





Dear clients, business partners and employees,

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Editorial



Patrik Nolåker, Group CEO



On behalf of the entire DSI Management Team, I am very pleased to be able to present the 21st edition of DSI Info to you.

Our DSI business continues to be characterized by stable and profitable development. Against the background of economic and political uncertainties in some markets, this development stands out even more positively. The two equally important pillars of our company – the Construction and Underground markets – form the basis of this stable course of business.

Innovative Developments for Construction

Within the Construction business, the Post-Tensioning market segment has developed very positively. Our focus on R&D activities in Wire Post-Tensioning Systems, for which we received a new European Technical Approval (ETA 07-0186) in June 2013, has been one of the main drivers for this development. Today, prefabricated Wire EX Post-Tensioning Tendons are globally used for the external post-tensioning of segmental precast concrete wind towers. In Geotechnics, we have successfully completed the development of innovative removable strand and bar anchors and have initiated global production and sales. The relevant patents have been applied for.

Extension of DSI's Presence in Underground: Growth Regions

In Mining, we successfully completed the acquisition of Schaum Chemie, a company located in Poland, in February 2014. In early August 2014, we acquired the mining business of a competitor in Canada and purchased a 49% stake in a resin cartridge producer in Australia. Furthermore, the acquisition of 50% of the shares in a South African producer of resin cartridges was successfully concluded. These investments are important milestones for us that strengthen our product portfolio and our presence in important global mining markets.

Staff Development and Commitment

We know that the long-term experience and performance of our employees have made DSI what it is today. Consequently, the continued investment in the training and development of our employees is an essential part of our corporate culture. Our highly qualified and experienced employees form the basis of our growth – both today and in the future.

Customer Focus

You, our customers, are always at the center of our thoughts and our actions. Our ultimate goal is to recognize your needs, demands and problems and to offer you technically sophisticated and reliable systems and solutions. In doing so, we demonstrate our comprehensive service commitment daily. That is why we always act in accordance with our slogan **“Local Presence – Global Competence”** and continue to expand our global operative structure. We are always there for you: **Everyone. Every day. Everywhere.**

Join us now on a fascinating journey through our regions and markets and let yourselves be inspired by the versatile applications of our high quality systems and solutions.

Sincerely yours,

Patrik Nolåker

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9/11 Memorial & Museum

On May 15th 2014, the 9/11 Memorial & Museum was opened to commemorate the terrorist attacks that took place on September 11th 2001. The large Foundation Hall is at the center of the museum. It displays a 19 x 20m (62 x 64ft) large wall tied back by double corrosion protected strand anchors that were produced and supplied by DYWIDAG-Systems International's plant in Toughkenamon, PA.

Photo reprinted courtesy of Jin Lee Photography, USA



Product Innovations at DSI Australia: The new Kinloc Bolt with 30t Load-Bearing Capacity

Underground

APAC

Australia

Mining

Recently, a customer asked DSI Australia for a high capacity single pass rock bolt for difficult and friable ground conditions. Within a short time, DSI Australia's technical team developed the new Kinloc Bolt that met the customer's requirement and solved his problem.

The Kinloc Bolt System is a mechanically operated, point anchoring friction bolt. The new rock bolt not only permits single pass bolting; it can also endure the shifting ground conditions often associated with friable ground. The Kinloc Bolt System has an internal solid bolt that provides both increased point loading capacity and enhances the bolt's performance in shear loading.

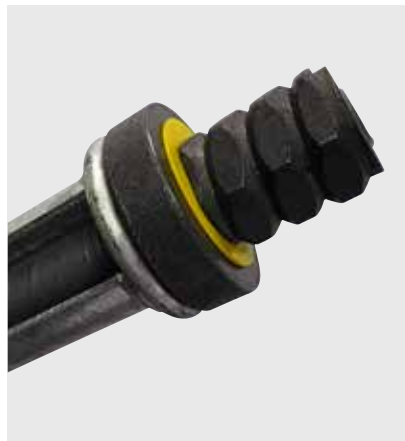
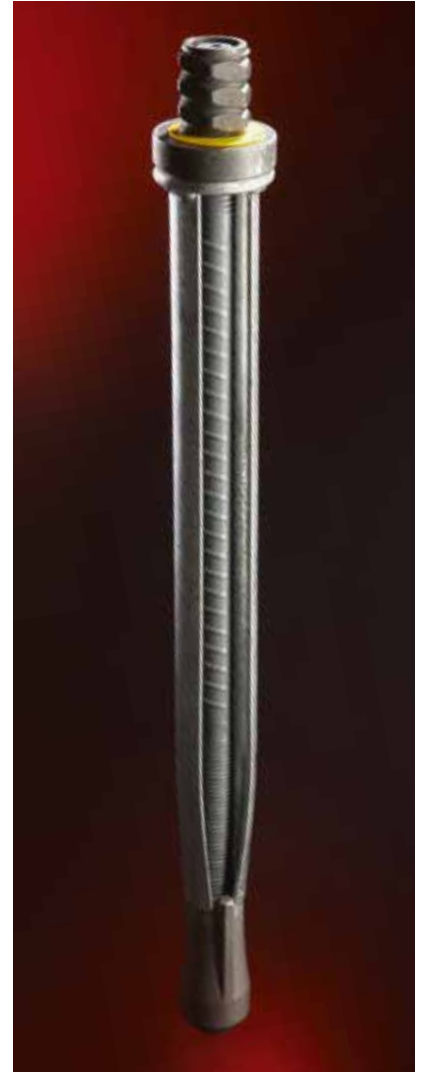
In metal mining, single pass bolting means that a hole is drilled and then a rock bolt is the only element that is inserted into the hole. This technique is frequently required where resin bolting is not possible due to instability caused by friable ground. The OMEGA-BOLT® with its high pressure water inflation system that ensures a tight connection to the borehole is frequently used in such conditions.

The customer needed a rock bolt that could be installed by a standard Jumbo bolting machine. Furthermore, they needed a bolt that could both accommodate high point anchor loads and was compatible with existing Mesh Xpress Anchor Plates.

The research and development team of DSI Australia decided on combining two existing products with a novel bolt head design to produce the Kinloc Bolt. The name of the rock bolt is derived from the concepts of "kinetic energy" and "locking ability", both of which are key features of the new bolt.

The Kinloc Bolt has a bar diameter of 47mm and can be installed in a single step. Its load-bearing capacity is 30t, and the bar has a minimum bar yield strength of 220kN and a minimum bar tensile strength of 305kN.

The Kinloc Bolt is positioned within the existing friction bolt range and affords the customers of DSI Australia best value solutions for anchoring in difficult ground conditions. As a one stop shop, DSI also offers its customers the complete range of accessories such as wrenches, washers and mesh plates, pull test rings etc.



You will find an animation of the Kinloc Bolt on DSI's Youtube channel.



DSI Australia's Product Range now also includes Injection Resins for Coal Mining

Resin injection has established itself as a system for strata control both in construction (civil) and underground applications. In addition, resins can also be used to control water inflow and to seal gas - an application that is of particular interest in underground coal mining. Towards the end of 2013, DSI entered the Australian market for this important field of activity.

The company plans to introduce a comprehensive range of products based on polyurethane and urea silicate technology. In addition to its range of products and systems for underground mining, DSI Australia will offer two types of high expansion, resin based cavity fillers: urea silicate foam resins and phenolic foam resins.

DSI Australia offers both material supply and product application. Distribution can either be carried out directly to the end user or through an appointed contractor. During product application, a type of pump is used that has never been utilized before in Australia.



DSI Australia is extremely well placed on the market and can integrate this type of technology perfectly into its existing steel ground support product range. The approval process for using these new products in New South Wales coal mines has commenced with the successful testing of a strata binding/water sealing urea silicate resin for which approval has been applied for.

In addition to stringent quality control, DSI Australia has also developed a training package that helps to ensure that customers benefit from the optimum application of these products for their projects.



DSI secures Supply of Ground Support to Ranger 3 Deeps Mine

Underground

APAC

Australia

Mining

Following the completion of mining in Ranger Mine's Pit 3 in 2012, Energy Resources of Australia (ERA) has begun the transition from open cut mining to underground exploration of the Ranger 3 Deeps mineral resource. DSI was invited to tender the supply of ground support for this project by MacMahon Mining Underground. DSI were successful in securing this work and commenced supply in December 2013. DSI supply a resin bolt system as well as friction bolts and mesh. This mine is serviced by DSI Mount Isa.

ERA is one of the largest continually operating uranium producers in the world. Uranium has been mined at Ranger for three decades and Energy Resources of Australia has an excellent track record of reliably supplying customers.

Ranger mine is one of only three mines in the world to produce in excess of 110,000t of uranium oxide. This product is used to generate electricity using nuclear energy, which produces minimal carbon emissions.

Ranger Mine is located 8km east of

Jabiru and 260km east of Darwin, in Australia's Northern Territory. Located on the 79km² Ranger Project Area, Ranger mine is surrounded by, but separate from, the World Heritage listed Kakadu National Park.

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Owner Energy Resources of Australia Ltd. (ERA), Australia
General Contractor Macmahon Mining Services Pty Ltd., Australia

DSI Unit DYWIDAG-Systems International Pty. Ltd., Australia

DSI Scope Production, supply

DSI Products Resin bolts, friction bolts, mesh



DSI Australia invests in increased Productivity

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Underground

APAC

Australia

Special

DSI's Mining Division has shown very dynamic growth within the last few years. The above average growth is based on strong organic growth on the one hand and on selective strategic acquisitions on the other hand. As a result, DSI is now one of the world's leaders in the development, production and supply of high quality mining products. In addition, DSI offers its clients the world's most comprehensive range of mining products.



All DSI companies around the world are continuously working to enhance their processes in production, supply chain, development and logistics. The continuous optimization of the production process is of key importance in this context.



Recently, DSI Australia reached an important milestone for optimizing production processes at its production facility in Bennetts Green, New South Wales, Australia. Here, two old stamping presses were replaced by two state-of-the-art 300t presses.

The new machines not only press conventional anchor plates. With the help of rigid tools, domed anchor plates can be produced in different shapes using the deep-drawing method – and the production procedure is twice as fast as with the old presses!

Thanks to rapid tool changes and significant reductions in down time, DSI Australia has been able to double the output for some of its products. The new presses were located above a purpose built underfloor scrap conveyor to ensure enhancements to the production and planning schedules.

The presses weigh 38t each and had to be lowered into position through the factory roof with a 250t mobile crane requiring 97t of counterweights for the lift that were delivered to the DSI yard on five semi-trailers. Thanks to a well-organized team, the machines could be placed at their exact final locations in just six hours.

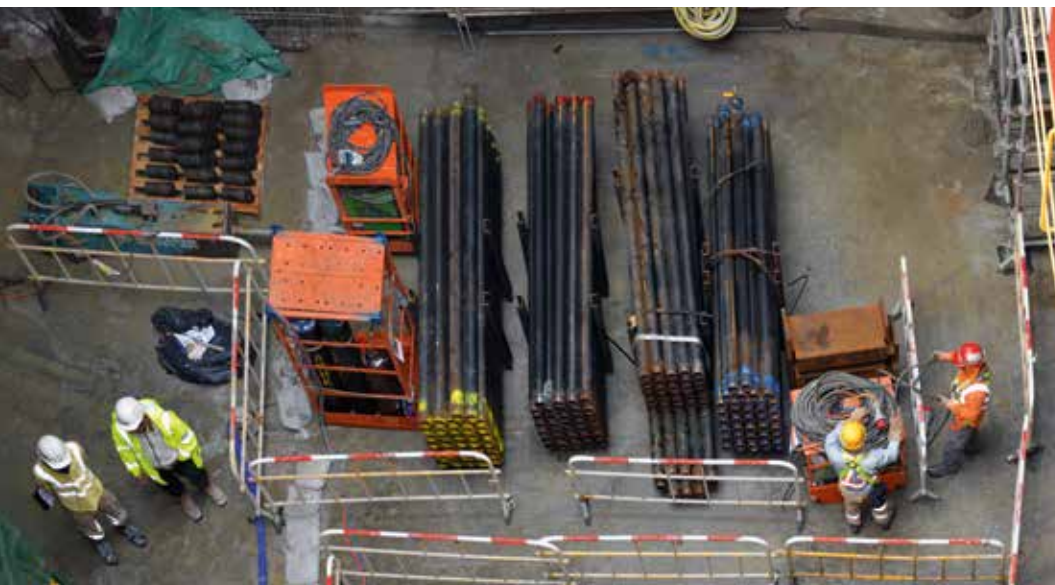
By continued investments in production, we are consistently extending our cost leadership in production around the world. Our aim is to offer our demanding customers the most comprehensive product range available on the market just in time as a one stop shop.

SCL Hong Kong: DSI Austria supplies Ground Support Products for Modern Transportation System

The Shatin to Central Link (SCL) is a new 17km railway connection that runs through several districts of Hong Kong. Once completed, the SCL will significantly shorten travel time between East Kowloon, the eastern, western and northern New Territories and the North of Hong Kong Island. The project consists of two parts – the East-West Corridor and the North-South Corridor.

As the SCL runs through existing districts along the entire planned route, the major part of the line will be underground. In the East-West Corridor in section SCL1103, several tunnels were built that will connect Hing Keng and Diamond Hill stations. Diamond Hill will be the future main traffic hub for East Kowloon.

Section 1103 has a total length of 3,877m and is built by VINCI Construction Grands Projets, Hong Kong. The two parallel tunnel tubes in this area were advanced using a 7.4m diameter Tunnel Boring Machine (TBM) along a 1,695m long section. The second, 2,182m long part of the section was built using the drill and blast method.



As the responsible engineering office, Ove ARUP and Partners supported the General Contractor with services including engineering, design and project management.

DSI Austria supplied a comprehensive range of ground support products for tunneling in section 1103. The fact that comprehensive certifications and quality demonstration records had to be provided once again for each individual product in Hong Kong represented a major challenge. Many products that had already established themselves many years ago on international markets had



to undergo comprehensive quality tests at accredited universities in order to obtain permission for use in Hong Kong.

In addition to DYWI® Drill Anchors, which were used as a self-drilling ground control solution, DSI Glass Fiber Anchors and POWER SET Self-Drilling Friction Bolts were used for rock stabilization. PANTEX Lattice Girders were used as passive support system for the excavated cross section. As a pre-support measure used in weak ground conditions, DSI Austria also supplied the Type AT – 114 Pipe Umbrella System with nipple connections.

The pipe umbrellas increase the stability in the working area by transferring loads in the longitudinal direction and decrease excavation induced deformations.

Experienced DSI Austria employees supervised the installation of the products and systems on site, ensuring smooth and efficient working procedures.



Owner MTR Corporation Limited, China
General Contractor VINCI Construction Grands Projets, China
Planner Ove ARUP and Partners, China/USA
Engineering Basler & Hofmann Singapur Pte Ltd., Singapore

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production, supply, supervision

DSI Products Type AT – 114 Pipe Umbrella System, DYWI® Drill Anchors, DSI Glass Fiber Anchors, POWER SET Self-Drilling Friction Bolts, PANTEX Lattice Girders





Ground Support Products by DSI stabilize Vienna's longest Subway Line: U1 Southern Extension

Work is advancing on the extension of the southern U1 subway line in Vienna.

The new section is 4.6km long, includes 5 stations and ends in Oberlaa. Beginning in 2017, the U1 subway line with a total length of 19.2km will be Vienna's longest.

The new section runs primarily underground – only the southernmost section will be above ground. Because the two parallel, single-track tunnel tubes are partly located at a depth of nearly 20m, tunnel excavation posed challenges to the participating companies.

The soil in this area is very cohesive, but also contains water-bearing strata that had to be drained.

For this purpose, a large number of wells and water gages were built that were necessary for relieving the water-bearing layers.

A large part of the subway station and tunnel sections as well as the crossways for this project were advanced using the New Austrian Tunneling Method (NATM). Most of the tunnel sections and crossways were advanced in a full-circle tunnel heading with an advancing crown being realized shortly before the invert. Ground support products that were used included spiles and forepoling boards in addition to reinforced shotcrete.

For tunneling pre-support, DSI Austria supplied DYWIDAG GRP Anchors and GRP Mats, lagging sheets and the Ø R32 and Ø R38 DYWI® Drill Hollow Bar System with accessories. Furthermore, DSI supplied Ø 51 x 3.2mm AT – TUBESPILE™ Vacuum Lances with accessories. 3-bar PANTEX Lattice Girders were used for immediate support in the open span area. In addition, the Type AT – 114 Pipe Umbrella System with nipple connections was used for pre-support. DSI's high quality products provide optimum support for local unstable areas in the work area and prevent stress relaxation during installation.





Owner Wiener Linien GmbH & Co KG, Austria

General Contractor STRABAG AG, Austria

Consulting Engineers Wiener Linien GmbH & Co KG, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria

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

DSI Products DYWIDAG GRP Anchors and GRP Mats, Ø R32 and Ø R38 DYWI® Drill Hollow Bar System with Accessories, lagging sheets, Ø 51 x 3.2mm AT – TUBESPILE™ Vacuum Lances, PANTEX Lattice Girders, Type 114 AT – Pipe Umbrella System



Construction of Germany's second longest Motorway Tunnel: The Hirschhagen Tunnel

The construction of the A 44 motorway between Kassel and Herleshausen is an important part of the trans-European motorway network. After its completion, the A 44 will efficiently connect the Benelux States in the West and Poland in the East.

In the section between Kassel and Herleshausen, the construction of the Hirschhagen Tunnel was necessary because of the local topography. The tunnel is designed as a double tube tunnel with 2 lanes each. The tunnel tubes are connected with each other by cross passages. The northern tunnel tube has a length of 4,128m, and the southern tube has a total length of 4,187m.



After its completion, the Hirschhagen Tunnel will be Germany's second longest motorway tunnel.

The tunnel portals are being built using open cut tunneling. Tied-back bored pile walls and a sheeting wall system are used for stabilizing the excavation at the western portal. Additionally, a vertical end wall with lateral retaining walls is being built in this area.

The cover above the crown measures up to 80m deep. Both tubes are being built using conventional tunneling methods and run mainly through colored sandstone formations. Tunneling is proceeding simultaneously from both tunnel portals.

The undercrossing of the Losse River near Eschenstruth is especially difficult. Underneath the river, there is a porous mixture of clay and sand deposits that is saturated. For undercrossing the river, an approx. 300m long gallery is being built at a depth of 15m through which the water will be drained from the surrounding ground.

The tubes are ventilated via a more than 80m deep shaft, the inner lining of which will be resistant to pressurized water and fitted with single-layer waterproofing.

DSI produced and supplied the AT – 139 Pipe Umbrella System for the construction of the two tunnel tubes. The system is especially suitable for tunneling in soft ground that is prone to subsidence and has the following principal advantages:

- Fast self-drilling installation
- Smallest possible stress relaxation due to an immediate support of the borehole wall during installation
- Accurate installation due to a minimized annular gap

In this project, a newly developed squeezed connection by DSI was used for the first time for the fast and safe connection of the casing tubes. This new squeezed connection is an important milestone in the history of the AT – Pipe Umbrella System that ensures an easy and cost-efficient connection of casing tubes on site.



In addition, DSI supplied numerous ground support products such as SN Anchors, DYWI® Drill Hollow Bar Anchors

as well as the AT – TUBESPILE™ and DYWI® Drill Self-Drilling Spiles for pre-support.



Owner Hessen Mobil Straßen- und Verkehrsmanagement, Germany
Contractor Köster GmbH and Baresel GmbH, both Germany

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Development, production, supply, technical support

DSI Products Type AT – 139 Pipe Umbrella System with newly developed squeezed connection for casing tubes; SN Anchors; DYWI® Drill Hollow Bar Anchors; AT – TUBESPILE™; DYWI® Drill Self-Drilling Spiles



The Alaufstieg: DSI supplies Tunneling Products for High Speed Rail Line

The Stuttgart-Ulm railway project includes several major projects that will shift traffic from the roads to the rails. The existing, winding rail line south-east of Stuttgart over the Swabian Alb only allows peak speeds of 70km/h. In the future, ICE and TGV traffic will be transferred to a new line that will allow maximum speeds of up to 250km/h on a 30.4km long tunnel section through the low mountain range.

DSI Austria participated in the construction of two tunnel structures in the 15km long Alaufstieg section – the 8.8km long Bossler Tunnel and the 4.8km long Steinbuehl Tunnel.



At an inclination of 17-25 %, this section reaches a height of 750m above sea level at its highest point.

The Bossler Tunnel overcomes a total change in elevation of approx. 213m and has a cover of up to 280m. After its completion, the double tube tunnel with two rails will be one of Germany's longest railway tunnels. The structure is being advanced from the western portal on a 2,830m long section using a Tunnel Boring Machine (TBM) in the direction of the eastern portal. The 20,000 segmental liners that are needed for the tunnel are produced in a field factory. The ensuing tunneling work is being undertaken using blasting advance and shotcrete. The double tube, single track Steinbuehl Tunnel is advanced using conventional blasting.

The Jura geology at the Alaufstieg is a major challenge for tunneling. The section is located in brown Jura with low rock stability and in Oxfordian and compact limestone formations, the latter of which tends to have karst formations and a high water potential.



Tunneling is first carried out at the crown, which is stabilized using rock anchors, PANTEX 3 bar Lattice Girders and shotcrete. After an advance section of approx. 500m, the bench and invert are blasted and dug off. In the rock areas that are sensitive to load shifting, the tunnel is advanced using an 11m diameter full-circle tunnel heading with fast ring closure.

DSI Austria supplied several high quality products and systems for stabilizing tunnel advancement. DYWI® Drill Hollow Bar Anchors and Self-Drilling Spiles, SN Anchors, DYWIDAG GRP Anchors, PANTEX Lattice Girders and OMEGA-BOLT® Rock Bolts were some of the products used for rock support.



Owner DB Netz AG, Germany

General Contractor Joint Venture Albaufstieg, consisting of PORR Bau GmbH, C. Hinteregger & Söhne Baugesellschaft m.b.H., ÖSTU-STETTIN Hoch- und Tiefbau GmbH and SWIETELSKY Baugesellschaft m.b.H., all of them Austria

Engineering iC consulenten Ziviltechniker GesmbH, IL - Ingenieurbüro Laabmayr & Partner ZT GmbH and ILF Beratende Ingenieure ZT GmbH, all of them Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production, supply

DSI Products DYWI® Drill Hollow Bar Anchors and Self-Drilling Spiles, SN Anchors, DYWIDAG GRP Anchors, PANTEX Lattice Girders and OMEGA-BOLT® Rock Bolts

Fault Zones in Borth Rock Salt Mine successfully stabilized

Underground

EMEA

Germany

Mining

Esco european salt company is Europe's largest salt producer and is part of the global production network of the K+S Group with locations in Europe as well as North and South America.

esco european salt company operates three salt mines in Germany. This includes the Borth rock salt mine in Rheinberg at the Lower Rhine in North Rhine-Westphalia. Approx. two million tons of salt are extracted in this mine per year. Rock salt from Borth is known for its high purity and is used in domestic salt shakers and in the chemical industry as well as in pharmaceutical products. It is used as road salt for winter services in Germany as well as throughout Europe.

In the Borth rock salt mine, the rock salt of the Lower Rhine region's salt pan is extracted from depths between 500m and nearly 1,000m over an area of 88km². The salt deposit has a thickness of approx. 200m and



extends for a length of about 10km from the German town of Rheinberg to the Netherlands.

All the salt removed from the mine is transported via a conveyor system. A large fault zone was identified near the main conveyor that had to be comprehensively stabilized. Together with project management,

DSI developed a stabilization concept that included DYWI® Drill Hollow Bar Anchors with expansion shells to immediately secure the anchors in their bore holes and posterior injection using DYWI® Inject SILO 8044 Resin.





The DYWI® Drill Hollow Bar Anchors with expansion shells were installed into pre-drilled boreholes and ensured immediate stabilization and fixation of the anchors in the borehole by expansion shell activation. In a second step independent of anchor installation, the annular space between the anchor and the borehole was completely injected using DYWI® Inject SILO 8044 Resin. Injection was realized through the hollow core of the DYWI® Drill Anchors from the bottom of the borehole. The short curing time of the silicate resin permitted the transfer of the full anchor force a mere 30 minutes after installation.

This way, the fault zone at the Borth rock salt mine was comprehensively stabilized to the full satisfaction of esco european salt company.

After assessing the submitted proposals, the Borth rock salt mine decided to use DSI's solution. A total of 900 Ø R32-280 DYWI® Drill Hollow Bar Anchors with expansion shells, Ø 32mm and maximum loads of 280kN in lengths of 5.7m was installed for stabilization. In the next step, the hollow bar anchors were fully injected with DYWI® Inject SILO 8044 Resin.

DYWI® Inject SILO 8044 is a 2-component silicate resin with excellent adhesive properties that cures quickly and solidly. It has been specifically developed for use with DYWI® Drill Systems. Both R32-280 DYWI® Drill Hollow Bar Anchors and DYWI® Inject Silo 8044 Resin have been approved for use in underground mining by the District Council of Arnsberg, department 6 mining and energy in North Rhine-Westphalia.



Owner esco european salt company, Germany
Operator esco european salt company, Germany

DSI Unit DYWIDAG-Systems International GmbH, Germany
DSI Scope Production, supply, engineering services, technical support
DSI Products 10t of DYWI® Inject Silo 8044 Resin; 900 Ø R32-280 DYWI® Drill Hollow Bar Anchors with expansion shells in individual lengths of 5.7m





High Quality Ground Support for difficult Terrain: Tunneling Projects along the A1 in Bosnia

The A1 in Bosnia and Herzegovina is a motorway project that will link Budapest with Southern Dalmatia as part of the Pan-European Traffic Corridor Vc. The section leads through difficult topography, resulting in a need for a large number of bridges and tunnels.

On the section that leads from the town of Vlakovo west of Sarajevo south-west towards the town of Tarčin, DSI Austria supplied ground support products and injection foam resins for five double tube tunnels:

- Tarčin Tunnel (400m long)
- Suhodol Tunnel (2,800m long)
- Grabosječ Tunnel (860m long)
- Tulica Tunnel (340m long)
- Gaj Tunnel (860m long)

The tunnels were primarily excavated using the New Austrian Tunneling Method (NATM).

Self-Drilling Ø R32-250 and R51-550 DYWI® Drill Hollow Bar Anchors were installed for excavation pre-support. In addition, DSI supplied the Type 114 AT – Pipe Umbrella System for pre-support. The pipe umbrella pipes increase the stability in the working area by transferring loads in the longitudinal direction.

In order to prevent the ingress of water and to consolidate loose rock in the tunnel working area, DSI Austria also supplied high quality DYWI® Inject Cement Injection Pumps with the necessary accessories.

DSI's products were completely and successfully installed until July 2014. The new road section will be opened to traffic in October 2014.





Owner JP Autoceste FBiH, Bosnia and Herzegovina

General Contractor Cengiz Insaat Sanayi ve Ticaret, Turkey

Subcontractor Euro Asfalt d.o.o., Bosnia and Herzegovina

Design DIVEL d.o.o., Trasa d.o.o., IPSA d.o.o., INTEGRA d.o.o., TZI d.o.o.,
all of them Bosnia and Herzegovina

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production, supply

DSI Products Ø R32-250 and R51-550 DYWI® Drill Hollow Bar Anchors,
Type 114 AT – Pipe Umbrella System, DYWI® Inject Cement Injection Pumps with
accessories

The Cassandra Mines in Greece: DSI's Silicate Injection Foam Resins ensure safe Underground Mining

Recently, the Canadian mining company Eldorado Gold has significantly expanded its places of production and resources via acquisitions and development programs. In 2011, Eldorado Gold also acquired Hellas Gold, Greece's largest gold producer.

Hellas Gold owns mining licenses for a 317km² large area with reserves of lead, zinc, silver, gold and copper. At the moment, extraction is also being carried out in the Cassandra Mines on the Chalkidiki Peninsula in northern Greece. This mine complex includes the Strationi and Skouries Mines as well as the Olympias Mine.

The Skouries Mine is the largest of the three mines and has gold, copper and porphyry reserves. Here, extraction will first be carried out in an open pit beginning in 2016.



Subsequent underground extraction has also been planned for this mine. For this purpose, a main gallery is being advanced that will permit access to the underground reserves.

Gallery advancement has been hindered by considerable water inflows of approx. 40m³ per hour.





At the Stratoni Mine, silver, lead and zinc are extracted in underground mining. Here, water penetrated into the main gallery with a volume of approx. 200m³ per hour so that a comprehensive sealing program was necessary. DSI Austria also supplied the silicate injection foam resins DYWI® MINERAL Bond and DYWI® MINERAL Fill together with pumps and accessories for sealing the gallery against incoming water.

The Olympias Mine is an underground mine with gold, silver, lead and zinc reserves. The existing galleries in this mine are being rehabilitated and new galleries are being built. Within the scope of this work, the owner asked DSI to supply DYWIDAG Rebar Rock Bolts and resin cartridges. The 25 x 500mm resin cartridges with curing times of 30 and 90 seconds were used to permanently fasten the Ø 22mm, 2.7m long DYWIDAG Rebar Rock Bolts in the boreholes.

To efficiently and permanently waterproof and seal the cavities around the gallery, DSI Austria supplied the silicate injection foam resins DYWI® MINERAL Bond and DYWI® MINERAL Fill together with the necessary pumps and accessories. As a result of their highly reactive foaming, the 2-component silicate injection foam resins ensure an immediate waterproofing against water ingress.



