viaduct is to cross over the existing Pan Island Expressway, which required 75m long spans. The free cantilever precast segmental construction method was adopted for the 5 spans involved.

A total of 1,500t of DYWIDAG Strand Tendons were needed for post-tensioning the viaduct, the crossheads and the precast concrete elements at the new railway station. Due to the variety of span lengths involved and the two different methods of construction – the span by span and the free cantilever method – Utracon supplied eight different Types of DYWIDAG Strand Tendons: 7-0.6", 12-0.6", 15-0.6", 19-0.6", 22-0.6", 27-0.6", 31-0.6" and 37-0.6". In total, 11,300 MA Anchorages were used for the tendons.

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The SkyGardens: DYWIDAG Strand Post-Tensioning Systems secure Cantilever Pools in lofty Heights

Fairway SkyGardens is a major modern condominium development project that was recently built in the city of Sri Jayewardenepura Kotte in Sri Lanka. The luxurious high-rise building features two cantilever private pools on the 30th floor and a cantilever 120m high rooftop sky garden on the 31st floor.

In Sri Lanka, the use of post-tensioning systems is not very widespread yet. Therefore, DYWIDAG Strand Tendons proved themselves as an innovative solution in the parking garage area: The initial design included non-prestressed reinforcement in the beams. This would have meant that the beams necessary for supporting the long roof slabs between the supports would have jutted very far into the room.

This design proved to be unrealistic because the headroom for cargo vehicles would have been insufficient. Therefore, the beams were redesigned as post-tensioned beams and Utracon was invited to supply and install a suitable beam Post-Tensioning System, which managed to reduce the depth of beams, thereby achieving the required headroom.

The two 10m long pools with a 4.7m cantilever and the rooftop sky garden with a 5.9m cantilever were also only possible with the DYWIDAG Strand Post-Tensioning Systems supplied by Utracon.

In order to support the long cantilevers, Utracon installed the DYWIDAG Strand Post-Tensioning Systems in the cantilever beams, the roof slabs and the walls of the swimming pools. Despite the congested reinforcement with small interstices, Utracon was able to successfully install the DYWIDAG Post-Tensioning Systems thanks to the close cooperation with the team of the General Contractor Maga.

In total, 18.2t of strand were used for this project; the post-tensioning systems used were Type 4-0.6" and 7-0.6" DYWIDAG Post-Tensioning Systems, which were supplied including anchorages and accessories.

The DYWIDAG Post-Tensioning Systems not only proved themselves by their high quality and cost effectiveness, but also by their versatile use in different project requirements. The General Contractor was very satisfied with the high standard of technical support provided by Utracon.
In the centrally located province of Chungcheongbuk-do in South Korea, Motorway 32 is being expanded between the cities of Daejon and Munui-myeon near Daechung Lake. The 9.64km long section also includes the four lane Daechung Bridge that crosses the Geum River near the city of Daejon.

The bridge will considerably improve the traffic flow in this region and will simultaneously stimulate local tourism and industry. The asymmetric stay cable bridge has a 48m high pylon and is 29.3m wide. The 330m long bridge was built using the cantilever method and consists of 5 spans: 85m + 105m + 2 x 50m + 40m.

The two 85 and 105m long spans crossing the river are supported by stay cables. The stay cables have galvanized, waxed and PE-sheathed strands weighing 99t. In total, 32 Type DG-P55 DYNA Grip® Stay Cables in HDPE ducts with 32 active and 32 passive anchorages were installed.

The DYNA Grip® Anchor System allows the replacement of individual strands including PE coating at any point of time without interrupting road traffic. The stay cables have a high fatigue performance and fulfill international fib and PTI standards.

The Daechung Bridge: DYNA Grip® Stay Cables for Korean Motorway 32

Owner
Chungcheongbuk-do Province, Korea

General Contractor
Joint Venture, consisting of Daewoo Engineering & Construction Co. Ltd. and 4 other companies, all of them Korea

Subcontractor
BNG Consultant Co. Ltd, Korea

Consulting Engineers
Naekyoung Engineering Co., Ltd., Hankyoung Co., Ltd., both Korea

Engineering
DM Engineering Co., Ltd., Korea

DSI Unit
DYWIDAG-Systems Korea Co. Ltd., Korea

DSI Scope
Supply, engineering services, technical support, supervision

DYWIDAG Products
32 Type DG-P55 DYNA Grip® Stay Cables
A pedestrian suspension bridge that was built between two peaks is part of this project. To tie back the support cables at the abutments of the bridge, DSI Korea supplied 24 double corrosion protected, 32mm and 40mm Ø, 10m long DYWIDAG THREADBAR® Anchors.

In addition to the 2 supporting cables, the suspension bridge is secured by 2 additional wind cables that were tied back in the foundations underneath the bridge in the load bearing rock. The two wind cables, which run parallel to the bridge deck underneath the suspension bridge, are braced multiple times upwards toward the bridge deck. Using this method, the suspension bridge is effectively stabilized against possible vibrations due to high wind speeds.

Because of the difficult accessibility of the construction site located at a height of 1,000m, both the equipment needed for tensioning the DYWIDAG THREADBAR® Anchors and the anchors themselves had to be transported to the jobsite individually by helicopter.

A safe Pleasure: Suspension Bridge on Gubong Mountain in Korea tied back using DYWIDAG Bar Anchors

Gubong Mountain in the southern province of Jeollabuk-do in South Korea is a popular destination that draws an ever increasing number of tourists. Some of the hiking trails leading to the different peaks of the Gubong Massif traverse very steep and dangerous sections. In order to increase safety for tourists, the province’s department of administration decided to build several safe ropes, steel stairways, observation platforms and bridges connecting the individual peaks.

Owner
Province of Jeollabuk-do, Korea

General Contractor
Daegeum Construction Co., Ltd., Korea

Subcontractor
Cabletek Co., Ltd., Korea

Engineering
KT Engineering Ltd., Korea

DSI Unit
DYWIDAG-Systems Korea Co. Ltd., Korea

DSI Scope
Supply, engineering services, technical support, supervision

DYWIDAG Products
24 double corrosion protected, 32mm and 40mm Ø 10m long DYWIDAG THREADBAR® Anchors
Chao Phraya River Crossing: DYNA® Link permits economic Construction of an Extradosed Bridge

The Chao Phraya River Crossing Bridge is part of an infrastructure project in the Province of Nonthaburi 30km north of Bangkok. As part of Nonthaburi 1 Road, together with new intersections and a new 6 lane road, the new, 6 lane hollow box girder bridge spans the Chao Phraya River, relieving three highly frequented bridges in its vicinity.

At a width of 32.4m, the 460m long two pylon bridge is Thailand’s widest bridge and also the first extradosed bridge in the country. The bridge structure’s main span measures 200m, and the two side spans are 130m long. On both sides of the bridge deck, 48 stay cables are evenly arranged parallel to each other in 12 layers. DSI supplied a total of 96 stay cables for this project:

- 48 Type DG-P 31 DYNA Grip® Stay Cables
- 48 Type DG-P 55 DYNA Grip® Stay Cables, with a maximum stay cable length of 87m

310t of galvanized, waxed and PE coated 1,770N/mm², 0.62" strands were required for the stay cables. External dampers were installed on the Type DG-P 55 Stay Cables. The DYNA Grip® Anchorages were sealed against water and air to ensure long-term corrosion protection.

Furthermore, the new DYNA® Link Anchor Box System was used for the first time on the Chao Praya River Crossing Bridge. The DYWIDAG DYNA® Link Anchor Box System replaces conventional saddle systems and is based on a steel structure in which stay cables are anchored using standard DYNA Grip® Anchorages.

Due to the single-plane cable-stayed span with a width of 32.8m, rigidity of the cross section was required. Therefore, 1.2m deep ribs with a spacing of 2.5m were included as part of the design. In order to speed up construction progress, Sumitomo Mitsui fabricated the ribs as precast elements on the deck.
Afterwards, the ribs were installed using a form traveler. This way, the time needed for assembling and disassembling the formwork could be reduced. Furthermore, the precast ribs were used for supporting the side spans. Sumitomo Mitsui also optimized some pre-cast elements for the foundations and the bridge substructure. These segments functioned like a wall at high tide, thus permitting a fast and safe construction progress in the river.

Comprehensive quality conformance tests of the materials that were installed and the components that were needed were continuously carried out and documented by the joint venture consisting of Italian-Thai Development Public Company Limited, Thailand and Sumitomo Mitsui Construction Co., Ltd., Japan, who carried out the contract.

After its completion, the bridge was named Maha Jessada Bodin.
The southern A2 Motorway leads from Vienna to Italy and is Austria’s longest motorway. Near Lake Woerthersee, a comprehensive rehabilitation of the southern motorway (km 346.30 - km 345.90) was carried out at the Velden West interchange in 2014. This project also included the repair of the V12-2A and V12-2B bridge structures.

DSI produced and supplied external tendons that were installed longitudinally along the webs of these hollow box girder structures. The prefabricated Type 66 Wire EX Tendons in lengths of up to 245m run on both sides of the hollow box girder without any couplers. Due to the fact that the external tendons were completely prefabricated and that no couplers were used, the installation of the tendons was carried out very quickly. This type of external tendon does not require the assembly of tendons that would have been necessary when using single strands nor the cutting of the excess lengths at the anchorages after finishing the stressing operation.

In order to effectively counteract dead weight and traffic loads, the tendons were deviated where necessary by deviation saddles. The bridge features a curved geometry, resulting in inclined diversion planes at the deflection points and supports. This would have resulted in a very complex production of conventional deviation saddles consisting of pre-bent steel tubes or steel boxes. In this project, however, the problem was avoided thanks to DSI’s standard plastic deflection half shells, which can be simply placed into straight steel tubes and slightly turned inside the steel tube whenever and wherever necessary.

To stress the external tendons, DSI supplied a Hollow Piston CFRP Cylinder that ensured a quick and easy stressing process due to its extremely low weight.

Owner
ASFINAG Bau Management GmbH, Austria
General Contractor
Steiner-Bau GesmbH, Austria
Engineering
Dipl.-Ing. Werner Ogris, Ziviltechnikergesellschaft m.b.H., Austria

DSI Unit
DYWIDAG-Systems International GmbH, BU Post-Tensioning, Germany

DSI Scope
Production, supply, installation and stressing

DYWIDAG Products
4 prefabricated, 245m long Type EX-66 Wire EX Tendons, Hollow Piston CFRP Cylinder
Within the scope of an official report that also used dynamic avalanche models, 88 buildings in the town were classified as endangered. The Timmelbach Avalanche is a dormant avalanche: incidents occur rarely, but are always extreme. The Timmel Stream itself also poses a threat to the town during heavy rainfalls because there are no structures that could retain potential mudslides or tree trunk and debris landslides.

In view of this obvious hazard, the Regional Construction Supervision of Eastern Tyrol decided to build several steel snow bridges, two avalanche retention dams consisting of reinforced soil as well as a reinforced concrete avalanche breaker near the alluvial fan at the upper part of the debris field that had formed in the course of time due to sedimentation brought here by the stream. The avalanche breaker is the key structure of the new protective measures. It greatly decreases the velocity of the avalanche so that it settles into the two retention dams below.

The debris flow and avalanche breaker is subject to extremely high loads that can total as much as 200 kN/m² over its gross surface area. A tectonic fault running through the valley posed an additional challenge for the engineers. The soil is relatively unfavorable for the foundation of the structure and does not permit clamping of the wings into the ground.

At a height of 23.14m above ground and a crown width of 69m, the breaker is one of the largest of its kind. The base slab is 26.30m wide, 27.50m long and has a thickness of 2m to 2.65m. The 2m thick wing walls are reinforced by five ribs and two 1.50m thick and 8.50m or 4.45m high beams. Each of the beams was stressed using either 8 or 6 DYWIDAG Tendons with posterior bond. 12 strand DYWIDAG Strand Tendons with Type MA Anchorages were used for this purpose. The tendon lengths vary from 20.8 to 53.9m, and the tendons have a total weight of approx. 7.3t.

In total, 3,900m³ of concrete and 438t of reinforcing steel were installed into the avalanche breaker. The structure weighs more than 10,000t, and the construction cost amounted to approx. 3 million Euros.
DYWI® Drill Micropiles secure new Ski Route in St. Anton am Arlberg

The St. Anton am Arlberg ski resort is one of the most well-known resorts in Austria. In order to offer tourists more safety in addition to modern lifts, several retaining structures were built in high alpine areas near the Mattun Lift in the summer of 2014.

A slope widening that was carried out for the new Zammermoos Ski Route formed part of these improvements. In this area, a steep slope that was endangered by avalanches was flattened and stabilized step by step.

The foundation of the slope widening had to be comprehensively anchored in load-bearing rock. For this purpose, DSI Austria produced DYWI® Drill Hollow Bars that were used as micropiles to stabilize the retaining structure. In this system, the tendon simultaneously serves as a drill rod as well as a micropile. This dual feature ensures a very quick installation procedure because the borehole does not have to be drilled in advance as the DYWI® Drill Hollow Bars are drilled and grouted simultaneously.

A total of 596 self-drilling DYWI® Drill Micropiles were used for the foundation. This included 447 6m long R51-800 DYWI® Drill Micropiles as well as 149 8m long R51-800 DYWI® Drill Micropiles, which were installed by HTB (Hoch-Tief-Bau Imst GmbH). Thanks to the slope widening, skiers will be able to enjoy this part of the ski resort with minimal risk.
Owner
Arlberger Bergbahnen AG, Austria

General Contractor
Hoch-Tief-Bau-Imst GmbH, Austria

Consulting Engineers
Ingenieurbüro Brandner, Austria

DSI Unit
DYWIDAG-Systems International GmbH, Austria

DSI Scope
Production, supply

DYWIDAG Products
596 6 and 8m long R 51-800
DYWI® Drill Micropiles
Stable and flexible: DYWIDAG Strand Anchors with restressable Anchor Heads secure Steyr Viaduct

A total of six bridge structures in lengths between 83m and 278m and heights between 25 and 50m were built during the widening of the A 9 Pyhrn Motorway near the Klaus Tunnels in Austria. The bridges also serve as access roads for the construction of the second tunnel tubes, which began at the end of 2014.

In the jobsite areas, there are many river valleys with steep slopes. The geology is characterized by gravel, loose sediments, carbonates and psephites. The construction of the second tube for the 2.2km long Klauser Tunnel required the construction of bridge No. PY51.2, also known as the Steyr Viaduct, at the Klaus Interchange. The construction of the bridge required several excavation and slope stabilizations as well as supporting structures due to the unstable foundation soil.

DSI Austria produced and supplied self-drilling DYWI® Drill Hollow Bar Anchors and accessories for the permanent stabilization of the deep river valley. A total of 2,000m of R32-400 DYWI® Drill Hollow Bar Anchors as well as 480m of R32-280 DYWI® Drill Hollow Bar Anchors were installed including accessories.

Furthermore, an anchor beam had to be tied back near the northern abutment using permanent DYWIDAG Strand Anchors with 8 strands.

For this purpose, DSI supplied DYWIDAG Strand Anchors with newly developed, restressable anchor heads. The anchor heads can be restressed at any time if necessary to ensure a permanent stabilization even in changing geological conditions. DSI has received an approval in Austria for the new restressable anchor heads.

To tie back the anchor beam at the bridge abutment, the following products were successfully installed:

- 6 permanent, 41.5m long DYWIDAG Strand Anchors
- 14 permanent, 31.5m long DYWIDAG Strand Anchors
- 6 permanent, 26.5m long DYWIDAG Strand Anchors

In addition, DSI supplied 26 restressable anchor heads as well as 5 anchor load plates with design loads of 1,250kN and rented the tensioning equipment.

Owner
ASFINAG Bau Management, Austria
Contractor Bridge Construction
STRABAG AG, Direktion IC Ingenieurbau, Austria
Contractor Rock Engineering
STRABAG AG, Direktion AC Verkehrswegbau, Gruppe Felstechnik, Austria
Geotechnical Engineering
INSITU Geotechnik ZT GmbH, Austria
DSI Unit
DYWIDAG-Systems International GmbH, Austria
DSI Scope
Production, supply, technical support
DYWIDAG Products
2,000m of R32-400 DYWI® Drill Hollow Bar Anchors, 480m of R32-280 DYWI® Drill Hollow Bar Anchors, 26 permanent DYWIDAG Strand Anchors with 8 strands and restressable anchor heads, 5 anchor load plates, stressing equipment
Several departments of TU Graz cooperate with the industry in order to make their research accessible for practical applications. The institute for lightweight construction, for instance, studies system reliability and operational stability for component parts and structures in mechanical engineering.