Owner Hellas Gold, Greece

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Supply

DSI Products

DYWI® MINERAL Bond and DYWI® MINERAL Fill Silicate Injection Foam Resins,
Ø 22mm Rebar Rock Bolts, 25 x 500mm resin cartridges

Bingham Canyon Copper Mine, West Jordan: Expansion to Underground Mining with DSI Products for Ground Support

Kennecott Utah Copper is a mining subsidiary of the global company Rio Tinto. For more than 110 years, Kennecott has been extracting copper, molybdenum, gold and silver in the Bingham Canyon Open Pit Mine southwest of Salt Lake City, Utah. Kennecott Utah Copper is the second largest copper producer in the US and satisfies between 13 and 25% of the country's demand for copper.

Bingham Canyon Mine is one of the world's largest open pit mines. As one of the top producing copper mines worldwide, Kennecott Utah Copper has reached a total production of more than 19 million tons of copper.

In the future, exploitation at the Bingham Canyon Mine will be expanded to include an underground



operation. During the excavation of the drifts and galleries for the new underground development, the ground conditions changed

from very competent hard rock conditions to fault zones and soft rock ground conditions.





To excavate in hard rock, DSI Underground Systems USA supplied uncoated and specially coated OMEGA-BOLT® Expandable Friction Bolts. In soft rock areas, DYWI® Drill Self-Drilling Spiles and the AT – TUBESPILE™,

two cooperation products of DSI Austria and DSI Underground Systems USA, were used for pre-support.

The AT – TUBESPILE™ is classified as a spile and permits a safe, reliable and easy installation in soft ground. Thanks to the AT – TUBESPILE™,

the rate of advancement was significantly accelerated, and the soft rock areas were efficiently stabilized.



Owner Kennecott Utah Copper, USA

DSI Units DSI Underground Systems Inc., USA;
DYWIDAG-Systems International GmbH, Austria

DSI Scope Production, supply, technical support

DSI Products OMEGA-BOLT® Expandable Friction Bolts;
Ø R32 DYWI® Drill Hollow Bar System; AT – TUBESPILE™

The Obduro® AP Coated OMEGA-BOLT®: Load-bearing Capacity in highly acidic Environments

Barrick Gold Corporation is one of the world's largest gold producers operating gold, silver and copper mines on four continents. The Goldstrike mining complex, which is also operated by Barrick, is located on the Carlin Trend, one of the most abundant gold deposits in the USA approx. 60km south-west of the town of Elko in Nevada. This is also where the Rodeo Mine, an extension of the Goldstrike Complex, is located.

Because of the highly corrosive environment at both the Goldstrike Complex and the Rodeo Mine, Barrick approached DSI for a solution. The aggressive environment had largely dissolved the previously installed mesh after only 6 days. A competitor's rock bolt with acid resistant coating could be pulled out by hand after only 30 days and was greatly damaged.

Barrick mining Engineers provided DSI with underground water samples from these mines, both of which were highly acidic and electronegative at pH values around 1.5. For 72 days, DSI tested OMEGA-BOLT® samples with a special Obduro® AP Coating



in the first solution with a pH value of 1.5 – this contained, but was not limited to a sulfuric acid concentration of 14%. In contrast to the competitor's product, which began to corrode after one day, the Obduro® AP coated OMEGA-BOLT® did not show any reaction at all to the highly acidic sample.

The second sample solution contained pH levels of 1.8, had other acids in addition to a sulfuric acid concentration of 13% and was highly electronegative. The Obduro® AP Coating did not show any reaction after 15 days in the second sample solution. Even a fully coated washer that sat in the solution for 400 days did not show any damage at all.

In contrast to this, the competitor's bolt that was tested reacted violently with the second mine sample only a few minutes after exposure.

The tests were conclusive and clearly demonstrated that the competitor's product does not protect the bolt against acid corrosion. In contrast, DSI's Obduro® AP Coating withstood tests that were even more severe. The coating was neither damaged by sulfuric acid with a pH value of 0.3 at a concentration of up to 93%, nor did it show any reaction to hydrochloric acid with a pH value of 0.7 and a concentration of up to 70%. Acid solutions with concentrations above 30% are very rare in nature.

In co-operation with the mine operator, DSI installed 12 Obduro® AP coated OMEGA-BOLT® Rock Bolts alongside the competitor's coated rock bolts in the mine. 30 days after installation, tests were carried out. The tests were completed using DSI's equipment - an Enerpac RCH 302 cylinder. All of the pull tests performed were carried out with the required load of 12t. All of the competitor's rock bolts pulled out by hand and were strongly corroded, whereas all of the Obduro® AP coated OMEGA-BOLT® Rock Bolts successfully passed the tests.



During the 90 day test, DSI also cored out the area around one of the bolts. The OMEGA-BOLT® was absolutely coated in acid solution buildup, but the bolt had no surface damage, and due to the high abrasive strength of the coating, the point anchoring locations along the bolt did not cut through the coating to the steel.

Before the tests, Barrick had to install new bolts in both mines every 30 – 90 days. The coated OMEGA-BOLT® Rock Bolts that were installed following the tests only require biannual tests. DSI has color coated the bolts so that the mine personnel know instantly when they were installed.

Since the successful conclusion of the test program, DSI has supplied 209,000 OMEGA-BOLT® Rock Bolts and washers with Obduro® AP Coating to the Goldstrike Complex and the Rodeo Mine so that the operator has been able to significantly reduce inspection and rehabilitation work.

The greatest technical challenge during the development of the Obduro® AP Coating was to develop a coating that could adapt its shape to the shape of the OMEGA-BOLT® that was to be installed in the Barrick Mines: The welded and crimped bolt expands during installation. In addition, the coating had to have a high abrasive strength, allowing the coating to withstand the pull tests with loads of 12t without suffering any damage. The Obduro® Coating is an extremely high-capacity coating and has resisted all acid environments it has been exposed to up to today.



Competitor's Product



Owner Barrick Gold Corporation, USA

DSI Unit DSI Underground Systems Inc., USA

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

DSI-Produkte 209,000 Obduro® AP coated OMEGA-BOLT® Rock Bolts and washers

Construction of the Desvio do Rio Joana Tunnel solves decades-long Flood Problem in Rio de Janeiro

Since the beginning of the 20th century, many districts in Rio de Janeiro have been regularly affected by flooding caused by land reclamation and river regulations. The first plans for a water diversion tunnel intended to divert excessive water inflow from the Juana River into the Guanabara Bay date back to the 1970s.

In time for the FIFA World Cup, construction work has begun on a new sewer system that will divert a third of the Joana River's water. The Desvio do Rio Joana water diversion system includes five shafts for the purpose of water collection and levelling of the water outflow, a 2.5km long tunnel and an open canal gallery (cut-and-cover section) close to Guanabara Bay.

The main challenge during this project is tunneling beneath a main railway line close to Maracanã stadium. In this critical area, the default single tube tunnel system is divided into two smaller tunnels to minimize the impact of tunnel driving

on the surface and particularly on railway infrastructure. An intense monitoring and surveying of surface settlement is conducted in this critical area to ensure a safe and efficient construction cycle.

In addition to the difficult task of having to re-arrange the existing underground cable and pipe infrastructure while maintaining the lines in service, the construction company was confronted with a strict construction time limit of only 720 days for completing the tunnel.

DSI Underground Brasil provided a variety of ground support products such as rebar rock bolts and resin cartridges as well as technical support on site for this important infrastructure project.

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Owner Prefeitura da Cidade do Rio de Janeiro, Brazil
General Contractor Mendes Júnior, Brazil
Designer HT Engineers, Brazil

DSI Unit DSI Underground Brasil, Brazil
DSI Scope Production, supply, technical support
DSI Products Rebar rock bolts, resin cartridges



The Petropolis Tunnel: A Fast and Safe Connection with Rio de Janeiro

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Underground

South America

Brazil

Tunneling

Petropolis, which is located about 70km from Rio de Janeiro, once was the summer residence of the emperor Dom Pedro II. That is why it is also known as the imperial city of Brazil. Until today, a winding and dangerous motorway that is underdesigned for the approx. 20 million vehicles that pass through every year connects the city of Petropolis with Rio de Janeiro.



A new and safe highway system that is currently being built by the Consórcio Nova Subida da Serra (CNSS) will completely replace the current motorway from the town of Juiz de Fora to Rio de Janeiro and thus greatly reduce travel times.

As part of the new motorway, the 4.8km long Petropolis Tunnel will run through the hills of the Serra de Petropolis. Preparation for tunnel excavation started at the end of 2013, and the expected completion date is June 2015.

Tunnel excavation is partly accomplished by mechanical excavators and partly by drilling and blasting. DSI Underground Brasil

supplied a comprehensive range of ground control products, including SAFEROCK® Rebar Rock Bolts, resin cartridges and steel fibers.

i

Owner Consórcio Nova Subida da Serra (CNSS), Brazil

General Contractor Triunfo, Brazil

Engineering Intertechne Consultores S.A., Brazil

DSI Unit DSI Underground Brasil, Brazil

DSI Scope Production, supply

DSI Products SAFEROCK® Rock Bolts, resin cartridges, steel fibers



ITA-AITES World Tunnel Congress, Iguassu Falls, Brazil

Underground

South America

Brazil

Special

May 9 - 15, 2014

Brazil is experiencing a period of strong growth demonstrated by a large amount of underground projects such as the widening of the metro systems in São Paulo and Rio de Janeiro. In view of this development, the organizers ITA-AITES and the Brazilian tunneling committee CBT of the organization ABMS decided to hold this year's World Tunnel Congress (WTC) in Iguassu Falls, Brazil.

From May 9th to 15th 2014, more than 1,500 international expert participants gathered information about recent developments in tunneling.

DSI was also present at the WTC with a company booth this year. Owners from South America and the whole world showed great interest in the technologies, products and systems of DSI. This year's participation at the WTC was very successful. There is a definite trend towards an international rise in

demand for approved high quality systems and an increased significance of additional services.

DSI offers a comprehensive package of systems and services. The support of owners during the planning stage and training during the application of products and systems on jobsites are important criteria that significantly influence the success of a system supplier on the underground market.

DSI is planning to participate at the next World Tunnel Congress 2015 in Dubrovnik, Croatia.



WTC Brazil: DSI presents innovative Connections for the AT – Pipe Umbrella System

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Underground

South America

Brazil

Special

For the first time, this year's World Tunnel Congress (WTC) in Iguassu Falls, Brazil offered authors the opportunity to present their papers during the Agora Poster Session. During this session, presenters were able to show their posters on monitors and explain them in a short speech.

Wolfgang Dolsak, DSI Underground Systems, presented innovative connections for pipe umbrella systems. Pipe umbrella systems are a pre-support measure that is used in weak ground conditions.

DSI offers three different coupler types for pipe umbrellas:

- The standard threaded connection,
- the squeezed connection and
- the threaded nipple connection.

These connection types are mainly distinguished from each other by their stiffness- and strength properties in relation to the pipes' full section.

Thanks to the different technical characteristics of the connections offered by DSI, the AT – Pipe Umbrella System can be custom-fitted and adapted precisely to individual requirements on site.



May 16, 2014

Underground

South America

Brazil

Special

On May 16th 2014, the “Instituto de Engenharia”, the university for engineering in São Paulo, organized a tunnel symposium in co-operation with the Austrian Economic Chambers (WKO). The half-day seminar to exchange expert knowledge in tunneling was held on the university's premises in São Paulo.

More than 80 participants accepted the joint invitation of the Austrian Economic Chambers and the Instituto de Engenharia and were greeted by the host and organizer, Dr. Ingomar Lochschmidt, the

delegate for economy of the Austrian Economic Chambers in São Paulo, in person. The president of the university, Eng. Camid Eid and the vice president, Eng. Miriana Marques, also welcomed all participants.

Dr. Roberto Kochen, head of the university's infrastructure department, presented current construction projects and developments and put the focus on tunneling in accordance with NATM. In his presentation, he discussed Line 2 of the São Paulo Metro among other projects. Afterwards, Prof. Dr. Galler of the Montanuniversitaet Leoben, Austria, greeted all participants as the moderator of the event and

presented recent developments in tunneling in Europe. His presentation was followed by that of Prof. Johann Golser, Geo Consult, who presented additional case studies and recent projects.

Afterwards, several companies presented themselves to the participants – DSI was represented by Karl Boehm and Wolfgang Dolsak, who talked about recent developments in tunnel advancement and presented self-drilling anchor systems. Dr. Klaus Rabensteiner gave a speech on behalf of Geodata that was followed by a speech by Barbara Prommegger representing the company Hobas.

After the presentations, participants posed many questions that were discussed in a plenary session. The event was received very positively by participants and in the long run will strengthen contacts between the Brazilian tunneling industry and the universities and specialized companies in Austria.



Prof. Johann Golser, Geo Consult



Karl Boehm, DSI



Dr. Klaus Rabensteiner, Geodata

NATM Engineering Seminar in Santiago, Chile

April 2 - 4, 2014

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Underground

South America

Chile

Special

From April 2nd to 4th 2014, the ITA Austria organized an NATM Engineering Special Seminar in Santiago, Chile together with ÖGG and ITA Chile. After the opening by host Alexandre Gomes (Geoconsult), the development of the NATM was described by Wulf Schubert (Technical University of Graz).

Presentations by Robert Galler (Montanuniversität Leoben) about the design basics for underground works, Gerhard Harer (ÖBB) on site investigation and Erich Saurer (ILF) on the geological-geotechnical basics for an NATM design of tunnels under deep overburden followed. After the explanation of the structured design process of geomechanical design by Wulf Schubert, Andreas Leitner (IGT) and Erich Saurer described appropriate examples for NATM applications in tunneling.

The second day was devoted to geotechnical monitoring and the associated interpretation before the principles of the NATM construction contract based on the Austrian standard ÖNORM B2203-1 were described and illustrated by examples.

The speakers on these subjects, Wulf Schubert, Klaus Rabensteiner (Geodata), Wolfgang Dolsak (DSI), Karl Boehm (DSI), Robert Galler and Anton Kaltenboeck (ÖSTU-Stettin), also answered numerous questions asked by the highly interested audience.

The day was concluded with a presentation of the Koralm Tunnel project by Gerhard Harer that included a film dubbed into Spanish about the assembly of the TBM on contract KAT2 which met with good resonance. Talks on the third day included examples of safety in underground railway construction through monitoring measures, presented by Klaus Rabensteiner, and the implementation of appropriate ventilation design both for the construction and operation phases by Peter Reinke (HBI).

Examples of the application of the NATM on international tunnel and mining projects brought this special seminar to a conclusion for the 70 participants from Chile, Argentina and Costa Rica. In addition to the intensive training program, some time was still available for socializing, with an extremely positive impression from numerous discussions with colleagues from South America and a range of new contracts in the leading mining country in South America.

Source: Geomechanics and Tunneling 7 (2014), No. 3



Inaugurated in 1975, Metro de Santiago is one of the largest and oldest subway systems in South America and a major method of transportation for the city of Santiago de Chile.

In the middle of 2013, work began on two new lines – line 3 and line 6. After completion of the new lines, the Metro de Santiago will be 140km long with 136 stops in 26 districts.

Line 6 will have a total length of 15.3km and include 10 stops; travel time to the city center of Santiago de Chile will be cut in half. The line will run from Cerrillos Station in the south-west to Los Leones Station in the city's north-east and is scheduled to be operational by the end of 2016. Line 3 with a total length of 22km is scheduled to be completed in 2018.

To complete the new lines 3 and 6 and their 28 new stations, approx. 37km of tunnels as well as many new access shafts are being built across the city.

In a first contract, DSI Chile is supplying lattice girders for the tunnels in section 3 and 4 of line 6.



Owner Metro de Santiago, Chile

General Contractor Joint Venture EI-OSSA S.A., consisting of Echeverría Izquierdo and OSSA (Obras Subterráneas S.A.), both Chile

DSI Unit DSI Chile Industrial Ltda., Chile

DSI Scope Production, supply

DSI Products Lattice girders

DSI Chile demonstrates Advantages of Resin Rock Bolt Systems in Chilean Copper Mine

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Underground

South America

Chile

Mining

The S.C. Minera Atacama Kozan copper mine is located approx. 15km south-east of the town of Copiapó in northern Chile. The owners, a joint venture consisting of Nittetsu Mining Co Ltd., a Japanese firm, and Inversiones Errazuriz Ltd., a Chilean company, have been mining copper at this location since 1998.

The extraction is carried out using the sub-level stoping method. In this method, the ore inside a vein is extracted vertically from an open stope in a series of sublevel drifts using drilling and blasting.

After extraction, the ore is processed in a 150,000t per month capacity finishing plant. The final product, copper concentrate, is mainly exported to Japan, but also sold on the Chilean domestic market.



In co-operation with the mine engineers, DSI Chile carried out a series of tests in order to define possible areas of application of polyester resins for the rock bolts used in the mine. At the moment,

the mine is using grout for injecting the anchor systems.

The test series, which was carried out in February 2013 in different parts of the mine, clearly demonstrated the advantages of the polyester resins supplied to the mine operator by DSI Chile:

- Significant time saving when using resin in comparison to grout
- Shorter curing times and therefore faster achievement of rock bolt load-bearing capacities
- Less time spent by the miner in the dangerous installation zone
- Automated installation process
- Improved profitability resulting from the use of the resin anchor system

The mine operator was convinced of the definite advantages of the system and is therefore investigating a changeover to resin anchors. DSI Chile is looking forward to supporting the mine with efficient resin anchor systems in the future.



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Owner Joint Venture, consisting of Nittetsu Mining Co., Ltd., Japan and Inversiones Errazuriz Ltda., Chile

DSI Unit DSI Chile Industrial Ltda., Chile

DSI Scope Technical support, supply, test installation

DSI Products Polyester resins, resin rock bolts

The ecological Alternative: Tunnel Excavation for the Cheves Hydroelectric Power Plant in Peru

In 2010, construction work began at the Cheves hydroelectric power plant that is located on the Huaura River approx. 130km north of Lima. When the plant is completed in 2015, it will add 168MW or 837GWh to the main electric grid via a 77km long transmission line.

The underground construction portion of this project consists of approx. 19km of tunnels and a power house cavern with two turbines. The tunnel is mainly excavated by drilling and blasting.



Ground conditions in the project area vary greatly. The tunnels were driven through sedimentary, igneous and volcanic rocks as well as swelling clay and fault zones, which posed additional challenges for the participating companies. Furthermore, the high overburden of up to 1.2km resulted in stresses that exceeded the rock mass strength, causing rock bursts. Water inflows and rock-bedded methane gas also made tunnel excavation difficult.

Due to the difficult ground conditions, high quality and modern ground control solutions were provided for the Cheves Hydroelectric Power Plant project by DSI. Self-drilling DYWI® Drill Rock Bolts and Spiles were installed in combination with PANTEX Lattice Girders to provide a safe underground environment during advancement and excavation.

In total, DSI Peru supplied 4,038 4m long Ø R32 DYWI® Drill Hollow Bars, 1,917 3m long Ø R38 DYWI® Drill Hollow Bars, 300 4m long Ø R38 DYWI® Drill Hollow Bars and PANTEX Lattice Girders for stabilizing the highly unstable zones.

Furthermore, 921 Ø 22mm CT-Bolt™ Combination Rock Bolts in standard lengths of 2.4m were used for rock reinforcement in the hard rock areas. In addition, DSI Peru supplied DYWIDAG Cable Bolts and resin cartridges for rock stabilization. DSI Peru also supplied 7 mortar mixing pumps to the client.

The project was registered as CDM (mechanism for environmentally friendly development) by the United Nations because it will balance the carbon dioxide driven energy mix in Peru by a more ecological alternative for generating energy. It is expected that the new hydroelectric power plant will reduce CO₂ emissions by an estimated 394,000t per year.



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Owner Joint Venture Tinguirica Energía, consisting of SN Power, Norway and Pacific Hydro, Australia

Client Cheves Empresa de Generación Eléctrica S.A., Peru

Engineering Norconsult, Norway

Contractor Joint Venture Constructora Cheves S.A.C., consisting of HOCHTIEF Solutions AG, Germany, SALFACORP S.A., Chile and ICCGSA, Peru

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

DSI Scope Production, supply, technical support

DSI Products Ø R32 and Ø R38 DYWI® Drill Rock Bolts and Spiles, PANTEX Lattice Girders, Ø 22mm CT-Bolt™ Combination Rock Bolts, DYWIDAG Cable Bolts, resin cartridges, mortar mixing pumps

The Quellaveco Project: Copper Extraction in one of the World's largest Mining Areas

43

Underground

South America

Peru

Tunneling

One of the world's largest copper deposits is located approximately 37km north-east of the town of Moquegua in southern Peru. The deposit includes estimated reserves of 1.1 billion tons of copper ore.

Anglo American is currently carrying out a new feasibility study thanks to which the planned copper extraction capacities in Quellaveco Mine could be increased by 20% to 270,000t of copper per year.

Although the main construction work for this development has been postponed to 2015, some work has already been carried out. The Asana River, which currently crosses the mining field, will be retained by a 40m high dam and then diverted into a tunnel.

The diversion tunnel project consists of the main, 7.8km long water tunnel with a 1.2km long access tunnel and a 4km long conveyor tunnel.

Slope stabilization in the portal areas has been accomplished using the DYWI® Drill Hollow Bar System, mesh, and shotcrete. For slope stabilization in this area, DSI Peru supplied a total of 508 3m long diameter T76 DYWI® Drill Hollow Bars as well as 461 4m long diameter T76 DYWI® Drill Hollow Bars. In addition, DSI supplied 875 couplers and 513 Ø 200mm button drill bits.

The main method used for the first part of the tunnel excavation was drill and blast. The ground support scheme consists of lattice girders, mesh, rock bolts, and reinforced shotcrete. For the second part of the tunnel that will be built, DSI Peru will presumably also supply forepoling systems that are required for driving through the expected fault zones.

i

Owner Anglo American plc, Great Britain

General Contractor Mas Errázuriz, Peru

Contractor Cosapi S.A., Peru

Design Ingendesa S. A., Chile

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

DSI Scope Supply, technical support

DSI Products 969 Ø T76 DYWI® Drill Hollow Bars with couplers and button drill bits



DYWIDAG Anchor Systems secure third Berth in Hay Point Harbor, Australia

Hay Point Harbor, one of the world's largest coal export ports, is located south of Mackay in the Australian state of Queensland, Australia's second-biggest coal producing state. The Hay Point Coal Terminal is currently undergoing its third expansion to increase capacity from 44 million t per year to 55 million t per year.

The expansion, which is known as HPX3, involves replacement of existing trestle conveyors and surge bins, construction of overland conveyors to transfer coal from the stockpile to the jetty, offshore dredging and the construction of a third berth with a ship loader.

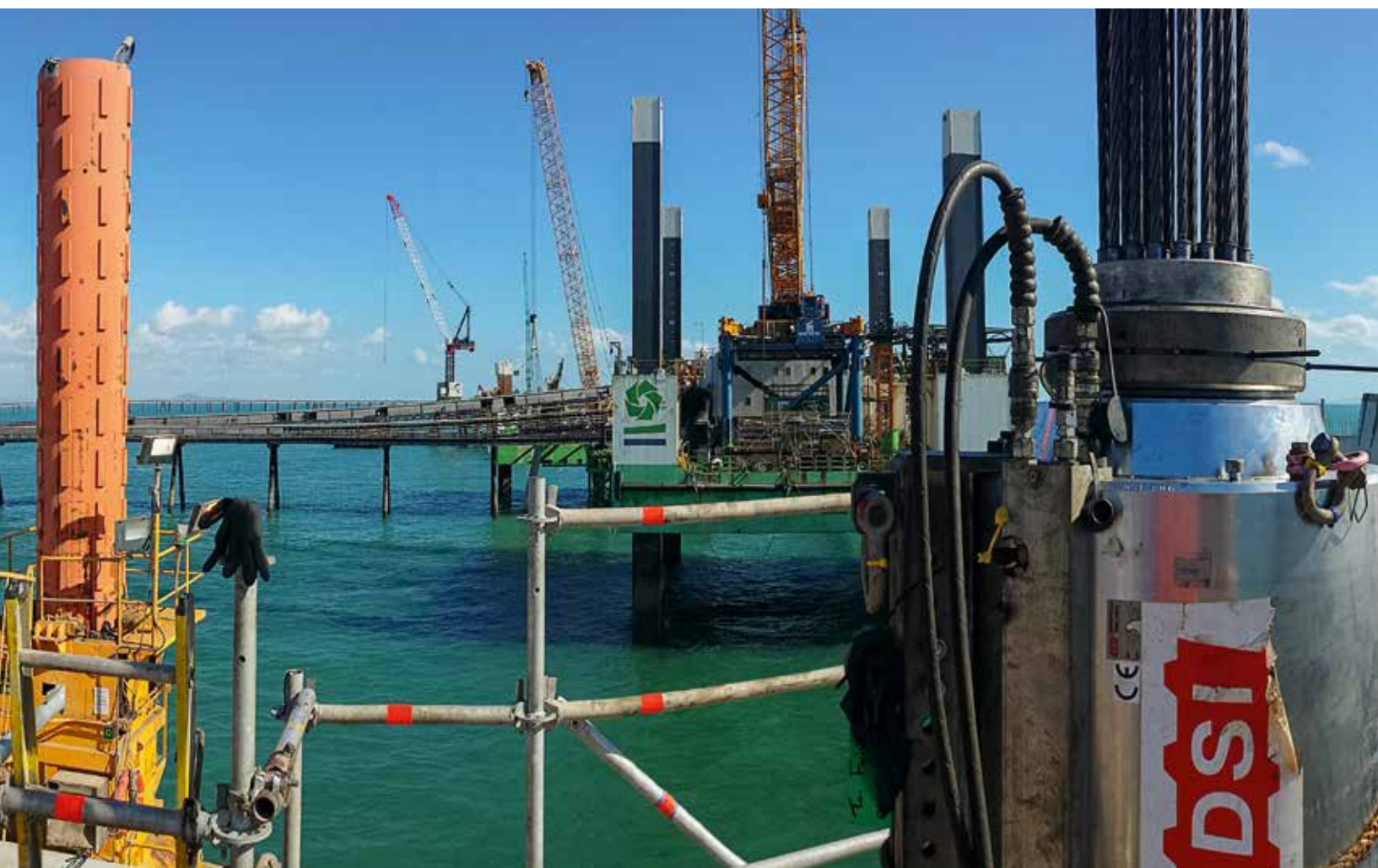
DSI Australia's Civils and Tunneling Division were awarded a contract to deliver

- 67 permanent Type 30-0.6" DYWIDAG Strand Anchors in lengths of 40 to 54m and
- 700 permanent Ø 57mm THREADBAR® Anchors in lengths of 11.8m

The production of the permanent DYWIDAG Strand Anchors presented a challenge, as prior to this project, DSI Australia had only produced anchors with up to 27 strands without sheathing. Transportation of the coiled anchors and their protection from damage during transportation over a distance of almost 2,000km from

Newcastle, New South Wales to the installation location also proved to be logistically complex.

The project called for close collaboration between DSI Long Beach and DSI Australia. An Australian team consisting of members from the logistics, production, engineering, quality assurance and sales departments designed the required system components and the anchor assembly technique required to pull the 54m long DYWIDAG Strand Anchors into corrugated PE sheathing. The team also planned the transport of the anchors that were coiled on steel reels to the jobsite and set up an extensive quality assurance program specific to this project.





Thanks to the excellent co-operation between the units, the first delivery of DYWIDAG Strand Anchors to the project site was successfully accomplished in June 2012. This project has not only proved DSI's ingenuity and teamwork, but has also shown that DSI's strategy of "**Local Presence – Global Competence**" is truly lived within the company.



Owner BHP Billiton
Mitsubishi Alliance (BMA), Australia

DSI Unit DYWIDAG-Systems
International Pty. Ltd., BU Civils,
Australia

DSI Scope Production, supply
DYWIDAG Products 67 permanent
Type 30-0.6" DYWIDAG Strand
Anchors, 700 permanent Ø 57mm
THREADBAR® Anchors

Cryogenic DYWIDAG Strand Tendons for Queensland's first Coal Seam Gas LNG Plant

On Curtis Island north of Brisbane, Australia, there is a modern LNG plant that turns coal seam gas into liquid natural gas. Coal seam gas is natural gas that is found in underground coal deposits.

On the premises of Australia Pacific LNG, Australia's largest producer of coal seam gas, three LNG tanks were built in which the gas is stored at a temperature of -162°C . The subcontractor STRABAG - DYWIDAG LNG Technology received the design and engineering contract for a total of four $140,000\text{m}^3$ LNG tanks.

DSI supplied cryogenic DYWIDAG Strand Tendons with MA Anchorages as ring tendons for the horizontal



post-tensioning of the two exterior reinforced concrete tanks. Type 19-0.6" DYWIDAG Strand Tendons were used in the horizontal direction and Type 15-0.6" DYWIDAG Strand Tendons were used as vertical tendons. All of the DYWIDAG Strand Tendons were inserted in GDP plastic ducts.



Owner Australia Pacific LNG, Australia
General Contractor Bechtel International Inc., USA
Subcontractor STRABAG - DYWIDAG LNG Technology, Germany
Engineering Golder Associates Pty Ltd., Australia

DSI Unit DYWIDAG-Systems International GmbH, GBU, Germany

DSI Scope Supply

DYWIDAG Products Type 19-0.6" and 15-0.6" cryogenic DYWIDAG Strand Tendons with MA Anchorages, $\varnothing 28$ and $\varnothing 32\text{mm}$ GEWI® Threadbars and cryogenic GEWI® Threadbars with accessories

LNG Production in Brunei: Cryogenic DYWIDAG Strand Tendons Stabilize new LNG Tank

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Construction

APAC

Brunei

Tanks

The sultanate Brunei in the South China Sea is very wealthy thanks to its revenues from its abundant oil and gas resources. In the coastal town of Lumut on the island of Borneo, Brunei LNG company produces liquid gas in a plant covering 130ha. 50% of the company's shares are owned by the government of Brunei, and 25% each are held by Shell Overseas Trading Limited and by Mitsubishi Corporation.