Recently, a new test facility for wheelset axles was built at the institute for lightweight construction. Wheelset axles are subject to high loads and must therefore be comprehensively tested in bending and alternating stress as well as wear and tear.

For this purpose, a new test rig was built at TU Graz. The test bench consists of two massive concrete cubes; each cube has a concrete volume of approx. 45m³ and contains approximately 6.5t of untensioned reinforcement. In order to achieve a rotation-symmetric vibration response of the test rig, each individual test bench must be square. Each cube is approx. 2.50m high, 5.50m wide and 5.50m deep. Both individual test benches can be tied together and coupled using long Type 47 WR DYWIDAG Bar Tendons in order to obtain a larger, rectangular test bench.

In order to be able to accommodate the high forces that develop during the tests, and to comply with the high requirements in terms of serviceability and rigidity of the system, both test bench components had to be tensioned using an unusually high number of Type SUSPA Systems Strand Tendons and DYWIDAG Bar Tendons.

In total, DSI produced and supplied 56 pre-assembled Type 6-4 Strand Tendons with anchor plates as well as 16 pre-assembled Type 6-7 Strand Tendons including anchor plates for the two concrete cubes. In addition, 36 Type 32 WR DYWIDAG Bar Tendons and 20 Type 47 WR DYWIDAG Bar Tendons were installed. The tendons were stressed and grouted using the tensioning jacks and equipment supplied by DSI.

The new test facility was inaugurated during a symposium on methods for testing structures and component parts in November 2014.
GEWI® Plus Piles secure Suspension Cables of a 403m long Pedestrian Suspension Bridge in Reutte

Since the end of 2014, the town of Reutte in Tyrol has a new attraction: Highline 179. The structure is a 403m long pedestrian suspension bridge that crosses the B 179 Fernpass Road. This structure is expected to be registered in the Guinness Book of Records as the world’s longest pedestrian rope bridge.

The suspension bridge was erected at a height of nearly 1,100m and leads across the fortification of Ehrenberg, linking the ruins of Castle Ehrenberg and Fort Claudia at a clear height of 110m. The overhead walkway sags by 17m, with the slack span being able to expand by approx. 1m subject to load and temperature. The 1.2m wide steel grid footpath is supported by cross-beams that are fastened to the suspension cables via vertical hangers.

Ground anchors or tensile piles are a very economical tieback solution in this case because the tensile loads emanating from the bridge cables can be directly transferred into the load-bearing soil. During the construction of the suspension bridge, four 60mm Ø support cables were tied back at each side of the bridge using GEWI® Plus tensile piles that reach into the load-bearing rock up to a depth of 17m. DSI Austria produced and supplied the following products for this purpose:

- 8 double corrosion protected Type 75 TR GEWI® Plus Tensile Piles in lengths of 20-26.5m
- 4 double corrosion protected 57.5mm Ø GEWI® Plus Tensile Piles in lengths of 9.2m-10.7m

As the GEWI® Plus Piles are skin friction piles, they can transfer compression, tensile and alternating loads. During construction work, load tests were carried out on site that proved the optimum transfer of loads via the anchoring elements.

DSI is proud to have contributed to this new attraction that is visible from afar.
General Contractor
STRABAG AG, Austria

Consulting Engineers
Dipl.Ing. Paul Nessler (statics), Dipl.Ing. Markus Götsch (geotechnics), both of them Austria

DSI Unit
DYWIDAG-Systems International GmbH, Austria

DSI Scope
Production, supply, technical support

DYWIDAG Products
8 Type 75 TR GEWI® Plus Tensile Piles, 4 57,5mm Ø GEWI® Plus Tensile Piles, both of them double corrosion protected
DYWIDAG Jacks facilitate the spectacular Transverse Shifting of a Steel Arch Bridge near Kramsach

Near Kramsach, 45km north-east of Innsbruck, Austria, an existing railway bridge was replaced by a new steel arch bridge. In contrast to the old structure, the new bridge leads over the A 12 Inntal Motorway with a single, 100m long cantilever span.

The arch and the beams of the new structure consist of steel. The 19m wide deck slab consists of slightly laterally post-tensioned reinforced concrete. The bridge contains 24 elements that were assembled on site. During construction, traffic on the motorway below was protected by a 1,900m² large safety scaffold.

To temporarily support the steel arches, DSI Austria supplied 63.5mm Ø GEWI® Plus Bars that were temporarily installed between the arches and the deck slab as auxiliary bars or hangers. The use of the threadbars was a decisive advantage because it ensured an exact adjustment and correction of the bridge deck’s superelevation. Once construction was completed, the temporary hangers were replaced by forged hangers.

The deck slab consists of 950m³ of concrete. It was poured in one piece from the middle of the roadway in both directions without any joints. For the longitudinal post-tensioning of the roadway slab, DSI Koenigsbrunn supplied a total of 60 Type MER/MEF 6-4, 101m long Monostrand Tendons with a total weight of 28.6t that were placed in the longitudinal direction before concreting.

The new arch bridge was erected parallel to the old railway bridge. The transverse shifting of the 3,500t railway bridge into its final position was an unusual challenge.

DSI Austria was asked to carry out the shifting of the bridge structure. For this purpose, 4 temporary Type 22-0,62“ and 27-0,62” DYWIDAG Strand Tendons were installed between the new bridge structure and a temporary abutment. Afterwards, 4 large DYWIDAG Tensioning Jacks with hydraulic pumps were supplied and put in place.

Thanks to the excellent cooperation of all of the partners involved in the construction of the bridge, the structure was successfully shifted into its final position.
Construction—EMEA—Austria—Bridges

Owner
ÖBB-Infrastruktur AG, Austria

General Contractor
TEERAG ASDAG AG, Austria

Engineering
BERNARD Ingenieure ZT GmbH, Austria

Consulting Engineers
BAUMANN + OBLER Ziviltechniker-Gesellschaft mbH, Austria

DSI Units
DYWIDAG-Systems International GmbH, Austria
DYWIDAG-Systems International GmbH, Germany

DSI Scope
Production, supply, technical support
DYWIDAG Products
GEWI® Plus Post-Tensioning Bars;
60 Type MER/MEF 6-4 Monostrand Tendons;
4 Type 22-0.62” and 27-0.62” DYWIDAG Strand Tendons; 4 DYWIDAG Jacks with accessories
Innovative Rehabilitation of the Lermooser Tunnel using permanent GEWI® Plus Anchors and DYWI® Inject Resins

The Lermooser Tunnel is a 3,168m long road tunnel in Tyrol, Austria. The tunnel is located on the eastern rim of the Lechtal Alps, a mountain range of the northern Tyrolean limestone Alps, on the B 179 Fernpass Road. The tunnel connects the German A 7 motorway with the Austrian A 12 in the South.

The single tube tunnel with a maximum cover of 350m was opened in 1984 and is now used by an average of 8,790 vehicles per day. At the end of 2014, the tunnel was closed for 4 weeks in order to adapt the tube to current safety regulations within the scope of structural repair work.

While the Lermooser Tunnel was closed for traffic, the tie beams in the cutouts were tied back into the rock using permanent GEWI® Plus Anchors. In the cutouts, the anchor beams serve as the abutment of the suspended ceiling for the ventilation system. DSI Austria produced and supplied 90 permanent, 5.50m long GEWI® Plus Anchors that were installed in the load-bearing rock strata above the tunnel ceiling. Core holes in lengths of approx. 1.70m had to be drilled into the tunnel lining in order to permit the installation of the permanent anchors.

To prevent ground water above the tunnel lining from ingressing, anchors with factory installed packer bags were used in those areas that were particularly at risk. The 1.20m long packer bags were inflated using DYWI® Inject Pure Polyurethane Injection Resin in order to seal the tunnel lining. DSI also supplied the mechanical packer and the resin pumps that were needed for this procedure. Experienced DSI employees instructed the on-site personnel in the proper techniques needed to inject the resin successfully.
All of the permanent anchors were equipped with plates capable of compensating for angle changes of up to 15°. Load cells were installed on every other anchor head in order to monitor the forces acting on the anchors in the required intervals.

To ensure long-term corrosion protection, special PE caps that also covered the anchor plates were placed on all anchor heads. This solution had been specifically developed for the project by DSI and was very challenging because the 500kN anchor load plates had to be fitted into the PE caps in addition to the anchor heads. The construction height of the complete anchor head (including anchor plate, angle compensation, load cell and PE cap) had to be less than 250mm in height in order not to interfere with the structural clearance of the tunnel.
The Cityringen: GEWI® Piles stabilize Subway Project of Historic Dimensions in Copenhagen

The large scale project Cityringen in Copenhagen is an extension of the existing subway systems in Denmark’s capital. The new subway line will run in a tunnel underneath the city center, the so-called Bridges districts and the town of Frederiksberg. The Cityringen will be served by the new subway lines M3 and M4; like the other subway lines, it will be operated automatically and thus be driverless. The project of historic proportions will be connected to the existing subway and urban railway lines and will significantly shorten travel times in all directions.

Led by the Italian company Salini, the Copenhagen Metro Team (CMT) is carrying out construction work on the 15.5km long section that includes 17 subway stations. Advancement of the double tube tunnel is being realized using four Tunnel Boring Machines (TBMs), and tunnel excavation is carried out in Copenhagen limestone with quartenary gravel sands.

Work for a total of 4 shafts and for the 17 subway stations with average depths of 22m is being carried out from 21 jobsites. A total of 3.1 million t of earth has to be moved. Construction work is made difficult by the fact that it is being carried out near historical buildings that are supported by wooden piles. In order to prevent damage to these pile foundations by exposure to oxygen, the ground water level was not to be altered by construction work. Consequently, the lowering of the ground water on the inside that was necessary for sinking the shafts, which would normally also have lowered the ground water level outside of the shafts, had to be compensated by re-infiltrating treated ground water into the aquifer. Approx. 600 extraction and re-infiltration wells were constructed for this purpose.

The subway stations and TBM starting shafts were constructed as up to 30m deep rectangular shafts with average dimensions of 65m x 20m from top to bottom using the open cut method. The roof structures of the subway stations are being built using 1.1m wide and 2m deep reinforced concrete girders spanning the shafts for their complete width.
The shaft walls consist of stiff, watertight diaphragm walls and overcut drilled piles reaching down into the limestone to a depth of 46m. The shafts were built as dry excavations – the wells lowered the water level to a level below the excavation floor. Before the shaft ceilings were completed, permanent uplift anchors had to be installed in order to ensure long-term protection against uplift forces. For this purpose, DYWIT Italy supplied permanent corrosion protected GEW® Piles. After drilling the boreholes, the GEW® Piles were lifted in place and properly fixed in terms of position and height. Before the lowering of the ground water level was completed, the anchor heads were installed and the piles were prestressed to the predetermined service loads. Afterwards, all cavities were sealed and the anchor heads embedded in the bottom slab were encased in concrete. In total, 18,200m of 63mm Ø GEW® Piles, 2,000m of 40mm Ø GEW® Piles, 650m of 50mm Ø GEW® Piles and 800m of 32mm Ø GEW® Piles were installed in the individual shafts.
Maximum Flexibility:
DSI develops Restressable Anchor Heads for Choranche Dam

The dam on the Bourne River near the city of Choranche south-east of Lyon in the French region Rhône Alpes was built in 1948. With an annual output of 88GWh, the hydroelectric power station is an important source of energy for the region.

Measurements and inspections showed that the forces acting on the dam have increased over time and are expected to become even higher in the coming years. For this reason, a decision was made to anchor the dam into the surrounding slopes using strand anchors and thus to sustainably increase the structure’s load bearing capacity.

For this purpose, DSI France produced and supplied eight 15m long Type 13-0.62" DYWIDAG Strand Anchors and eight 17m long Type 22-0.62" DYWIDAG Strand Anchors. Afterwards, DSI installed the anchors vertically on both sides of the dam through the dam flanks and into the bedrock.

In order to be able to adjust the load bearing capacity of the dam to the anticipated increasing future loads, the anchor system had to be de- and restressable with minimum effort. For this purpose, DSI developed and installed specially designed anchor heads. Each anchor head consists of a wedge plate with an external thread and a load bearing trumpet with an internal thread in order to ensure the adjustability of both elements with each other. This way, the anchor head can be screwed to the desired height, simultaneously regulating the anchor load.

The main advantage of the special anchor heads is the high adjustability of the anchor forces as well as the possibility of executing multiple detentioning and retentioning procedures. In case of a load cell malfunction, the anchor can be fully distressed, and the load cell replaced. DSI provided, installed and connected all of the load cell systems, including lightning protection and a remote monitoring system.

In addition to installing the anchors, DSI also carried out the anchor tests and prestressed all of the 16 DYWIDAG Strand Anchors. On two anchors, 4 DYNA Force® Sensors were installed with a readout unit instead of load cells in order to ensure a long-term and safe monitoring of the anchor forces.
Construction—EMEA—Germany—Excavations

Gutting and Enlargement of the former Muenzarkaden, Maximilianstrasse 6-8, Munich

Within the scope of the 1863 widening of Munich’s Maximilian Street into a boulevard, the architect Friedrich Buerklein designed the Muenzarkaden. The historical front façade with its arcades that open towards the street is a listed historical monument.

The group of buildings was completely removed in order to create space for modern shops, offices and an underground garage. During construction work, the Bavarian State Office for Monument Protection carried out investigations and exposed remains of the 13th century city wall, the 15th century bailey wall as well as of many 18th and 19th century buildings. The remains were first removed and then returned to their original position once construction work was finished.

The façade of the Muenzarkaden was comprehensively stabilized within the scope of construction work. In addition, the roof of the building containing house number 6 had to be preserved due to stipulations of the Bavarian State Office for Monument Protection.

The exterior walls were underpinned, and the buildings were shored up using bored piles. Due to the limited space on site, the stabilization of the façades could only be accomplished using a small drilling rig. As an economic solution for tying back the exterior façade, a total of 768 self-drilling R32 Ø and R38 Ø DYWI® Drill Hollow Bar Anchors were used.

The excavation pit was dug to a depth of 14.75m and tied back step by step with a second and third level of anchors. For this purpose, DSI supplied a total of 7,683m of temporary 4 and 5 strand Type 0.60” DYWIDAG Strand Anchors.

Owner
Terrena Dr. Brunner KG, Germany

General Contractor
Brunner + Co. Baugesellschaft mbH & Co., Germany

Contractor
Stump Spezialtiefbau, Germany

Foundation Construction
IGG Ingenieurgem. Grundbau GmbH, Germany

DSI Unit
DYWIDAG-Systems International GmbH, BU Geotechnics, Germany

DSI Scope
Production, supply

DYWIDAG Products
768 R32 Ø and R38 Ø DYWI® Drill Hollow Bar Anchors, 7,683m temporary Type 0.60” 4 and 5 strand DYWIDAG Strand Anchors.
The 118m high Upper West Tower will be one of the tallest buildings in Berlin. When completed in 2016, the 34 story building on Breitscheid Square will offer a panoramic view of Kurfuerstendamm after its completion.

It took almost a year to excavate the 16m deep pit into an approx. 3,500m² large excavation area and to stabilize it using sheet piling. The design of the building included four entire basement floors.

In order to carry out the challenging task of waterproofing the underground levels, the general contractor decided to use conceptual solutions with contec® Waterproofing Systems as well as recostal® Formwork Systems by DSI Porta Westfalica.

Sectoral Planning using contec® Waterproofing Systems

A waterproofed concrete structure known as white tank system had to be constructed together with a waterproofing membrane for poured concrete according to the guidelines for watertight structures. DSI designed a concept for the complete watertight structure of the building, including a detailed plan for the outer surface seal and the interior joint structures. The concept included contec® Waterproofing Systems.

Due to the projected high level use of the building, the high strain resulting from 13m of hydrostatic pressure and the requirement to also prevent damp patches around cracks, joints and surfaces in the underground parking garage, the Preprufe® waterproofing membrane for poured concrete was specified as the primary waterproofing for the exterior tank shaped structure. This way, the minimum requirement of a calculated crack width of 0.3mm could be assumed for designing the watertight concrete structure, which resulted in a reduced reinforcement steel demand for the complete watertight structure.

Preprufe® Waterproofing Membrane for Poured Concrete as Primary Sealant

The Preprufe® waterproofing membrane for poured concrete has been effectively used in a large variety of climatic conditions around the world for over 20 years. The multilayer waterproofing membrane consists of robust HDPE and is thus watertight, gas proof and extremely elastic. This way, even post-formed cracks of up to 5mm in concrete structures can be reliably bridged and waterproofed. This unique selling solution ensures a maximum degree of effectiveness in the waterproofing of buildings for all planned and unplanned cracks in watertight structures.

In contrast to comparable products, the Preprufe® waterproofing membrane for poured concrete is nearly diffusion resistant. The Sd value is significantly higher than that of comparable sealing membranes for poured concrete and thus results in a vapour diffusion resistance that is up to 15 times higher – the decisive criterion when choosing waterproofing materials for high quality construction projects.

The unique bond to concrete structures is very advantageous. This adhesion seal is created by a full-surface, permanent adhesive bond between the hardening concrete and the Preprufe® waterproofing membrane. Water ingress can be ruled out even if local damage occurs. In addition, the concrete structure is permanently protected from aggressive media. The material is very robust and resistant, thus permitting installation in any kind of weather condition. When badly soiled, the product’s full functionality can be re-established by simple cleaning. Furthermore, the self-adhesive selvage on one edge, which does not require any special shaped parts or tools, ensures an easy and safe handling during installation. With only two types of membrane, the product line is straightforward and simple – even in detail.
Consequently, faster construction cycles can be planned.

Cost-effective and efficient Installation of Construction Joints using recostal® Formwork Systems

Trapezoidally profiled recostal® 2000 GTF-Z formwork units were used during the installation of the construction joints in the up to 3.00m thick base slab. The profile meets the demands of Eurocode 2 for the highest category "key profiled".

The customized, self-supporting recostal® formwork units ensured a trouble-free installation and fast construction progress thanks to an optimized installation sequence. Since the recostal® formwork units for the first area pour were factory-fitted with tie bars, work continued quickly and with no obstructions in the second section.

contaflex activ Metal Waterstops with a sodium bentonite coating are integrated in the recostal® formwork units. The coating is characterized by its high expanding capacity and ensures effective waterproofing without delay in the critical construction joint zone.

The permanent activation behavior in changing water levels has been established.

For leakage prevention in the lower 13 layers of reinforcement with different diameters and centers, the DSI experts also developed a project-related, installation optimized solution consisting of reinforced expanded metal elements that can be combined as system components with the recostal® formwork units and the Preprufe® waterproofing membrane without any problems. For the construction joint stop ends in the walls of the four basement floors, recostal® 1000 F activ formwork units, which form part of the system, were used.

The complete concept for the high-grade waterproofing of the building developed by DSI convinced the general contractor.

The comprehensive, complete and single-source waterproofing system by DSI, which was planned, produced and supplied just in time, permitted an economic, efficient and effective waterproofing of the Upper West Tower.
Extension of the A 100 Federal Motorway in Berlin: DSI supplies Specialized Systems for Waterproof Excavations

Due to the historical separation of Berlin, the A 100 Federal Motorway runs through the middle of former West Berlin and connects the district of Bezirk Mitte to Neukoelln in a south-western curve. The motorway is of great importance for Berlin’s trunk, regional and urban road system and will therefore be extended in two sections to Frankfurter Allee.

The first section, BA 16, begins at the Neukoelln Interchange and ends at the Treptower Park Junction. It will ensure a better connection of the Eastern districts to the A 113 and the middle ring road. The approx. 3.2km long segment located in section 16 runs through a 385m long tunnel near Grenzallee and through a 2.3km long and up to 7m deep trough structure. Three lanes and one continuous emergency lane are being built in this area.

Lot 1 in section 16 has a length of 500m and includes the 385m long tunnel near Grenzallee. The tunnel is being built using the cut-and-cover method. The waterproof excavations were designed to include underwater concrete base slabs and tied-back diaphragm walls.

The underwater base slabs have thicknesses ranging from 1.5 to 2m. The concrete slabs are stabilized against uplift by perpendicular micropiles. In order to find the suitable pile and bond length for this purpose, the contractor awarded DSI with the supply of 50m long, 63.5mm Ø GEWI® Plus Test Piles which were equipped with various measuring instruments. For the entire construction period that will be undertaken in several sections and last until mid-2018, these test piles will supply comprehensively measured results.

The complex assembly of the GEWI® tendons including the measuring instruments required special system accessories that had to be adapted in order to ensure proper installation of the tendons into the boreholes. This was made difficult by the restricted effective cross section.

The diaphragm walls reach depths of up to 34m and have thicknesses between 1 and 1.5m. To tie back the diaphragm walls, DSI supplied 44 pregrouted, permanent, 6-8 strand, Type SUSPA Systems Strand Anchors in lengths of up to 50m for an advanced phase with a total length of approx. 1,500m. Due to the limited space on site, the installation of the long strand anchors was complex. In addition, in some areas, up to 5m deep empty bores were required.

The comprehensive special heavy construction work and measures for constructing the waterproof excavations are scheduled for completion in the course of 2018. Following the earth moving phase and the pumping down of the ground water levels in the excavations, the construction of the tunnel cross section will begin.
Reliability against Water under Pressure: DSI supplies DYWIDAG Strand Anchors for Stadtbahn Tunnel Karlsruhe

In the center of the city of Karlsruhe, Germany, a major project is being built that is known as the Kombiloesung (combined solution). The project consists of a 2.4km long, double track, single tube tunnel for the light rail system underneath the centrally located Kaiser Street as well as a 1km long southern branch from the market square to the congress center, allowing Karlsruhe’s city center to be converted into a pedestrian zone without tracks.

The reconstruction of busy Kriegs Street south of the center into a tram route with 5 stops planted with greenery is another component of the combined solution. Road traffic will be diverted into a new, 1.4km long automobile tunnel from Karlstor to Mendelssohn Square. For the road tunnel, tied-back bored pile walls were built at a distance of one meter from the tunnel, and an integrated sealing blanket was grouted. The tunnel will be built in this trough structure using the open cut method.

The railway tunnel underneath Kaiser Street was constructed using a 70m long Tunnel Boring Machine (TBM) and the shield tunneling method. The TBM has a cutter head with a diameter of more than 9m and an advance rate of 10m per day. Directly behind the cutter head, the machine places reinforced concrete segments for the tunnel lining after each meter that the TBM is advanced. Due to the shortness of the section, the southern branch is being excavated using the classic mining method. In areas with shallow construction depths, the open cut method is used.

Most of the underground stations of the new light rail tunnel were built using the cut-and-cover method. The tunnel is located in the Upper Rhine Lowlands, a fracture zone that can be filled with sediments up to a depth of several thousand meters. Consequently, the excavation walls were not located in solid or waterproof strata. High ground water made it necessary to waterproof the excavation in several sections near the underground stations. The waterproofing method chosen for these sections consisted of bored pile or diaphragm walls with tied-back floors that were realized using the jet grouting method.

To tie back the different bored pile and diaphragm walls on the jobsites, DSI supplied semi-permanent 4-8 strand Type 0.6", St1570/1770 DYWIDAG Strand Anchors. In total, approx. 100t of DYWIDAG Strand Anchors were installed in several levels. A special permit of the owner was necessary before the strand post-tensioning system was authorized for use.

All of the strand anchors had been fitted with a special anchor head design for waterproofing to protect against water under pressure.
Removable DYWIDAG Strand Anchors for unobstructed Construction Progress: The new Student Apartments SUED.FLUEGEL in Cologne

In Cologne, only 4,700 rooms of the student union are available for the city’s nearly 100,000 students, which is why the demand for small apartments and flats is very large.

For this reason, the real estate company Bouwfonds decided to build a new group of buildings with a total of 208 apartments that are primarily adapted to the needs of students on Dassel Street in the immediate vicinity of the university. In an area named SUED.FLUEGEL, 195 single room apartments as well as 13 flats will be built on a total area of 2,570m².

The walls of the excavation for the new building complex had to be tied back using temporary anchors that were not to be obstacles for subsequent construction work in some parts. For this purpose, DSI produced and supplied the newly developed, completely removable DYWIDAG Strand Anchor. This system is a compression body anchor in which patented compression bodies ensure load transfer from the strands to the grout body.

The fully removable strands are covered by a PE tube along their entire anchor length. The patented end anchorage system ensures an easy and safe removal of the anchors within a few minutes.
Only the PE tubes, cast compression bodies and footboxes remain in the ground, so that subsequent excavation, driving or drilling work can be carried out without any problems.

To stabilize the excavation, DSI supplied a total of 150 temporary DYWIDAG Anchors with 3-5 strands and a total length of 2,000m.

The anchor tests that were carried out confirmed the excellent load-bearing capacity of this compression body anchor type. All of the anchor strands could be removed quickly and without any problems.
A Project of International Importance:
DYWIDAG Systems secure new Rail Line between Stuttgart and Ulm

The expansion of the rail network between Stuttgart and Ulm is an important part of what is known as the Magistrale for Europe: The railway corridor that connects Paris and Budapest. This project also includes the expansion of the new rail line between the towns of Wendlingen and Ulm as well as the connection with and the lowering of Stuttgart’s main station.

In the planned 1.2km long PFA 2.5a1 section, the main station in Ulm is being rebuilt and connected to the new rail line. In the run-up to the construction work at the station, the access roads to the jobsite as well as to the future emergency rescue area are under construction. Simultaneously, the existing railway overpass is being dismantled. The new overpass will be built in the excavation pit and slid in place afterwards.

A Berlin-type support system filled in with wood and shotcrete was chosen for the up to 8.80m deep excavation pit. To stabilize the support walls, one layer of bracing and 4 layers of temporary, Type 4-0.60” and 5-0.60” DYWIDAG Strand Anchors were installed. The total length of the 86 strand anchors used was 2,050m with a maximum anchor length of 31.5m.

This sub-project includes the construction of the Albabstieg Tunnel’s portal wall as well as the portal structures including the subsequent troughs 1 to 3. The portal wall was constructed up to a depth of approx. 27.0m. For this purpose, the existing gallery was stabilized using permanent DYWIDAG Strand Anchors, and the adjacent embankment was stabilized using shotcrete and GEWI® Rock Bolts.
The excavation of the tunnel portal underneath was built using an intermittent, tied-back bored pile wall. The excavation walls, which were partly tied back in 8 sections, were constructed using 194 temporary and 146 permanent Type 4-0.60", 5-0.60" and 7-0.60" DYWIDAG Strand Anchors. In total, 3,700m of anchors with maximum lengths of 37.5m were installed. In addition, 102 25mm Ø GEWI® Rock Bolts with a total length of 538m were used. The adjacent excavation pits for the troughs TN1-3 were built using sheet pile walls. For this purpose, the lime stone in the construction soil was drilled out. The tie-backs, consisting of 80 temporary and 60 permanent Type 4-0.60" and 5-0.60" DYWIDAG Strand Anchors with a total length of 2,100m, were installed in 2 layers.
South of Brunswick, Germany, between the towns of Othfresen and Liebenburg, State Road L 500 runs directly next to the Floeteberg – a mountain with a steep rock embankment that has generated many rockfalls in the past.

In order to permanently stabilize this area, the Lower Saxon Provincial Authority for Road Construction and Traffic asked the engineering company Dr. Spang GmbH to carry out a comprehensive geological analysis of the embankment and to design a long-term stabilization concept.

The engineers suggested covering the embankments with high-strength steel mesh. For this purpose, a fine mesh was fixed to the slope and covered by a coarse mesh. Both mesh varieties consist of a special steel alloy that is galvanized for corrosion protection. They were rolled down the face by climbers.

To tie back the steel protection mesh, DSI Koenigsbrunn supplied approx. 2,000 32mm Ø GEWI® Soil Nails with a total weight of 48t.

The GEWI® Soil Nails were installed in the stable layers of the slope at a depth of up to 10m and grouted using a special mortar, thus ensuring the stability of the 6,500m² large mesh area.

The approx. 7,500m of GEWI® Soil Nails were galvanized on a 1m long section. At DSI Koenigsbrunn, the accessories, i.e. the couplers and domed anchor nuts – were reamed before galvanizing in order to ensure optimum threadability.

The permanent inventory of galvanized 25mm, 28mm and 32mm Ø GEWI® Bars including accessories that DSI Koenigsbrunn has maintained since 2014 ensured very short delivery times.
Currently, the first section of a comprehensive rehabilitation of the hospital is being carried out. In this section, a compact, cubical-shaped building with approximately 300 beds is being built. Additionally, several specialized departments, the kitchen and the pharmacy, will move into the 8 level building that will include a floor space of approx. 12,300m². In the second section, another, 10,800m² area will be built for additional medical departments. In total, a new hospital with approx. 500 beds will be created in two sections.

In the first section, a total of 85,000m³ of earth is moved on an area of roughly 10,000m². A slope located in close proximity to the jobsite had to be stabilized by retaining walls in several sections from top to bottom. For this purpose, an approx. 2,000m² large shotcrete wall stabilized by soil nails was built up to a height of 15m.

To stabilize this area, DSI supplied a total of 4,000m of DYWIDAG GEWI® Steel Soil Nails.

In the second section, the excavation was dug up to a depth of 40m – a depth that was required by the hillside location – and an anchored bored-pile wall with more than 70 piles in lengths of approx. 23m was constructed. Once the bored-pile wall had been completed, the earth was removed from the excavation.

In order to prevent the piles from buckling during the excavation work, each pile had to be tied back into the slope by up to 6 permanent DYWIDAG Strand Anchors. The DYWIDAG Strand Anchors reach up to 27m deep into the stable slope strata and were installed up to a height of 14m. In total, DSI supplied 7,000m of permanent anchors with up to 5 strands in lengths of up to 28m to stabilize the excavation.
More Energy with DSI: Strand Tendons stabilize new Digesters of the Wuerzburg Sewage Plant

With a catchment area of approx. 269km², the waste water treatment plant in Wuerzburg is one of the largest purification plants in Bavaria, Germany.

Until recently, the sludge was treated in two 1,700m³ capacity egg-shaped digester tanks that were built in the 1960’s. In these tanks, the sludge was coagulated through the fermentation of bacteria, which considerably reduced the volume of residual sludge. Per year, the Wuerzburg sewage plant produced approx. 27,000t of dewatered sludge. Due to the limited capacity of the plant, just under half of the sludge that was produced could be digested.

Consequently, the decision was made to construct two new digesters with an additional volume of 5,000m³ each. Thanks to the new tanks, all of the sludge will be completely digested in the future, and gas production will rise by approx. 2,500-3,000m³ per day. The sewage plant will therefore produce 2,200,000kWh more energy per year than before.

The two new digesters were built while the plant was in operation. The tank foundations consist of hopper walls with reinforced concrete floors. The digesters were built using cast-in-place and prestressed concrete. 3 different kinds of Type SUSPA Systems Strand Post-Tensioning Systems were used for this purpose.

In the relatively vertical areas of the walls, DSI Koenigsbrunn employees installed mainly ring tendons and loops. Per digester, 70 bonded Z Tendons with a tendon weight of...
32.6t were used for circumferential post-tensioning. 57 Type St.6-8, 8 Type St.6-4 and 5 Type St.6-2 Tendons were used for this purpose. 18 Type 6-7 Strand Tendons with a weight of 9.6t were used as loops.

In the predominantly horizontal areas in the lower part at the floor of the egg-shaped tanks, 30 Type 6-9 strand tendons with a weight of 5.2t were used for post-tensioning.

All of the post-tensioning tendons that were supplied consist of St 1660/1860 strand.

Due to the very limited space conditions, the placing of the ducts for the tendons proved to be difficult. The prestressing steel was pushed in after the ducts had been placed. Despite the limited space in the reinforcement, the loops were successfully pushed in within the predetermined schedule.
Efficient Corrosion Protection: DYWI® Drill Micropiles successfully tested in non-cohesive Soil

In October 2014, DYWI® Drill Micropiles were installed in non-cohesive soil in the Weihersbach gravel pit near Vilshofen at the Danube, Germany, in order to have them inspected by external inspectors.

All of the piles were installed inclined to the horizontal at 20°. Two 18m long Type R32-400 DYWI® Drill Micropiles, one 30m long Type R38-550 DYWI® Drill Micropile, two 27m long Type R51-800 DYWI® Drill Micropiles and two 27m long Type T76-1900 DYWI® Drill Micropiles were installed for the inspection. A cross drill bit with carbide inserts was used for all installations. The drilling was carried out by the Hans Eberhardt company.