At the time of its completion in 1973, the facility was the first LNG producing plant in the western Pacific region. After a comprehensive rehabilitation and renovation in 1993, the plant now produces approx. 7.2 million tons of liquefied natural gas per year. Within the scope of the rehabilitation work carried out 20 years ago, the former Dyckerhoff & Widmann AG built two large LNG tanks with a volume of 65,000m³ each and with outer shells consisting of post-tensioned reinforced concrete.

A short while ago, the company now known as STRABAG International GmbH – DYWIDAG LNG was awarded a contract to build an additional LNG tank nearly twice as large with a capacity of 120,000m³. The tank has an outer diameter of 75.9m and reaches a height of 46.15m at its highest point.

The tank's foundation includes 1,328 vibro displacement columns, and the floor slab has a diameter of 77.9m. The 14,000m³ of concrete for the exterior tank required 800t of



cryogenic reinforcing steel in addition to 4,200t of conventional reinforcing steel.

The concrete wall has a thickness of 120cm at the bottom and narrows to 60cm at the ring beam underneath the roof. The 1,700t steel roof will be brought into its final position using air pressure once the post-tensioned exterior tank is complete.

DSI supplied cryogenic DYWIDAG Strand Tendons for post-tensioning the exterior reinforced concrete tank. In total, 316 Type 6819 DYWIDAG Strand Tendons with MA Anchorages were installed in the exterior walls. The strand tendons are inserted into approx. 20,000m of PP ducts. In addition, 18t of Ø 28 and 32 GEWI® Bars and 5t of cryogenic GEWI® Bars with accessories were required to build the tank.



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Owner Brunei LNG Sendirian Berhad, Brunei

Client STRABAG International GmbH – DYWIDAG LNG Technology, Germany

General Contractor Toyo Kanetsu K.K., Japan

Contractor STRABAG International GmbH – DYWIDAG LNG Technology, Germany

Engineering STRABAG International GmbH – DYWIDAG LNG Technology, Germany

DSI Unit DYWIDAG-Systems International GmbH, GBU, Germany

DSI Scope Supply, technical support

DYWIDAG Products 316 cryogenic Type 6819 DYWIDAG Strand Tendons with MA Anchorages, 18t of Ø 28 and 32 GEWI® Bars, 5t of cryogenic GEWI® Bars with accessories

DYWIDAG Ductile Connector System stabilizes Cilacap Oil Refinery against Earthquakes

Indonesia is one of the most important producers of crude oil in South-East Asia. Nevertheless, the country continues to depend on oil imports because of its high domestic demand. Consequently, the government has decided to increase its production capacity in its effort to become self sufficient in regards to oil supply.

The upgrade of the refinery near the town of Cilacap in Central Java is an important part of this plan. This project includes the construction of a new residue fluid catalytic-cracking unit that will increase the refinery's LPG production by 62,000 barrels per day to a total of 350,000t per year.



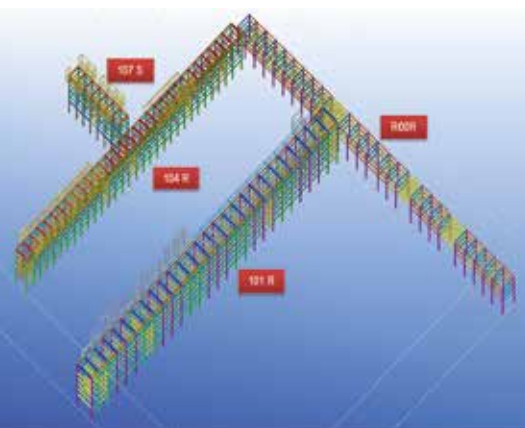
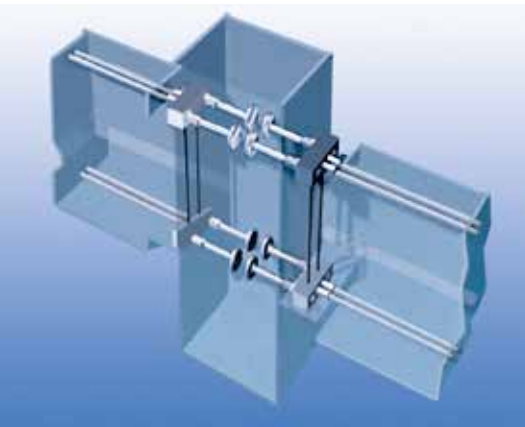
Originally, the pipe rack system for Cilacap Oil Refinery was to be built as a steel frame structure. However, due to cost savings of approx. 20% and the shortened construction period of 10 instead of 14 months, the client decided to build the pipe rack using precast concrete elements.

As Cilacap city is located in the seismic zone 3, the owner decided to use the DYWIDAG Ductile Connector (DDC) System for achieving a ductile connection between the precast concrete beams and the precast concrete columns. The use of the DDC system improves the flexural capacity of connections between beams and columns as well as between columns and foundation in comparison to monolithic systems.

The key element of the connector is a high strength DYWIDAG Steel Bar in which the entire post-elastic behavior occurs, protecting the beam and column from any possible damage. The required inelastic response of the connection is completely provided by the remaining connector components.

The flexible and economic DDC frame system makes it possible to assemble the precast concrete elements in a short period of time. The excellent earthquake stabilization abilities of the DDC System have been successfully proven through extensive testing. In fact, the ductile connector can accommodate a story-drift of over 4% without significant loss of strength.

For the expansion of the oil refinery, DSI Korea supplied a total of 978 sets of DDC for 340 columns and 1,438 beams consisting of 5,200m³ of concrete. DSI Korea is proud to have contributed to the stability and seismic resistance of the Cilacap Oil Refinery.



Owner PT Pertamina, Indonesia

General Contractor Joint Venture, consisting of GS Engineering & Construction Co., Ltd., Korea and PT Adhi Karya (Persero) Tbk., Indonesia

Subcontractor Joint Venture, consisting of Wika Beton (PT Wijaya Karya Beton), Indonesia and Euro Engineering, Korea

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

DSI Scope Development, production, supply, technical support, supervision

DYWIDAG Products 4,472 forged ductile rods; 35t of Ø 40mm DYWIDAG Bars, St 1080/1230; 65t of Ø 36mm DYWIDAG Bars, St 950/1050;

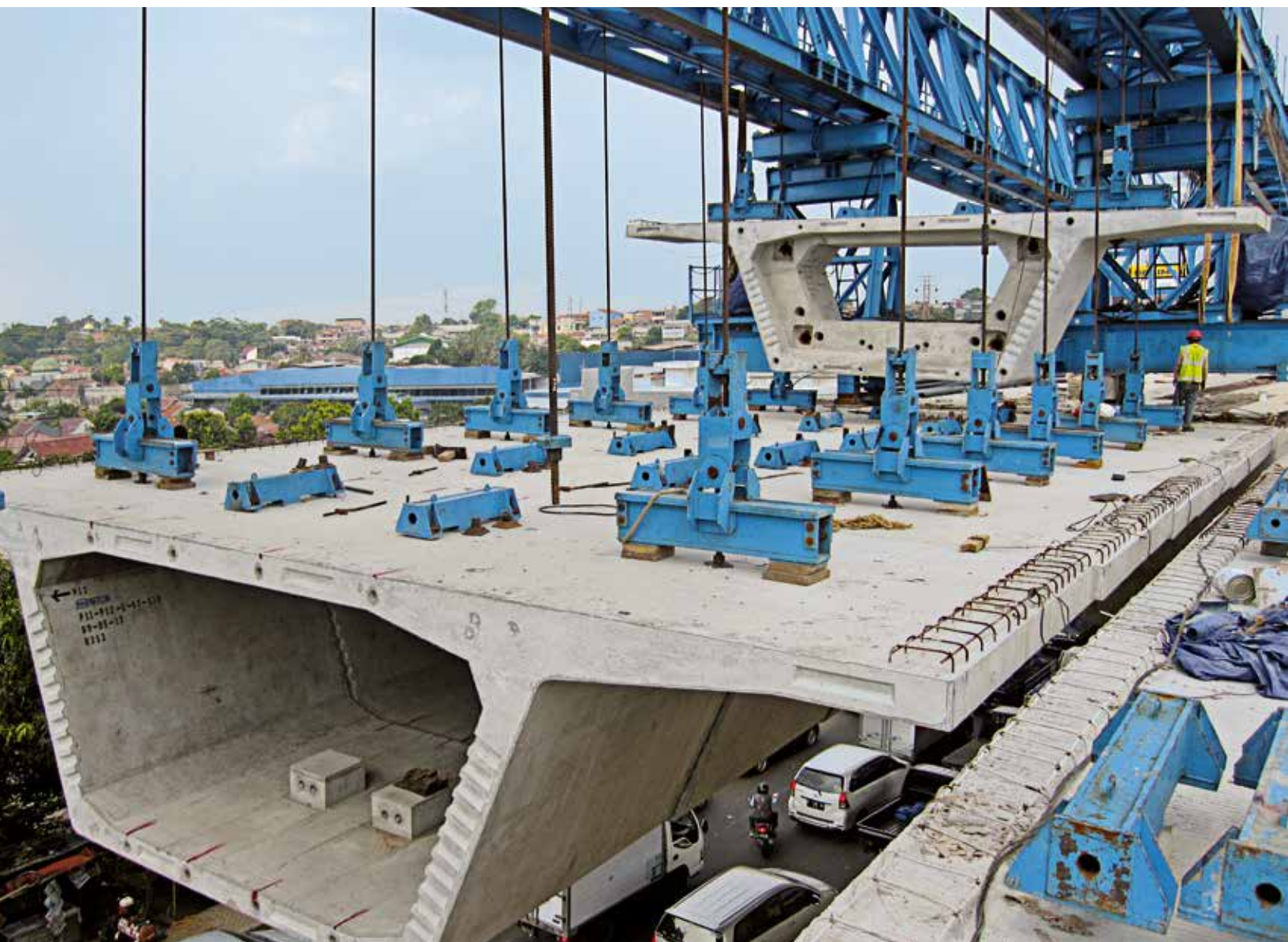
1,396 100 x 127 x 386mm connector plates and 560 100 x 127 x 480mm connector plates

Large Scale Project for DYWIDAG Strand Tendons: Bogor Outer Ring Road

Bogor Outer Ring Road is a new 11km bypass that circles the center of the city of Bogor in West Java, Indonesia. The highway allows traffic to bypass the road network in the center of the city, permitting a faster connection to Jakarta and Soekarno-Hatta Airport.

The project is divided into three sections, the first of which, a section that is just under 4km long, was opened to traffic in 2009. At the moment, the second, 4km long section is under construction. The third, 3.2km long section is currently in the planning phase.

In section II, DSI licensee PT Delta Systech Indonesia supplied and installed external and internal DYWIDAG Strand Tendons for several new elevated highways. PT Delta cooperated with DYWITECH Co. Ltd., Taiwan, to supply and operate the launching gantry for the erection of the precast segments using the span by span method and to provide technical support.





The launching gantry was designed by Wiecon engineering consultants, Taiwan, with a fully automatic system using an electric winch to lift the precast segments and a hydraulic system for launching the segments, so that overall construction time was reduced.

In total, the hollow box girders of the new elevated highways consist of approx. 1,000 precast segments. The box girders and pier heads were post-tensioned using internal and external DYWIDAG Strand Tendons with Type MA 6812, MA 6815, MA 6819 and MA 6822 Anchorages. More than 1,150t of Type 0.6" strand was used for the DYWIDAG Strand Tendons on this project. In addition, Ø 32 and 36mm DYWIDAG Bar Tendons were used for permanent stressing, temporary stressing and for hanging the segments during erection work.



Owner PT Marga Sarana Jabar, Indonesia

General Contractor PT Wijaya Karya (Persero) Tbk, Indonesia

Subcontractor PT Delta Systech Indonesia, Indonesia

Architect PT Eskapindo Matra, Indonesia

Engineering Wiecon Co. Ltd., Taiwan

DSI Licensees PT Delta Systech Indonesia, Indonesia;
DYWITECH Co. Ltd., Taiwan

Scope Supply, installation, engineering services, technical support, supervision

DYWIDAG Products DYWIDAG Strand Tendons with Type MA 6812, MA 6815, MA 6819 and MA 6822 Anchorages; Ø 32 and 36mm DYWIDAG Bar Tendons; supply of a span by span launching gantry

The K.H. Noer Ali Fly-Over in Summarecon - Bekasi: Efficient Infrastructures with DYWIDAG Tendons

Like many other cities in Asia, the Indonesian city of Bekasi east of Jakarta is dealing with an ever increasing traffic volume. Recently, a new fly-over was built there as an important infrastructure enhancement that provides a better connection of the city center to the east and to the modern district of Summarecon.

Named after the Indonesian independence patriot from the city of Bekasi, K.H. Noer Ali, this fly-over, opened for the public on April 13th 2013, is an east-south connection in Bekasi that leads over the main station. The elevated road is approx. 1km long and 22m wide and consists of approx. 724m long access ramps as well as a bridge structure consisting of a 130m long main span and two 73m long side spans. The side spans consist of a simple continuous prestressed concrete girder and the main span is a balanced cantilever two cell hollow box girder bridge. This project is one of the first two cell box girder bridges in Indonesia.

To post-tension the continuous prestressed concrete girder and the hollow box girder, DSI licensee PT Delta Systech Indonesia supplied and installed 650t of DYWIDAG Strand Tendons with Type MA 6819, MA 5912 and MA 5919 Anchorages. Furthermore, PT Delta cooperated with DYWITECH Co. Ltd., Taiwan, to supply and operate the DYWIDAG Form Travelers.



Owner PT Summarecon Agung, Indonesia
General Contractor PT Wijaya Karya (Persero) Tbk, Indonesia
Consulting Engineers PT Partono Fondas, Indonesia
Engineering PT Delta Systech Indonesia, Indonesia; DYWITECH Co. Ltd., Taiwan

DSI Licensees PT Delta Systech Indonesia, Indonesia; DYWITECH Co. Ltd., Taiwan
Scope Supply, installation, engineering services, supervision
DYWIDAG Products 650t of DYWIDAG Strand Tendons with Type MA 6819, MA 5912 and MA 5919 Anchorages; 6 DYWIDAG Form Travelers

DYWIDAG Strand Tendons stabilize Lemah Ireng II Bridge along the Trans Java Toll Road

As one of the main islands of Indonesia, Java is very important for the economic development of the country. Currently, a 1,000km long toll road is being built that will connect Jakarta's Capital city in the west with Surabaya city in the east: The Trans Java Toll Road. The new road will improve the road network on Java Island and thus the island's infrastructure as a whole.

The 75.7km long Semarang-Solo section in Central Java is part of this toll road. It will significantly improve the current road network in this region, which is often heavily congested, and will therefore considerably shorten travel times.

In this area, Lemah Ireng II Bridge is being built in hilly terrain. The bridge was originally going to be built with 40m long, simple precast concrete beams on 7 concrete piers. Together with the architect Wiecon, the DSI licensee PT Delta Systech Indonesia proposed changing the original design to a balanced cantilever bridge design. Thanks to the redesign, the bridge only needed two piers so that both the environmental impact and construction time could be minimized.

The nearly 300m long Lemah Ireng II Bridge with a height of 36m is one of the largest single cell hollow box girder balanced cantilever bridges in Indonesia. The bridge structure has a main span of 132m and two side spans with lengths of 83.75m each.

The lateral cantilevers of the hollow box girder have widths of 25.2m.

For prestressing the hollow box girder, PT Delta Systech Indonesia supplied and installed a total of 354.4t of DYWIDAG Strand Tendons with Type 6819 MA Anchorages for longitudinal tensioning and Type 5904 MA Anchorages for transverse tensioning. In cooperation with DYWIDAG Co. Ltd., Taiwan, PT Delta Systech Indonesia also supplied and operated four sets of DYWIDAG Form Travelers.



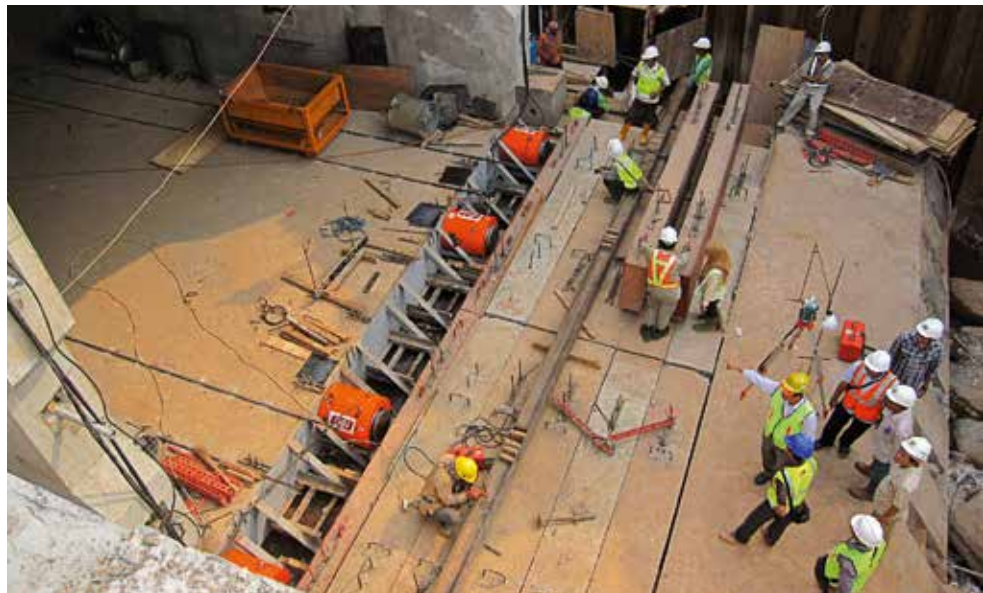
Owner PT Trans Marga Jateng, Indonesia
General Contractor PT Waskita Karya, Indonesia
Architect Wiecon Co. Ltd., Taiwan
Engineers PT Delta Systech Indonesia, Indonesia; DYWIDAG Co. Ltd., Taiwan

DSI Licensees PT Delta Systech Indonesia, Indonesia; DYWIDAG Co. Ltd., Taiwan
Scope Supply, installation, engineering services, supervision
DYWIDAG Products 354.4t of DYWIDAG Strand Tendons with Type 6819 and Type 5904 MA Anchorages, 4 DYWIDAG Form Travellers

Modern Tunnel Construction Method in Jakarta: The Cibubur Underpass

Recently, a new underpass was completed in eastern Jakarta in Central Java, Indonesia that will improve what was a tight traffic condition in this area: The Cibubur Underpass.

The 1,030m long Cibubur Underpass is part of a road construction program of the Indonesian government. The underpass consists of a 151m long access ramp in the east, a 93m long box underpass tunnel and a 786m long exit ramp in the west. As one of the first tunneling projects in Indonesia, the underpass was built using the Jacked Box Method.





For this challenging project, PT Delta supplied and installed a total of 1,670m temporary DYWIDAG Ground Anchors and 17.2t of DYWIDAG Strand Tendons with Type MA 5907 and 5912 Anchorages. In addition, they supervised the project and supported the owner with the design.

At the same time, Cibubur Underpass is also the longest tunnel in Indonesia to have been built using this method.

In box jacking, a large reinforced concrete box girder is driven through the soil using hydraulic jacks. By using this method, flat tunnel structures can be built underneath existing infrastructure without affecting traffic on the surface. In Jakarta, this construction method was ideal because the tunnel was built underneath one of the most important connecting roads between Jakarta and Bogor and because it permitted a significant reduction in construction time.

The DSI licensee PT Delta Systech Indonesia contributed to this project by providing the review design, detail design and engineering services. The review design replaced the 93m continuous box girder originally intended with 10 precast concrete box segments that were tightly connected using Type 5907 DYWIDAG Post-Tensioning Tendons with MA Anchorages.

The 450t box segments were 9.3m long, 9.7m wide, 7.4m high and had a wall thickness of 60cm at the top and 80cm at the bottom. The segments were driven using eight hydraulic jacks with a capacity of 1,000t each that were supplied and operated by PT Delta Systech Indonesia.



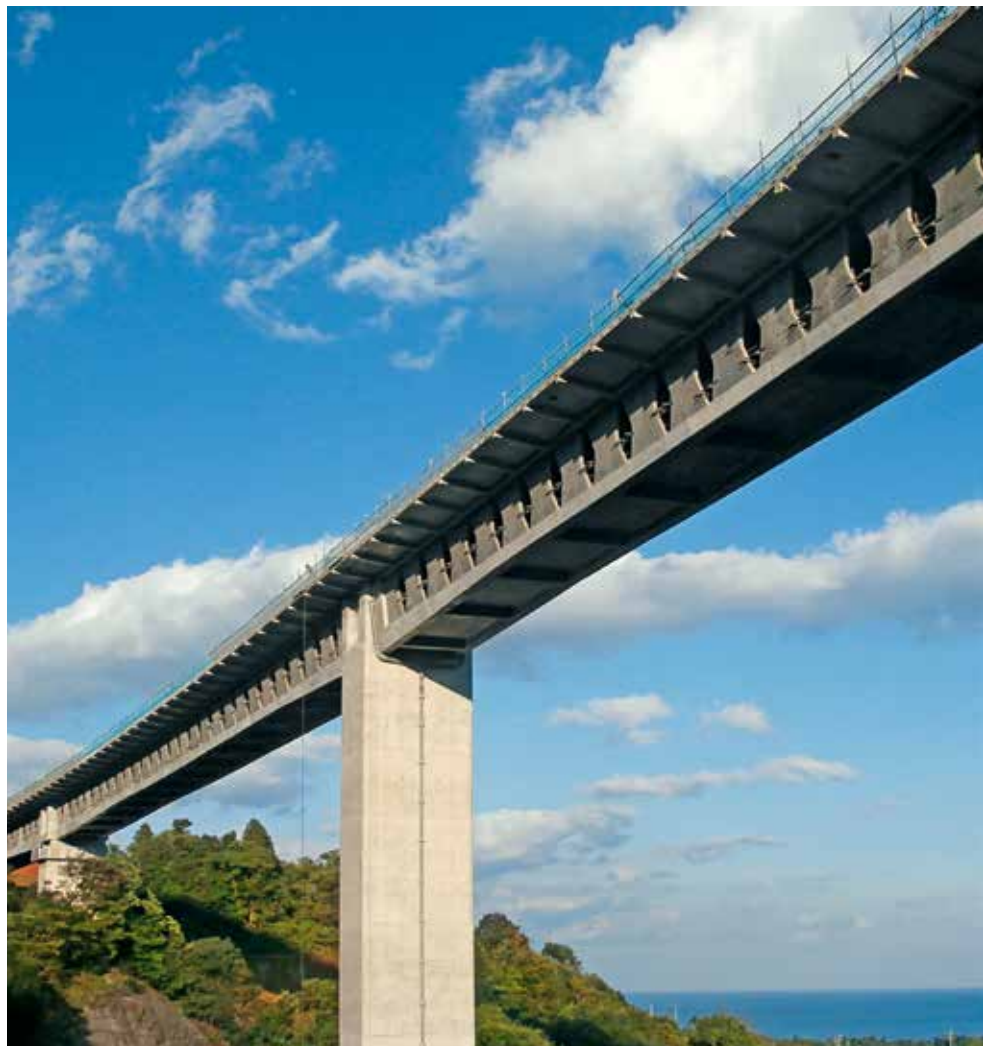
Owner Department of Public Works, Indonesia
General Contractor PT Brantas Abipraya (Persero), Indonesia
Architect Department of Public Works, Indonesia
Consulting PT. Epadascon Permata, Indonesia

DSI Licensee PT Delta Systech Indonesia, Indonesia
Scope Supply, installation, engineering services, supervision
DYWIDAG Products 17.2t of DYWIDAG Strand Tendons with Type MA 5907 and 5912 Anchorages; 1,670m of temporary DYWIDAG Ground Anchors; rental of 8 jacks with 1,000t capacity

A new Type of Bridge using Butterfly Shaped Panels: The Terasako Choucho Bridge

Terasako Choucho Bridge is a 712.5m long continuous ten-span prestressed concrete box girder bridge. It is part of the Higashi-Kyushu Expressway located on the island of Kyushu in southern Japan. The bridge is the world's first bridge to employ a unique structural method based on precast concrete "butterfly web" panels.

Butterfly webs are precast concrete panels consisting of high-strength concrete and steel fibers. 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, making the structure behave much like a double Warren truss.



The concrete can resist compressive forces, and the prestressing force induced into the panels resists tensile forces. Butterfly web panels are made of durable, high-strength concrete, reducing maintenance costs even when the bridge is located in a corrosive environment.

The weight of a butterfly web is about 20% of the weight of a concrete web, helping to reduce the weight of the main girder.



In comparison to the main girders of conventional structures, butterfly webs reduce the weight of the entire main girder by approx. 10%. The lower weight of the main girder makes it possible to increase the segment length for cantilever erection, in turn reducing the number of segments as well as overall construction time. Reducing the number of bearing supports and the weight of the steel in the prestressed concrete also helps reduce construction costs.

To maximize ultraviolet resistance to light entering through the openings, the external and diagonal DYWIDAG Tendons inside the box girder of the bridge consist of 15.2mm epoxy

coated and filled strands, with polyethylene ducts. 19S 15.2 MC DYWIDAG Strand Tendons were used as external prestressing tendons. The diagonal tendons consist of 12S 15.2 MC DYWIDAG Strand Tendons.

12S 15.2 MA DYWIDAG Strand Tendons were used for vertical tensioning during cantilever erection. Pre-grouted Type 1S 19.3 Prestressing Strands were used as transverse tendons in the bridge deck.



Owner West Nippon Expressway Co., Ltd., Kyushu Branch, Japan
General Contractor Sumitomo Mitsui Construction Co., Ltd., Japan
Architect Sumitomo Mitsui Construction Co., Ltd., Japan

DSI Licensee Sumitomo Electric Industries Co., Ltd., Japan
Sumitomo Scope Supply
DYWIDAG Products Type 19S 15.2 MC, 12S 15.2 MC and 12S 15.2 MA DYWIDAG Strand Tendons

Permanent Road Connections in Steep Terrain: The Agematsu Bridge

Since the Edo Period from the 17th to the 19th century, the road connection from Edo (the former name of Tokyo), which was known as Nakasendo at the time, has been very difficult to build because it runs directly through the precipitous Kiso Valley in the southwest of Nagano Prefecture on Japan's main island Honshu.

Even today, the construction of the Agematsu Bridge on National Road No. 19, which is located in this area, confronted participating companies with major challenges. Within the scope of improvement works in the

Kakehashi Region, an approx. 2.7km long section of National Road No. 19 was relocated to the opposite bank of the Kiso River.

While various upgrade projects have been carried out for this particularly steep section of the rational road, which is also highly prone to rock avalanches, relocation of the road was undertaken as a final step in the process.

The rapid currents of the Kiso River posed difficult conditions for foundation work, particularly since the bridge had to cross the Kiso River at an angle, requiring curved road alignments. The design detailed a long-span arch bridge with a

span of over 150m. In addition to cost-effectiveness, other basic design concerns were to achieve a 100-year service life and harmony with the natural environment. Due to the aspects of durability, low maintenance, and aesthetic appearance, a concrete arch bridge form was employed.

High-strength concrete with a design strength of 50N/mm² and high-strength SD490 reinforcement bars were used to enhance earthquake-resistance and durability, resulting in streamlined cross sections for the arch ribs.





One of the structural features on this bridge is the linear alignment of the arch rib with the curve of the road, using a rib deck plate structure for the stiffening girders, which allowed horizontal adjustment for the cantilevered deck plates.

The arch ribs of the bridge were built of reinforced concrete, while the stiffening girders are made of prestressed concrete. The main longitudinal stiffening girder is tensioned by a combination of internal and external DYWIDAG Strand Tendons. Type 12S 15.2 MA DYWIDAG Strand Tendons with bare strands were used for internal post-tensioning, and Type 19S 15.2 MC DYWIDAG Strand Tendons with epoxy coated and filled strands were used for external tensioning. Pre-grouted Type 1S 21.8 Prestressing strands were used as transverse tendons in the bridge deck.



Owner Chubu Regional Bureau, Ministry of Land, Infrastructure and Transport, Japan

General Contractor Sumitomo Mitsui Construction Co., Ltd., Japan

Architect Sumitomo Mitsui Construction Co., Ltd., Japan

DSI Licensee Sumitomo Electric Industries Co., Ltd., Japan

Sumitomo Scope Supply

DYWIDAG Products Type 12S 15.2 MA and 19S 15.2 MC DYWIDAG Strand Tendons

DYWIDAG Tendons Stabilize Pier Underpinning above Singapore's new Downtown Line

The Downtown Line is Singapore's fifth mass transit line and, when it is completed, will link Singapore's North-West and East regions with the city center. The completed subterranean line will have a total length of approx. 42km and is designed to transport half a million passengers per day. Downtown Line Stage 1 (DTL1), with a length of 4.3km, was opened on December 22nd 2013.