With the help of the Karl Groß Kieswerke company, the installed micropiles were carefully exposed using an excavator, freed from gravel and sand and then measured and examined.
The hollow bars were especially exposed at the couplers and thus at the spacers using a hammer and chisel in order to be able to examine coverage at precisely these spots. Mr. Thomas M. Frey, DSI engineer in Koenigsbrunn, supervised the tests. In Germany, corrosion protection for micropiles may only consist of cement stone or grout coverage or alternatively of double corrosion protection (DCP).

Galvanizing or coating are currently not permitted. During the inspection carried out by external evaluators, evidence was provided that all micropiles had sufficient coverage for corrosion protection.
Extension of the A 14 Trunk Road:
Greenax Slope Protection Mesh saves Time and Money

Near the city of Cambridge in Great Britain, the trunk road between Girton and Histon is being widened by one lane per direction. The A 14 is an important national highway that connects the Port of Felixstowe on the east coast with the British road network.

A number of steep sidehill cuts had to be comprehensively stabilized within the scope of the A 14 widening. Soil nails were installed top down in accordance with the side hill cuts that were carried out in individual stages, and the cut face was secured immediately as construction progressed. The GEWI® Soil Nails supplied by DSI Great Britain were ideal for top down construction in this project because they provide a permanent, safe and economic reinforcement of slopes without the requirement for additional support.

The GEWI® Soil Nails installed featured galvanized protection in accordance with EN 1537, which provides comprehensive corrosion protection for soil nailing applications. Galvanizing ensures a top coating of zinc over the zinc alloyed layer of the bar, which is fully integrated with the base metal. In order to achieve the lifespan required for the soil nails, additional protection was provided by sacrificial corrosion allowance. The calculated loss of section was taken into account in advance during the proof of load bearing capacity by thickening the soil nail during the design stage. DSI supplied the soil nails to the jobsite just in time complete with spacers, tremie pipes, articulating wedge bosses and bearing plates and carried out the necessary anchor tests on site.

To install the 1,490, 25mm Ø, 9-15m long GEWI® Soil Nails, the bore holes were drilled with two rigs working concurrently to maintain progress consistent with the tight time frame. Afterwards, the GEWI® Soil Nails were installed using spacers to centralize the bars within the holes, and then grouted via a tremie pipe from the bottom to the mouth of the borehole. This ensured full column bonding of the soil nail to the ground. The protruding ends of the soil nails were trimmed back to 120mm on the surface.

Afterwards, the sidehill cuts were stabilized using Greenax Mesh. This new product offers superior strain stiffness and can be installed up to twice as quickly as standard mesh. The olive green Mesh has a higher performance than comparable products and blends with the environment.
Greenax Mesh consists of a high strength chain link mesh with an integrated polypropylene erosion mat on its underside. With a higher strength of 53kN/m as opposed to 50kN/m for standard mesh, Greenax Mesh ensures reduced deflection of the slope face over its complete lifespan.

The installation of Greenax Mesh is two times quicker than that of conventional hex meshes, as it neither rolls back nor springs. Since the mesh is supplied in 3.9m roll widths, which is nearly twice as wide as conventional mesh roll widths, the number of vertical seams is reduced by 50%. Each Greenax Mesh panel features an exposed mesh seam of 50mm on the right hand side and a 150mm overrun of erosion mat, thus ensuring full continuity of the erosion mat and the protection mesh at each seam. In total, DSI Great Britain supplied 3,000m² of Greenax Slope Protection Mesh, complete with connection clips.

After installing the mesh, the GEWI® Soil Nails were installed with 300 x 300 x 12mm bearing plates, wedges bosses and domed nuts. Angle compensation of the bearing plate was achieved using special articulating wedge bosses. Thanks to this component, large angles can be accommodated and variation of angle on the soil nail is possible as the slope face undulates. The bearing plates featured a slot, as opposed to a circular hole, to achieve a maximum degree of articulation.
Loch Arklet is a remote and beautiful loch north-west of Glasgow. In order to provide water to the city, an 800m wide masonry and concrete dam was built there 100 years ago. Due to increasing leakage, the dam had to be strengthened using high capacity ground anchors.

In total, 64 vertical DYWIDAG Strand Anchors were installed from the crest of the existing dam into the underlying bedrock to act as tie-backs. The double corrosion protected anchors have 235mm external diameter corrugated plastic sheathing. The ground anchors supplied by DSI UK have 22, 23 or 27 strands and load-bearing capacities between 3,000 and 4,000kN; the strongest anchors reach an ultimate strength of 8,100kN.

Load testing was carried out to a maximum of 1.5 x working load, i.e. at a maximum of 6,000kN (for the 27 strand anchors), with suitability tests applied to three working anchors initially, followed by acceptance testing on all anchors. The anchors were locked off at 110% of working load.

Logistics was a major challenge for the contractors involved. The only access to the job site was via a narrow and winding single track road south of the dam on which only four DYWIDAG Strand Anchors could be delivered on each vehicle. Installation of the anchors had to be carried out from the top of the dam, as there was no possibility of working from a barge mounted crane due to the loch level having been drawn down for safety reasons.

The 311mm Ø boreholes for the strand anchors were drilled into bedrock consisting of schist with quartz veins using reverse circulation flush. The deeper the boreholes were drilled, the more water entered the drill holes. The maximum anchor length of 54.5m and their weight of 2.2t required specialized handling for installation on the narrow dam crest.
A protective nose cone was provided at the base of the anchors, with each anchor delivered to site on special ring frames, which fit onto a specialized anchor spooling wheel of a fork lift.

In order to overcome buoyancy, the internal anchor sheathing was filled with water. Since the anchors had to be spooled for delivery to the jobsite, the grout for the 8 to 9.25m long bond lengths had to be placed in situ. The high strength grout was pumped into the anchors using a tremie line, thus displacing the water previously injected. The external grout needed for bond in the borehole was also placed by tremie. Following the stressing procedures, special sealed corrosion protected caps were installed on the anchor heads.

For both the anchor tests and the final stressing, a special 6,800kN long stroke jack was used that had been supplied by DSI Germany. It is thought that this is the highest capacity anchor stressing jack in the UK at present. Furthermore, the DYWIDAG Strand Anchors supplied by DSI UK are some of the highest capacity ground anchors that have ever been installed in the UK.
The Botlek Bridge: DYWIDAG Jacks lift Steel Girders for Europe’s largest Lift Bridge into Position

As an integral part of the construction of the A 15 Motorway from Maasvlakte to Vaanplein in the Netherlands, the new Botlek Bridge was built as a new element of the 37km long route.

The new lift bridge rests on three oval concrete pillars on which two 64m high reinforced concrete lifting towers were erected in pairs. At the 6 reinforced concrete towers, tensioning ropes mounted to counterweights run over large wheels towards the most important cross girders of the bridge structure. The two-part bridge system includes two separate steel decks measuring approx. 94 x 50m each that were floated into position using barges and lifted into position from the water. When in operation, the bridges can be lifted or lowered by 30m in less than 100 seconds in order to permit the passing of large ships.

Due to their comprehensive know-how and technical competence, the company Waagner-Biro AG headquartered in Vienna, Austria, was awarded the contract for the extremely complex bridge drive system.

The first lifting of the bridge was a special challenge. The bridge and the counterweight basically have the same weight. Despite this, there was an imbalance towards the bridge during the first lifting. Consequently, the flying shores on which the counterweight had been concreted had to be lowered during the first lifting operation. This measure resulted in an alteration of the complete static system, which is why the anchors had to be retensioned simultaneously during the lifting procedure. That is why 16 jacks with hydraulic pumps that could be used simultaneously were needed for the lifting process.
Waagner-Biro AG asked DSI Austria to supply the necessary jacks and hydraulic units. DSI Austria cleared the availability of the needed jacks and pumps with their colleagues in the Netherlands and in Germany because the simultaneous use of 16 jacks posed a technical challenge. Lead-managed by DSI Austria, all 16 jacks and hydraulic pumps were sent to Rotterdam on schedule. In addition, DSI Austria also supplied 550m of Type WR, 26.5mm Ø DYWIDAG Post-Tensioning Bars with 32 couplers, 64 nuts and 64 solid steel plates.

On site, the colleagues from DSI Netherlands supported the jobsite during the instruction on how to assemble the jacks and hydraulic units as well as during the lifting procedure.

Thanks to the excellent co-operation between the jobsite and the participating DSI units, the lifting procedure could be realized according to plan and to the full satisfaction of the owner.
The Galecopper Bridge: DSI contributes to Strengthening an important Link on the A 12 Motorway

The Project: Lifetime Safety

The Galecopper Bridge, which crosses the Amsterdam-Rhine Channel in Utrecht as part of the Dutch A 12 Motorway, is approx. 40 years old. The structure consists of two parallel steel bridges with main spans of 180m and two side spans of 70m each. The longitudinal girders of the bridge are carried by stay cables that are attached to two pylons in the middle of each bridge deck.

Since the bridge has been exposed to steadily increasing traffic loads, Rijkswaterstaat, the executive arm of the Dutch Ministry of Infrastructure and Environment, decided to strengthen the steel bridge decks with a layer of high strength concrete. Due to the extra weight of the new concrete layer, the main steel structure of the bridge had to be strengthened as well.

Within the scope of the comprehensive repair work, the bearings and tie downs had to be replaced. Simultaneously, the main spans of both bridge structures were lifted in order to create a larger clearance for ship traffic on the Amsterdam-Rhine Channel. The repair work will ensure a safe use of the bridge for the next 30 years.

Reinforcement of the Bridge Structure: A stable Solution

Along the existing bridges, four 327m long steel box girders were installed – two on the outside and two on the inside. For these girders, new foundation blocks were built on piles. Each girder consists of three parts that were transported to the jobsite on pontoons and then lifted and longitudinally joined together.

These new girders were also connected to the existing steel structure. At the abutments, tie down anchors were installed in order to keep the girders on the bearing plates. At the intermediate supports, the new girders were lifted approximately 0.7m using hydraulic jacks. This way, the girders were prestressed and accommodated some of the loads from the existing bridge structure.

The Tie Downs: Flexibility and Performance

The anchors used to keep the new steel girders on the bearings at their ends were tie downs with parallel strands based on the DYNA Grip® System. The existing tie downs (fully locked steel cables) in the mid-girders of the old bridges were replaced by the new Type DYNA Grip® Tie downs. In total, DSI supplied 12 Type DG-P 19 DYNA Grip® Tie Downs with 19 parallel strands and 12 Type DG-P 31 DYNA Grip® Tie Downs with 23 parallel, 0.82" Ø, St 1860 N/mm² strands. Each strand is galvanized and additionally protected against corrosion by a PE-sheath filled with wax. The fixed anchorages are located at the upper side of the steel girders, and the stressing anchorages with ring nuts are located at the lower end in the concrete foundation blocks. The length of the tie downs that were used for the steel girders ranged between 5 and 7m.

The tie downs were fitted with DYNA Grip® Anchorages due to the flexibility and high fatigue resistance of this system. The tie downs were installed strand by strand and partly stressed using monostrand post-tensioning jacks. The transfer of the final tensioning forces was made using gradient jacks. DSI Netherlands carried out both the installation and the tensioning work.
Efficient Fire Protection: Load Bearing Capacity in Extreme Situations

The existing, fully locked stay cables are essential for the load bearing capacity of the Galecopper Bridge, which is why the owner decided to have them fitted with a fire protection system. All of the existing stay cables were equipped with fire protection up to 20m above the bridge deck. At each pylon, there are two stay cables at the main span and two stay cables at the side span. In total, there are 16 stay cables, each consisting of 6 parallel, fully locked 76mm Ø steel cables.

DSI proposed a new type of fire protection consisting of flexible panels filled with silica powder which have superior insulation properties. The stay cables were wrapped with 1.2m long and 7mm thick panels. Afterwards, rectangular, 220 x 300mm protection girders consisting of two stainless steel half shells were installed around the stay cables. The installation of the fire protection was carried out by DSI in close cooperation with Civiele technieken deBoer BV and Janssen Lastechniek.

Success through Know How and Special Systems

The complex and difficult rehabilitation of the Galecopper Bridge had to be carried out within a very tight schedule in order to obstruct shipping and road traffic as little as possible. DSI is proud to have contributed to the successful realization of this project with expertise and high quality products.
Success with Know-How and DYWIDAG Tendons:
New Bridges for Nijmegen and Lent

The Project: Room for the Waal River

As a result of climate changes, water in the Waal River may reach levels which exceed its capacity and therefore dangerous for the inhabitants of Nijmegen, the oldest city in the Netherlands. In order to cope with this problem, a unique project that is called “Room for the Waal River” was launched. Within the scope of this project, approx. 5 million m³ of earth will be moved, and a new ancillary channel will be created along the village of Lent located on the North side of the Waal River. As a result, a new island will be created between the old river bed and the new channel. This new area will be used for urban development and recreational activities. The project also required new infrastructure: Among other things, a few new bridges had to be built, and the existing Waal Bridge on the A 325 motorway had to be lengthened.

Lengthening of the Waal Bridge:
A Challenge

The steel arch bridge over the Waal was extended by a 278m long concrete arch bridge which was designed by Zwarts & Jansma Architects from Amsterdam. The new structure consists of two 79m long main spans and two 57 and 63m long side spans. The cross section of the bridge is approx. 34m wide and consists of six cells divided by 5 vertical walls. The geometry of the bridge is very complicated as it curves in all directions; consequently, the formwork for the entire bridge was a real challenge for the contractor.

In the bridge deck, 211 Type 9-0.62” DYWIDAG Strand Tendons with SD 6809 Anchorages were used as transverse tendons. DSI Netherlands gradually installed, stressed and grouted the tendons in the 5 construction stages necessary for the erection of the bridge arches. The longitudinal tendons are situated in the vertical walls between the bridge cells – in total, there are 36 Type 31-0.62” DYWIDAG Tendons. After the last bridge arch had been cast, the strands for the approx. 300m long post-tensioning tendons were pushed in, tensioned and grouted. At both ends of the bridge, the DYWIDAG Tendons were stressed using Type MA 6831 Stressing Anchorages, i.e. there are no intermediate anchors or couplers.

The Promenade Bridge: Lean Structures with DYWIDAG Tendons

Ney - Poulissen Architects & Engineers from Brussels designed the Promenade Bridge as an extremely slender structure with a very thin deck that is curved in all directions. The bridge is 222m long and features 5 spans in different lengths – the longest span is 56m long, and the shortest side spans measure 30m. This bridge was especially designed for pedestrians, cyclists and local traffic to the new island.

Due to the complex geometry and the very limited thickness of the bridge deck, which ranges from approx. 600mm in the middle of the cross section to 320mm at the ends, the construction of the bridge was extraordinarily challenging. The bridge deck was erected in three construction stages in lengths of 97, 57 and 68m.

The transverse post-tensioning of the slender bridge deck was carried out using 277 Type 4-0.62” DYWIDAG Strand Tendons with SD 6804 Plate Anchorages. The length of these tendons varies from 16 to 23m. In the longitudinal direction, 12 Type 22-0.62” DYWIDAG Tendons were installed. The individual tendons were force-fitted using intermediate stressing anchors with Type R 6822 Couplers. Furthermore, 4 Type 22-0.62” DYWIDAG Strand Tendons with MA 6822 Anchorages were installed in two transverse girders between the inclined bridge columns.
Parmasingel Bridge and Citadel Bridge: Efficiency with DYWIDAG Tendons

The Parmasingel and the Citadel Bridge were built using precast, prestressed concrete elements. The Parmasingel Bridge on the A 325 motorway is about 32m long and 28m wide. It consists of 18 precast concrete segments which were assembled to form a box girder on the jobsite using 53 transverse Type 4-0.62” DYWIDAG Tendons and SD 6804 anchorages.

The Citadel Bridge is a curved bridge for pedestrians and cyclists. It consists of 7 spans with 2 longitudinal precast concrete beams that act as a bearing structure for the light, 5.7m wide bridge deck. Each beam has a cross section of 1,200 x 900mm in which 4 Type 18-0.62” DYWIDAG Tendons and Type MA6819 Stressing Anchorages were applied. The tendons were tensioned and grouted prior to the transportation of the beams from the precast concrete yard to the jobsite.

Successful Project Realization with DSI

The construction work on the bridges started in 2013 and is scheduled for completion at the end of 2015. DSI Netherlands supplied, installed, tensioned and grouted DYWIDAG Strand Tendons with a strand weight of approx. 600t for this project. All of the tendons incorporated Type 0.62”, St 1860 N/mm² strands.

In addition, DSI Netherlands assisted the General Contractor in the final design of the post-tensioning systems for all bridges. The know-how and the experience of the DSI employees contributed to the optimization and the successful realization of this major project.

DSI Netherlands is proud to have contributed with expertise and high quality DYWIDAG Products to this project which ensures that Nijmegen and Lent will be safe from floods in the future.

Owner
City of Nijmegen, Netherlands

General Contractor
Joint Venture I-Lent, consisting of Dura Vermeer Divisie Infra and Ploegam BV, both Netherlands

Subcontractor Post-Tensioning
DYWIDAG-Systems International B.V., Netherlands

DSI Scope
Design, production, supply, installation, tensioning, grouting, technical support

DYWIDAG Products
330 Type 4-0.62” DYWIDAG Strand Tendons; 211 Type 9-0.62” DYWIDAG Strand Tendons; 8 Type 18-0.62” DYWIDAG Strand Tendons; 16 Type 22-0.62” DYWIDAG Strand Tendons; 36 Type 31-0.62” DYWIDAG Strand Tendons
DSI supplies 1,820 Permanent GEWI® Anchors for A 4 Motorway Construction from Delft to Schiedam

The plan to close the gap on the A 4 between Delft and Schiedam in the South-West of the Netherlands in order to create an efficient connection from The Haag to Rotterdam dates back to the 1950’s. However, the implementation was delayed several times and finally started in 2012 on the authority of Rijkswaterstaat, a department of the Dutch Ministry for Infrastructure and the Environment.

The gap on the A 4 is being closed by a 2km long tunnel as well as a 4km long, depressed road section. The recessed area is an open box construction that is being built within an artificial landfill cell. Cement-bentonite walls with sheet piles are constructed in the water-sealing clay layer in the jobsite area, creating a 1.5km long watertight dam.

Due to the excavation depth of 13m, the sheet piles had to be stabilized against uplift and safely anchored. For this purpose, DSI Netherlands produced and supplied 1,820 corrosion protected, permanent 63.5mm Ø GEWI® Anchors. The anchors supplied by DSI had lengths ranging from 19 to 41.5m because of the variable and unstable soil conditions.

Each of the 1,820 permanent GEWI® Anchors was subjected to a control test by DSI in cooperation with the subcontractor Volker Staal en Funderingen B.V. The applied stressing forces varied from 607kN to 1,284kN. The subcontractor also installed the anchors. In total, approx. 50km of GEWI® Anchors were installed for closing the gap on the A 4 Motorway.
The Foz Tua Dam: High Quality DYWIDAG Products for increased Sustainability

The dam project on the Tua River in Portugal is one of the largest construction projects for renewable energy of EDP - Energias de Portugal S.A., one of the most important energy suppliers in Europe. The new pumped storage power station will considerably increase the percentage of hydroelectric power in Portugal’s energy mix while at the same time reducing the consumption of fossil fuels.

The Foz Tua Dam is located between the municipalities of Carrezzada de Ansães and Alijó in northern Portugal. The double curvature arch dam measures 108m at its highest point and has a crest length of 275m. In addition to a bottom outlet and a device for releasing residual flows, a flood spillway and flood gates will be built into the dam.

On the right river bank, approx. 500m downstream from the dam, a shaft powerhouse is being built that includes an underground discharge chamber and two shafts as well as two reversible turbine units. The project also includes the construction of a 700m long underground hydraulic circuit consisting of two separate, lined tunnels with inner diameters of 5.5 to 7.5m. With an installed capacity of 252MW, the Foz Tua hydroelectric plant will produce an average of 667GWh/year once completed in 2016.

DSI produced and supplied a wide range of products for several slope stabilization and reinforcement efforts in this project:

- 110 permanent DYWIDAG Strand Anchors
- 943m of R32-210 DYWI® Drill Hollow Bar Anchors
- 240 1.5 to 3.0m long Type ERB120 OMEGA-BOLT® Expandable Friction Bolts
- 840m of 20mm Ø DYWIDAG THREADBAR®
- 6,179 3 to 24m long Double Corrosion Protected DYWIDAG Soil Nails consisting of 25/32 and 40 mm Ø GEWI® Steel

Various products and systems were customized by DSI in accordance with project specific requirements. DSI met all the technical requirements, and was able to supply the best solution in short response times thanks to the close cooperation with the designers and the contractors.
One of the most important components of this construction project is a new bridge that crosses the Ceira River near Coimbra in a very deep valley. At its highest point, the bridge is located 140m above the river bed. The construction of the bridge was very challenging because it crosses several other municipal roads in addition to National Road No. 17.

The Rio Ceira Bridge is 930m long. The bridge deck consists of two different structures: The 250m long main span with a width of 26.4m was built as a prestressed hollow box girder using the balanced cantilever method. The access viaducts consist of two prestressed reinforced concrete bridge decks with a double T cross section that were built span by span using a launching gantry.

In order to balance the vertical plane curvature of the bridge during construction, asymmetric loads were counteracted by DYWIDAG Post-Tensioning Tendons that were anchored in the pier foundations and connected to the top of the bridge deck. Once the individual segments of the box girder deck had been connected, these temporary tendons were removed.

One of the largest infrastructure projects of the country is currently under construction in the Portuguese region of Pinhal Interior. The two most important axes of this project are the connecting roads between the towns of Tomar and Coimbra from South to North and the extension of the connection from Pombal towards the west to Vila Velha de Ródão. With a total length of 520km, this major project will reduce travel times by more than 40% in the affected regions.
1,450t of prestressing steel were used for this purpose. For post-tensioning the new bridge, DSC Spain supplied DYWIDAG Strand Tendons with 12, 22, 27, 31 and 37 strands, 664 MA Anchorages and 1,940 Type FA Flat Anchorages.

Mota-Engil Engenharia e Construção S.A. is DSI’s exclusive partner for DYWIDAG Strand Post-Tensioning Systems in the Portuguese market. Thanks to a supply plan that had been prepared by both companies, DSC Spain was able to ensure punctual supply of the post-tensioning systems at all times within the tight schedule.

DSI is proud to have participated in such a demanding project.
The Venda Nova III Pumped Storage Power Station: Permanent DYWIDAG Anchors, TWIN-Corr System, ensure higher Energy Production

With an installed capacity of 781MW, the Venda Nova III Power Plant is Portugal’s largest pumped storage power station. The construction of this project in northern Portugal started in 2010. The new power plant increases the generating capacity of the existing power plants at the Venda Nova Dam on the Rabagão River and at the Salamonde Reservoir.

The project includes the construction of an underground powerhouse, a pressure pipeline, a surge shaft as well as several auxiliary shafts and access tunnels. The underground powerhouse will be equipped with two left- and right- turning (reversible) Francis turbines with a total maximum output of 781MW.

Within the scope of the project, a comprehensive slope stabilization program is being carried out in the Salamonde Reservoir. A more than 60m high slope embankment was built in the metasediment embedded in granite.

To stabilize the slope, DYWIDAG Sistemas Constructivos (DSC) supplied 45 permanent 5 strand DYWIDAG Anchors to the subcontractor Mota-Engil Engenharia e Construção S.A. The TWIN-Corr System Strand Anchors each have a double sheath. Permanent corrosion protection is achieved by strands that are greased, individually sheathed and covered by one corrugated sheathing at the factory. The bonded length is additionally protected from corrosion by a second, concentric corrugated sheath.

The TWIN-Corr System DYWIDAG Strand Anchors were produced at DSC’s plant in Madrid and pregrouted at the factory. The anchors were supplied to the jobsite with preconfigured anchor heads, and DSC provided on-site support during installation.
Due to the limited space on site, all anchors had to be transported individually and manually to the jobsite by site personnel. The following anchors were used for slope stabilization:

- 45 permanent DYWIDAG Strand Anchors with double sheathing, TWIN-Corr System, with 5 strands
- 2,300m of 25mm Ø GEWI® Plus Rock Bolts
- 30m of 35mm Ø GEWI® Plus Rock Bolts
- 768m of 57.5mm Ø GEWI® Plus Rock Bolts
- 1,000m of 32mm Ø GEWI® Rock Bolts

All of the rock bolts were supplied to the jobsite just in time within the tight schedule.

DSC is proud to have participated in such a technically demanding project together with Mota-Engil Engenharia e Construção S.A.
Long Service Life in Aggressive Environments: DYWIDAG Strand Anchors Stabilize Caniçada Dam

The Caniçada Dam on the Cávado River in north-western Portugal was built in 1955. The 246m long arch dam forms part of the Cávado-Rabagão-Homem cascade system which produces energy in 8 different hydroelectric power plants. The Caniçada Dam is 76m high and has an active capacity of approx. 150 million m³ of water that can be used to generate 32GWh of electrical energy.

In order to meet recent requirements of the Portuguese dam safety legislation, the operator EDP conducted a safety assessment of the dam. The analysis concluded that an additional spillway was needed.

EDP awarded Mota-Engil Engenharia e Construção S.A. the contract for the construction of the new overflow weir consisting of a control structure equipped with two radial gates. The gates are connected to a 200m long tunnel that ends in a ski jump structure. If there is a large amount of rainfall, water can be diverted via the ski jump into the absorption basin by opening a stop valve.

As DSI had already successfully contributed to other dam projects, the owner invited DSI Portugal to provide an efficient and long-term solution to stabilize the slopes on both sides of the spillway.

For this purpose, DSC produced and supplied 82 permanent, 4 strand, double sheathed, TWIN-Corr System DYWIDAG Strand Anchors. The anchors were pregrouted in the factory and supplied to the jobsite together with the necessary anchor heads. Afterwards, the general contractor installed the DYWIDAG Anchor Systems in the slopes.

As a durable system for permanent use with a service life of more than 100 years, the TWIN-Corr System proved to be the best solution for such a technically demanding project. The DYWIDAG Strand Anchor System has two plastic sheaths in the bonded length, thus ensuring a permanent tie back in structures that are located close to the water and therefore highly susceptible to corrosion.
Due to the fact that it is located at the edge of a steep coast, and because the surrounding geology is shaped by alternating clays, fractured quartzite and slate with unfavorable dips, the tower is both endangered by possible landslides and cave formations.

Consequently, the decision was made to stabilize the slopes endangered by landslides using deep, permanent DYWIDAG Strand Anchors. Seventeen 30m long double corrosion protected Type 10-0.6” DYWIDAG Strand Anchors with free lengths of 23m each were used to tie back the slope into the stable rock strata.

Anchor installation proved to be very difficult because work had to be carried out on a precipice more than 80m above sea level. The contractor, Geocisa, designed a special mast mounted on an excavator for this purpose. Using this method, the anchor points could be accessed using a high performance, portable drilling rig.

In addition to the required DYWIDAG Strand Anchors, DSI Spain also provided technical support and supplied the HOZ 3000 Stressing Jack needed for working in these difficult conditions.
In northern Sweden, the third construction section of Blaiken Wind Park is currently under construction. Up to 100 wind turbines with a total output of 250MW are being built in this area. Once completed, Blaiken Wind Park will have an average annual electrical generating capacity of 700GWh, which will meet the demands of approx. 150,000 households, and will be one of the largest wind farms in Europe.

In the third and last section of this project, 23 turbines, designed for wind velocities of 4-25m/s and a maximum performance of 2.5MW each are being installed. The wind towers have a hub height of 100m and a rotor diameter of 100m. The design of the foundations for the wind towers had to take into account the strongly changing gusts of wind that often occur in this region. In order to ensure the structural safety of the wind generators, massive foundations were erected that were permanently anchored in the load-bearing soil using DYWIDAG Strand Anchors.

For the deep anchoring of the tower foundations, DYWIDAG Sverige supplied a total of 184 18 to 23m long permanent Type 27-0.62" DYWIDAG Strand Anchors. After drilling the boreholes, the strand anchors were inserted, grouted in their bonded lengths and post-tensioned.
Construction—EMEA—Sweden—Wind Energy Structures

General Contractor
Joint Venture BlaikenVind AB, consisting of Skellefteå Kraft, Sweden and Fortum Oyi, Finland

Contractor
Peab Grundläggning AB, Sweden

Architect
WSP, Sweden

Consulting
WSP, Sweden

DSI Licensee
DYWIDAG Sverige AB, Sweden

DYWIDAG Sverige Scope
Production, engineering services, technical support

DYWIDAG Products
184 permanent Type 27-0.62" 18-23m long
DYWIDAG Strand Anchors
The Biel Bypass:  
**GEWI® Micropiles stabilize giant Subterranean Waterproofing against Uplift**

The Biel Bypass closes one of the last gaps in the Swiss federal road network: The connection between Solothurn and Neuenburg. Simultaneously, the new section around Biel will connect the A 5 Motorway with the A 16 Motorway and the T 6 in the direction of Bern. The Biel Bypass will also consolidate regional traffic, which will be primarily redirected into tunnels underneath the town. This way, large parts of the town and the region can be relieved from the very dense thru traffic.

The Brueggmoos intersection in what is called the Ostast (eastern branch) of the Biel Bypass is a complex structure in a densely populated area with challenging geological conditions. In addition to the main traffic arteries from Jura-Solothurn, Neuenburg and Bern, the Ostast also includes a tight network of regional roads as well as the Biel-Bern railway line. During construction, the traffic flow had to be maintained for all traffic participants and adapted to the constantly changing conditions.

The centerpiece of the Brueggmoos intersection is a giant concrete subterranean waterproofing in which the traffic flows are brought together. First of all, an excavation with a base area of 45,000m² and a depth of approx. 8m was realized in the in-situ ground water. The excavated material amounts to approx. 400,000m³. Since the ground water is located in close proximity to the surface, the large excavation pit will be surrounded by a slurry wall with a total length of 1,200m and a depth of 25m. Inside the subterranean waterproofing, the in-situ ground water table is lowered using ditches and wells.

The basement waterproofing consists of a watertight, 1.2m strong concrete structure that is anchored in the soil using 3,500 tensile piles in lengths of 10-20m to resist the enormous uplift forces. Each pile consists of a 40mm Ø, Grade B500B GEWI® Bar and an anchor plate that anchors the tensile forces in the concrete.
The GEWI® Bars were inserted into plastic ducts and grouted at DSI’s plant in Koenigsbrunn and supplied to the jobsite in lengths of 3-6m. On site, the GEWI® Bars were then assembled to complete piles using couplers. The subcontractor Marti AG Bern then installed the piles into 212mm Ø boreholes and grouted them.

The GEWI® Micropiles were supplied by the DSI licensee SpannStahl AG.

The contract included approx. 7,000 pregrouted base and middle pieces with a total length of 33,700m.

For the pile heads, 80cm long, crude GEWI® Bars were supplied that ensured force transmission into the base slab via anchor plates.
Following in Dr. Finsterwalder’s Footsteps: GEWI® Plus Micropiles stabilize innovative Elephant Park at Zurich Zoo

On the 7th of June 2014, the Kaeng Krachan Elephant Park was opened at the Zurich Zoo. In addition to the impressive elephant house, the new park also includes a large outdoor area for the animals and has been designed to resemble the natural habitat of elephants.

The roof of the elephant house consists of an innovative, cantilever wooden structure with a diameter of 85m in which 271 openings are irregularly arranged to let in daylight. The plywood shell structure includes a circumferential ringwall opening consisting of post-tensioned concrete that connects the few local abutments with each other. As a result, the prestressed ringwall absorbs the forces from the shell and transfers them into the foundation. The engineers Walt + Galmarini received the 14th Ernst & Sohn Engineering Award for the innovative, wide span dome. This important award is presented every other year to a construction project characterized by exceptional engineering services. The award was recently renamed the “Ulrich Finsterwalder Engineering Award” and is thus dedicated to one of the outstanding engineers of the 20th century who carried out important developments in prestressed concrete as an executive employee of Dyckerhoff & Widmann.

Out of 46 projects, the jury unanimously chose the elephant park as the winning project because it impressively fulfilled all of the criteria for winning the award.

Works by Ulrich Finsterwalder such as the Zeiss Planetarium in Jena that was built with the world’s first reinforced concrete dome in 1926 or the 1929 market hall in Basel that was repaired by the engineers Walt + Galmarini in 2012 are considered as models for the novel wood structure.
The micropiles anchoring the elephant house in the soil also go back to one of Dr. Finsterwalder’s inventions. For the foundation of the spectacular dome structure, the DSI licensee SpannStahl AG supplied pre-grouted, double corrosion protected, ST S670 GEWI® Plus Micropiles.