Currently, the Downtown Line Stage 2 (DTL2) is being built. DTL2, which is made up of more than 10 contract packages, has a length of 16.6km and includes the construction of 12 stations. Contract 912 is a design and build contract secured by Lum Chang Building Contractors Pte Ltd. for the construction of Bukit Panjang Station and its connecting tunnels along the DTL2. Utracon was engaged as Lum Chang's post-tensioning specialist subcontractor.

One of the most technically challenging aspects of this project involved the construction of a cut and cover tunnel below an existing pier that supports a viaduct for the LRT (Light Rail Transport) system. The steel piles of the pier were directly in the way of the new tunnel. The contractor proposed an underpinning system that would permanently transfer the pier's load to the newly constructed tunnel. For this purpose, two rows of diaphragm walls were constructed adjacent to the affected pier, and the existing pier's pile cap and steel piles were exposed.

Afterwards, a post-tensioned, 7m wide, 2.5m deep and 24m long transfer beam was built directly underneath the pile cap that horizontally linked the two diaphragm walls. To post-tension the beam, Utracon supplied a total of 14 Type 22-0.6" DYWIDAG Tendons with MA Anchorages. The dead ends of the tendons were anchored into designated recesses in both diaphragm walls.

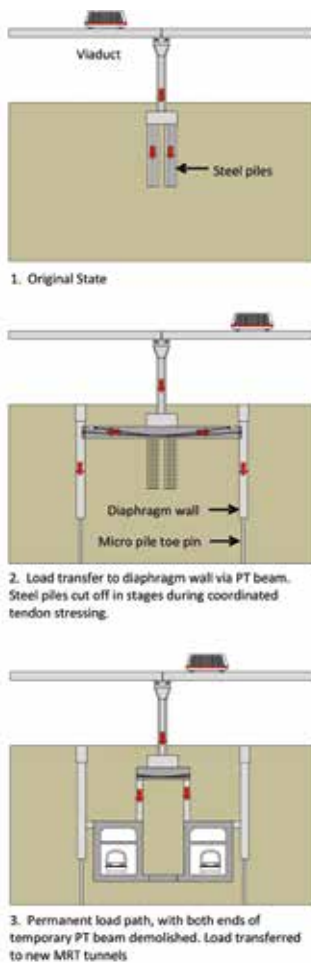
Of the 14 DYWIDAG Tendons, two were spare tendons to be used as a contingency should more prestressing be required. Consequently, the two spare tendons were galvanized to ensure efficient corrosion protection during a long service life.



Stressing of the DYWIDAG Strand Tendons was carried out in three stages. In the first stage, 6 tendons were tensioned and the first 5 steel piles were cut. This was followed by tensioning 4 more tendons and cutting an additional 5 piles. In the last stage, the remaining 2 tendons were stressed and the remaining 2 piles were cut.

While stages 1 and 2 were carried out during normal train operating hours, the last phase had to be undertaken after LRT train operating hours. To ensure that public safety was not compromised, a very stringent monitoring system was used to track the movement of the pier during the work. Since the behavior of the transfer beam was very much within the expectation of the engineer, the 2 spare tendons did not have to be used.

After the pile foundation was removed, the DYWIDAG Tendons were grouted, and tunnel excavation was carried out below the transfer beam. After completion of the new tunnel tubes, both ends of the transfer beam will be cut off, and the pier loads will be directly transferred to the lateral tunnel walls. The remaining heavily reinforced portion of the transfer beam will then act as the new pile cap for the pier.



Owner Land Transport Authority, Singapore

General Contractor Lum Chang Building Contractors Pte Ltd., Singapore

Subcontractor Utracon Structural Systems Pte Ltd., Singapore

Architect Land Transport Authority, Singapore

Consulting Engineers Fung Consult Pte Ltd., Singapore

Consulting and Design of Underpinning System TY Lin International Pte Ltd., Singapore

DSI Licensee Utracon Structural Systems Pte Ltd., Singapore

Utracon Scope Supply, installation, technical support, supervision

DYWIDAG Products 14 Type 22-0.6" DYWIDAG Tendons with MA Anchorages, 8.2t

The Naluchi Bridge: Pakistan's first Extradosed Bridge

Following a severe earthquake in Muzaffarabad in northern Pakistan on October 8th 2005, a comprehensive concept was developed for rebuilding the city in which the “West Bank Bypass Construction Project” had very high priority. The project included the construction of a new bypass in western Muzaffarabad to relieve some of the city's traffic congestion.

In addition to a new, 5km long road from Naluchi to Chela Bandi, a new bridge had to be built across the Jehlum River. With its centrally located, 60m high pylon, the Naluchi Bridge is Pakistan's highest bridge.

The new street bridge is 473m long and includes a 246m long main, extradosed bridge leading across the river as well as a 59m long eastern and a 168m long western ramp that were built as viaducts.

The bridge deck consists of a twin cell prestressed concrete box girder that is carried by two levels of stay cables. The 15.6m wide bridge deck was constructed with a pair of form travelers using the balanced cantilever erection method.

A total of 17,000m³ of soil was moved and 188m of piles were installed to stabilize the foundation. In addition, the project required approx. 1.729t of ST 60 steel reinforcement and 15,771m² of formwork.

DSI produced and supplied 28 Type 19 and 27 DYNA Bond® Stay Cables weighing approximately 120t for the extradosed bridge. The stay cables consist of galvanized and waxed strands that are protected by a HDPE pipe. DSI also produced and supplied 28 deviation saddles that were installed in the pylon as well as 120t of strand. DSI employees supervised the installation of the stay cables on site. Work at the Naluchi Bridge began in May 2009, and the bridge was successfully completed in December 2013.



Owner National Highway Authority, Pakistan

General Contractor Joint Venture GRC-CCPG

(Ghulam Rasool & Company (Pvt) Ltd., Pakistan

Consulting Engineers Joint Venture, consisting of NESPAK and Infinite, Pakistan

Consulting Wiecon, Taiwan

DSI Unit DYWIDAG-Systems International GmbH, GBU, Germany

DSI Scope Development, production, supply, technical support, supervision

DYWIDAG Products 28 Type 19 and 27 DYNA Bond® Stay Cables;

28 deviation saddles; 120t of strand

DYWIDAG Tendons stabilize modern PCT Girder Bridge in Incheon

The 17th Asian Games will be held in the city of Incheon in the north of South Korea from September 19 to October 4th, 2014. The event is the largest sporting event in Asia with a total of 13,000 athletes competing in 36 different sports. In order to prepare the city for this event and to enhance infrastructure for the country's import and export activities, several significant projects are under construction in Incheon.

Bukhang Overpass is one of these projects: Once completed, the new bridge will help to relieve traffic congestion in downtown Incheon. The bridge features a 255m long, elevated abutment in order to avoid any interference with the supply lines for oil and gas located underneath the bridge deck.

Bukhang Overpass was built as a modern PCT (Precast Concrete Technology) Girder Bridge – a construction method that has been used for several bridges in South Korea and that has proven to be efficient for spans that measure more than 50m in length. The lower part of the bridge deck consists of post-tensioned concrete and supports a trussed girder consisting of steel pipes. The trussed girder accommodates the superstructure consisting of reinforced concrete that is strengthened by synthetic fibers.

For the post-tensioned lower deck structure consisting of reinforced concrete, DSI Korea supplied the following types of DYWIDAG Strand Tendons with MA Anchorages: 12 Type 15-0.6", 24 Type 19-0.6", 100 Type 22-0.6" and 66 Type 27-0.6" tendons. Construction work on the Bukhang Overpass began in September 2013, and the bridge was opened to traffic in June 2014.



Owner Incheon City Council, Korea
General Contractor IL Ryu Construction Co., Ltd., Korea
Subcontractor GIF Construction Co., Ltd., Korea
Engineering Darin ENG, Esan, Korea

DSI Unit DYWIDAG-Systems Korea Co. Ltd., Korea
DSI Scope Production, supply, technical support
DYWIDAG Products DYWIDAG Tendons with MA Anchorages:
 12 Type 15-0.6", 24 Type 19-0.6", 100 Type 22-0.6" and 66 Type 27-0.6" tendons

The Outer Circular Highway: Sri Lanka invests in the Future

For the past decade, the government of Sri Lanka has extended its existing road network and the country's infrastructures to cope with the rapid increase in traffic volume. One of these projects is the 29.2km long Outer Circular Highway (OCH) that bypasses the City of Colombo and thus facilitates a fast north-south connection.

The OCH will initially be constructed as a 4-lane highway that can be expanded to be a 6-lane highway if needed. The project is divided into three phases – an 11km long section from Kottawa to Kaduwela, an 8.9km long section from Kaduwela to Kadawatha and a 9.3km long section from Kadawatha to Kerawalapitiya.



Utracon Overseas Pte Ltd. was asked to execute the post-tensioning work for the second, 8.9km long section. This section includes three bridge structures and a viaduct. In total, approx. 2,000 precast I-shaped girders that are mainly 35m long and between 1.6m and 2m high are needed for this section. The heaviest girder weighs about 80t.

For the fabrication of the I-girders, Utracon supplied 1,416 Type 7-0.5" DYWIDAG Strand Tendons, 770 Type 7-0.6" DYWIDAG Strand Tendons and 10,309 Type 12-0.6" DYWIDAG Strand Tendons as well as the necessary post-tensioning equipment. In addition, Utracon supplied the precast yard equipment. Utracon's scope also included the supply of overhead gantry cranes with lifting capacities of 10t and 100t as well as the forms for precasting the 2,000 I-girders.

Erecting the girders posed the greatest challenge during this project. Prior to the actual launching work, a detailed analysis was necessary that took into account the varying widths, gradients, cross-falls and turning radiuses of the elevated highway at different locations. Utracon developed a solution for erecting the precast girders over swampy lands and rivers at the jobsite.

A special, self-launching Travelling Erection Girder (TEG) was used for launching the I-girders that could be universally used to satisfy the different requirements. Where road access underneath the bridge was not available to permit side-feeding of the girders during the erection operation,

Utracon also supplied a pair of beam trolleys, which can travel on rails placed on the erected spans to feed the approx. 35m long precast girders to the rear of the TEG. Throughout the project, Utracon supported the General Contractor with timely and customized solutions to ensure the smooth running of the project work on site.



Owner Sri Lanka Road Authority, Sri Lanka

General Contractor TAISEI Corporation, Japan

Consulting Engineers ORIENTAL CONSULTANTS Co., Ltd., Japan

DSI Licensee Utracon Overseas Pte Ltd., Singapore

Utracon Scope Design, supply, installation, engineering services, technical support, supervision

DYWIDAG Products 1,416 Type 7-0.5" DYWIDAG Strand Tendons, 770 Type 7-0.6" DYWIDAG Strand Tendons and 10,309 Type 12-0.6" DYWIDAG Strand Tendons; tensioning equipment; overhead gantry cranes; formwork moulds; travelling erection girder

AEON Shopping Mall in Ho Chi Minh City stabilized using DYWIDAG Strand Tendons

A EON Mall, a Japanese company that specializes in the development of new shopping malls for their retail business, has heavily invested in countries outside of Japan such as China, Malaysia and Vietnam by continuously building and opening up new shopping malls.

Utracon Vietnam is proud to have carried out the post-tensioning work for the first two AEON shopping malls in Vietnam. The first shopping mall, AEON Celadon, was opened in Ho Chi Minh City in the south of Vietnam in January 2014. The second mall, AEON Canary, will be opened in Binh Duong Province in October 2014. Utracon has also been asked to propose post-tensioning solutions and has been awarded the post-tensioning sub-contract for a third shopping mall in Hanoi, the country's capital city in the north.

The shopping malls are designed with long post-tensioned floor beams and incorporate unique cantilevering features. The post-tensioned beams are used to support the floor slabs.

Utracon supplied a total of 689 7-0.6" DYWIDAG Strand Tendons for post-tensioning the beams. Thanks to the use of DYWIDAG Tendons, the longest beam can span 22m from column to column.

During the construction of the first shopping mall, the post-tensioned floors with a total area of approx. 72,000m² had to be completed within a mere 5 months. The completion of the work within this tight timeframe was made possible by close cooperation of all companies involved.



Owner AEON Vietnam Co., Ltd., Vietnam

General Contractor Obayashi Vietnam Corporation, Japan

Architect International Construction Investment Consultancy Co, Vietnam

DSI Licensee Utracon Overseas Pte Ltd., Singapore

Utracon Scope Design, production, supply, installation, technical support

DYWIDAG Products 689 7-0.6" DYWIDAG Strand Tendons

DYWIDAG Strand Tendons stabilize Bridge in Northern Vietnam's largest Housing Estate

The Bac Hung Hai Bridge in Hanoi, Vietnam forms part of an infrastructure project that will promote the social and economic development of Hung Yen Province.

The bridge is located in what is known as the Ecopark: Northern Vietnam's largest housing estate with a total surface area of approx. 500ha. Located 10km from the city center, the residential area will offer approx. 20,000 residential units in villas, semi-detached houses and apartments and will include 110ha of green space and lakes.

After stringent selection, a joint venture consisting of Utracon Overseas Pte Ltd., Singapore and Utracon Vietnam Co., Ltd., Vietnam was chosen as the general contractor

for the design and construction of Bac Hung Hai Bridge.

The project consists of two parallel bridge structures crossing the Bac Hung Hai River in Ecopark located 10m from each other. Each bridge is 370m long, 18.5m wide and carries 3 lanes of traffic as well as a pedestrian lane. The length of the main span crossing the river measures 88m – the number 88 is considered a lucky number in Vietnam.

The main bridge consists of a single cell, cast-in-place box girder that was constructed in the balanced cantilever method using the DYWIDAG Form Traveller System. The casting and installation of a pair of cantilever segments was achieved in an average cycle time of only 9 days instead of the 14 days that had been scheduled.

8 DYWIDAG Strand Tendons, 7-0.6", 16 DYWIDAG Strand Tendons, 12-0.6", 32 DYWIDAG Strand Tendons, 15-0.6" and 376 DYWIDAG Strand Tendons, 19-0.6" were supplied and installed by Utracon in the webs and slabs of each of the box girders.

Since its completion, Bac Hung Hai Bridge has been a new landmark within the Ecopark project.



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Owner Viet Hung Urban Development and Investment JSC (Vihajico), Vietnam
General Contractor Joint Venture, consisting of Utracon Overseas Pte Ltd., Singapore and Utracon Vietnam Co., Ltd., Vietnam

Architects CPG Consultants Pte Ltd., Singapore

Consulting Engineers CPG Consultants Pte Ltd., Singapore

DSI Licensee Utracon Overseas Pte Ltd., Singapore

Utracon Scope Supply, installation, engineering services, technical support, supervision

DYWIDAG Products 8 DYWIDAG Strand Tendons, 7-0.6";
 16 DYWIDAG Strand Tendons, 12-0.6";
 32 DYWIDAG Strand Tendons, 15-0.6" and 376 DYWIDAG Strand Tendons, 19-0.6"

Tying back the Pardatschgrat Gondola Lift in Ischgl using Wire EX Post-Tensioning Tendons

Currently, a new, wind-resistant tricable gondola lift is being built in the Austrian skiing resort of Ischgl. The new Pardatschgrat Gondola Lift rises 1,251m, leading directly from the eastern town center of Ischgl to the 2,616m high Pardatschgrat.

The Pardatschgrat is known for its difficult geological conditions; furthermore, the mountain station is located in a permafrost zone. The mountain station is built as an eastern expansion of the existing cable lift's mountain station. In order to be prepared for possible settlements, the station is being built on several individual foundations that can be readjusted using heavy duty hydraulic jacks. Furthermore, the special geological situation required that the complete mountain station be tied back using post-tensioning tendons.

In order to minimize potential shifting, the new mountain station was tied back approx. 140m using post-tensioning tendons that run through a tunnel. The maximum possible displacement was calculated to measure up to 1.5m.



Therefore, the design of the tendons used had to take into account a certain yield path. In case of conventional tendons with strands and wedges, the problem is that the clamping indentations of the wedge bite are transferred into the free length

when the tendon is detensioned. This is not allowed because the wedge bite on a post-tensioned strand represents a kind of predetermined stress riser or potential breaking point.



Consequently, DSI supplied 4 Type SUSPA Systems Wire EX 66 Wire Tendons in lengths of 153m for tying back the new mountain station.

On Wire EX Tendons, the wires are anchored by forged heads and different threaded steel components. To reduce the post-tensioning force, the support nut can simply be unscrewed further from the clamping sleeve. Special, longer clamping sleeves with a larger yield path were produced for this project. At first, the tendons were not tensioned to their full post-tensioning force. Should the mountain move, there is a certain built in excess capacity until the permissible post-tensioning force is reached. If there are additional movements, a tensioning jack must be placed on the anchorage and the support nuts must be slightly unscrewed from the clamping sleeves.



Builder Silvretta Seilbahn AG, Austria
Owner HOCH-TIEF-BAU-IMST Gesellschaft m. b. H, Austria
Engineering BAUCON ZT GmbH, Austria

DSI Unit DYWIDAG-Systems International GmbH, BU Post-Tensioning, Germany
DSI Scope Production, supply, tensioning work, technical support
DSI Products 4 Type 66 Wire EX Tendons

Closing the Gap between St. Poelten and Loosdorf: New High Performance Rail Line in the Danubian Corridor

The Westbahn in Austria is not only one of the most important railway lines in the country, but is also located in the Danubian Corridor from Paris to Bratislava and thus is of key importance for the entire European Union. In many sections, the Westbahn railway line had already reached its capacity limit and was therefore in need of a comprehensive expansion. One of the aims is to achieve a two hour travel time between Vienna and Salzburg.

One of the last construction elements on this project is to close the gap between St. Poelten and Loosdorf west of Vienna. A new, double track line is being built for freight trains along a 24.7km long section that will bypass the center of St. Poelten in the south. The new line will permit speeds of up to 120km/h.

The new line will not only relieve St. Poelten's station from transit and freight traffic, but will also nearly double freight traffic capacity. The line is being built in four sections – Wagram traffic junction, the St. Poelten area, the western section and the Rohr traffic junction.



STRABAG AG was awarded the contract to construct the western section between St. Poelten and Loosdorf. The project includes earthwork, track substructures, roadwork, drainage systems and noise control structures in addition to reinforced concrete structures.

To stabilize the slopes and embankments in this section, DSI Austria supplied 820 250kN SN Anchors in lengths of 6m.

In addition, DSI Austria produced and supplied 120 Ø R32, 250kN DYWI® Drill Hollow Bar Anchors in lengths of 4m, 1,945 Ø R32, 360kN DYWI® Drill Hollow Bar Anchors in lengths of 2m as well as 3,890 Ø R32, 360kN DYWI® Drill Hollow Bar Anchors in lengths of 4m with accessories.



Owner ÖBB-Infrastruktur AG, Austria
General Contractor STRABAG AG, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production, supply

DYWIDAG Products 820 250kN SN Anchors;

5,955 Ø R32, 250kN and Ø R32, 360kN DYWI® Drill Hollow Bar Anchors

DSI supplies DYWIDAG Strand Anchors for Rail Freight Bypass Loosdorf, Austria

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Construction

EMEA

Austria

*Slope
Stabilization*

Priority Project 17 of the European Union includes the expansion of the Westbahn railway line in Austria to four tracks. Closing of the gap between the towns of St. Poelten and Loosdorf west of Vienna is one of the last parts of the railway expansion that has not yet been completed. In this area, a 24.7km long, double tracked bypass for freight trains is being built south of St. Poelten's center.

The new high performance line considerably shortens travel time for passenger traffic. The transit time from Vienna to St. Poelten will be reduced to approx. 25 minutes. The new rail freight bypass is scheduled for completion in 2017.

The project consists of 4 sections and includes 23 bridge structures as well as 3 railway tunnels. In section West between St. Poelten and Loosdorf, Züblin Spezialtiefbau GmbH

stabilized slopes along the new track between Melk and St. Poelten.

The slopes were stabilized using 2,352m of temporary 0.62" DYWIDAG Strand Anchors. In total, DSI Austria supplied 100 DYWIDAG Strand Anchors in lengths of 19m, 27m and 31m for this project. In addition, 6 anchor bearing plates with a load-bearing capacity of 750kN were used.



Owner ÖBB-Infrastruktur AG, Austria
General Contractor Züblin Spezialtiefbau GmbH, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production, supply

DYWIDAG Products 2,352m of 0.62" DYWIDAG Strand Anchors; six 750kN anchor bearing plates

The Montafon Ski Jump Center in Tschagguns: High Quality DYWIDAG Products for Skiing Records

Ski jumping has a long tradition in Tschagguns in the south-west of Austria: The first 40m jump in this area dates back to 1930. Recently, the Montafon Ski Jump Center was built in Tschagguns at the location of the former Zelfen Jump. This jump center can be used year-round.

The new facility is divided into four jumps of various sizes – the smallest training jump is 22m long and the longest has a hill size (measuring unit for defining the size of ski jumps) of 108m. In addition to the jumps, an inclined elevator, a functional building and several smaller structures were built on the site.



During the planning stage of the new center, deep landscape cuts and dominantly veering landing areas were avoided. Nevertheless, construction work required the excavation of 85,000m³ of soil in partly very steep terrain.

For slope stabilization and the required tiebacks, DSI Austria produced and supplied 1,253m of galvanized Ø R32, 280kN DYWI® Drill Hollow Bars, 1,371m of Ø R38, 500kN DYWI® Drill Hollow Bars as well as 651m of galvanized Ø R32 bars and 400kN DYWI® Drill Hollow Bars including accessories. Installation of the proven, self-drilling DYWI® Drill Hollow Bars was carried out by the General Contractor Jäger Bau.

In addition, DSI also supplied 500m of Ø 32mm GEWI® Bars including accessories for this challenging project. GEWI® Bars are characterized by their excellent load transfer in concrete structures via the anchoring elements. The coarse GEWI® Thread ensures an optimum bond between the steel and the cement mortar.

The Montafon Ski Jump Center in Tschagguns, Austria, was completed and inaugurated in March 2014. The first major international event that will be held at the new ski jump facility is the European Youth Olympic Festival (EYOF) 2015.



Owner Montafon Nordic Sportzentrum GmbH, Austria
General Contractor Jäger Bau GmbH, Austria
Architect Mitiska Wäger Architekten ZT OEG, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production, supply

DYWIDAG Products 3,275m of Ø R32 and Ø R38 DYWI® Drill Hollow Bars with 280kN, 400kN and 500kN, partly galvanized, 500m of Ø 32mm GEWI® Bars incl. accessories

The Nentilla Pressure Pipeline: Challenging Work on a Steep Slope

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Construction

EMEA

France

Hydro- & Marine
Structures

The Nentilla pressure pipeline 65km south of Carcassonne is operated by EdF, France's largest energy producer. The pipeline with an average flow capacity of 4m³/s and a maximum output of 54MW is supplied with water from a balancing reservoir through several galleries.

Some time ago, corrosion was detected on the pipeline that was built in 1952. The corrosion detected in the transition area from the steel to the concrete anchor blocks entailed the possible risk of cracking. Consequently, the lower part of the old pressure pipeline had to be replaced by a corrosion resistant system along a length of 400m up to

the lower blocking valve. In addition, the interior of the complete pressure pipeline was coated with corrosion resistant paint.

At the bearings, the existing anchor blocks in which the pipeline was partly embedded had to be demolished. The new pressure pipeline is supported by a metal structure that was anchored by 8 anchor blocks and 70 simple guide supports. As a result, the new pipeline is accessible for maintenance at any time.

Apart from the three anchor blocks that were tied back using Type 7-0.62" DYWIDAG Strand Anchors with a load-bearing capacity of 104t, the anchor blocks are supported in the rock using passive Ø 57.5mm GEWI® Plus Anchors that permit angle compensation after drilling.

As the slope inclined as much as 60°, job site personnel had to be supported by ropes during anchor installation. Tests brought to light that the calciferous rock was so fractured at two anchor blocks that cement mortar had to be injected before installing the tendons in order to enhance the load-bearing capacity of the surrounding rock. Afterwards, the strand anchors were installed using a cable crane and grouted.

Tensioning work also had to be carried out by rope supported personnel. In order to be able to detect eventual changes in tension in the years to come, some anchors were fitted with load cells. All of the anchors supplied by DSI successfully passed all required tests.



Owner EdF, France

General Contractor Spie batignolles, France

Subcontractor GTS, France

DSI Unit DSI-Artéon SAS, France

DSI Scope Production, supply, test installation, tensioning

DYWIDAG Products Ø 57.5mm GEWI® Plus Anchors and Type 7-0.62" DYWIDAG Strand Anchors

GEWI® Soil Nails with Fabric Tubes: Excellent Injection Results in Fractured Rock

In December 2013, a new, 5.2km long bypass was opened around the town of Bédarieux near Montpellier in southern France. The new road not only relieves the town of freight traffic, but also improves the connection to the A 75 motorway running north to Clermont Ferrand and south to Béziers.

In the western section, it was necessary to construct several soil nail stabilized retaining walls in order to properly build the road. The section is located in a fault zone between the Pyrenees and the Alps. Consequently, geological conditions are mainly predominated by calciferous dolomite with karst zones. Due to the unstable geological conditions, a retaining wall



that was originally designed to have a height of 8m had to be increased to a height of 22m during construction work.

In order to prevent the loss of large volumes of cement mortar in the highly fractured rock while still obtaining good injection results, some of the GEWI® Soil Nails were encased in elastic fabric tubes following drilling operations.

In total, DSI France supplied 7,500m of GEWI® Soil Nails in diameters of 28, 32 and 40mm with matching fabric tubes.



Owner General Council of the Département of Hérault, France
Contractor Entreprise Buesa Frères S.A.S., France
Engineering retaining walls Fondasol SA, France

DSI Unit DSI-Artéon SAS, France

DSI Scope Production, supply

DYWIDAG Products 7,500m of GEWI® Soil Nails, Ø 28, 32 and 40mm with fabric tubes

GEWI® Plus Piles secure Flood Basin for new High-Speed Line

75

Construction

EMEA

France

Foundations

The Ligne à grande vitesse “Sud Europe Atlantique” (LGV SEA) is a new high-speed line for the TGV in France that will reduce travel time from Paris to Bordeaux from three to two hours. The new, 300km long section, which will be opened in 2017, connects Tours and Bordeaux.

In the municipality Ambarès located 20km from Bordeaux, the section runs through a natural depression. Because rain water accumulates in this dip, a retention basin had to be built in this area.

The 5,000m³ basin was built as a subterranean reinforced concrete retention basin. The floor slab was anchored using Ø 57.5mm GEWI® Plus Micropiles for uplift control.



The walls of the basin were anchored in the surrounding marl. The complete structure is stabilized by the 800m² floor slab and a concrete cover plate. The micropiles were installed from an elevated platform in a 2.5m grid and cut to the level of the excavation floor after filling with soil. In addition, the 10m long GEWI® Plus Micropiles were anchored using a special reinforcement structure mounted on the floor slab.

The general contractor, Solétanche Bachy, installed a total of 111 micropiles supplied by DSI France into cased boreholes. The casing was removed during cement mortar injection. DSI France supplied the GEWI® Plus Micropiles to the jobsite just in time within the limited timeframe so that pile installation was successfully completed within two months.



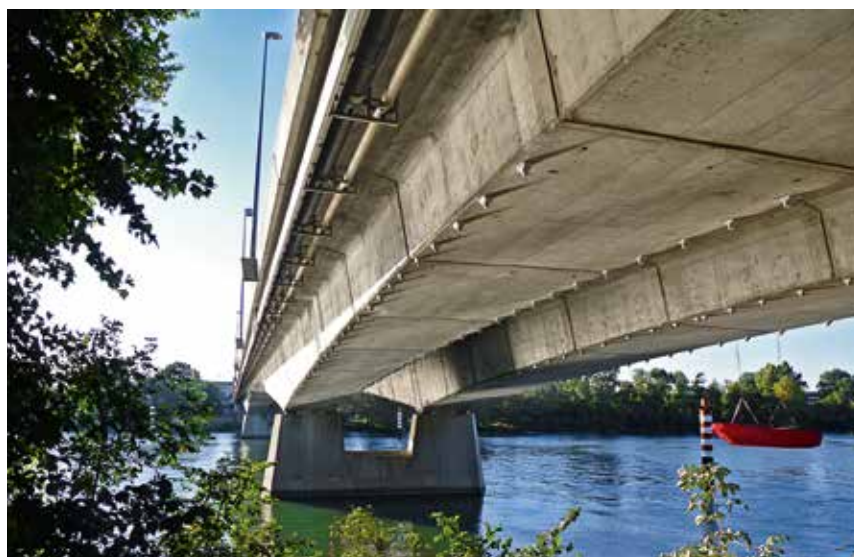
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Owner COSEA, France
General Contractor Solétanche Bachy, France

DSI Unit DSI-Artéon SAS, France
DSI Scope Production, supply
DYWIDAG Products 111 Ø 57.5mm GEWI® Plus Micropiles in lengths of 10m

Repair of two Connecting Bridges from Villeneuve to Avignon with DYWIDAG Systems

In Avignon in southern France, two identical bridges that were built between 1973 and 1975 connect the towns of Villeneuve and Avignon across the Rhône River. The two bridges were no longer able to cope with the significantly increased traffic volume of 55,000 vehicles per day. Consequently, both bridges had to be reinforced using external DYWIDAG Strand Tendons, external DYWIDAG Bar Tendons and unbonded DYWIDAG Bar Tendons.



The bending load capacity of each bridge was increased by installing six 209m long external Type 19-0.62", Grade Y1860S7 DYWIDAG Strand Tendons into each box girder. The DYWIDAG Strand Tendons are located on the left and right hand side at the bottom of the hollow box girders. The tendons are protected by PE ducts and are injected with hot wax in order to achieve permanent corrosion protection.

The bridges were strengthened by cross girders in the areas of the anchorages and deviations of the external DYWIDAG Strand Tendons. The cross girders were prestressed against the box girders using DYWIDAG Bar Tendons.

Additionally, prestressed DYWIDAG Bar Tendons were installed in some areas to increase the shear force by means of a steel structure underneath the bridge. DSI developed optimized anchorage plates and caps in accordance with ETA-05/0123 specifically for this project.

To reinforce both bridges, DSI supplied a total of 416 1.76 to 1.90m long Ø 36mm WR steel DYWIDAG Bar Tendons, 1,008 2.10 to 4.40m long Ø 26mm WR steel DYWIDAG Bar Tendons as well as 400 5.10 to 5.40m long Ø 32mm WR steel DYWIDAG Bar Tendons.



General Contractor Eiffage, France

DSI Unit DSI-Artéon SAS, France

DSI Scope Production, supply, technical support

DYWIDAG Products 24 external Type 19-0.62" DYWIDAG Strand Tendons; 416 Ø 36mm DYWIDAG Bar Tendons; 1,008 Ø 26mm DYWIDAG Bar Tendons; 400 Ø 32mm DYWIDAG Bar Tendons

Ready for the Future with Products by DSI-Artéon: Rehabilitation of Paris-Orly Airport

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Construction

EMEA

France

Commercial
Buildings

Aéroports de Paris (ADP) operates three major airports in metropolitan Paris: Paris-Charles de Gaulle and Paris-Le Bourget in the north-east of Paris as well as Paris-Orly south of the city. With a total of 88.8 million passengers handled in 2012, the airports operated by ADP rank second in Europe in number of passengers.

ADP's growth strategy is based on strengthening its airport terminal facilities and enhancing its services. From 2013 to 2018, the company is planning to modernize Paris-Orly Airport. As a first step, the southern terminal in Orly was rehabilitated to offer passengers facilities that meet highest international standards.

ADP replaced all expansion joints on the parking lots of Orly Airport by high quality MIGUA Expansion Joints that are exclusively distributed by DSI-Artéon, France. MIGUA expansion joints are characterized by their reliability and high durability.

The repair and sealing work on the 16,000m² large area started in April 2013 and was successfully completed in January 2014.



DSI-Artéon supplied a total of 1,000 linear meters of MIGUA Expansion Joints and provided technical studies. Experienced DSI-Artéon employees provided technical advice on site and supported the customer throughout the repair project.

Since January 2014, DSI-Artéon has been supplying high quality products for the second part of the project – work on an area with a surface of 8,000m² at the West Terminal.



Owner Aéroports de Paris (ADP), France

DSI Unit DSI-Artéon SAS, France

DSI Scope Supply, technical support, supervision

DSI Products More than 1,000 linear meters of MIGUA Expansion Joints

New Hybrid Tower Technology in Germany: Stability at great Heights with Wire EX Tendons

Wind energy structures are being built increasingly taller because the wind is stronger and more constant in higher air layers. Today, wind tower hubs often reach a height of more than 100m. These very high towers are exposed to great dynamic and static loads and thus pose special structural requirements. In addition, modern wind towers are very slender so that the construction elements that are used need to have extremely high strengths.

Max Bögl Wind AG has tackled these special requirements by developing new hybrid towers that incorporate precast high strength self-compacting concrete elements with strengths of up to C100/115. The extremely long-lasting concrete self-compacts after concreting due to acting gravity so that common and technically difficult vibration methods are no longer necessary.

The new hybrid towers consist of precast concrete elements in their lower sections up to heights of approx. 90m. The upper part of the towers consists of steel sections that are erected using conventional steel construction methods. The precast concrete parts are either supplied to the jobsite as complete rings or half shells. The cone-shaped and cylindrical rings are available in a modular system and can be combined to form towers of different heights and geometries. This way, hybrid towers can be flexibly adapted to individual static and dynamic on-site requirements.

The precast concrete elements are post-tensioned against each other by means of external wire tendons located inside the tower. At the bottom, the tendons are anchored in the tensioning area of the foundation. At the top, a special ring serves both for anchoring the tendons and as a steel concrete composite structure for connecting the steel tower above.





After tensioning the external tendons, the first steel section is erected on the concrete tower. The tendons are tightly connected with the anchor rods concreted in the transition piece. Afterwards, the steel tower is completed.

For two new, 143m high hybrid towers at Deining Wind Park, the contractor decided to use 20 84.1m long external Type SUSPA Systems Wire EX 82 Post-Tensioning Tendons. The tendons had a total weight of 41.7t per tower.

Additionally, DSI supplied external tendons for a Wind Park in Denkendorf. The tendons were used to connect the 3.8m high and 30cm thick precast concrete elements that were produced in a nearby precast factory. 24 80.29m long Type SUSPA Systems Wire EX 60 Wire Tendons were used for each of the two hybrid towers. The supreme building authority granted the individual approval for the use of these systems.

After the defined service life of 20 years, the wind towers can be disassembled and the individual construction segments can be re-used.



In 2013, DSI also supplied the Wire EX Post-Tensioning System for a large number of other wind parks in Germany. The following table provides an overview of the systems that were supplied:

| Project | Number of Wind Towers | Tendon Type [Amount per Tower] | Tendon Length [m] | DSI Scope |
|----------------------------------|-----------------------|-----------------------------------|----------------------|----------------------------------|
| Deining | 2 | 20 x Wire EX 82 | 84.10 | Production, supply, installation |
| Denkendorf | 2 | 24 x Wire EX 60 | 80.29 | Production, supply, installation |
| Framersheim | 2 | 24 x Wire EX 66 | 58.47 | Production, supply, installation |
| Oening | 1 | 20 x Wire EX 82 | 84.10 | Production, supply, installation |
| Lengenfeld | 1 | 20 x Wire EX 82 | 84.10 | Production, supply, installation |
| Rotes Land (near Diemelstadt) | 5 | 24 x Wire EX 60 | 80.29 | Production, supply, installation |
| Hohen Luckow | 13 | 24 x Wire EX 66 | 58.47 | Production, supply, installation |
| Lettweiler 1 | 14 | 24 x Wire EX 61 | 87.89 | Production, supply, installation |
| Kirchhain | 5 | 24 x Wire EX 66 | 80.29 | Production, supply, installation |
| Waigolshausen | 2 | 24 x Wire EX 66 | 91.72 | Production, supply, installation |
| Schnaittenbach | 1 | 24 x Wire EX 60 | 80.29 | Production, supply, installation |
| Helena | 2 | 24 x Wire EX 60 | 80.29 | Production, supply, installation |



General Contractors Servion SE, Nordex SE, GE, ABO Wind AG et al., all of them Germany
Contractor Max Bögl Wind AG, Germany

DSI Unit DYWIDAG-Systems International GmbH, BU Post-Tensioning, Germany
DSI Scope Production, supply, installation
DSI Products Type 60-82 Wire EX Tendons



Hybrid Tower Construction: Poelzig Wind Park near Gera

The performance of wind power plants is steadily increasing due to the construction of increasingly higher wind towers. At the moment, the Poelzig Wind Park, which will consist of hybrid towers, is being built near Gera, Germany.

Max Bögl hybrid towers rank among the most innovative systems currently on the market. The highly precise precast concrete elements – conical and cylindrical rings – are combined to form concrete towers of different heights and geometries as part of a modular tower construction system. Using this system, different tower designs can be precisely adjusted to the special static-dynamic requirements of all modern wind turbines.

In order to transfer the loads resulting from wind and the weight of the tower safely into the ground, hybrid towers rest on circular foundations consisting of cast-in-place concrete. The foundations also include a lower abutment that serves for tensioning the external wire tendons.



The towers consist of post-tensioned reinforced concrete segments that are placed on top of each other with dry joints, i.e. without any mortar or similar levelling layers.

DSI produced and supplied Type 82 Wire EX Post-Tensioning Tendons with installation lengths of 84.09m and cut lengths of 83.69m. The prefabricated Wire Ex Tendons were produced by DSI at the Langenfeld plant in Germany. Afterwards, the prefabricated tendons were coiled at the factory and supplied to the jobsite ready to be installed.

At the jobsite near Poelzig, the individual post-tensioning tendons were lifted to the upper ring to what is known as the transition piece using a crane. The tendons were then inserted into the inside of the wind towers and anchored at the upper abutment. After the insertion of the external tendons that run along the inside of the concrete tower, the tendons were tensioned and anchored in the second abutment located in the foundation.

Once tensioning force has been applied and the tendons have been anchored, the concrete tower is load-bearing and can be extended by additional steel sections.



Owner WSB Windpark Pölzig GmbH & Co. KG, Germany
General Contractor WSB Projekt GmbH, Germany
Contractor Max Bögl Wind AG, Germany
Design WSB Projekt GmbH, Germany
Supervisor WSB Projekt GmbH, Germany

DSI Unit DYWIDAG-Systems International GmbH, BU Post-Tensioning, Germany
DSI Scope Production, supply, installation, tensioning work
DSI Products Type 82 Wire EX Post-Tensioning Tendons

Permanent DYWIDAG Strand Anchors stabilize modern A8 Motorway Routing near Remchingen

The A8 federal motorway is one of the most important east-west connections in Germany. The approx. 505km long motorway runs from the Luxembourg border to Karlsruhe, Stuttgart and Munich before reaching the Austrian border near Salzburg. The A8's state of construction has not changed much from its original condition in the 1930s and has therefore reached its capacity limit. Consequently, among other sections, a 9.15km long section of the A8 between Karlsbad and Remchingen is being widened in four sections to six lanes.

In section 4, the western section of the motorway is being widened over a length of 5.7km. Between Karlsbad and Pfinztal, comprehensive earthwork is required in order to insure that the new alignment will comply with modern planning criteria.

Within the scope of the work for the new southern lane in the direction of Stuttgart, several road cuts had to be done and the slopes in this area had to be stabilized. For the stabilization of a slope at one of these road cuts near Remchingen, DSI Koenigsbrunn supplied approx. 650 permanent 0.62" DYWIDAG Strand Anchors with 6 to 12 strands weighing approx. 180t. In co-operation with the planning office, DSI Koenigsbrunn also developed a pre-design of special anchor plates and special covering caps for long-term corrosion protection.

The slope stabilization required high load-bearing tiebacks with a long service life. Therefore, the general contractor Max Bögl decided to use permanent 0.62" grade St1570/1770 DYWIDAG Strand Anchors with 6 to 12 strands (150mm²), for which DSI holds an approval issued by the German Institute for Civil Engineering.



Photos reprinted courtesy of ARTIS-Photographie & Pressefoto, Germany

i

Owner Regional Council of Karlsruhe, Germany

General Contractor Max Bögl Bauunternehmung GmbH & Co. KG, Germany

Subcontractor Max Bögl Bauunternehmung GmbH & Co. KG, Germany

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

DSI Scope Production, supply, engineering services, technical support

DYWIDAG Products 650 permanent 0.62" DYWIDAG Strand Anchors with 6 to 12 strands

Slope Stabilization with DYWIDAG Anchors in the Alpine Foothills

83

Construction

EMEA

Germany

*Slope
Stabilization*

More than 20,000 vehicles per day use federal road B 472 south-west of Munich, Germany. In order to increase the capacity of the only supra-regional connection from East to West in the alpine foothills between Kempten and Salzburg, work began on a bypass for the town of Peissenberg in 2002, with the road opened for traffic in December 2008.

Originally, the expansion of the hazardous bend near Hohenwart west of Peissenberg was also going to be a part of the new bypass. However, construction work had to be stopped for a long time in this section because a geological sliding joint was located underneath the surface that endangered the entire slope above the section.

In co-operation with Munich Technical University, the building authority developed a concept for the comprehensive stabilization of the slope, which had been classified as extremely prone to sliding by a geological study. Afterwards, the B 472 OU – Peißenberg Los 8.1 Joint Venture was awarded the contract for carrying out the construction work in this area.

Initially, to stabilize the slope, the soil was excavated at the jobsite to the level of the sliding joint. Subsequently, 730 bored piles were installed in the ground for foundation reinforcement.

Both in the area of the sliding joint and during the backfill operation, the slope was tied back in sections.

Once the original ground level had been restored, work began on a slope stabilization project east of the Hohenwart bend for a rural road that will permit direct access to a vacation village located nearby.



A retaining wall had to be built to stabilize the slope and the property located above the jobsite. To tie back this retaining wall, DSI supplied 218 permanent DYWIDAG 5 Strand Anchors in lengths of 16-19m that were installed in one or two layers.

The 5.2km long Hohenpeissenberg bypass will be opened to traffic in 2016.

i

Owner Building Authority, Germany

General Contractor Joint Venture B 472 OU – Peißenberg Los 8.1, consisting of Max Bögl Bauservice GmbH und Co. KG and Schneider Erd- Tiefbau GmbH, Germany

Consulting Engineers Munich Technical University, Germany

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

DSI Scope Production, supply

DYWIDAG Products 218 permanent DYWIDAG 5 Strand Anchors

Post-Tensioning Tendons for extraordinary Architecture: The “Ulmer Zentrum”

The major construction project Stuttgart 21 not only includes a new low-level train station in Stuttgart, Germany and the construction of a new railway line to Ulm: It also includes the remodeling of Ulm's train station as well as the surrounding districts. One of the first projects in this area is the construction of the “Ulmer Zentrum”, also known as “UZ”.

The modern building with a net surface area of approx. 7,000m² consists of seven levels above and two levels below ground. The 62m long, 49m wide and 24m high L-shaped new building includes a hotel and also accommodates parts of Ulm's revenue office.



The building's supporting structure was designed as a reinforced concrete frame unit that was built in two sections due to limited space conditions. The jointless floor slabs are 30cm thick and were built with edge beams. Piles and bored pile walls were used for the foundation of the new building. The pile walls were purposely left visible as a unique design element.

The building features an eye-catching 8m long and 3 level high cantilever wing. The load-bearing system for this wing consists of two post-tensioned trusses integrated into the two parapets that carry the load back to the main composite columns. Moreover, the dead load of the system was reduced by using light weight concrete for the slabs in this area.

In order to ensure rapid assembly of the trusses, the structural engineer decided to use preassembled 15-0.6" and 22-0.6" Type SUSPA Systems Strand Tendons.

For the sake of reducing sensitivity and increasing robustness, the columns in the cantilever wing and the rear anchorages of the trusses were post-tensioned using Ø 26mm Type WR DYWIDAG Bars. Continuous monitoring of the wing tips has not shown any deflections caused by creep or shrinkage.

The UZ was successfully completed in summer 2013 and can now be considered one of Ulm's new signature structures.



Owner MS Immo Ulm GmbH & Co.KG, Germany

General Contractor Matthäus Schmid Bauunternehmen GmbH & Co.KG, Germany

Architect Mühlich, Fink & Partner, Germany

Engineering Support Structure Planning statix GmbH, Germany

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

DSI Scope Production, supply, installation, technical support

DYWIDAG Products 15-0.6" and 22-0.6" Type SUSPA Systems Strand Tendons; Type WR, Ø 26mm DYWIDAG Bars

Replacement of Railway Bridges across the Waetern and Aller Rivers in Verden

85

Construction

EMEA

Germany

*Slope
Stabilization*

The rail line from Hannover to Bremerhaven is an important and heavily travelled line in northern Germany. On this route, two old railway bridges across the Aller River and the Waetern Stream near the town of Verden south-east of Bremen are currently being replaced.

The bridges are being built east of the existing bridge structures on a new, 2.1 km long line. Vibro-replacement columns had to be installed in order to increase the load-bearing capacity of the soil in the embankment that was to be widened between the two bridges.

Within the scope of construction work, the existing embankment had to be stabilized along a length of approx. 1,700m using 21,200m of temporary Ø R32-280 DYWI® Drill Soil Nails and steel wire mesh.



Photos reprinted courtesy of Jähning GmbH Felssicherung & Zaunbau, Germany



Since construction work was carried out in the flood zone of the Aller River, construction work had to be temporarily suspended in June 2013 due to flooding.

Nevertheless, the stabilization of the embankment was successfully completed thanks to the excellent co-operation of all parties involved.

i

Owner DB Netz AG Regionalbereich Nord, Germany

General Contractor Max Bögl Bauunternehmung GmbH & Co. KG, Germany

Contractor Jähning GmbH Felssicherung & Zaunbau, Germany

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

DSI Scope Production, supply

DYWIDAG Products 21,200m of temporary Ø R32-280 DYWI® Drill Soil Nails

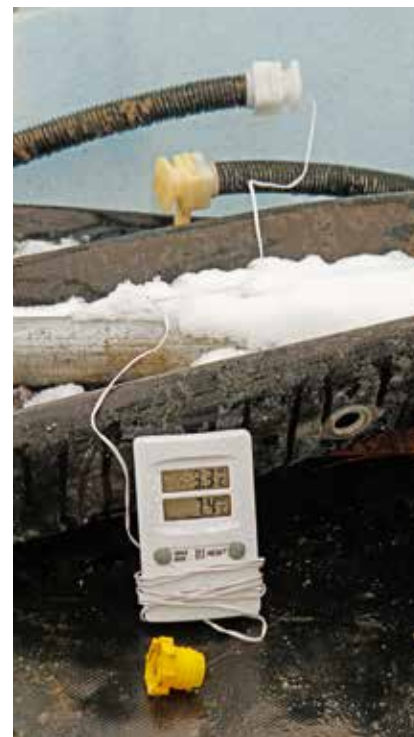
Incremental Launching: The Danube Bridge near Untermarchtal

After its completion in the 1950s, the Danube Bridge near Untermarchtal, approx. 40km south-west of Ulm, was one of the longest jointless concrete post-tensioning bridges in Europe. By 2012, the approx. 370m long bridge was severely damaged and had to be replaced by a new structure.

The new viaduct was built parallel and to the west of the old Danube Bridge and was constructed as a five span continuous bridge. The bridge has a total length of 362.5m between the end abutments and includes a roadway that is 8.6m wide. Distances between the supports range from 55 to 90m. The Danube viaduct was built as a post-tensioned bridge using the incremental launching method.

The individual reinforced steel segments were preassembled and concreted in the jobsite casting yard located at the northern abutment. The individual segments were post-tensioned following assembly. Afterwards, the bridge was incrementally launched using the individual segments. The structure was built in a series of 18 increments in maximum lengths of 26m.

DSI Koenigsbrunn supplied bonded DYWIDAG Strand Tendons and MA Anchorages for coupling the individual segments and for post-tensioning the bridge deck. The DYWIDAG Strand Tendons were



inserted in metal ducts and were grouted in each of the sections once the tensioning work of the respective individual increment had been completed.

As grouting of the tendons was

carried out in winter, the temperature of the mortar had to be continuously monitored.

The bridge opened to traffic in October 2013.



Owner Regional Council of Tuebingen, Germany

Contractor Matthäus Schmid GmbH & Co. KG, Germany

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

DSI Scope Production, supply, installation

DYWIDAG Products Bonded DYWIDAG Strand Tendons and MA Anchorages

The Filder Tunnel: *GEWI*® Soil Nails stabilize Portal of the longest Tunnel for Stuttgart 21

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Construction

EMEA

Germany

Slope
Stabilization

Within the scope of the large scale project Stuttgart 21, a new railway tunnel is being built on the new Stuttgart-Wendlingen line. After its completion, the Filder Tunnel will connect Stuttgart's main station, which is located in a basin, with the Filder plain located 155m higher than the basin north of Stuttgart Airport.

The approx. 9.5km long tunnel will not only be the longest tunnel of the major project, but also the longest double tube railway tunnel in Germany. The Filder Tunnel ascends from approx. 230m to 385m and thus climbs an average of 16m in altitude per kilometer.



The tunnel cover only measures a few meters near the main station and rises to up to 220m in its course. Both tunnel tubes are designed for a single track and have predominant center distances of approx. 30m.

At the Filder portal, tunnel construction is being carried out using a Tunnel Boring Machine (TBM). In this area, clay and residual clay are situated directly underneath the surface.



Due to the prevailing ground conditions, the tunnel cut of the Filder portal had to be permanently stabilized.

For this purpose, DSI Koenigsbrunn supplied approx. 4,600m of permanent Ø 25mm *GEWI*® Soil Nails fitted with spacers at regular intervals.

i

Owner Deutsche Bahn AG, Germany
General Contractor Tunnelbaukonsortium ATCOST 21, Austria
Contractor Züblin Spezialtiefbau GmbH, Germany
Consulting Engineers ILF Beratende Ingenieure GmbH, Germany
Engineers Deutsche Bahn AG, Germany
Operator DB Netz AG, Germany

DSI Unit DYWIDAG-Systems International GmbH, BU Geotechnics, Germany
DSI Scope Production, supply, technical support
DYWIDAG Products Approx. 4,600m of permanent Ø25mm *GEWI*® Soil Nails

GEWI® Piles stabilize Sheet Pile Wall at Naval College Bremerhaven

The Naval College (MOS), a training center for the German Marines, is located in the center of Bremerhaven. The area on Geeste Island borders on the Geeste River in the north, west and south, and the bank is surrounded by a sheet pile wall.

After a service life of 80 years, the sheet pile wall at the west and south side of the area was badly corroded so that an economic rehabilitation was not possible. Due to the soft soil and the prevailing ground water conditions, a new sheet pile wall had to be built as a combined, heavy sheet pile wall with pile lengths of up to 33m. Work was complicated by the influence of the tides and the ensuing installation time schedule.

The approx. 600m long sheet pile wall was tied back using double corrosion protected Ø 63.5mm GEWI® Injection Piles in lengths of approx. 35m. The GEWI® Piles were connected by couplers and had to be installed from a pontoon located in the river. The GEWI® Micropiles, which were used as inclined piles, were anchored into the sands underneath the clay and the backfill behind the sheet pile wall at a depth of approx. 14m and at angles of 42.5° and 47.5°. The GEWI® Piles had a total length of 13,200m. At their upper end, the piles were factory-fitted with an injected duct that consisted of plastic and steel.

In total, 3,900t of steel sheet piling profiles and GEWI® Injection Piles with a weight of 330t were used for the new sheet pile wall at the Naval College.



Owner Immobilien Bremen, Statutory Body, Germany

General Contractor Joint venture MOS, consisting of Colcrete-von Essen GmbH & Co. KG and AUG. PRIEN Bauunternehmung (GmbH & Co. KG), both Germany

Contractor Neidhardt Grundbau GmbH, Germany

Engineering Ingenieurgesellschaft Spundwand MOS, consisting of bremenports GmbH & Co. KG and grbv Ingenieure im Bauwesen GmbH & Co. KG, both Germany

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

DSI Scope Production, supply

DYWIDAG Products 13,200m of Ø 63.5mm DCP GEWI® Micropiles

Extension of A 94 Motorway using DSI Quality Products: The Lappach Bridge

89

Construction

EMEA

Germany

Bridges

The A 94 federal motorway runs from Munich towards the north-east to the town of Pastetten, Germany. A new section from Pastetten to Dorfen is now being built as an extension of this motorway.

One of the parts of this new, 17.4km long section is the Lappach Bridge that is being built using the cantilever construction method. The new bridge has two 85m long main spans and two 58.5m long side spans. The bridge passes over the Isen Valley at a height of up to 15m and is supported by large-diameter bored piles. The width between the guard rails is 29.62m.

For internal post-tensioning of the cantilever erection and the deck slab, DSI produced and supplied a total of 121.12t of 19-0.62" and 22-0.62", St 1570/1770 Prefabricated Tendons.



In addition, DSI produced and supplied 34.1t of external Type SUSPA Systems Wire EX 66 Wire Tendons in individual lengths from 61m to 231m.

DSI's services also included the installation, stressing and grouting of the internal tendons in accordance with the approval Z-13.1-129 as well as the installation and tensioning of the external wire tendons.



i

Owner Motorway Authority Southern Bavaria, Germany
Contractor Max Bögl Bauservice GmbH und Co. KG, Germany

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

DSI Scope Production, supply, installation

DYWIDAG Products 121,12t of Type 19-0.62" and 22-0.62" internal tendons;
34,1t of external Type SUSPA Systems Wire EX 66 Wire Tendons

250m long Wire Tendons strengthen A7 Stader Street Bridge in Hamburg

In the district of Heimfeld south of Hamburg, the A7 Motorway crosses Stader Street (federal road B73) and a railway line via a bridge structure. The motorway bridge was built between 1969 and 1971 and is no longer able to accommodate the high traffic volume in this area. In 1995, the first cracks were detected in the post-tensioned bridge superstructure. Consequently, comprehensive strengthening of the bridge started at the end of 2013.

Within the scope of the repair and strengthening work, the two longitudinal girders of the bridge structure were reinforced using external Type SUSPA Systems Wire EX 60 Wire Tendons, Approval No. Z-13.3-85. The prefabricated tendons were supplied to the jobsite on coils and installed on both sides of the longitudinal girders.



Beforehand, deviation blocks were installed at the girders through which the Wire EX 60 Wire Tendons were first inserted and then tensioned at the abutments.

Tendon installation could only be carried out at night during the weekends because the federal highway underneath had to be closed for traffic during installation.

The exceptional uncoupled tendon lengths of 245.8m and 247.0m are particularly noteworthy. The limited, tight time frame for installation during the closing of the federal highway and the very limited space at the abutments that was available for tensioning posed special challenges during this project.



Owner Free and Hanseatic City of Hamburg, Germany

Contractor Jürgen Martens GmbH & Co., Germany

Engineering Thormählen + Peuckert Beratende Ingenieure GmbH & Co. KG, Germany

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

DSI Scope Production, supply, installation

DYWIDAG Products 4 external Type SUSPA Systems Wire EX 60 Wire Tendons

The Future of Education: A new Campus for UAS Duesseldorf

91

Construction

EMEA

Germany

Excavation

With approximately 6,500 students, the University of Applied Sciences (UAS) Duesseldorf is one of the largest colleges in the federal state of North Rhine-Westphalia, Germany. Until now, this college has made use of two main locations in Duesseldorf. Since the university's buildings, which were built in the 1970s, no longer met modern-day requirements and were in need of rehabilitation, the decision was made to rebuild the university on a single campus in the district of Derendorf.

The UAS is being built on a 47,700m² piece of property near the city center that formerly was a slaughterhouse and a brewery. The new Derendorf Campus will include five new buildings as well as two historic buildings. In addition to the buildings that will house lecture halls, laboratories and administration, the campus will also have student accommodation and recreational facilities.

Along Muenster Street, a 9m deep excavation was built that had to be stabilized by a temporary support system. To tie back the retaining wall, DSI supplied 163 completely removable grade St 950/1050 WR DYWIDAG Ground Anchors in diameters of 26.5, 32 and 36mm.



Due to special requirements regarding future construction activities, the owner required a completely removable anchor system. The ground anchors supplied by DSI to stabilize the retaining walls therefore had to be completely removed. Due to the fact that the completely removable DYWIDAG Bar Anchor is designed as a compression type anchor, its removability can be

tested immediately after installation by a removal torque test.

In addition to the 2,300m of completely removable DYWIDAG Bar anchors, DSI supplied 460m of Type SUSPA Systems Compact Temporary Strand Anchors for stabilizing the retaining walls.



i

Owner Building and infrastructure organization of North Rhine-Westphalia, Germany

General Contractor Hochtief Solutions AG, Germany

Contractor Pohl Erdbewegungen GmbH, Germany

Subcontractor Heinsberger Grundbau GmbH, Germany

Engineering Joint Venture Campus Derendorf, consisting of Nickl & Partner Architekten AG, Ebert-Ingenieure GmbH and Pfefferkorn Ingenieure, Beratende Bauingenieure VBI, all of them Germany

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

DSI Scope Production, supply

DYWIDAG Products 163 completely removable St 950/1050 WR DYWIDAG Ground Anchors; 460m of Type SUSPA Systems Compact Temporary Strand Anchors

Hammecke Bridge: Post-Tensioning Systems for incrementally launched Bridge in Germany

The German A 46 federal motorway runs from Heinsberg near the Dutch border to the town of Bestwig east of Dortmund. Within the scope of the extension of A 46 near Bestwig, 13 new bridges are being built in addition to a 2.7km long distributor road.

One of the four technically challenging major bridges in this section is structure number 186, the Hammecke Bridge. The 507.5m long reinforced concrete bridge is located north of Bestwig's train station and supported by 12 pairs of piers with distances between the piers of



2 x 40m and 9 x 47.5m. Some of the piers were cast as concrete circular columns in steel tubes. Drilling lengths of more than 2,000m were required for the pile foundations.

Hammecke Bridge was incrementally launched and features two parallel decks consisting of prestressed concrete hollow box girders. Incrementally launched bridges are very economic due to the minimal amount of equipment needed, a good utilization of formwork and equipment as well as the optimization of repetitive work procedures. The superstructure is curved, and individual segments are launched in lengths of approx. 24m.

DSI produced, supplied and installed the complete post-tensioning systems needed for this project. Longitudinal post-tensioning of the precast concrete hollow box girder elements is carried out in accordance with incremental moving work using 370t of external prefabricated 15-0.6" Type SUSPA Systems Tendons. The large, lateral cantilevers on both sides of the bridge deck were post-tensioned using a total of 120t of 4-0.6" Type ME Monostrand Tendons, which is somewhat unusual in Germany.

In addition, DSI supplied temporary tendons for pier support, tendons for the launching nose, the launching gantry and the abutments.