The micropiles were particularly needed for the foundation of the water basins so that they would not experience any settling due to the high loads. The supply included 21 12m long micropiles complete with accessories. Drilling and installation of the GEWI® Plus Micropiles was carried out by the company Greuter AG in Hochfelden, Switzerland.

In comparison to the old site, the new elephant park offers more room for the elephants and allows visitors to get closer to the animals. The different watering holes and water basins play a central part: Visitors can observe the swimming and plunging elephants through a glass pane in the indoor area.
Wire EX Tendons for Renewable Energy: The Gouda Wind Park in South Africa

The Gouda Wind Park is located north of the town Gouda and 35km north-east of the town of Malmesbury on the Western Cape in South Africa. The project consists of 46 prefabricated concrete segment wind towers with hub heights of 100m and a rotor blade diameter of 100m. Once completed, the new wind park will have a total generating capacity of 138MW – 3MW per wind tower. The park is designed for a service life of 20 years.

The project will not only supply the region with renewable energy, but will also contribute to the economic and social development of the country by creating new jobs and supporting several nonprofit programs.

DSC Spain supplied and installed prefabricated Wire EX Tendons for tensioning the prefabricated concrete elements inside the wind towers. DSI Germany produced 276 Type SUSPA Systems Wire EX 56 Wire Tendons for this project.

The tendons consist of 56 7mm Ø wires in their free length. Button heads permitting a slip-free anchorage in the base anchors are cold-forged onto the wire ends. In the factory, the tendon ducts were completely filled by pressure injection using a special corrosion protected compound mass in order to ensure long-term protection in aggressive environments. Afterwards, the prefabricated tendons were placed on auxiliary coils and shipped to South Africa in containers.
With the help of 6 South African technicians, two experienced DSC Spain employees installed the prefabricated Wire EX Tendons inside the wind towers from bottom to top. Thanks to the successful cooperation of this international team, the tendons were installed from bottom to top and tensioned in 3 wind towers per week.

The Gouda project is only one of many projects in which DSC and ACCIONA Energy S.A. are working together: In addition to 5 large wind parks in Brazil, a new wind power project using prefabricated Wire EX Tendons is also under construction in north-eastern Mexico.
The Walterdale Bridge:
DYWIDAG Micropiles stabilize Edmonton’s new Landmark

In Edmonton, Alberta, Canada, the new Walterdale Bridge is currently being built. When completed, the arch bridge with two 56m high arches will replace an old bridge structure built in 1913. The Walterdale Bridge crosses the North Saskatchewan River with a 230m long span. With three lanes instead of the previous two lanes and additional lanes for bikes and pedestrians, it will ensure a better link to the center of the city.

The arch loads are transferred to deep foundation thrust blocks at both river banks, and the abutments are stabilized using micropiles. The piling subcontractor, R.S. Foundation Systems Ltd. (RSFS), was contracted to design, supply, install and test the micropiles. After a competitive bidding process, DSI Canada was selected by RSFS to supply the micropiles.

The four foundations thrust block bases are each supported by 44 triple corrosion protected, galvanized, 75mm Ø DYWIDAG Micropiles in lengths of approx. 18m; in total, 3,168m of DYWIDAG Micropiles with a total weight of 114t were installed.

Prior to the installation of the 176 DYWIDAG Micropiles, 2 demonstration anchors were installed on each side of the river. The test anchors differed from the production micropiles in that bare bar was utilized, a free stress length was installed through the overburden soils and the pile was installed vertically.

The test consisted of cyclically loading each pile between compression and tension loads, to a maximum of 2,175kN in compression and 1,131kN in tension. RSFS was requested to conduct the tests through approx. 12-15m (40-50ft) of overburden soils. The largest challenge to satisfying this request was to isolate the pile section through the overburden, allowing it to move while maintaining the structural rigidity and capacity of the test piles required to resist the large compression loads. This was accomplished by installing a highly reinforced pile section complete with a free stressing length through the overburden.

Each test took approximately 35 hours to set up, and 14 hours to perform. In addition, each test was conducted in sub-freezing outside temperatures of down to -28°C. Despite all difficulties, the tests were very successful and proved the load-bearing capacity of the installed micropiles.
In order to permit the installation of the DYWIDAG Micropiles in the foundation, berms were temporarily constructed on the river bed. Behind these berms, intermediate levels were excavated on the dewatered, approx. 14-15m² large area in the river bed. It was only from these berms situated approx. 13-17m below grade that the 18m long DYWIDAG Micropiles could be installed in the foundation of the abutments.

Although the majority of ground encountered while drilling was clay bedrock, the formation was also full of fractures, coal and bentonite seams, causing both artesianing water and positive gas pressure. In some instances, several cycles of consolidation grouting and re-drilling was required. Each micropile was installed approximately 50° from horizontal in a 200mm Ø and 19m deep hole. The DYWIDAG Micropiles were first installed with 50 MPa primary grout and post-grouted through 7 Post Grout Valves. Each pile was designed to provide a long term service load of 1,131kN in both compression and tension and an ultimate load of 1,600kN and 2,830kN in tension and compression.
Stable Solutions in an Area prone to Landslides: The Peace River Project

The Peace River Project is a slope stabilization project that was recently carried out near the Canadian town of Peace River in north-western Alberta. The Peace River lowlands are a historically active landslide area: Every year, nearly half of all the slides in the Province of Alberta occur here. Since Highway 744 was opened to traffic in 1985, 14 landslides in this area have had to be stabilized using various methods.

In May 2013, a large landslide occurred on Judah Hill and closed an important section of Highway 744. A large scale rehabilitation project began that required the construction of three cast-in-place (CIP) pile walls. The CIP pile walls vary in length from 40m to 120m and are topped with a concrete cap beam.

Lateral support is provided by a total of 519, 32mm Ø double corrosion protected (DCP) DYWIDAG Soil Anchors having a weight of 142.34t. The soil anchors supplied by DSI Canada were installed in the concrete cap beam as well as through the center of each of the 1.2m diameter piles. Additional anchors with bond lengths of 12m were installed through some of the CIP piles, at angles varying from 25 to 32 degrees from horizontal. Total tendon lengths from 35m to 58m were required in order to reach the competent, very stiff clay till layer beneath the landslide slip plane surface.

The design lock off loads for the DYWIDAG Soil Nails varied from 162kN to 272kN. Several vibratory wire load cells were also installed with the soil nails for permanent load monitoring at each pile wall. The DYWIDAG DCP Soil Anchors were injected with cement grout following installation.

Work had to be carried out within a very short time frame in order to be able to reopen the important federal Highway 744 as soon as possible. DSI worked closely with the drilling subcontractor to ensure timely delivery of the soil anchors and the necessary testing equipment throughout the project.

Despite severe cold weather conditions during the winter of 2014, the project was successfully completed and the road quickly reopened to traffic. The new pile walls will provide a safe and efficient connection of the town of Peace River to the region.
The Grandview Heights Aquatic Centre: CFRP Cylinders ensure Fast Construction Progress

The city of Surrey in south-western Canada recently completed the construction of a modern swimming facility: The Grandview Heights Aquatic Centre. The new aquatic facility includes a 50m pool with 10 lanes suitable for competition. In addition, the swimming center accommodates a leisure pool, a waterslide, a dive tower, a wellness area and a large weight exercise room.

Due to its environmentally-friendly and sustainable design, the building received LEED Silver Certification. The center is a very modern open space with large windows all around providing unobstructed views of the mountains.

The undulated roof structure consisting of glulam is supported by inclined post-tensioned concrete buttresses. 6 vertical tendons are located in each of the inclined but nearly vertical buttresses on both ends of the building. In the eastern buttresses, a total of 42 46mm Ø DYWIDAG Bar Tendons with a total weight of 10.1t were used. The western buttresses were post-tensioned using 42 66mm Ø DYWIDAG Bar Tendons with a total weight of 29.9t.

The installation of the tendons supplied by DSI Canada required a high degree of accuracy in order to ensure both the correct concrete cover and to fit the additional reinforcing steel. Furthermore, the inclines of the buttresses complicated tendon installation.

After the first section of the roof had been poured, the tendons were stressed. Stressing was carried out using a Portable Hollow-Piston CFRP Cylinder. The use of this stressing ram ensured that the post-tensioning could be completed safely. Due to its light weight, the jack could be easily transported by the assembly technicians at all times.

Once all tendons had been duly installed and approved, they were grouted, taking precautions to ensure no voids were located in the top of the tendon sheaths.

Thanks to the use of the light weight and portable CFRP Jack, work for this complicated project was completed efficiently and ahead of schedule.
DYWIDAG Strand Anchors secure Willow Island Hydro-Electric Project in West Virginia

The Willow Island Hydro-Electric Project is currently under construction in northern West Virginia, USA, near the town of St Marys. The Willow Island reservoir has a total surface of 6.65km² (1,644ac) and is retained by a 343.8m (1,128ft) long dam.

The powerhouse will generate an average annual output of 239GWh with two horizontal 22MW bulb turbines. The water will be diverted from the dam and the Willow Island locks that were built in the 1970’s to the turbines. In addition to a reinforced concrete powerhouse, an intake approach channel and a tailrace channel are being built for the new hydroelectric project.

For the construction of the new hydroelectric powerhouse, an approx. 30.5m (100ft) deep rock excavation had to be built. The excavation support was mainly needed due to a fault line discovered in the rock. Consequently, the design engineer decided to use DYWIDAG Strand Anchors to ensure the stability of the dam during the excavation.

DSI USA supplied twenty-eight 59-0.6” DYWIDAG Strand Anchors. In order to monitor the forces in the anchors during excavation, three DYNA Force® Sensors were installed on each permanent anchor, totaling 84 DYNA Force® Sensors.

For the first few months during anchor installation, sensor readings were manually taken once a day to monitor the forces acting on the anchors as the excavation progressed. Afterwards, the DYNA Force® Sensors were connected to several multiplexers using extension cables, and all multiplexers were connected to the readout unit via a main cable. A modem, a controller and a cell SIM card were installed so the data could be accessed from a remote location. A battery and solar panels were used to power the readout unit.

The data from the DYNA Force® Sensors are being remotely taken every 3 hours, analyzed and reported to the owner. The sensor readings are providing valuable information and added safety during the construction of the powerhouse.

In addition, DSI USA also supplied 42 temporary DYWIDAG Strand Anchors with 3-12 strands to provide temporary soldier pile wall support in the excavation.
DYWIDAG Bar Tendons ensure a long Service Life: The Zilwaukee Bridge in Michigan

One and a half hours north-west of Detroit, Michigan’s Zilwaukee Bridge crosses the Saginaw River with two separate bridge structures, one each for north and south bound traffic. The single cell, segmental post tensioned box girder bridges accommodating four lanes each were originally constructed between 1979 and 1988 replacing an obsolete bascule draw bridge.

Each bridge is approximately 2,414m (1.5mi.) long and consists of 1,592 precast concrete elements. Each of the segments weighs 145t on average. The main river spans have a length of 120m (393ft), and the structures’ highest point above river level is at 38m (125ft). Traffic volume on this part of I-75 averages about 60,000 vehicles per day.

Prior to 2012, the Zilwaukee Bridge had already undergone several repair projects. In order to sustainably extend the service life of the bridge, the owner decided to replace all of the bearings. In total, 34 expansion bearings, 106 pier bearings and 10 abutment bearings were replaced on the bridge. Each pier consists of two columns linked by a cross-beam. At each pier, up to eight 600t capacity jacks were required to lift the superstructure for bearing replacement.

To strengthen the piers, DSI supplied Grade 150 DYWIDAG Post-Tensioning Bars in diameters of 36mm, 46mm and 65mm.

The post-tensioning bars were installed as external transverse tendons in the hollow box girders near the piers.

High-strength DYWIDAG Bars were also used as tendons for replacing the bearings. The post-tensioning bars were first installed in the girders of the lifting system and stressed. Afterwards, the girders were hydraulically lifted.

DSI USA not only provided the necessary post-tensioning bars and the complete stressing equipment, but also supported the General Contractor in properly sizing the stressing equipment and selecting the materials that were to be used. Matching stressing jacks were provided for each bar diameter.

DSI also helped the General Contractor plan the complicated access to the bearings from a suspended work platform which was lifted from grade level.

Owner
Michigan Department of Transportation (MDOT), USA
General Contractor
PCL Constructors Inc., USA
Engineering
T.Y. Lin International Group Ltd., USA
DSI Unit
DYWIDAG-Systems International USA Inc., Structural Repair, USA
DSIScope
Production, supply, technical support, equipment
DYWIDAG Products
36mm, 46mm and 65mm Ø DYWIDAG Post-Tensioning Bars
The Lowry Avenue Bridge crosses the Mississippi River in Minneapolis, Minnesota, USA and is an important transportation corridor in Hennepin County. The old steel truss bridge that was built in 1905 and remodeled in 1958 was officially closed in 2008 and imploded in 2009 after an in depth inspection questioned the stability of the bridge foundation. Construction of the new bridge began in early 2010, and the new structure was opened to traffic on October 27th, 2012.

The steel through arch bridge spans the Mississippi with a 137.1m (450ft) long main span. The Lowry Avenue Bridge deck is designed as a post-tensioned hollow box girder bridge with stay cable suspenders and, unlike the old bridge, features only 2 instead of 5 piers.

The two large arch ribs, topping out approx. 39.6m (130ft) above the mean water elevation, are tilted towards one another and meet in the middle of the main span, thus creating a kind of “basket handle”. The arch ribs rise up from two delta shaped piers. Vehicular traffic passes between the arch ribs while the sidewalk for pedestrian traffic curves out around the pillars. In summary, the bridge deck carries 4 lanes of traffic at a varying width of 27.7 to 32.6m (91 to 107ft).

DSI USA supplied all post-tensioning systems that were needed for the bridge girders and the bridge deck and provided the necessary equipment for the tensioning and grouting works. 100 pieces of Type 4-0.6” DYWIDAG Strand Tendons with FA Anchorages were used as transverse tendons in the deck slab.

For the transverse tensioning of the deck slab at the edge girders, DSI supplied 100 pieces of 4-0.6” DYWIDAG Strand Tendons with FA Anchorages that were pre-assembled at DSI’s facility in Bolingbrook. 100 pieces of 19-0.6” DYWIDAG Strand Tendons were used as curved tendons at the curved sidewalk lookout. In addition, 100 pieces of 27-0.6”
DYWIDAG Strand Tendons were installed for all web tendons in the box girders. 100 pieces of 27-0.6” DYWIDAG Loop Tendons were used in the delta pier/thrust blocks supporting the steel arch ribs. Furthermore, Type 37-0.6” DYWIDAG Strand Tendons were installed in the edge girders.

36 Type DG-P 19 DYNA Grip® Stay Cables were used as suspenders. DSI also provided 4 DYWIDAG jacks with capacities of 300t each. The hydraulic jacks were used for lifting the 453t edge girders from barges on the river into their final position. Afterwards, the steel arches were assembled directly above the river. Per arch, 9 segments and four connecting elements were placed and then bolted together.

In 2013, the exceptional project received the Engineering Excellence Grand Award of the American Council of Engineering Companies (ACEC) as well as an award by the American Public Works Association.
Fast Repair with DYWIDAG Strand Tendons: The Plymouth Avenue Bridge in Minneapolis

The Plymouth Avenue Bridge is a four lane, twin segmental box girder bridge carrying Plymouth Avenue over the Mississippi river on the north side of Minneapolis, Minnesota. The bridge has a total length of 287.4m (943ft), with the longest span reaching 43.6m (143ft). Built in 1983 using form travelers, it was the first segmental cast in place bridge in Minnesota.

Following a 2010 routine inspection, the bridge was closed after corroded post tensioning tendons were discovered. Upon further evaluation, it was later determined that the post tensioning tendons had corroded due to a failure of the bridge’s drainage system. The drainage pipes are located inside the box girders. Due to the failure, deicing chemical leakage accumulated in the interior of the box, thereby corroding both the rebar and the post-tensioning tendons in the structure’s bottom slab.

A long-term and economical strengthening solution was needed to restore the bridge to service as quickly as possible. Corven Engineering proposed to install an additional external multistrand post tensioning system inside the hollow box girders. The General Contractor hired DSI USA to provide a suitable post-tensioning system and to support the jobsite with engineering services and installation techniques. 5 new Type 12-0.6” DYWIDAG Strand Tendons were installed as external tendons in each hollow box girder. Each tendon was anchored in new concrete blisters created at the ends and running through new concrete deviators cast at the appropriate box floor slab locations.

The design required the steel embed ducts to deviate in two planes, creating difficulty in obtaining field measurements for the production and installation of these components. In addition, the concrete anchor blisters newly installed at the upper regions of the girder interior for anchoring the tendons left little space to maneuver a post-tensioning jack into position. Consequently, DSI was tasked with developing a unique stressing protocol for stressing each strand individually using monostrand jacks.

The special stressing system developed by DSI for accomplishing the tensioning work proved very successful so that the work was completed safely, on budget and within the limited schedule.
Stabilization of a dangerous Landslide at California’s White Point Nature Preserve near Los Angeles

During the rainy month of November of 2011, a part of the Paseo del Mar Road at the White Point Nature Preserve suddenly collapsed, sliding down a 36.5m (120ft) cliff side into the Pacific Ocean. The owner of the road, the city of Los Angeles, hired the geotechnical consultant Shannon & Wilson to suggest a suitable stabilization measure.

The consultants found that an excess amount of water had accumulated beneath the surface due to poor drainage and the general slope setup had caused coastal erosion and the landslide. Furthermore, sensors placed in drilled shafts detected continuing ground movements in this area.

The city council was able to choose from different rehabilitation plans and decided to undertake the most economic solution, which was also the quickest alternative. The final design scheme included the horizontal drilling and installation of drainage pipes into the slope and the use of DYWIDAG Strand Anchors as tiebacks.

The engineer recommended slope stabilization with 18 Type 6-0.6” DYWIDAG Strand Anchors. At the beginning, two test anchors that were each fitted with seven DYNA Force® Sensors were used for realizing Shannon & Wilson’s proposal. Three of the sensors were placed at distances of 3m from each other in the bonded length of the test anchors, and four were placed at distances of 10m along the unbonded length.

The up to 55m long DYWIDAG Strand Anchors were placed in two levels of 9 anchors each. The anchorages are restressable so that loads can be adjusted after the stressing tails are cut. The anchor load is distributed to the soil through large, cast in place reinforced concrete pads.

The general contractor Hayward Baker Inc. selected DSI to supply the anchors and anchor stressing equipment as well as to provide technical assistance for the first anchors to be installed.

Testing went well with the DYNA Force® Readout Unit showing readings that were very close to those of the jack gauge. The cables of the DYNA Force® Sensors are connected to a waterproof NEMA box so that load monitoring can be carried out on a permanent basis.
A challenging Task: Excavation Support and Anchoring of the Foundation of San Francisco’s Trinity Place with DYWIDAG Anchors

In San Francisco, a new block of high-rise buildings are being constructed on an area of 130,715m² in the centrally located South of Market (SoMa) district. The development, named Trinity Place, is divided into four construction sections designed to relieve the city’s tight market for rental apartments by providing approx. 2,000 new units.

In section III, a 19 floor, L-shaped building is being built that will contain 546 apartments. Furthermore, a multi-level underground garage with a total of 940 spaces is under construction in sections III and IV.

The slab and piling foundation one level below grade for the tower that had been built during phase II had to be stable enough to construct the three adjoining basement levels for phase III.

The piling was used to prevent the settlement of the phase II building into the excavation for phase III. In order to efficiently stabilize the building and the excavation, 89 piles were sunk up to 10.7m (35ft) deep for the foundation.

To tie back the soldier beam and lagging system, DSI supplied 623 temporary Type 0.6” DYWIDAG Strand Anchors with a total length of 12,404m (40,695ft). Since there are many utilities under the adjacent road, the shoring of the building was very complex: The tiebacks had to be installed from the utility space in the surrounding streets. DSI also supplied the
equipment needed for testing some of the anchors.

To prevent uplift, 789 double corrosion protected (DCP) 57mm Ø, Grade 75 DYWIDAG Bar Anchors were installed and connected with the foundation using plate anchorages.

The limited space on site was a major challenge for all companies involved because there was no storage space on site. DSI reacted quickly to the customer’s continuously revised schedules and was able to supply the required products to the jobsite just in time.

Owner
Trinity Properties, USA

General Contractor
Swinerton Incorporated, USA

Subcontractor
Malcolm Drilling Company, Inc., USA

Engineering
Brierley Associates Corporation, USA

Architect
Arquitectonica International Corporation, USA

DSI Unit
DYWIDAG-Systems International USA, Inc., BU Geotechnics, USA

DSI Scope
Production, supply

DYWIDAG Products
623 temporary Type 0.6” DYWIDAG Strand Anchors; 789 double corrosion protected 57mm Ø, Grade 75 DYWIDAG Bar Anchors
Newport Beach South of Los Angeles, California, is witnessing a flurry of new construction projects. One of them is the Newport Bay Marina, a bayfront mixed use project that is built at a former World War II shipyard site. When completed, it will provide 1,394m² (15,000ft²) of retail space below 1,951m² (21,000ft²) of office space. The project also includes a new 23-slip marina and a public plaza.

Since the job site is at the waterfront below sea level, the entire perimeter of the project is enclosed by a combination of sheet pile walls and secant pile walls with a series of de-watering sump pumps running continuously until the waterproofed concrete walls over the sheet piles are complete.

The design engineer selected DYWIDAG Micropiles to resist the uplift force on the underwater concrete slab and to prevent structural damage due to high potential of soil liquefaction in the event of an earthquake. A total of 624 double corrosion protected (DCP) 57mm Ø DYWIDAG Micropiles were installed in a grid pattern at approx. 3.66m (12ft) spacing for this project.

One of the reasons why Vertical Earthworks, Inc. was successful in winning the contract was the fact that DSI USA produced the 170t of DYWIDAG Micropiles in customized lengths of 12.2m (40ft). This way, the contractor was able to make a cost efficient offer because the bars, which are normally supplied in standard lengths of 18.3m (60ft), did not have to be cut, and consequently, no material had to be wasted.

Drilling in the local soil, mainly silt deposit and alluvium, was a challenge. After experimenting with different micropile installation methods including the vibratory method with pre-drilling,
full displacement auger etc., the contractor selected a partial displacement auger using the pre-drilling method. The boreholes were pre-drilled with a 610mm (24") diameter auger and then re-drilled with a slightly smaller diameter auger. In order to keep the drilled hole from collapsing, premixed slurry grout was tremie pumped through a grout port at the bottom of the auger bit as the auger was being extracted from the hole. Afterwards, the DYWIDAG Micropiles were inserted into the slurry filled drilled holes.

In addition to supplying the micropiles and associated hardware, DSI also provided stressing equipment for pile testing in order to prove the suitability of the chosen system for the conditions on site. The micropiles were successfully installed in January 2015 and the entire project is scheduled for completion in 2016.
Bluff Park: DYWIDAG Soil Nails secure the nicest View of the Pacific Ocean in Long Beach

Bluff Park is located directly on the Pacific Ocean and is one of the most beautiful parks in Long Beach, California. The park is named after a bluff that forms part of the park and that had previously been damaged by erosion. In order to stabilize the bluff on a long-term basis and to eliminate potential risks of collapse or earthquake-triggered landslides, the bluff was stabilized by a soil nail wall with a shotcrete facing.

Soil Nailing is a very fast and economic earth retention system. DSI has long been a pioneer in the use of DYWIDAG Soil Nails for reinforcing embankments and slopes. Soil nail systems can be installed top-down using very light construction equipment. Furthermore, they are characterized by their simple components and trouble-free assembly and are very easy to install and test.

To stabilize the steep bank in Bluff Park, DSI USA supplied a total of 1,670 9.4m (30.75ft) double corrosion protected 25mm Ø, Grade 75 DYWIDAG Soil Nails as well as 25 4.5m (14.75ft) long DYWIDAG Soil Nails.

The soil nails were installed with a standard horizontal drill rig using an air flush system to remove soil from the holes. To stabilize the facing, two layers of welded wire mesh were installed which were fastened using rebar and shotcrete.

Owner
Long Beach City Council, USA
General Contractor
Drill Tech Drilling and Shoring Inc., USA
Engineering
Kleinfelder, USA
DSI Unit
DYWIDAG-Systems International USA, Inc., BU Geotechnics, USA
DSI Scope
Production, supply
DYWIDAG Products
1,695 double corrosion protected 25mm Ø DYWIDAG Soil Nails
Since 2007, work has been underway on the most comprehensive expansion in the history of the Panama Canal. In addition to a third set of locks, the project also includes several new access channels as well as a third navigation channel. Furthermore, the existing navigation channels are widened and new lock gates are installed that will permit faster opening and closing of the locks.

The capacity of the canal will be doubled: In the future, Panamax-II type ships with a length of up to 366m, a width of 49m and a draft of 15.2m will also be able to navigate the canal.

Within the scope of the project, an access channel is being built that will link the new Pacific lock with the Pedro Miguel Locks towards the North and, further along, with the section of the Canal that is known as Gaillard Cut or Culebra Cut.

North of the Pedro Miguel Locks, a peninsula known as Punta Norte de Cartagena had to be stabilized. For this purpose, the soil was strengthened using cast iron piles.

In addition, several prestressed reinforced concrete girders were placed in the form of a fan into a concrete structure that was formed like a sickle. The girders were anchored using 46mm Ø, Grade 150, double corrosion protected (DCP) DYWIDAG Bar Anchors.
The Cutzamala System: DYWIDAG Hoop Tendons reinforce one of the World’s largest Drinking Water Systems in Mexico

The Cutzamala System is one of the world’s largest potable water systems, providing approx. 485 millions of m³ of water per year for several districts and communities in Mexico State. The system includes two parallel, 75km long pipelines. The oldest part of the system was opened in 1982, and it has been continuously expanded in order to supply the growing population of Mexico City and its surrounding districts with fresh water.

In 2014, CONAGUA started repairing several pipe sections from both pipelines in the Cutzamala System using hoop tendons.

DSI USA participated in phases three and four of the rehabilitation project, during which the pipelines from Tower 5 (TO5) to the Analco San Jose Tunnel were examined and repaired. Twelve 2.5m Ø Prestressed Concrete Cylinder Pipes (PCCP) had to be reinforced because the prestressing wires underneath the cement mortar coating were found to be damaged.

533 extrusion coated Type 0.6” DYWIDAG Hoop Tendons in lengths of 10.7m were installed around the PCCP pipes in order to re-establish their original design properties.

External DYWIDAG Hoop Tendons have been developed especially for the repair and strengthening of circular structures such as silos or pipes. They are ideal for repairing pipelines in operation because only that part of the pipeline that needs to be repaired has to be excavated. Once excavated, the polypropylene polymer sheathed hoop tendons can then be installed directly around the pipe.

The extruded monostrand tendons are installed in hoops around the pipe, and the strand ends are stressed at a coupler. Using this method, an efficient prestressing is created that can be installed quickly. The system proved to be ideal for the Cutzamala potable water system: The repair work was carried out quickly and trouble-free in less than 50 hours.
Owner
CONAGUA - Organismo de Cuenca Aguas del Valle de México, Mexico

General Contractor
Consultoría en Obras Estructurales de Tuberías S de RL de CV, Mexico

DSI Unit
DYWIDAG-Systems International USA Inc., BU Post-Tensioning, East, USA

DSI Scope
Production, supply, technical support
DYWIDAG Products
533 extruded Type 0.6" DYWIDAG Hoop Tendons
Efficient and Fast:
Wire EX Tendons for new Wind Parks in Rio Grande do Norte, Brazil

Voltalia Energia do Brasil has commissioned two new wind parks in the federal state of Rio Grande do Norte in northeastern Brazil: The wind parks near the towns of Areia Branca and São Miguel do Gostoso. The Areia Branca Wind Park includes 30 wind towers with a total capacity of 90MW and the park in São Miguel do Gostoso includes 36 wind towers with a capacity of 108MW. The turbines supplied by Acciona each have a generating capacity of 3MW.

The tower shafts consist of prefabricated concrete segments that were produced on site in a field casting yard in order to minimize both transportation costs and impact on the environment. When in operation, the 120m high towers are exposed to large dynamic loads, which is why they are prestressed using external Wire EX Tendons. The precast concrete elements are post-tensioned against each other using external wire tendons located inside the tower.

In total, DSI Germany produced 396 Type 62 Wire EX Tendons in individual lengths of 115m for the two wind parks: 180 tendons to Areia Branca and 216 to São Miguel do Gostoso. The prefabricated tendons were supplied to the jobsite on coils.

The coordination of global wind parks with the General Contractor Acciona Windpower, Spain and Acciona Energía Windfarm is lead-managed by DYWIDAG-Sistemas Constructivos (DSC), Spain. The DSI companies Protendidos DYWIDAG and DSC carry out the installation and tensioning of the Wire EX Tendons on site in Brazil. At the upper part of the tower, the tendons were anchored in a special ring using 396 Type D Fixed Anchorages. In the tensioning area of the foundation, the tendons were anchored using 396 Type C Stressing Anchorages. Hollow-Piston CFRP Cylinders were used for tensioning the tendons because they could be easily positioned inside the towers thanks to their low weight.

The experienced employees carried out the installation and the tensioning work successfully within the short time frame. DSI is looking forward to contributing to additional wind parks with excellent service and a product that is unique in Brazil.
Owner
Voltalia Energia do Brasil Ltda, Brazil

General Contractor
Acciona Windpower

Engineering
Acciona Windpower

Foundations (Areia Branca)
Cortez Engenharia, Brazil

Foundations (São Miguel do Gostoso)
DOIS A Engenharia, Brazil

DSI Units
Protendidos DYWIDAG Ltda., Brazil; DYWIDAG Sistemas Constructivos S.A., Spain

DSC and Protendidos Scope
Production, supply, installation, technical support

DYWIDAG Products
396 Type 62, 115m long Wire EX Tendons, incl. Type D Fixed Anchorages and Type C Stressing Anchorages
DYWIDAG Bar Anchors stabilize Cut in brittle Rock: Warehouse Construction in Brazil

The Brazilian chain store Loja Elétrica has been selling electronic and do-it-yourself products since 1948. Recently, the company built a large warehouse in the city of Belo Horizonte in south-eastern Brazil.

To facilitate the construction of the new warehouse in the Engenhão Nogueira district, a 21m high, vertical sidehill cut had to be undertaken and stabilized by a retaining wall. The construction of the retaining wall was a technical challenge because the jobsite is located in a former quarry and the construction soil is mainly characterized by sedimentary rock.

Grade 85/105, 32mm Ø DYWIDAG Bar Anchors proved to be the optimum, most economical solution for tying the retaining wall back safely. The retaining wall was constructed in several sections from the top down. Protendidos DYWIDAG supplied DYWIDAG Bar Anchors with a total weight of 35t as well as all accessories for this project.

Owner
Loja Elétrica Ltda., Brazil

General Contractor
GVS Engenharia e Consultoria Ltda, Brazil

Subcontractor
Vallum Engenharia Ltda, Brazil

Architect
Sérgio Velloso Projetos Ltda, Brazil

 Consulting Engineers
Sérgio Velloso Projetos Ltda, Brazil

DSI Unit
Protendidos DYWIDAG Ltda., Brazil

Protendidos Scope
Production, supply

DYWIDAG Products
35t of Grade 85/105, 32mm Ø DYWIDAG Bar Anchors

Photos reprinted courtesy of Vallum Engenharia Ltda, Brazil
Flexible Rock Bolt Systems for all Requirements: The Chilean Ruta 5 near Cuesta de las Chilcas

Ruta 5, one of the most important highways in Chile, runs from the border with Peru to the southern city of Puerto Montt. Within the scope of a 300 million US Dollar project, the Ruta 5 Norte section leading from Santiago to the Port of Los Vilos located approx. 230km further north is being widened to create a modern highway.

In the section from km 74 to 79 near Cuesta de las Chilcas, Ruta 5 leads steeply uphill. Here, a viaduct is being built parallel to the current road. The project includes a new lane towards the South, an additional lane uphill for freight traffic and new prefabricated concrete crash barriers on both sides for safe lane separation. The new roadway alignment, with a maximum inclination of 7%, will also curve less and ascend less steeply than the previous road.

The slopes were comprehensively stabilized at the cuts necessary for the new route in order to prevent landslides caused by instability or earthquakes. The difficult geological conditions required long anchor lengths. Furthermore, the installation of the anchor systems had to be carried out on steep hillsides.

In view of these requirements, DSI Chile proposed a combination of self-drilling DYWII® Drill Hollow Bar Systems and massive DYWIDAG and GEWI® Rock Bolts.