The piers had to be stabilized against the forces caused by the incremental launching work. For this purpose, DSI provided the pier support consisting of 2 x 2 Type ME 6-4, 150mm², St 1570/1770 Monostrand Tendon pairs with an average length of approx. 50m per pier. They were anchored in the foundation using a coupler plate with two Ø 28mm GEWI® Bars. At the pier head, they were deviated at the

bearing pedestals, which were in turn tensioned against each other using two smooth Ø 32mm (WS) tensioning bars.

The launching nose was longitudinally connected to the superstructure using short Type 6/7, 150mm², St 1570/1770 Strand Tendons in lengths of 2.80m to 4m. Vertically, post-tensioning was realized using Type 40 (WR) Bar Tendons in average lengths of approx. 5.00m.

The Eberspäecher launching gantry was set up in the construction yard at the abutment and tightly connected to the abutment using 6 tendons consisting of 7 strands each (average length 5.20m, 150mm², St 1570/1770) in the upper part and 2 tendons consisting of 4 strands each (average length 4.40m, 150mm², St 1570/1770) in the lower part.



Owner Landesbetrieb Straßenbau NRW, RNL Sauerland Hochstift, Germany
Contractor Adam Hörnig Baugesellschaft mbH & Co KG, Germany
Engineering Kinkel & Partner Gesellschaft Beratender Ingenieure mbH, Germany

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

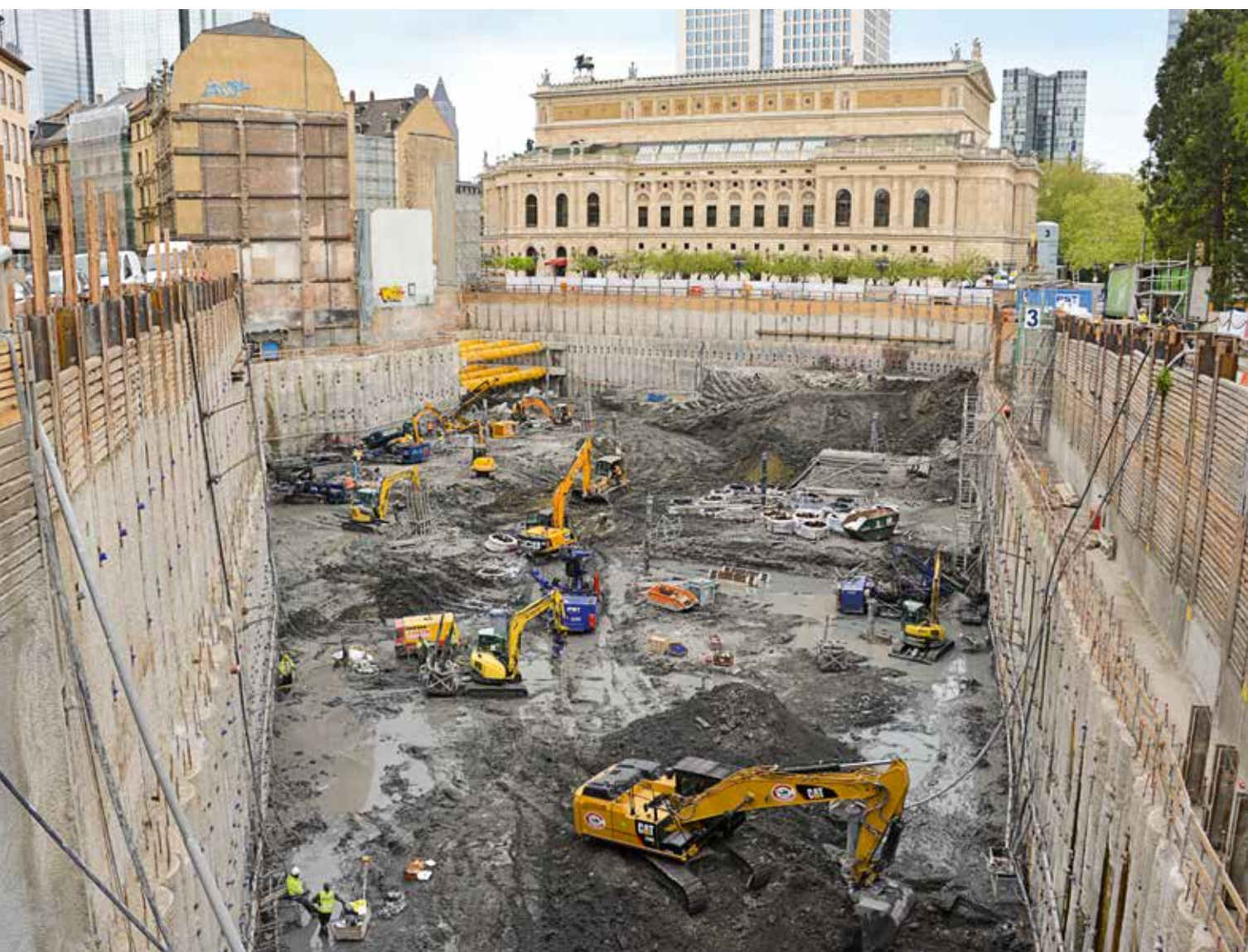
DSI Scope Production, supply, installation, technical support

DYWIDAG Products 370t of 15-0.6", Type SUSPA Systems, 150mm² Prefabricated Tendons; 80t of Type SUSPA Systems Wire EX 66 Wire Tendons; 120t of 4-0.6", Type ME Monostrand Tendons

DYNA Force® System Premiere on Frankfurt's Opera Square

Currently, comprehensive construction work is underway near the old opera house in Frankfurt, Germany. An old transformer station was demolished and re-built underground near the old location, and an old office building was pulled down.

A new five star hotel is now being built on the cleared land between Wallanlage and the Opera Square that will accommodate office space, retail facilities and apartments in addition to 135 to 165 hotel rooms.



An approx. 20-25m deep excavation had to be prepared for the new building's underground parking garage, the walls of which were tied back using temporary Type 4-0.6", St 1570/1770 DYWIDAG Strand Anchors.

DSI Koenigsbrunn supplied the 2,500 DYWIDAG Strand Anchors with a total length of approx. 45,000m and an approximate tonnage of 200t.

Furthermore, the project was the first major project in Germany in which the DYNA Force® System was used for a geotechnical application. 30 DYNA Force® Sensors were mounted on a total of 12 DYWIDAG Strand Anchors in order to ensure an exact



measurement of the forces acting on the anchors during excavation work.

DSI experts designed a detailed arrangement drawing for the installation of the sensor technology and provided comprehensive advice



to the contractor. The measurements and analysis of the readings provided by the DYNA Force® Sensors were also carried out by DSI employees on the job site.



The contractor was very satisfied with the DYNA Force® System which permits efficient and accurate measurements with minimum effort.



Owner CELLS Bauwelt GmbH, Germany

Contractor Joint venture Spezialtiefbau Opernplatz, consisting of PST Spezialtiefbau Süd GmbH and DEMLER Spezialtiefbau GmbH & Co. KG, both Germany

Engineers IGG - Ingenieurgemeinschaft Grundbau GmbH, Germany (planning of excavation)

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

DSI Scope Production, supply, installation, test installation

DYWIDAG Products 2,500 temporary Type 4-0.6" DYWIDAG Strand Anchors, 30 DYNA Force® Sensors, readout unit

Testing, Inspection and Maintenance of Multistrand Cables using the Example of the Schoenebeck Bridge over the Elbe River

As stay cable are exposed, they are subject to both constant static loads and fluctuating fatigue loads. Consequently, the testing, inspection and maintenance of stay cable systems is of decisive importance. The following text presents a testing concept that was used for the DYNA Grip® multistrand cables of the Schoenebeck Bridge over the Elbe River in Germany.

Vibration measurements that were evaluated while specifically taking into account bending stiffness were used to determine stay cable forces. The vibration measurements were also evaluated with regard to the damping behavior of the stays. Elasto-magnetic force sensors were also installed to permit easy cable force measurement.

Acceleration sensors and a recently developed camera system were used for determining the first two eigenfrequencies and the dampening of the cables as well as the eigenfrequencies and the deflection of the superstructure. The measurements relating to the stay cables were carried out near the anchorages using a compact tri-axial accelerometer.

Ambient measurement data were compiled in order to measure the natural vibration behavior of the stay cables, and the measurements were carried out using manual excitation. With the help of this test series, the eigenfrequencies, natural frequencies, free vibration lengths of the stay cables, damping values and stay cable forces of all 36 stay cables were determined.

Measurements before and after the activation of the guide deviator were carried out on several stay cables in order to determine how well they functioned and their degree of efficiency in terms of damping. The performance and functionality of the installed guide deviators was demonstrated using this technique.

In addition, DYNA Force® Sensors were installed on individual strands of 6 cables on the Schoenebeck Elbe Bridge in order to measure the stay cable forces. For comparison, lift-off tests were carried out on the strands with sensors, and the DYNA Force® Sensor readings were subsequently collected. Deviations had a mean value of +0,5%, confirming that DYNA Force® Sensors are a very efficient and simple way of monitoring stay forces. Since the sensors are installed during stay cable installation, the access to individual strands that is necessary for subsequent lift-off tests can be omitted.

An electromagnetic testing device that had been specially designed for strand bundle cables was used to detect possible wire fractures outside of the anchorages. Thanks to magnetizing coils that are placed around the stay cable circumference, this modular testing device permits full magnetization and thus also ensures a detection of prestressing steel fractures in the cable. With this testing device, the 36 stay cables protected by HDPE ducts were magnetized until saturation had been obtained and thus tested with regards to possible damaged areas such as wire fractures and significant section attenuations.





Visual inspection forms the basis of all further inspections. Automatic camera systems are used for this purpose: they can create high resolution panoramic pictures using the original length of the construction component that is to be inspected. The pictures can then be evaluated and compared at any time. Data collection only requires a fraction of the previous inspection time, thus saving time, minimizing traffic disruptions and costs.

Ultrasonic techniques are particularly suitable for inspecting anchorage areas. When ultrasonically tested, wire fractures or cracks and major corrosion damage generate signals that can be evaluated by

examining the corresponding amplitude and form.

Endoscopy is another method that can be used for cable evaluation. Large sections of exterior wires around the cable perimeter can be inspected optically along the entire free length using an endoscope.

As the strands in this bridge are galvanized, waxed and inserted in PE ducts at the factory, the free cable length can be considered as permanently corrosion protected and thus completely maintenance free.

Special attention is paid to the leak tightness of the anchorages in order to ensure permanent corrosion protection of the strands near the anchorages and anchorage wedges.

Leak tightness was proven during the verification tests by a leak tightness test in accordance with *fib* Bulletin 30. If any leaks are detected during the major tests, the special design of the DYNA Grip® anchorages allows the reactivation of the squeeze-type gasket by means of a retightening of the threadbars.

The inspection methods that have been presented using the example of the Schoenebeck Elbe Bridge are product related and state of the art. The condition of the stay cables can be determined reliably and nondestructively.



DSI UK: The Full-Range Supplier for Slope Stabilization

For many years, **DYWIDAG-Systems International Ltd.**, Great Britain has specialized in the stabilization of slopes and cuts, offering a comprehensive product range of high quality **DYWIDAG Soil Nails and Rock Bolts**.

Two years ago, DSI expanded its slope stabilization product portfolio with two new mesh products: Deltax and Greenax Mesh. Both are CE certified and hold a European Technical Approval (ETA). Since then, DSI UK has established itself as a full-range supplier for permanent slope stabilization solutions on the British and Irish markets.

Deltax Mesh is mainly used as slope protection mesh in combination with soil nails or as drape mesh with rock bolts. The mesh consists of a high strength chain link with a strength of 1770N/mm² and features an Ultracoat protection coating that is considerably more durable and robust than galvanized or PVC coatings.



The Ultracoat protection consists of zinc with aluminum plus an additional corrosion inhibitor that is applied to the wire prior to drawing. Afterwards, the coating is further consolidated on the wire by re-drawing, offering additional abrasion resistance and increased corrosion protection. Consequently, lifespans of up to 60 years can be reached if the product is used in mildly aggressive inland locations in accordance with EN ISO 12944-2 and EN 12500.

The chainlink construction allows the mesh to follow the contours of the slope or rock face and offers rapid installation without springing or roll-back. The superior stiffness of 6% in comparison to 12% for conventional mesh ensures greater restraint for soil nailed slopes resulting in less displacement and an effective restraint for loose rocks during rockfall prevention even on steep slopes.



Thanks to the increased mesh aperture, high strength Deltax Mesh has a low visual impact. During soil nailing for slope stabilization, the mesh aperture also permits the use of standard drill bits (\varnothing 76 and 100mm). Soil nails can be drilled through the mesh without the need to cut any wires.

Deltax Mesh is supplied in roll widths of 3.5m or 3.9m. Weighing 68 and 76kg respectively, the light weight rolls ensure a quick and easy installation on slope faces.

For drape mesh applications, the mesh is easily attached to top border ropes by using rope clips and then rolled down the rock face. The large roll widths ensure a cover rate of the rock face that is twice as fast as conventional systems, minimizing waste and seams. If one wire is cut, the unravelling effect is limited to a width of two chain links due to the stiffness of the bend at each link. Also, in contrast to conventional mesh, unravelling remains localized around a circle.



Greenax Mesh, which is also offered by DSI UK, is a slope protection facing comprising of Deltax mesh with an integrated monofilament erosion mat. In contrast to comparable erosion mats, the olive green Greenax mat blends with the environment.

Deltax and Greenax Mesh have been successfully used for stabilizing slopes and cuts on many road and railway projects throughout Great Britain and Ireland. Additional areas of use are large slope faces in quarries as well as the stabilization of a crater in a cave in north western Scotland.



Impressive Views: The new Gondola at Pointe Helbronner in the Mont Blanc Massif

The Pointe Helbronner is a 3,462m high mountain in the Mont Blanc Massif between Savoy and the Aosta Valley. The mountain station of the Funivie Monte Bianco funicular that transports passengers from the Italian side in La Palud near Courmayeur to the Mont Blanc Massif is located in this area.

The original cable car built in 1948 is being replaced by a modern gondola lift that will reach Pointe Helbronner in two sections. The valley station is being built approx. 700m from the previous station, and the mountain station will stand approx. 30m to the left of the old building. The new gondola lift with three supports features spherical cabins that can be rotated by 360° and can transport up to 800 people per hour.



The mountain station of the second section is being built on the same spot as the old station due to restricted space. The upper gondola lift with two supports has a maximum capacity of 610 passengers per hour and is also fitted with cabins that can rotate completely.



The valley station has an undulating roof structure consisting of steel and glass elements that are supported by curved steel trusses. The roof rests on 4 columns, each of which divides into 4 supports that are inclined towards the exterior.



To post-tension the floor slab of the new building, DYWIDAG Italy supplied a total of 52t of unbonded DYWIDAG Monostrand Tendons. The monostrand tendons are inserted into PE ducts that are placed parallel to each other and then anchored and tensioned in bundles.

Due to very limited space, the summit station is being built mainly vertically with cantilevered terraces reminiscent of Mont Blanc's quartz crystals with its intentionally irregular form. The building is anchored in highly fractured granite by a 70m deep, vertical gallery with an interior diameter of 5m.

The funnel accommodates lifts and a stairway that permits access to a pedestrian tunnel leading to the Torino Cabin. At the same time, the gallery also serves to safely anchor the gondola lift.



4m long, 26 WR DYWIDAG Rock Bolts with double corrosion protection were used as ground support during excavation of the funnel and the pedestrian tunnel. In total, DYWIDAG supplied 2,300m of DYWIDAG Rock Bolts for stabilizing tunnel advancement. In addition, the DYWIDAG team also provided technical support on site both during the work in the valley and at the summit station.



Owner Funivie del Monte Bianco S.p.A., Italy
General Contractor Cordée Mont Blanc consorzio ordinario, Italy
Consulting Engineers HOLZNER - BERTAGNOLLI, Italy
Engineering DIMENSIONE INGENIERIE s.r.l., Italy

DSI Unit DYWIDAG S.P.A., Italy
DYWIDAG Scope Production, supply, technical support
DYWIDAG Products 52t of unbonded DYWIDAG Monostrand tendons,
 26 WR DYWIDAG Rock Bolts with double corrosion protection

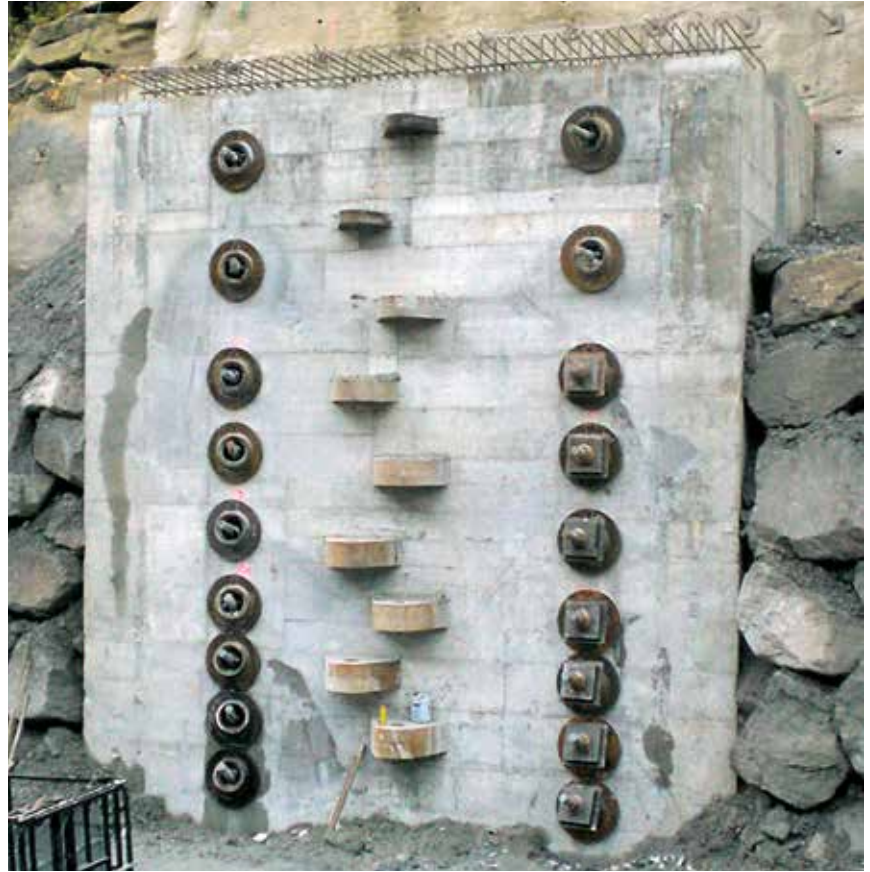
Flood Control with *GEWI® Plus* Anchors: Driftwood Cable Barrier near Bruneck

The town of Bruneck in South Tyrol is located in a basin beneath the Rienz Gorge. In order to protect the town from driftwood and debris during floods, the Autonomous Province of Bolzano decided to build a new cable barrier in the Rienz Gorge in addition to the construction of a driftwood grate east of Bruneck.

For the 7m high driftwood cable barrier, nine 50m long steel cables had to be erected across the river bed of the Rienz. Two retaining walls on each side of the river bed to which the cables were attached were tied back to stable rock using permanent bar anchors. For this purpose, DYWIDAG supplied 36 25m long Ø 75mm double corrosion protected St 670/800 *GEWI® Plus* Anchors.



First, the general contractor Klapfer Bau drilled the boreholes for the anchors on both sides of the river embankment. Afterwards, spacers were placed on the corrugated sheathing in the bonded length. Then the pregrouted *GEWI® Plus* Anchors were horizontally lifted and installed in the boreholes. This was followed by the primary grouting of the 12m long bonded lengths up to the deepest point of the boreholes using cement mortar. Last of all, Klapfer Bau carried out the postgrouting work a few hours after primary grouting in order to ensure the development of high anchor forces.



After assembling the anchor heads on the *GEWI® Plus* Anchors, they were tensioned to 2,000kN. In order to ensure long-term corrosion protection, the anchors were also



injected with corrosion protection compound, and the anchor heads were furnished with permanent protection caps.



Owner Autonomous Province of Bolzano, Department for Soil Conservation, Torrent and Avalanche Protection Structures, Italy
General Contractor Klapfer Bau GmbH, Italy
Architect Ingenieurteam Bergmeister, Italy

DSI Unit DYWIDAG S.P.A., Italy
DYWIDAG Scope Supply, test installation
DYWIDAG Products 36 double corrosion protected Ø 75mm St 670/800 *GEWI® Plus* Anchors

Luka Koper: *GEWI® Plus* Micropiles rehabilitate Slovenia's only Harbor

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Construction

EMEA

Slovenia

Hydro- & Marine
Structures

The city of Koper is the only seaport in Slovenia and is located on the country's 47km long Adriatic Coast. The port of Koper – Luka Koper – is an international multi-purpose harbor linking Central and Eastern Europe with the Mediterranean Sea and facilitating access to the Americas and the Far East via the Straits of Gibraltar and the Suez Canal.

The Luka Koper harbor has a water depth between 7 and 18m, accommodating ships with up to 180,000t capacity. Currently, the harbor has reached its capacity limit: The existing shortage of space often causes waiting times of several days during the loading and unloading of ships. Within the scope of a major, 5-year expansion program, the harbor will be enlarged from 268 to 404ha.

Expansion work includes a much larger container terminal, deepening the harbor and the construction of two new docks. At the same time, the mooring area for smaller ships in the inner harbor located directly in front of the old town is being rehabilitated. In this area, a quay wall had to be repaired and stabilized comprehensively.



To stabilize the quay wall, DSI Austria supplied Ø 43mm St 670/800N/mm² *GEWI® Plus* Micropiles. The 25m long *GEWI® Plus* Micropiles were

installed vertically into the quay wall in three parallel layers. Furthermore, DSI provided a DYWIDAG jack for tensioning.

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Owner City of Koper, Slovenia/Luka Koper, Slovenia
Contractor Adriaing d.o.o., Slovenia
Engineering Geoeng & Co., Slovenia

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Production, supply, technical support
DYWIDAG Products Ø 43mm *GEWI® Plus* Micropiles

70m long DYWIDAG Strand Anchors stabilize new Quay Wall in Amazonehaven Rotterdam

Rotterdam harbor in the Netherlands is one of Europe's most important harbors. After the western port area was enlarged to accommodate the newest generation of container ships, the Amazonehaven area in Rotterdam harbor also had to be widened.

The expansion is being executed at the southern side of the port basin along the entire length of 2.5km. The basin is being widened, and a new wharf is being built parallel to the existing wharf at a distance of 50m.

The new, 2.5km long quay wall consists of a combi wall with tubular piles and sheet piles.





Combi walls can absorb higher loads and have higher retaining heights than conventional sheet pile walls. The new combi wall in Amazonehaven has a heavy concrete cap beam and a retaining height of 17 to 19m.

For the construction of the combi wall, tubular piles were driven into the ground first. Afterwards, the sheet piles were installed between the tubular piles. In order to stabilize and secure the combi wall, it was tied back using permanent DYWIDAG Strand Anchors. In total, DSI Netherlands supplied 1,285 permanent 10-13 strand DYWIDAG Strand Anchors for this project.

The presence of existing heavily loaded foundations and a 380kV cable only a few meters behind the quay wall necessitated a vibration free anchor system with long anchor lengths. The permanent DYWIDAG Strand Anchors totaling 841t that were used had individual lengths of up to 70m. Each Strand Anchor was successfully tested with loads up to 225t. Each tubular pile was tied back in the load-bearing soil using two DYWIDAG Strand Anchors.



Owner Havenbedrijf Rotterdam, Netherlands

Supervisor Gemeentewerken Rotterdam, Netherlands

Contractor Joint Venture, consisting of Besix Nederland B.V. and Van Oord Nederland B.V., Netherlands

Contractor Anchor Installation De Vries Titan Verankeringen en Funderingstechnieken B.V., Netherlands

Consulting Engineers Gemeentewerken Rotterdam, Netherlands

DSI Unit DYWIDAG-Systems International B.V., Netherlands

DSI Scope Production, supply, technical support

DYWIDAG Products 1,285 permanent DYWIDAG Strand Anchors with 10-13 strands

DYWIDAG Products for Bridge with Unique Design: De Oversteek, Nijmegen

In Nijmegen, one of the oldest cities in the Netherlands, a new bridge crossing the Waal River was opened for traffic in November 2013. The 1,400m long bridge is known as “De Oversteek” and consists of different sections that were built using different construction techniques. The main span is a 285m long steel arch bridge. The approach bridges on both sides of the main span are built as a combination of conventional concrete and lightweight foam concrete. Post-tensioned concrete viaducts are positioned at both ends of the approach bridges and are connected to the local road network.

Most of the arch spans are 42.5m long and 25m wide. The approach bridge at the north side of the river consists of 15 arches, and the south side consists of 5 arches. BAM-Infraconsult proposed a unique concrete design for the arches: Each arch consists of a conventional concrete shell structure with a curved bottom plate and vertical side walls.



These concrete shell structures were then filled with lightweight foam concrete, providing a flat deck for traffic. The bottom part of the concrete arches is only 0.5m thick in the middle and is supported by approx. 1.1m thick V-shaped transverse concrete girders. The transverse girders rest on two concrete columns rising from a concrete foundation block on piles.

DSI supplied, installed, stressed and grouted the DYWIDAG Post-Tensioning Strand Tendons for all transverse girders. As a rule, 5 Type 27-0.62", 1860N/mm² DYWIDAG Strand Tendons were used per transverse girder. In each construction cycle, the columns and V-girders were built prior to the construction of the concrete arches. Three forms were used for each arch.

Furthermore, DSI supplied Ø 63.5mm GEWI® Bars that were installed at the highest points of the concrete arch shells. The bar tendons ensure the stability of the arches during erection - particularly after the removal of scaffolding and formwork.

In a few locations, temporary diagonal DYWIDAG Strand Tendons were placed between the top of the columns and the next foundation blocks. Two tendons with 31 PE-sheathed strands per column were applied for additional safety against progressive collapse. DSI also supplied, installed and tensioned these strand tendons and de-tensioned them once all arches had been completed.

The bridge deck of the main span consists of two longitudinal steel girders and an orthotropic steel deck with a 150mm thick concrete top layer. The 60m high and 285m long steel arch structure is the longest arch bridge in Europe. Fully locked steel stay cables connect the arch structure and the bridge deck.

Construction work on the main span was carried out in a site yard next to the river. The assembly of the arch structure using temporary supports in an area similar to a dry dock allowed the transportation of the complete steel arch on pontoons from the site yard to its final position on the main concrete pillars at both sides of the river Waal. The spectacular floating in place of the arch structure was successfully completed in April 2013.

The dynamic behavior of the stay cables will be monitored for one year. DSI supplied frictional dampers for some of the stay cables in order to investigate the differences between damped and undamped cables.

The two viaducts were designed with variable lengths and widths in order to provide suitable connections to the existing local roads. Both viaducts are built as pre-stressed concrete structures. 42 Type 27-0.62", St 1860N/mm² DYWIDAG Strand Tendons were used for the

Oosterhousdijk viaduct. 46 Type 22-0.62", St 1860N/mm² DYWIDAG Strand Tendons were used for the Weurtseweg viaduct. The length of the DYWIDAG Tendons that were supplied, installed and grouted by DSI varied from 32 to 50m.

The co-operation between the various parties involved in the design and construction of this very challenging project was pleasant and successful.



Owner City of Nijmegen, Netherlands

General Contractor Joint Venture "Stadsbrug Nijmegen", consisting of BAM Civiel B.V. and Max Bögl Nederland B.V., both Netherlands

Architect Ney & Poulissen, Netherlands

Consulting Engineers (steel arch bridge) Leonhardt Andrä & Partner, Germany

Consulting Engineers (approach bridges) BAM-Infraconsult, Netherlands

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

DSI Unit DYWIDAG-Systems International B.V., Netherlands

DSI Scope Production, supply, installation

DYWIDAG Products 42 Type 27-0.62", St 1860N/mm² DYWIDAG Strand Tendons; 46 Type 22-0.62", St 1860N/mm² DYWIDAG Strand Tendons; Ø 63.5mm GEWI® Bars; temporary diagonal DYWIDAG Strand Tendons with 31 strands; frictional dampers

DYWI® Drill Hollow Bars Secure the Future of Granary Island in Gdansk

At the junction of the Motława River and the Dead Vistula River lies a block of land known as Granary Island, located in the heart of the famous Amber district in downtown Gdansk. Until 1945, Granary Island was an important part of the city's industry with wharfs and warehouses. In the course of time, the island was slowly being lost to the two rivers, which caused both landslides and increasing damage to the quayside.

Due to the city's growing economy and tourist industry, it became more and more important to stabilize both quaysides and deepen the waterway along the Motława River in the Gdańsk area. To stabilize the quaysides, 1,036 Ø T76-1200 DYWI® Drill Hollow Bar Anchors with a total length of 23,930m were chosen as the tie back solution for the new sheet piles.





In this section (Granary Island), sheet piles were installed 15-17m deep into the ground, and Energopol Szczecin SA installed the DYWI® Drill Hollow Bars to depths of 17-26m. Installation was carried out using a Soilmec SM-14 tracked drill rig with a Krupp HB50A hammer.

The DYWI® Drill Hollow Bars were installed in maximum lengths of 3m. Initial flush to depth was carried out with a 0.9 w/c grout ratio, followed by a 0.5 w/c grout ratio with flush back to the surface. The cement grout was injected using a Hany grout pump through a Type H90/T76 DYWIDAG Rotary Injection Adaptor.