To stabilize some areas of unstable rock strata, DSI Chile supplied a total of 3,000m of 12m long, R32 Ø self-drilling DYWII® Drill Hollow Bar Systems. For anchoring in deeper, load-bearing rock, 25t of 50mm Ø GEWI® Rock Bolts were used. For an additional section, DSI supplied self-drilling, passive DYWII® Drill Hollow Bar Soil Nails that were installed into the slope in depths ranging from 9 to 35m and injected with grout along their entire lengths.

In the area underneath the loose soil wedge at the surface, a combination of 57t of 32mm Ø DYWIDAG Rock Bolts and self-drilling R51 – 660 Ø DYWII® Drill Hollow Bar Anchors with a total length of 1,160m were used. In some sections, the embankment cuts were stabilized using mesh and 39.5mm Ø friction bolts with a total length of 2,050m as well as 13t of 25mm Ø GEWI® Rock Bolts.

DSI Chile provided competent technical support to the General Contractor in all project sections. Thanks to the versatility of the DYWIDAG Systems, DSI was able to supply suitable products for all requirements to the jobsite just in time.
The seaport of Barranquilla in northern Colombia is the country’s fourth largest city and the most important Colombian harbor on the Caribbean coast. Located 10.5km from the Magdalena River estuary, the harbor is an important port for exporting coal, coke and other fuels as well as general cargo.

At the moment, the port operator Compas S.A. is undertaking an expansion of the harbor that also includes a realignment and reinforcement of the piers using steel piles. In the future, large cargo ships with drafts of up to 11m and a gross weight of up to 55,000t will be able to land and unload here.

The General Contractor Centra Ingeniería y Construcción S.A. was awarded the design & build contract for a 211m long section at the southern end of the 800m long harbor. This section has not yet been developed and is characterized by relatively low water depths that extend up to 30m into the 400m wide river channel. The construction of the sheet pile walls was made difficult by the restricted space on site, and the very solid limestone complicated the drilling work in the harbor area.

Consequently, the General Contractor planned the construction using steel piling tied back with tie rods. The tie rods were secured to a rigid reinforced concrete cross girder that was founded on micropiles. The micropiles were installed in depths ranging from 15 to 18m into the load-bearing soil and are designed to transfer the expected alternating loads.

The micropiles that were supplied by DSI Colombia for this purpose are self-drilling R38-550 and R51-800 DYWI® Drill Hollow Bar Systems with hardened 115mm Ø cross drill bits.
To accommodate pressure loads, R38-550 DYWI® Drill Hollow Bars were installed at angles from 5° to 20° up to a depth of 18m. For accommodating tensile loads, R51-800 DYWI® Drill Micropiles were installed at angles of 45°. All of the DYWI® Drill Micropiles are covered by steel ducts up to a depth of 6m. In total, approx. 4,000m of DYWI® Drill Micropiles were used for this project.

The 32mm Ø, double corrosion protected DYWIDAG Tie Rods are epoxy-coated and protected by corrugated, galvanized ducts. The anchors are designed for loads up to 40t. In total, 1,500m of DYWIDAG Tie Rods were installed with spacing of between 2.8 and 4.2m. They ensure a safe connection of the steel pile walls with the massive reinforced concrete cross girder that serves as an abutment.
GEWI® Soil Nails protect Residents of Ciudad Bolívar in Bogotá from Landslides

In the South-West of the Colombian capital of Bogotá, approx. two million people live in the world’s third largest slum: Ciudad Bolívar. Since its development at the beginning of the 1980s, more and more people have moved to this region every year.

Some areas of Ciudad Bolívar used to be quarries. Even today, this area still has unstable sidehill cuts that are up to 25m high, creating a high risk of rock falls and landslides. As the winter of 2011 made the problem significantly worse, the Colombian Government decided to undertake an extensive effort to stabilize the affected areas.

Especially in Jerusalén and Canteras – two areas that form part of Ciudad Bolívar – several slopes had to be stabilized.

A passive, high-strength spiral rope net system that was anchored into the stable soil using GEWI® Soil Nails proved to be the best technical and most economical solution.

DSI Colombia supplied approx. 6,000m of 32mm Ø GEWI® Bars that were installed in the slopes in lengths ranging from 3 to 8m. The GEWI® Soil Nails are corrosion protected by an epoxy coating and were supplied by DSI to the jobsite including all accessories.

Owner
IDIGER (Instituto Distrital de Gestión de Riesgos y Cambio Climático), Colombia

General Contractor
Consorcio HN Ingeniería, Colombia

Contractor
Warco S.A.S., Colombia

Consulting Engineers
Geocing S.A.S., Colombia

DSI Unit
DSI Colombia S.A.S., Colombia

DSI Scope
Production, supply, technical support, supervision

DYWIDAG Products
6,000m of epoxy coated, 32mm Ø, 3-8m long GEWI® Bars
Quality from the very Beginning: DSI Peru supplies GEWI® Soil Nails for Slope Stabilization at the La Zanja Mine

La Zanja is an open pit mine located 35km north-east of the city of Cajamarca in the Province of Santa Cruz in northern Peru. The mine is currently being expanded, and the operator, Minera La Zanja – a subsidiary of Minas Buenaventura S.A.A. and Newmont Mining Corporation – is expecting gold production of more than 100,000 ounces per year as a result.

Minera La Zanja awarded a contract to Stracon GyM S.A. to perform the excavation work necessary for expanding the mine. Approx. 67.8 million t of ore and excavation material will have to be moved for the expansion. Within the scope of the work, some embankments along a road that leads to the new section of the mine had to be stabilized comprehensively.

The slopes were stabilized using geotextile and steel mesh that were anchored in stable rock using 32mm Ø GEWI® Soil Nails. A total of 1,898 3.5m, 4m and 4.5m long GEWI® Soil Nails were needed to stabilize the slopes. DSI Peru supplied a total of 22,611.5m of GEWI® Soil Nails, 1,898 anchorages, 8,580 lock nuts, 4,290 couplers and 3,797 spacers for this project.

For the complete duration of the project, DSI Peru remained in contact with the engineers and supported the owner of the mine responding to technical questions relating to the use of GEWI® Soil Nails for slope stabilization.
To stabilize the excavation wall, Flesan Anclajes, who had been assigned the geotechnical work, installed 34,700m – respectively 216t – of 32mm Ø DYWIDAG Soil Nails.

As passive anchorage elements, the DYWIDAG Soil Nails stabilized the excavation walls both during the excavation of the pit and during the construction of the basement floors. The soil in the excavation area consists of backfill in the upper layer with clay and loamy sands underneath. The conglomerate soil typical for the city of Lima lies underneath these deposits.

The DYWIDAG Soil Nails were installed into the excavation in nine layers. The DYWIDAG Soil Nails in layers 1 to 3 were 14.75m long, the soil nails in layers 4-7 had lengths of 11.8m, and 8.85m long DYWIDAG Soil Nails were installed in layers 8 and 9.
Construction—South America—Peru—Excavations

Owner
Corporación EW S.A.C., Peru

Subcontractor
FLESAN ANCLAJES S.A.C., Peru

Consulting Engineers
FLESAN ANCLAJES S.A.C., Peru

DSI Unit
DSI Peru S.A.C., Peru

DSI Scope
Production, supply, engineering services, technical support, test installation

DYWIDAG Products
34,700m of 32mm Ø DYWIDAG Soil Nails
PT DSI Underground Indonesia opens new Manufacturing Facility for Mining Products in Indonesia


DSI has a long history of exporting mining products and systems to Indonesia. In 2010, the company PT DSI Indonesia was founded with its head office based in Jakarta and has since successfully established its mining business all over Indonesia.

In order to serve their clients in Indonesia more efficiently and flexibly in the future, a new, 3,000m² manufacturing facility was built in Gresik, Surabaya, East Java, at the end of 2014. The new facility primarily produces friction bolts for mining. The new manufacturing facility includes storage for 400t of raw friction bolt feed material and a container unloading dock. In addition, it is fitted with a roll former having a roll diameter capacity of 55mm, a conveyor system and two semi-automated welding centers. The in-house testing facility ensures easy and fast anchor tests. The new production facility will allow customers to purchase locally manufactured products and to profit from PT DSI Indonesia’s technical support as well as efficient logistics services.

DSI has the most extensive product range available on the Indonesian market and offers its clients everything from a single source as a one stop shop supplier. DSI also assists with customer stock management to ensure product availability and minimize inventory costs.

At the new facility in Indonesia, DSI continuously invests in Research & Development in order to always offer its clients high quality, state of the art products. 18 highly qualified employees offer their clients and business partners the best service possible combined with rapid response times.
For the 1,573 participants from 54 different countries, this was the ideal opportunity to exchange global technical experience and knowledge in tunneling and the use of underground space.

With a total of 390 different technical presentations and posters, WTC 2015 focused on advancements in technology. The congress also included a workshop on tunnel safety during renovation focusing on the promotion of tunneling in south-eastern Europe. Counteracting problems such as traffic congestion or flooding was another important topic addressed during the event.

As an expert supplier of ground support systems, DSI was a silver sponsor of this year’s event and was represented with its own company booth. Many interested expert visitors stopped at the DSI booth to gather information about DSI’s latest products and systems for tunneling.

This year, DSI focused on the innovative squeezed coupler connection for the AT – Pipe Umbrella System. The squeezed connection is an important milestone in the history of the AT – Pipe Umbrella System because the force fit squeezing of a tapered tube end with its counter piece speeds up the self-drilling installation of the pipe umbrella tube and simultaneously enhances safety for jobsite personnel.

Once again, this year’s WTC proved to be a success for the DSI team, who are already looking forward to the next edition of this important global event.
SME Annual Conference, Denver, USA
February 15 – 18, 2015

In the shadow of the Rocky Mountains, the Society for Mining, Metallurgy & Exploration (SME) conducted their largest annual conference to date. The SME Annual Conference & Expo was held in Denver, Colorado, on February 15-18 and set records by accommodating 906 exhibit booths and 7,804 attendees.

The conference included more than 100 sessions from experts around the world focusing on coal, energy, mining, geology, or underground construction.

This year’s conference theme “Navigating Global Waters” was embodied well in the presentation of a technical paper titled “Innovative Rehabilitation of Existing Tunnels under Minimum Impact on Operation” that was co-authored by Wolfgang Dolsak, DSI Underground Systems. The paper detailed a combined support system consisting of yielding TH Steel Sets and BULLFLEX® Backfilling Hoses. This system has been successfully used during the rehabilitation of a conveyor tunnel at the Rio Tinto Kennecott Utah Copper (RTKC) Bingham Canyon Mine (Utah, USA).

The BULLFLEX® product line of the German construction and mining company Beton-und Monierbau GmbH (BuM) was featured at the DSI booth along with selections from DSI’s extensive product line. The SME Annual Conference & Expo provided an excellent platform for DSI’s dedicated staff to reinforce existing customer relationships as well as to showcase new products to potential buyers in the industry.

Within the scope of the SME Conference, DSI organized a customer event on February 16th during which technical questions and recent developments were discussed.

IFCEE - International Foundations Congress and Equipment Expo, USA
March 17 – 21, 2015

From March 17th to 21st 2015, the International Foundations Congress and Equipment Expo 2015 – or IFCEE – was held in San Antonio, Texas, USA. The event is the world’s largest congress for the foundation industry.

In addition to indoor and outdoor exhibits at the JW Marriott Hill Country Resort, the event also featured technical presentations, discussions, meetings and educational short courses. Topics included deep foundation designs, drilled shaft best practices and advanced modeling of geotechnical systems.

More than 150 exhibitors showcased their new technologies and products for the foundation industry. With more than 2,700 participants, the event was an ideal opportunity for developing existing and creating new business relationships.

DSI Construction North America participated in the event with an outdoor company booth. Despite bad weather, the event proved to be a big success for DSI. The booth was heavily attended by the key Deep Foundations Contractors in North America.

Visitors expressed a strong interest in DSI’s Carbon Fiber Jacks and the new QuickEx Removable Strand Anchor, both of which were featured at the DSI tent. Sandra Kriesten, Sales Manager Equipment for DSI Koenigsbrunn, Germany, assisted her American colleagues and provided her expertise on CFRP Jacks.
4th Mexican Congress on Tunnel Engineering and Underground Construction
October 8 - 10, 2014

From October 8th to 10th 2014, the Mexican Association for Tunnel Engineering and Underground Construction, AMITOS, held its fourth Mexican Congress on Tunnel Engineering and Underground Construction in Mexico City, Mexico.

The congress focused on the present and future use of underground space in Mexico’s metropolitan area, which is becoming increasingly important due to the growing population in this region.

During the technical program, DSI employees Wolfgang Dolsak (DSI Underground Systems, Inc., USA), Jorge Gonzalez (DSI International México, S. A. de C. V., Mexico) and Guenther Volkmann (DYWIDAG-Systems International GmbH, Austria) presented a technical paper. The title of the presentation was “State-of-the-art pre-support methods in underground excavation”. The DSI employees explained various pre-support elements to the expert public, focusing on forepoling systems such as pipe umbrella support systems and spiles. At DSI’s company booth, they presented the DYWI® Drill Hollow Bar System as well as the AT – TUBESPILE™ and the AT – Pipe Umbrella System together with Emmanuel García and Martin Hernandez (both DSI Mexico). Furthermore, the new image brochure for Latin America, “Soluciones para Control de Terreno en Excavaciones Subterráneas”, was presented for the first time. The DSI booth was highly frequented by many interested tunneling experts from Mexico and Central America.

II. Mountain Roads Seminar (Seminario sobre Carreteras de Monaña) in Columbia
October 16 - 17, 2014

From October 16th to 17th 2014, the organization SAI (Sociedad Antioqueña de Ingenieros y Arquitectos) organized their second seminar on mountain roads – the II. Seminario sobre Carreteras de Monaña. The event took place in Rionegro, a city in the Departamento of Antioquia in northwestern Columbia.

SAI is Antioquia’s society for engineers and architects and was founded in 1913 to promote science and its application in engineering and architecture and to solve technical and economic engineering problems.

The seminar targeted topics such as the widening and construction of mountain roads, slope stabilization, and technical aspects related to tunnels and viaducts. Another aspect that was discussed was technology related to the management of water above and below ground in mountainous areas.

DSI employees Wolfgang Dolsak (DSI Underground Systems, Inc.) and Camilo Zabala (DSI Colombia S.A.S.) contributed to the event with a technical presentation titled “Elementos de sostenimiento autoperforantes para la estabilización de taludes y portales” (self-drilling ground support systems for stabilizing slopes and portals). In their presentation, they introduced self-drilling soil nails and rock bolts as well as self-drilling pipe umbrella and drainage systems.

Emmanuel García and Martin Hernandez (both DSI Mexico). Furthermore, the new image brochure for Latin America, “Soluciones para Control de Terreno en Excavaciones Subterráneas”, was presented for the first time. The DSI booth was highly frequented by many interested tunneling experts from Mexico and Central America.

DSI’s product focus during the event was on the DYWI® Drill Hollow Bar System, the AT – Pipe Umbrella System and the AT – Drainage Drilling System. The expert public showed great interest in DSI’s high quality products and systems.
Stable Solutions in an Area prone to Landslides:
The Peace River Project
Photos reprinted courtesy of Double Star Drilling, Canada

The Newport Bay Marina:
Stable underwater Foundations with DYWIDAG Micropiles
Aerial photo reprinted courtesy of Vertical Earthworks, Inc., USA

The Cutzamala System:
DYWIDAG Hoop Tendons reinforce one of the World’s largest Drinking Water Systems in Mexico
Photos reprinted courtesy of Consultoría en Obras Estructurales de Tuberías S de RL de CV, Mexico

DYWIDAG Bar Anchors stabilize Cut in brittle Rock:
Warehouse Construction in Brazil
Photos reprinted courtesy of Vallum Engenharia Ltda, Brazil

GEWI® Soil Nails protect Residents of Ciudad Bolivar in Bogotá from Landslides
Photos reprinted courtesy of Warco S.A.S., Colombia

Quality from the very Beginning:
DSI Peru supplies GEWI® Soil Nails for Slope Stabilization at the La Zanja Mine
Photos reprinted courtesy of Desnivel Perú SAC, Peru

The Centro Comercial Sur:
DYWIDAG Soil Nails secure one of the largest Shopping Centers in Lima
Photos reprinted courtesy of FLESAN ANCLAJES S.A.C., Peru

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