Ground conditions consisted of silts with sand and gravels overlying clay. To drill into this ground, Type T76 TSB retroflush drill bits in diameters of 200mm and 280mm were used. In the deep end of the boreholes, full reaming was employed to clean the boreholes and enhance the bond at the grout/ground interface.



Owner City of Gdansk; Harbor Authorities in Gdynia, both of them Poland
General Contractor Budimex S.A.; Energopol Szczecin S.A., both of them Poland
Drilling Contractor Energopol Szczecin S.A., Poland

DSI Unit DYWIDAG-Systems International Sp. z o.o., Poland
DSI Scope Production, supply, technical support
DYWIDAG Products 1,036 Ø T76-1200 DYWI® Drill Hollow Bar Anchors

Relief for Noia: New Stay Cable Bridge ensures Summer Months without Traffic Jams

During the summer months, the town of Noia near Santiago de Compostela in northwestern Spain experiences exceptionally large traffic volumes. On average, two million vehicles per year drive to the estuary beaches of Noia and Muros.

Today, Noia's residents finally have some relief: Since December 2013, a new stay cable bridge crosses the estuary near Noia.



The bridge connects Testal with A Barquina and is the main part of a new road to Santiago de Compostela that significantly reduces travel time between the two cities.

The new viaduct is a prestressed concrete bridge with two precast beams supporting a concrete slab. The bridge has a total length of 1,700m and average spans of 30m. This excludes the spans carried by stay cables – two of those spans are 48m long, and the middle span has a length of 102m. The bridge deck has a total width of 16.5m and accommodates two traffic lanes as well as two pedestrian and cycle paths.



The stay cables are mounted on two symmetrical steel pylons that reach a height of 26.3m above the bridge deck. The 24 stay cables are arranged symmetrically on the main bridge with 12 tendons anchored at each pylon in a fan-shaped arrangement.

DSI Spain supplied and installed Type DG-P 31, DG-P 37, DG-P 55 and DG-P 61 Stay Cables in lengths between 21 and 55m. The stay cables meet all *fib* requirements and are inserted into white ducts with an external helix to reduce the wind-rain induced vibrations. The strands with a total weight of 59t are galvanized, waxed and sheathed, fulfilling the technical requirements of prEN 10337.

Installation work was carried out and supervised by DSI Spain's experienced employees. The stressing operation was smoothly executed thanks to the patented ConTen System, and the fine tuning of stay cable forces was achieved using DSI's gradient jacks.

As an additional reinforcement of the precast concrete segments in the main span, DSI supplied and installed 48 external Type 27-0.62" DYWIDAG Strand Tendons. The precast concrete segments, which were 30m long on average, were tightly connected using Ø 36, 40 and 47mm DYWIDAG Bar Tendons near the abutments. In total, DSI supplied 16t of DYWIDAG Bar Tendons with accessories for this purpose.



Owner Xunta de Galicia, Spain

General Contractor Puentes y Calzadas Infraestructuras, S.L.U., Spain

Subcontractor Estructuras y Montajes, Spain

Consulting Engineers Pondio Ingenieros SL, Spain

DSI Unit DYWIDAG Sistemas Constructivos S.A., Spain

DSC Scope Production, supply, installation, engineering services, technical support

DYWIDAG Products 24 DG-P 31, DG-P 37, DG-P 55 and DG-P 61 DYNA Grip® Stay Cables;
48 external Type 27-0.62" DYWIDAG Strand Tendons;

16t of Ø 36, 40 and 47mm DYWIDAG Bar Tendons with accessories

DYWI® Drill System stabilizes important Example of Mudéjar Art: Church of San Andrés, Zaragoza

The Church of San Andrés, which is located in the northern Spanish town of Calatayud, Zaragoza, is an important example of Mudéjar Art. This architectural style dates back to the muslims that lived in Spain during the Reconquista. Like many churches in Spain, the Church of San Andrés was originally built as a mosque and then remodeled into a Christian Church between the 14th and the 16th Century.

Due to its age, as well as the poor ground on which the church was built, past problems of subsidence were detected that required restoration time and again – the last repair work was carried out between 1990 and 1992.



At the end of 2012, the church had to be immediately closed because additional subsidence had caused movements of the building and new cracks in the masonry that put the stability of the entire church in question.

In early 2013, the special foundations specialist CIMSSA, who closely cooperates with DSC Spain, was commissioned to carry out the repair work. Since the work had to be executed as quickly as possible, CIMSSA and DSC decided to install the high quality DYWI® Drill Hollow Bar System for stabilizing the church foundation.

DYWI® Drill Micropiles, Ø R51-660, were installed, underpinning the entire church building. The micropiles with hardened arc-shaped Ø 115mm

button drill bits were installed self-drilling to a depth of 12m. In total, 3,600m DYWI® Drill Hollow Bars and 300 lost drill bits were installed.



Owner Diocese of Tarazona, Spain

General Contractor Construcciones Puente Argal, S.L., Spain

Subcontractor CIMSSA – Cimentaciones Singulares S.A., Spain

Architect Jesús Fernando Alegre, Spain

DSI Unit DYWIDAG Sistemas Constructivos S.A., Spain

DSC Scope Production, supply, supervision

DYWIDAG Products 3,600m of DYWI® Drill Hollow Bars, Ø R51-660; 300 hardened arc-shaped Ø 115mm drill bits

GEWI® Micropiles stabilize Excavation in Jaber Al Ahmad City, Kuwait

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Construction

EMEA

Kuwait

Excavation

Jaber Al Ahmad City is a residential project located 25km west of Kuwait City.

The development area will offer living facilities for a total of 80,000 people on an area of 1,244ha. In addition to 4,134 villas, the estate will accommodate public facilities such as schools, universities and hospitals as well as a variety of shops.

On the jobsite, new highways will have to cross over gas pipes that are buried only 6m below ground level. The task of the contractor was to protect the active pipelines from future highway loads by building a concrete shield around it.

The pipelines had to remain in use during the construction phase, and therefore, the risk of an explosion caused by small impacts during construction work on the exposed pipelines was significant.

In some areas, the soil was so weak that ground support for the new housing was needed. DSI proposed the installation of double corrosion protected (DCP) GEWI® Micropiles in lengths of 11.8m for enhancing the load-bearing capacity of the soil.

The installation of the Ø 40mm GEWI® Micropiles was the optimum solution for this project. The installation of the micropiles only required small boreholes so that vibrations during the drilling work were kept to a minimum and safety during installation was significantly enhanced. DSI supplied a total of 874 DCP GEWI® Micropiles with spacers and anchor plates.



The use of GEWI® Micropiles ensures a long service life and rapid installation cycles.

DSI supervised the installation on site and ensured a successful and safe completion of the construction work.



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Owner Public Authority of Housing Welfare, Kuwait

General Contractor Ahmadiyah Contracting & Trading Co. K.C.S.C. , Kuwait

Subcontractor Drilling Work Edrasis Middle East Ltd., Kuwait

DSI Unit DYWIDAG-Systems International GmbH, GBU, Germany

DSI Scope Production, supply, supervision

DYWIDAG Products 874 Ø 40mm GEWI® Micropiles

The New Al Tameer Office Building, Kuwait: DYWIDAG Strand Tendons for one of the World's largest Oil Producers

Kuwait Oil Company (KOC), a subsidiary of the state-owned Kuwait Petroleum Corporation, is one of the largest oil producers in the world. With an output of approx. 2.3 million of barrels of oil per day, KOC is the fourth largest producer in OPEC.

The company is located in Ahmadi, a district in southeastern Kuwait City. Here, KOC recently built a new headquarters. The new office building is located directly at the main entrance of Ahmadi City, a company-owned private town that includes residential buildings, parks, schools and recreational facilities for KOC employees.



The new headquarters has four floors and a three level underground parking garage with an average area of 18,000m² per level.

DSI's licensee Kuwait Prospects Co W.L.L supplied DYWIDAG Post-Tensioning Systems for prestressing the flat slabs in the new office building. In total, Bonded DYWIDAG Strand Tendons with more than 9,000 Type FA Flat Anchorages were used in the 120,000m² large prestressed flat slabs.



Owner Kuwait Oil Company (KOC), Kuwait
Contractor Khalid Ali Al-Kharafi & Brothers Co., Kuwait
Consulting WorleyParsons Ltd., Kuwait

DSI Licensee Kuwait Prospects Co W.L.L, Kuwait

Scope Supply

DYWIDAG Products Bonded DYWIDAG Strand Tendons with more than 9,000 Type FA Flat Anchorages

The Crystal Tower: DYWIDAG Post-Tensioning Systems for Kuwait's new Landmark

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Construction

EMEA

Kuwait

Commercial
Buildings

The Crystal Tower is a new office and multi-purpose building that is being built in the commercial quarter of Sharq in Kuwait City. With its elegant and modern design, the high rise building will become a new landmark of the city.

The 228m high building has more than 50 floors, three of which will accommodate a shopping center. The skyscraper also includes a 7 story parking garage with a total surface of 9,500m².

The DSI licensee Kuwait Prospects Company was awarded the full structural design and execution contract for the car garage, where



7 floors were executed using the DYWIDAG Strand Post-Tensioning System. The 18cm thick flat slabs in the car park are supported by prestressed girders with spans of 25m. A total of 600 Bonded DYWIDAG Strand Tendons with FA59 03 and FA59 05 Flat Anchorages was used for prestressing the girders and slabs.



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Owner Al Arabiya Real Estate Company, Kuwait

General Contractor Bukhamseen International Group of Contractors (BIG Contractors), Kuwait

Consulting Osama Bukhamseen Design Engineering & Consultants, Kuwait

Architect Hellmuth, Obata & Kassabaum Inc. (HOK Consultants), USA

DSI Licensee Kuwait Prospects Co W.L.L., Kuwait

Scope Design, supply, installation

DYWIDAG Products 600 Bonded DYWIDAG Strand Tendons with FA59 03 and FA59 05 Flat Anchorages

A Major Project for DSI: The Haramain High Speed Rail Project in Saudi Arabia

The Haramain High Speed Rail Project is a major transportation initiative in Saudi Arabia that will connect the holy cities of Mecca and Medina via Jeddah and King Abdulla Economic City (KAEC) in Rabigh. The new high speed rail line will have a total length of approx. 450km and will transport 3 million passengers per year at maximum speeds of 320km/h.

Approx. 140 bridges (rail viaducts, rail bridges, road bridges, road underpasses and camel crossings) are being built in addition to four train stations along the line (Medina, KAEC, Jeddah and Mecca). The project is split into six sections. Phase 1 (infrastructure) is being executed by the Al Rajhi Alliance – the main companies interacting with DSI are China Railway (CRCC), Al Arrab (ACC) and Al Rajhi Contracting (ARC).

2010 to date:

DSI supplies Post-Tensioning Systems for the project in all six sections through its local partners.

2013:

DSI decides to get directly involved as a subcontractor for Post-Tensioning in the following sections:

King Abdullah Economic City (KAEC) – Bridge at km 181.381 (KAEC2) and at km 181.181 (KAEC3)

In KAEC, a new megacity that is being built north of the city of Jeddah, China Railway (CRCC) awarded DSI the Post-Tensioning package for the bridges KAEC2 and KAEC3.

For two bridges, DSI and its licensee BIC Prestressed Concrete supply 159t of bonded Type 27-0.62" and 22-0.62" DYWIDAG Strand Tendons and anchorages.

The tendons were installed under DSI supervision and tensioned and grouted by DSI-BIC employees.

Bridge at km 3.934



Thanks to the excellent partnership of DSI-BIC and CRCC, the bridge at km 3 was successfully completed on time.



Owner Saudi Railways Organization, Saudi Arabia

General Contractor China Railway 18th Bureau Group Co., Ltd. (CRCC), China

DSI Unit DYWIDAG-Systems International GmbH, GBU, Germany;
BIC Prestressed Concrete, Saudi Arabia

DSI Scope Supply, supervision of installation, stressing & grouting

DYWIDAG Products 159t of bonded Type 27-0.62" and 22-0.62" DYWIDAG Strand Tendons

Bridge at km 38.900

Together with BIC, DSI supplied 152t of bonded Type 12-0.6" and 9-0.6" DYWIDAG Strand Tendons with MA Anchorages.



Owner Saudi Railways Organization, Saudi Arabia
General Contractor China Railway 18th Bureau Group Co., Ltd. (CRCC), China

DSI Unit DYWIDAG-Systems International GmbH, GBU, Germany;
 BIC Prestressed Concrete, Saudi Arabia;

DSI Scope Supply, supervision of installation, stressing & grouting

DYWIDAG Products 152t of bonded Type 12-0.6" and 9-0.6" DYWIDAG Strand Tendons

Bridge at km 183.139

In partnership with its long-time client and partner Ziad Saeed Al Qasas Est. for Contracting, DSI supplied 440t of bonded Type 31-0.62" DYWIDAG Strand Tendons with MA Anchorages and R Couplers. Construction work on this viaduct was completed within a very tight schedule: 100t of DYWIDAG Strand Tendons were supplied to the jobsite within one month in order to meet the schedule. The tendons that were installed in the floor slabs of the viaduct were tensioned using a 9,750kN Jack.



Owner Saudi Railways Organization, Saudi Arabia
General Contractor China Railway 18th Bureau Group Co., Ltd. (CRCC), China

DSI Unit DYWIDAG-Systems International GmbH, GBU, Germany;
 Ziad Saeed Al Qasas Est. for Contracting, Saudi Arabia

DSI Scope Supply, installation, stressing & grouting

DYWIDAG Products 440t of bonded Type 31-0.62" DYWIDAG Strand Tendons with MA Anchorages and R Couplers

DYWIDAG Soil Nails protect Railway Embankments against Landslides in Malawi

The Republic of Malawi is located in south eastern Africa in the east African fracture zone. In the north of the republic, the Nacala-Moatize railway line connects the most important coal mines near Moatize with the port of Nacala-à-Velha.

The railway is part of a logistics corridor commissioned by Vale, a globally active Brazilian mining company. It will serve to open the vast coal reserves of the Tete basin by way of a route traversing remote



areas, crossing through southern Malawi and reaching the east coast of Mozambique.

The extension of the existing railway line includes comprehensive earth stabilization measures. Existing strand anchor slope stabilization installations had to be reinforced, and new slope stabilization measures had to be undertaken in order to prevent rock falls. The heavy rainfall and storms that are characteristic for this area constituted another problem: they had repeatedly caused damage on the railway embankments that

would lead to an interruption of railway service. Beginning with the planning stage, DSI South Africa supported the engineers and project managers with the planning of efficient stabilization measures for the slopes.

The customized DYWIDAG Soil Nails supplied by DSI South Africa consist of 650MPa steel grade. The Ø 25mm soil nails were produced in standard lengths of 5m, 10m and 15m and installed in multiple lengths using couplers. Additionally, the DYWIDAG Soil Nails were produced in lengths of 13m in order to be able

to react as quickly and flexibly as possible to geological fault zones using the optimum product.

The transportation of the drill rigs was very challenging due to the steep and impassable terrain that was difficult to access. After the predrilling of the boreholes, the soil nails were inserted, fully grouted and tensioned. DSI South Africa is supplying a large number of DYWIDAG Soil Nails with accessories such as nuts, anchor plates, or spacers for this special project.



The production of the DYWIDAG Soil Nails at DSI's factory in Johannesburg started in December 2013, and the first deliveries reached the jobsite in January 2014. As the construction work for this infrastructure project will continue for two more years, DSI South Africa is expecting follow-up orders.

DSI South Africa is proud to be contributing to the successful repair and widening of this important railway line with competent advice and the support of the project team.



Owner Vale S.A., Brazil

DSI Unit DYWIDAG-Systems International Pty. Ltd., South Africa

DSI Scope Development, production, supply, engineering services

DYWIDAG Products Ø 25mm DYWIDAG Soil Nails and accessories

DYWIDAG Strand Tendons stabilize challenging Pier Footings for Motorway 73 in Quebec

Canadian Highway 73 connects the middle of the Province of Quebec with the south. In 2012, the Quebec Ministry of Transportation awarded the contract for the extension of Highway 73 in the municipality of Notre-Dame-des-Pins to the contractor Couillard Construction.

The contract included the construction of the two 365.76m long and 45.72m high east and west structures of bridge P-15582 over the Gilbert River. For two of the three pier footings, the engineer specified 40 permanent, double corrosion protected strand anchors as well as two test anchors.





The specialty contractor Entreprises Michel Beupied Inc was awarded a contract to install the strand anchors and, in turn, gave an order for the supply of the DYWIDAG Strand Anchors and related equipment as well as technical service to DSI Canada, Eastern Branch.

The pre-assembled, 30.48m long Type 27-0.6", ASTM A416, 1,860MPa DYWIDAG Strand Anchors were supplied to the jobsite coiled on pallets. The 80 strand anchors are protected by corrugated HDPE ducts complete with pre-installed grout tubes and centralizers. In addition to the anchors, DSI Canada also supplied the accessories such as wedge plates, wedges, bearing plates and base plates with welded-on steel trumpets.

When working on the pier footings, the specialty contractor ran into highly fractured rock layers and substantial water issues that required rock consolidation. The anchor holes had to be grouted and re-drilled to ensure water tightness and an alignment of the holes in accordance with the specifications.

The subsequent installation, grouting, testing and stressing of the DYWIDAG Anchors was achieved to the satisfaction of the owner and all companies involved in the project.

An experienced team from DSI's office in Gormley provided technical support on site during the complete construction work, thus contributing to the successful completion of the project within the tight schedule.



Owner Department of Transportation Quebec, Canada
General Contractor Construction Couillard Ltée., Canada
Subcontractor Entreprises Michel Beupied Inc (Les), Canada
Architect WSP Canada Inc., Canada
Consulting WSP Canada Inc. and Roche ltée, Groupe-conseil, both Canada

DSI Unit DYWIDAG-Systems International Canada Ltd., Eastern Division, Canada
DSI Scope Design, production, supply, engineering services, technical support, supervision
DYWIDAG Products 80 double corrosion protected Type 27-0.6" DYWIDAG Strand Anchors

Spectacular Use of DYWIDAG Systems: The Glacier Skywalk in Canada's Jasper National Park

Since May 2014, Jasper National Park in Alberta, Canada, features a spectacular highlight for visitors: The Glacier Skywalk. The skywalk is a visitor platform with a glass floor on a steel frame structure that extends from a cliff at a height of 280m. The cantilevered platform was erected at an existing road and extends over 30m from the rock. It provides tourists with an impressive view of the Sunwapta Valley with its glacier fields and steep rock walls.



The viewing platform contains a draped cable in its inside radius. A large compression chord acts together with steel framing members to provide torsional resistance under partial load. Tuned mass dampers in the walkway minimize vibrations caused by walking, and wind deflectors attached to the outer handrails reduce swinging caused by crosswinds.

The 30m long glass skywalk is supported by 600t of cantilevered, trapezoidal box girders secured onto

tyed back foundation blocks. The foundations were anchored in depths of 10 to 20m in the load-bearing rock using rock anchors. DSI Canada supplied 48 Ø 63mm DYWIDAG Rock Anchors for tying back the foundation blocks.

64 Ø 46mm GEWI® Micropiles and Ø 46mm double corrosion protected (DCP) DYWIDAG Rock Anchors were installed in the concrete foundations for the box girders. The concrete foundations were further post-tensioned with 77 Ø 46mm

THREADBAR® Tendons. The steel frame structure was secured to the concrete foundations using 80 post-tensioned Ø 36mm DYWIDAG Anchor Bolts. 2 Type 9-0.6" DYWIDAG Strand Tendons in steel ducts were used to support the cantilevered glass platform. DSI Canada provided technical assistance for all of the products that were supplied and also provided the equipment needed for tensioning the anchors. An experienced DSI technician supervised the construction work on site.

DSI worked closely with the design engineers and the general contractor from the beginning conceptual stage through to completion of the project. Due to the remote sub-alpine terrain, construction work was very difficult. The constrained site access prevented using cranes for the stressing. Scaffold sections had to be set up and manual chain falls had to be used to hoist equipment.

This meant all materials and equipment had to be prepared ahead of moving the suspended structure into place, as the large lifting crane blocked any subsequent access to the jobsite.

Site conditions required quick design changes. In some cases, DSI had to produce and supply additional products just in time in order to make use of the short time frame in which

the construction work could be carried out due to the extreme local weather conditions. Even before construction of the skywalk started in 2011, the project won the Future Projects Category at the World Architecture Festival in Barcelona.



Owner Brewster Travel Canada, Canada

General Contractor PCL Constructors Inc., Canada

Subcontractor Josef Gartner GmbH, USA, BOVA Steel Inc. and

BAT Construction Ltd., both Canada

Consulting Engineers Read Jones Christoffersen Consulting Engineers (RJC), Canada

Architect Sturgess Architecture, Canada

Engineering (Geotechnics) Thurber Engineering Ltd., Canada

DSI Unit DYWIDAG-Systems International Canada Ltd., Western Division, Canada

DSI Scope Production, supply, installation, technical support, supervision

DYWIDAG Products 48 Ø 63mm DYWIDAG Rock Anchors;

64 Ø 46mm GEWI® Micropiles; Ø 46mm DCP DYWIDAG Rock Anchors;

77 Ø 46mm THREADBAR® Post-Tensioning Tendons; 80 Ø 36mm DYWIDAG Anchors;

2 Type 9-0.6" DYWIDAG Strand Tendons

The Port Mann Bridge: Geotechnical and Post-Tensioning Systems for North America's second largest Stay Cable Bridge

Port Mann Bridge is part of Canadian Highway 1, connecting Vancouver with Surrey over the Fraser River. The new, 10-lane stay cable bridge replaces the original 5-lane bridge that was built in the early 1960s and doubles its capacity. The Port Mann Bridge is the second largest stay cable bridge in North America. At a width of 65m, it is the world's widest long-span bridge according to the Guinness World Records, overtaking the world-famous 49m wide Sydney Harbour Bridge, which held the record since 1932.

The 2km long bridge consists of a 850m long stay cable bridge, a 360m long southern and an 820m long northern approach structure that were built using 1,158 precast concrete segments. The bridge crosses Fraser River, providing a clearance of 42m.

For this large infrastructure project, DSI Canada supplied both high



quality geotechnical products and DYWIDAG Post-Tensioning Systems. For geotechnical applications, DSI supplied double corrosion protected (DCP) bar anchors for the retaining walls located along the entire length of the project. In total, 900 Ø 25mm DYWIDAG Bar Anchors, 800 Ø 29mm

DYWIDAG Bar Anchors and 180 Ø 32mm DYWIDAG Bar Anchors in lengths of 18.3m each were installed in the retaining walls. In addition, DSI supplied the stressing equipment and supported the contractor during the performance and proof tests of all ground anchors.





In addition, DSI Canada rented the stressing equipment and provided technical support during material inspection and site troubleshooting.

The major challenge for DSI Canada's team was the fact that design information was only provided a short time before the material was needed. Thanks to the excellent co-operation between DSI and the jobsite, all products were supplied within the required schedules.

The great flexibility and the depth of training of all DSI technicians, engineers and sales personnel ensured that work was always completed when needed.

For the superstructure of Port Mann Bridge, DSI Canada produced and supplied the necessary post-tensioning systems. In total, 272 Type 12-0.6" DYWIDAG Strand Tendons, 1,245 Type 19-0.6" DYWIDAG Strand Tendons, 1,915 Type 27-0.6" DYWIDAG Strand Tendons and 48 Type 37-0.6" DYWIDAG Strand Tendons were installed in the superstructure. In addition, 10,100 Type 4-0.6" DYWIDAG Strand Tendons with Flat Anchorages were used as transverse deck tendons.

DYWIDAG THREADBAR® Post-Tensioning Systems were needed for the temporary tensioning of the precast segments and the permanent tensioning of the bridge structure. For this purpose, DSI Canada supplied 182.9m each of Ø 26 and 32mm DYWIDAG THREADBAR®, 2,179m of Ø 36mm of DYWIDAG THREADBAR®, 4,542m of Ø 46mm DYWIDAG THREADBAR® and 884m of Ø 66mm DYWIDAG THREADBAR®.



Owner BC Ministry of Transportation and Infrastructure, Canada
General Contractor Joint Venture, consisting of Peter Kiewit Sons Co. and Flatiron Constructors Canada Limited, both Canada

DSI Unit DYWIDAG-Systems International Canada Ltd., Western Division, Canada

DSI Scope Production, supply, technical support, engineering services

DYWIDAG Products Ø 25, 29 and 32mm DYWIDAG Bar Anchors;
 Type 4-0.6", 19-0.6", 27-0.6", and 37-0.6" DYWIDAG Strand Tendons;
 Ø 26, 32, 36, 46 and 66mm DYWIDAG Bar Tendons

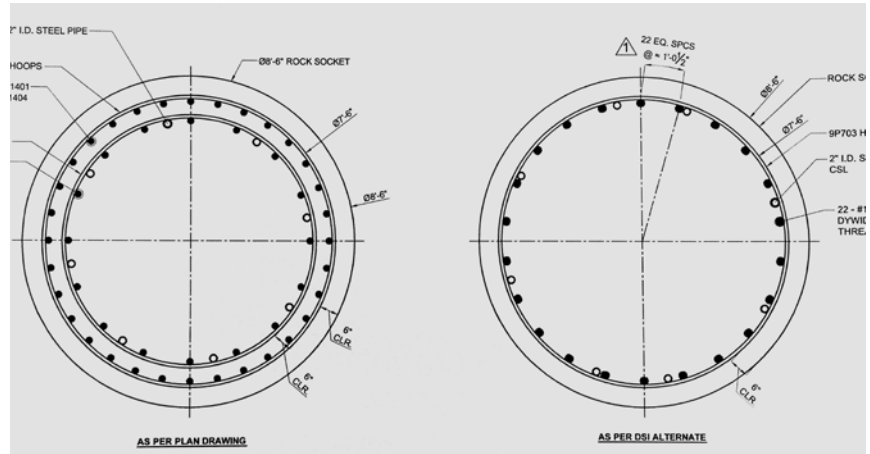
The St. Croix Crossing: DYWIDAG Bar Reinforcement Saves Time and Money



Opened in 1931, Stillwater Bridge is a lift bridge that crosses the St. Croix River between Stillwater, Minnesota and Houlton, Wisconsin. Within the last few years, the historic bridge became a bottleneck for traffic because of its out-dated lifting mechanism. Furthermore, it was beginning to show structural deficits.

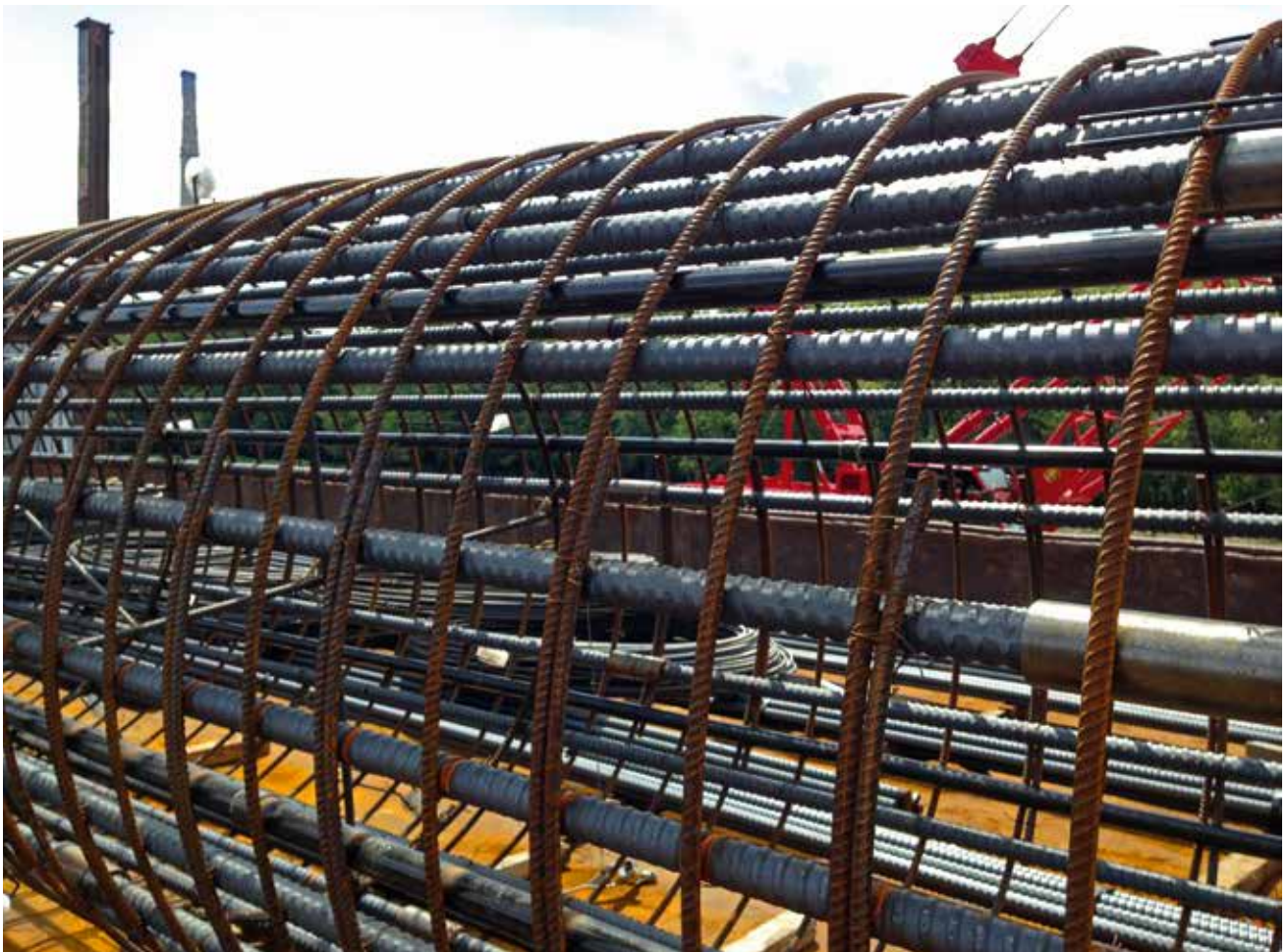
Consequently, work has begun on a new, four-lane bridge approx. 1.6km downstream of the Stillwater Bridge. After completion of the new structure, the historic bridge will only be used by pedestrians and cyclists.

The new bridge has an approx. 1.6km long main span consisting of precast segments supported by two abutments and 13 piers. It is the second bridge in the USA to be built as an extradosed bridge.



The soft river bed was a major challenge for the participating companies. At the deepest point, a nearly 26m thick clay layer had to be drilled through for the bridge foundation in order to reach the load-bearing limestone of the river bed located at a depth of 30-40m.

The General Contractor, Edward Kraemer & Sons, drilled five pile foundations that were needed for the 40 caissons in diameters of approx. 2.7m. Steel cased drilled shafts were installed through the water and river bed. They bear on competent limestone material at their tips.





Afterwards, the mud was removed from the caissons, and large reinforcing cages were set into the caissons, which were subsequently filled with concrete. The interior reinforcing cages were tied using vertical, high-strength DYWIDAG THREADBAR®.

The drilled shafts were originally designed with an inner reinforcing cage consisting of 16 Ø 43mm, Grade 60 vertical reinforcing bars and an outer cage consisting of 32 Ø 43mm, Grade 60 vertical reinforcing bars inside the steel casing.

DSI proposed a more economical alternative using only 22 high strength, Ø 57mm, Grade 75 DYWIDAG Bars with a yield strength of 264kN per vertical bar for the reinforcing cages. The owner, Minnesota Department of Transportation, accepted DSI's proposal in March 2013. A total of 30,050m (98,590ft)

of DYWIDAG THREADBAR® were supplied to the jobsite together with 1,470 EA Couplers.

Thanks to the higher strength of the DYWIDAG THREADBAR®, only one cage was necessary per drilled shaft, so the contractor was able to save on labor costs as well as construction time.



Owner Minnesota Department of Transportation (MnDOT), USA

General Contractor Edward Kraemer & Sons, Inc., USA

Subcontractor Case Foundation Company, USA

Consulting Engineers HDR, Inc., USA

Engineering Minnesota Department of Transportation (MnDOT), USA

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

DSI Scope Production, supply, engineering services

DYWIDAG Products 30,050m (98,590ft) of Ø 57mm DYWIDAG THREADBAR®, 1,470 EA Couplers

Wolf Creek Dam: Comprehensive Structural Repair prevents Dam Failure

Built in the 1940s, Wolf Creek Dam in Kentucky, USA, not only generates electricity, it also protects the entire region from floods. When the 1,748m long and 79m high dam was built as a combination of a concrete structure and an earth-fill embankment structure, the geotechnical knowledge that would have been necessary for a detailed analysis of the surrounding subsoil was not yet available. Consequently, the original cutoff trench designed for the dam foundation was too shallow. In addition, water leakage containing carbonic acid partially dissolved the limestone underneath the earth-fill embankment which resulted in cavities that were up to 12m high.

In the 1960s, seepage at the dam reservoir and two large sinkholes indicated imminent dam failure, which was initially prevented by filling the bedrock with approx. 221,720m³ of pressurized grout and by building a concrete diaphragm wall.



Since the cutoff wall that was built at the time was too shallow and not wide enough to intercept the decisive cavities, in 2005, the U.S. Army Corps of Engineers once again detected

uncontrollable seepage that resulted in a high risk of dam failure.

In order to prevent a catastrophe, a comprehensive structural repair program was begun in March 2006.





Photos reprinted courtesy of Deep Foundations Institute (DFI), USA

To stabilize the dam, a new, approx. 1,160m long and 84m deep concrete diaphragm wall consisting of overlapping secant piles and rectangular panels that reach through the earth-fill embankment into load-bearing soil was built. The diaphragm wall consists of 1,197 overlapping Ø 1.27m concrete piles that were used in combination with 3.2m long and 0.8m wide panels.

Initially, grout curtains were installed upstream and downstream of the dam in order to consolidate the foundation and prevent slurry loss. Afterwards, a Protective Concrete Encasement Wall (PCEW) consisting of concrete panels was built through which the guide holes for the larger secant piles boreholes were bored into the bedrock.

The piles were installed using five Wirth Drill Rigs supplied by DSI Underground Systems USA. The bottom hole assembly of the drills is fitted with an inclinometer and has a roller rock bit face that was fitted with a 0.6m long stinger. On March 6th, 2013, the last pile was installed – a full nine months faster than originally planned.

Thanks to these innovative and comprehensive structural repair measures, residents below the dam can now relax, and tourists can return to the popular recreation area at Lake Cumberland without having to worry. The structural repair of Wolf Creek Dam was distinguished with the Outstanding Project Award by the Deep Foundations Institute in 2013.

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Owner U.S. Army Corps of Engineers Nashville District, USA

General Contractor Joint Venture Treviicos-Soletanche, consisting of Treviicos, Italy and Soletanche-Bachy, France

DSI Unit DSI Underground Systems Inc., USA

DSI Scope Supply

DSI Products 5 Wirth Drill Rigs

DYWIDAG Strand Anchors prevent Settlements at a large Retail Center

North America

USA

Slope
Stabilization

25 miles south of Birmingham, Alabama, USA, a steep slope located adjacent to a large retail center was reinforced by a Mechanically Stabilized Earth (MSE) Wall. After the completion of the MSE Wall, settlement was detected at the building foundation. The settlement resulted both from the forces applied by the structure above and the instability of the soil both under the building and behind the wall. The foundation of the shopping center settled nearly 90cm (3ft).



The MSE Wall was additionally stabilized using three rows of anchored reaction blocks. These blocks consisted of approx. 3.7m (12ft) square shotcrete leveling pads and precast concrete panels placed against the existing wall.

The permanent DYWIDAG Strand Anchors with design loads of approx. 1,779kN (400kips) had to be installed into formations of competent rock deep behind the wall. The anchor length varied from 38m to 61m (125ft to 200ft).

The DYWIDAG Strand Anchors were loaded against the reaction blocks, thus providing lateral forces that efficiently stabilize the MSE Wall.

One anchor in each row at both ends of the MSE Wall had a single DYNA Force® Sensor installed in its unbonded length. DSI supplied detailed technical literature in addition to the readout box to ensure that the customer was able to self-perform the readings of the 6 DYNA Force® Sensors.

Because of the long anchor lengths, a 500t jack with a 600mm (24") stroke and an EZ Chair were supplied by DSI. The jack was modified in order to allow the DYWIDAG 12 strand Strand Anchors to fit through the center hole of the jack.



To facilitate installation of the wedge plates and stressing head, an alignment plate that had the same hole pattern was used. The alignment plate was pulled to the end of the anchor and the wedge plates and stressing heads were guided onto the strands. In locations where a crane was not accessible to lift the DYWIDAG Anchors for installation, DSI provided a vertical uncoiler for easier installation of the anchors.



General Contractor Hayward Baker, Inc., USA
Engineering Burns Cooley Dennis, Inc., USA

DSI Unit DYWIDAG-Systems International USA, Inc., BU Geotechnics, USA
DSI Scope Production, supply
DYWIDAG Products 80 permanent 12-0.6" DYWIDAG Strand Anchors;
 6 DYNA Force® Sensors; rental of equipment

DYWIDAG Tie Rods create better Access: New Pier on Akutan

North America

USA

Hydro- & Marine
Structures

Among its other operations, Trident Seafoods, the largest seafood producer in North America, also operates a seafood plant on Akutan Island in the Aleutians, a chain of islands that belongs to Alaska. Since the island only has a very small amount of infrastructure, Trident Seafoods has its own dock for the fishing boats that supply its plant.

In order to expand the docking capacity of the facility, a new quay wall was built at the east dock. To construct the new quay wall, a 305m long sheet pile wall was built that was tied back with DYWIDAG Tie Rods into load-bearing soil.

To tie back the sheet pile wall, DSI USA supplied a total of 170 Ø 57mm double corrosion protection (DCP) DYWIDAG Tie Rods in lengths between 21 and 40m. In addition, 11 Ø 43mm DCP DYWIDAG Tie Rods in lengths between 13 and 16m were supplied.

All tie rods featured cover caps on both ends and were supplied to the job site with accessories such as couplers, nuts and ducts.



Owner Trident Seafoods Inc., USA

General Contractor Western Marine Construction, Inc., USA

Consulting Engineers Northern Geotechnical Engineering, Inc., USA

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

DSI Scope Production, supply

DYWIDAG Products 170 Ø 57mm DYWIDAG Tie Rods,
11 Ø 43mm DYWIDAG Tie Rods

The Wilshire Grand Center Hotel: DYWIDAG Products for a Football Field Sized Excavation

133

Construction

North America

USA

Excavation

In downtown Los Angeles, work is progressing on the new Wilshire Grand Hotel, a 73 story, 900 room, 4-star hotel. The project also includes 37,160m² (400,000ft²) of office space as well as 4,190m² (45,100ft²) for restaurants and retail shopping. After its completion, currently scheduled for 2017, the approx. 335m (1,100ft) high building will be the tallest building in Los Angeles and on the West Coast. The main tower includes a special sail-shape crown illuminated with LED lighting at night.

To build the new hotel tower, the old Wilshire Grand Hotel had to be demolished. Afterwards, an excavation the size of an American Football field with a depth of up to 32m (105ft) was needed for the foundation of the new structure. Approx. 160,556m³ (210,000yd³) of soil had to be excavated and removed from the jobsite.

The specialist subcontractor Malcom Drilling was awarded a contract to build the tall retaining walls consisting of structural steel soldier piles with wood lagging for the excavation.

DSI USA supplied a total of 662 temporary DYWIDAG Strand Anchors with 4 to 12 strands in lengths of up to 22m (72ft) for tying back the retaining wall. In addition, 365 temporary DYWIDAG THREADBAR® Anchors in diameters of 26, 32, 36 and 46mm (1", 1 1/4", 1 3/8" and 1 3/4") were used. DSI USA also supplied the stressing and uncoiling equipment.

Work on the retaining wall was successfully completed in December 2013. The project set the new Guinness World Record of the largest continuous concrete pour with 16,209m³ (21,200yd³) of concrete.



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Owner Korean Air, USA

General Contractor Turner Construction Co., USA

Subcontractor Malcolm Drilling Company, Inc., USA

Architect AC Martin Partners, Inc., USA

Engineering Brandow & Johnson, Inc., USA

Engineering Shoring Design Cefali & Associates, Inc., USA

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

DSI Scope Production, supply

DSI Products 662 temporary DYWIDAG Strand Anchors with 4 to 12 strands, 365 temporary DYWIDAG THREADBAR® Anchors, stressing and coiling equipment

Slope Stabilization Using DYWIDAG Strand Anchors at Sellwood Bridge in Oregon

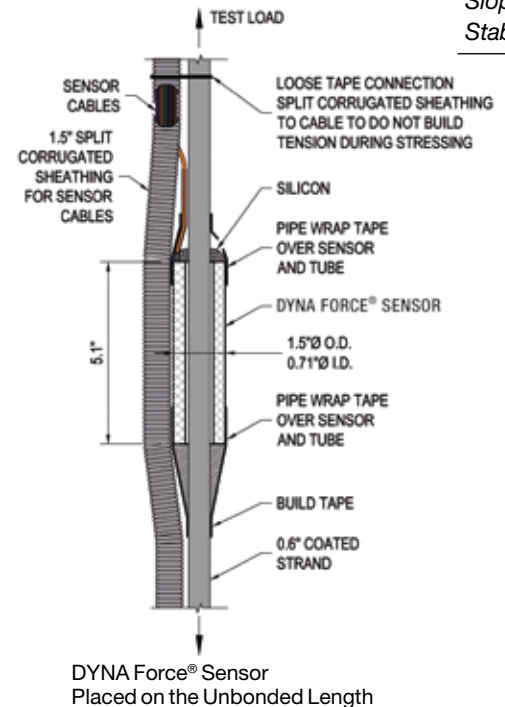
Built in 1925, the existing Sellwood Bridge over the Willamette River south of Portland, Oregon was very narrow and no longer suitable for heavy traffic. Furthermore, the bridge was not designed to withstand major earthquakes, and the west abutment sits on fill material that caused cracks in the structure. Multnomah County, the owner of the bridge, approved the replacement with a new steel deck arch bridge, the construction of which began in 2012.

The west abutment was prone to landslides and needed stabilization for the duration of the entire time the new bridge was under construction. The purpose of the stabilization project was to prevent any landslide movement larger than 1mm (0.04") per month. The geotechnical engineer chose a combination of concrete shear piles with top grade beams and 3 x 3m (10ft x 10ft) precast concrete anchor blocks, both of which were tied back with long DYWIDAG Strand Anchors. An elaborate system of instrumentation monitoring was also included in the project. Due to the proximity of Willamette River to the installation site, the drilled holes were filled with water, so the anchors were

installed through steel casing that was removed as grout was installed.

DSI convinced the engineer that DYNA Force® Elasto-Magnetic Sensors would be a more accurate and cost effective replacement for the specified strain gauges. 56 sensors were installed on anchors at DSI's warehouse. 6 test anchors with 15 and 23 strands in lengths of up to 43m were manufactured first. The engineer wanted to know exactly how much load would be transferred along the very short 3 and 4.6m (10ft, 15ft) bonded length. 3 of these anchors had five sensors placed at about 1m spaces along the bonded length, and the sixth sensor was located about 1.5m above the bonded length.





DYNA Force® Sensor
Placed on the Unbonded Length

Initial test anchors results were inconclusive; consequently DSI produced two additional 26 strand test anchors with 7 sensors on the bonded length and the eighth placed 1.5m above the bonded length. For better sensor protection during installation, 2 temporary anchors were fully encapsulated inside corrugated HDPE sheathing, and the sensor group cables were placed into a smaller plastic tube running along the anchor length. All sensor cables were connected to a readout unit through a multiplexer for easier load monitoring during proof and performance tests. This time, the readouts provided better results that helped the engineer determine the final length of the production strand anchors.

DSI produced 82 anchors with 8 to 27 strands in lengths of up to 52m (170ft). 15 of these anchors had two DYNA Force® Sensors placed on their unbonded length about 1-1.5m below the bearing plate.

Experience dictates that is always better to have at least 2 sensors installed per anchor for better control readings. Sensor cables were connected to 15 readout units placed inside waterproof containers together with 24V batteries for power supply. The readout units with storage software automatically record the anchor load several times a day.

So far, reading results have not shown any ground movements, thus ensuring a safe continuation of the construction work at the bridge.

The installation of the DYWIDAG Strand Anchors was successfully completed in 2013, and the new bridge is scheduled for completion at the end of 2015.

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General Contractor Slayden/Sundt JV consisting of Slayden Construction Group and Sundt Construction, Inc., both USA

Geotechnical Subcontractor Northwest Cascade, Inc., USA

Geotechnical Engineer Cornforth Consultants, Inc., USA

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

DSI Scope Production, supply, technical assistance

DYWIDAG Products 8 DYWIDAG Test Anchors with 9 to 26 strands, $L_{max}=43m$;
82 DYWIDAG Strand Anchors with 8 to 27 strands, $L_{max}=52m$;

64 DYNA Force® Sensors with 15 Readout Units;

Rental of equipment and uncoiling equipment

Expansion of Lucile Packard Children's Hospital with DYWIDAG Systems

Lucile Packard Children's Hospital (LPCH) is one of the USA's most prominent children's hospitals. It is part of the Stanford University system, located adjacent to the university campus in Palo Alto, California. LPCH was founded in 1991 after a \$40 million donation from David and Lucile Packard.

The \$3-billion modernization project at Stanford University Medical Center includes a new hospital, the modernization of the original Palo Alto Hospital and new laboratories for the School of Medicine as well as an expansion of LPCH.

Within the scope of the project, both new and existing facilities will be designed to comply with the seismic safety design requirements of the State of California.

Groundbreaking for LPCH took place in 2012, and construction is scheduled to be completed in 2016. The geotechnical subcontractor Malcolm Drilling built a temporary retaining wall around the existing hospital facilities and adjacent roads.

To tie back the wall, DSI USA supplied 282 temporary DYWIDAG Strand Anchors with 4 to 7 strands in lengths of up to 22m (72ft).

In addition, 230 temporary DYWIDAG THREADBAR® Anchors in diameters of 32, 36, 46 and 66mm were required to stabilize the retaining wall.

The DYWIDAG THREADBAR® Anchors with ultimate tensile strengths of 1,034MPa (150ksi) were 30m long on average.

In addition, DSI USA also supplied the stressing equipment needed for post-tensioning the tendons as well as the coiling equipment to be used on the jobsite. The retaining wall was successfully completed in 2013.



General Contractor DPR Construction, USA
Subcontractor Malcolm Drilling Company, Inc., USA
Architect Hammel, Green and Abrahamson, Inc., USA
Engineering Degenkolb Engineers, USA

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

DSI Scope Production, supply

DSI Products 282 temporary DYWIDAG Strand Anchors with 4 to 7 strands, 230 temporary DYWIDAG THREADBAR® Anchors, stressing and coiling equipment

The New Stanford Hospital: Foundations with DYWIDAG THREADBAR® Anchors

137

Construction

North America

USA

Excavation

Similar to Lucille Packard Children's Hospital, Stanford Hospital is part of Stanford University and is located directly next to the university campus in Palo Alto south of San Francisco. Within the scope of the modernization of the complete Stanford University Medical Center, the buildings of Stanford Hospital, which were built in the 1950s, will also be replaced.

368 patient rooms, an emergency unit that will be nearly three times as large as the former emergency department as well as new operating and treatment rooms are being built on an area of approx. 76,552m² (824,000ft²). The new buildings will be connected to the existing hospital by a bridge and a tunnel.

Work on the new building complex started in April 2013 and is scheduled for completion in 2017. The 7-story building is designed to meet the strict seismic requirements of the state of California that all healthcare facilities have to meet by 2030.

The foundation of the building includes a base isolation system consisting of 206 friction pendulum isolators that work like a pendulum in the event of an earthquake. Each of these pendulums sits below a column of the building so that the building can slide back and forth up to 1.8m (6ft).



A new retaining wall, tied back using permanent 15.2m Grade 150 DYWIDAG THREADBAR®, had to be built for the foundation of the new Stanford Hospital. DSI USA produced and supplied 800 double corrosion protected DYWIDAG THREADBAR® Anchors in diameters of 32, 36 and 46mm. In addition, DSI USA supplied the necessary stressing equipment and provided technical assistance for the stressing process at the beginning of the project. The retaining wall was successfully completed in 2013.



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General Contractor Joint Venture Clark/McCarthy, USA
Subcontractor Condon-Johnson & Associates, Inc., USA
Architect Rafael Viñoly Architects and Lee, Burkhart, Liu, Inc., both USA
Structural Engineering Tuan and Robinson Structural Engineers, Inc., USA

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

DSI Scope Production, supply, technical support

DYWIDAG Products 800 double corrosion protected DYWIDAG THREADBAR® Anchors, Ø 32, 36 and 46mm; stressing equipment

St. Lucia: Efficiency in difficult Conditions with DYWIDAG Ductile Iron Piles

In addition to many hotels, restaurants and shopping facilities, Rodney Bay in the north of the Caribbean island of St. Lucia also offers tourists a comfortable marina. Currently, a new dive resort is being built overlooking the famous Rodney Bay Lagoon. The facility is being built on reclaimed land that was once part of an extensive salt marsh. The marsh was dredged in the 1970s to build the marina.

The ground conditions at the job site were challenging for the development because the underside of the pile caps and beams were all at or below sea level. Some of the pile caps and beams required for the dive training pool slab were more than 2m below sea level in a site bounded by the saltwater lagoon to the west and a river to the south.

The substrate consisted of approximately 1m of compacted fill on top of 9m of blue clay with highly weathered bedrock at around 10m. The design engineers had originally planned to excavate the back fill and some 2m of clay before backfilling with rock and casting a raft foundation. Finally, 118mm x 7.5mm grouted annulus DYWIDAG Ductile Iron Piles were selected as a much faster and economically attractive alternative.

During installation, it quickly became apparent that this was the perfect solution for the project: Excavations could be opened up and the piles installed immediately from existing ground level without having to open up access for equipment to work in the excavation on wet and unstable clay. This process also reduced the risk of inundation with saltwater, and there were no equipment related delays.

The 122 DYWIDAG Ductile Iron Piles with a total length of 1,230m supplied by DSI USA were driven in only six days, thus allowing the development to come out of the ground and back above water level very quickly.



Photos reprinted courtesy of
Complete Marine Services Limited, St. Lucia



Owner Sunrod Properties, St. Lucia

General Contractor Prudence Montrope, St. Lucia

Subcontractor Pile Installation Complete Marine Services Limited, St. Lucia

Architect Inter-Island Architects, St. Lucia

Consulting Engineers Marigot Hill Ltd., St. Lucia

Consulting Bradley Paul Associates, St. Lucia

Engineering Theobalds Consulting, St. Lucia

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

DSI Scope Supply

DYWIDAG Products 122 DYWIDAG Ductile Iron Piles with accessories

Repair of the Androscoggin River Bridge in Maine

139

Construction

North America

USA

Structural
Repair Solutions

The Maine Turnpike, Interstate 95 in Maine in northeastern USA, also known as the Gold Star Memorial Highway, crosses the Androscoggin River on two separate bridge structures – one for northbound traffic and one for southbound.

Built in 1955, the bridges had to be repaired and strengthened due to their age, condition and the increased traffic volume. For this purpose, the longitudinal main girders of both bridges were strengthened using a multistrand post-tensioning system consisting of Type 7-0.6", 1,862 MPa (270 ksi) DYWIDAG Strand Tendons with epoxy-coated post tensioning strands. At the mid spans, the post-tensioning tendons were installed along the bottom of the girders. Above the piers, the tendons are installed along the top of the girders.

DSI USA supplied tendons to strengthen eleven locations on each bridge. The epoxy-coated DYWIDAG Tendons were approx. 15.2m (50ft) long and protected by HDPE ducts. DSI designed and developed the anchor brackets consisting of galvanized high strength steel.



The work above the piers proved to be especially difficult due to very low clearance between the girders and the bridge deck. DSI therefore developed a special stressing plan for the DYWIDAG Tendons which allowed for proper stressing in these tight conditions.

In addition, DSI designed eight special anchor bracket mounting plates that had to match up with existing rivet locations on the girders.

For structural reasons, the drilling of new holes into the girders was not permitted.

Work for phase one of this project was difficult because it was carried out in late fall and the severe winter of 2013/14. The second phase of this project was successfully completed in the first quarter of 2014.



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Owner Maine Turnpike Authority, USA

General Contractor Technical Construction, Inc., USA

Subcontractor DYWIDAG-Systems International USA Inc., Structural Repair, USA
Engineering HNTB, USA

DSI Unit DYWIDAG-Systems International USA Inc., Structural Repair, USA

DSI Scope Design, development, production, supply, installation

DYWIDAG Products Type 7-0.6" epoxy coated DYWIDAG Strand Tendons, anchor bracket mounting plates

The Liberty University Tunnel: DYWIDAG Tendons for the USA's first Jacked Box Tunnel

Liberty University is the largest university in Virginia and the largest private nonprofit university in the USA. Until recently, the university campus's only connection to the highly frequented Wards road was via a dangerous access road. The U-turns university visitors had to make in order to get to the campus regularly caused traffic disruptions.

Consequently, Liberty University decided to build a tunnel at the Wards Road/Harvard Street intersection to provide a direct connection to a new 1,400 car parking lot and to create a new main access to the university. The new tunnel also helps to reduce the traffic on the campus itself.

The new, 39.6m long tunnel consists of two tubes with a clearance of 4.7m, each of which accommodates two lanes and a sidewalk within a width of 8.5m. The tunneling work had to be carried out underneath a railroad embankment. In order to prevent disruptions to railroad traffic, the Jacked Box Method was used for the first time in the USA.

First of all, a temporary retaining wall with soil nails was built at Wards Road. The wall served both to prevent settlements at the railway embankment and to fasten the six hydraulic jacks that were needed for the Jacked Box Method.

In a construction yard near the university campus, two 39.6m long, box-shaped concrete culverts with wall thicknesses of 0.6m and a weight of 1,905t each were pre-cast on site and then positioned exactly in front of the embankment. Simultaneously, three cased boreholes were realized on the left and right side of each of the future tunnel tubes through the embankment.





6 Type 27-0.6" DYWIDAG Strand Tendons in HDPE ducts were inserted in the cased boreholes. The tendons were fastened to the exactly positioned tunnel culverts on one side and attached to the temporary retaining wall using tensioning jacks on the other side of the railway embankment. Afterwards, the tensioning jacks, which were run using hydraulic pumps, pulled the tunnel segments that were attached to the tendons step by step through the embankment. Simultaneously, the loose soil at the tunnel portals was removed from the site using two small excavators and a conveyor line.

Above both tunnel segments, bentonite was injected that served as a lubricant during tunnel advancement. Furthermore, the bentonite was used to fill eventual cavities in order to prevent future settlements of the rail line located above the tunnels. After successfully completing construction work, the first Jacked Box Tunnel in the USA was opened in January 2014.



Owner Liberty University, USA
General Contractor Southland Contracting, USA
Engineering Brierley Associates, USA

DSI Unit DYWIDAG-Systems International USA Inc., BU Post-Tensioning, East, USA
DSI Scope Production, supply, technical support
DYWIDAG Products 6 Type 27-0.6" DYWIDAG Strand Tendons; 6 jacks

DYWIDAG Bar Post-Tensioning Tendons for Elevated Train in São Paulo

Approximately 4 million people use the metro system in São Paulo every day. The new metro, Line 15 – Silver, connects the densely populated districts of Vila Prudente and Cidade Tiradentes with São Paulo's large commercial center.

The new metro line has a total length of 24.5km and includes 17 stations. The path of the elevated train runs in the center of the main roads that are located below. The stations are accessible via crosswalks that can also be used for crossing the main roads.



The new Oratório Station was built at the terminal stop of the new connection. It has a capacity of 58 train lines with a maximum of 1,000 passengers per train. On average, half a million passengers pass through the new Oratório Station every day. In addition, the new station also has a service depot in which trains can be parked and maintained. There is space for 54 trains on a total of 5,600m of rails in this area.

Protendidos DYWIDAG has been supplying DYWIDAG Bar Post-Tensioning Systems to construct the different metro lines for many years. High quality systems by Protendidos DYWIDAG were also used for the construction of the new Oratório Station and service depot.

In order to adhere to the tight deadlines and minimize construction time, the consortium primarily used precast elements that were produced in a field factory directly next to the site for the construction of the depot. The precast supports were fixed at the foundation using DYWIDAG Bar Tendons and post-tensioned. Afterwards, the long horizontal precast girders were also moved using launching girder equipment, connected to the DYWIDAG Tendons and post-tensioned.

Protendidos DYWIDAG supplied approx. 32,000m Ø 36mm DYWIDAG Bar Post-Tensioning Tendons and accessories such as anchor plates or nuts to construct the new station. The new Oratório Station and service depot have been operational since the end of 2013.



Owner Companhia do Metropolitano de São Paulo, Brazil
General Contractor Consórcio Expresso Monotrilho Leste, Brazil
Architect Planservi Engenharia Ltda., Brazil
Design Planservi Engenharia Ltda., Brazil

DSI Unit Protendidos DYWIDAG Ltda., Brazil
Protendidos DYWIDAG Scope Production, supply
DYWIDAG Products 32,000m Ø 36mm DYWIDAG Bar Post-Tensioning Tendons and accessories

Laguna Bridge, Brazil: Precast Cantilever Elements Post-Tensioned using DYWIDAG Bar Tendons

The town of Laguna is a five hour drive south of Curitiba. Here, the 2,815m long, four-lane Laguna Bridge also known as the Anita Garibaldi Bridge is being built. Once completed, it will be Brazil's third longest bridge and, as part of the federal highway BR-101, it will significantly improve the transport connection from north to south to other South American countries.

In October 2012, work started on this 52 span bridge that includes a 400m long main span stay cable bridge. The bridge deck consists of four lanes and two hard shoulders. The bridge is built using precast concrete segments that are produced in a field factory located 5km from the installation location. From there, the individual segments are floated to the job site on barges and lifted into position using a lifting gantry.

Protendidos DYWIDAG supplied the following products for this project:

- 30,600m of Ø 32mm DYWIDAG Bar Tendons
- 860m of Ø 36mm DYWIDAG Bar Tendons with Accessories.

Diameter 32mm DYWIDAG Bar Tendons were used both for the production of the precast segments and for widening the bridge deck using laterally mounted precast cantilever elements.



For this purpose, the precast cantilever elements were lifted into position using a trailing gantry and laterally attached to the precast concrete segments. The post-tensioning bars that were inserted into the lateral precast cantilever elements were then tightly connected to the hollow box girder using couplers. Once the precast concrete segments were longitudinally stabilized using strand tendons, transverse tension was applied and the outer deck slabs on both sides were cast.

Diameter 36mm DYWIDAG Bar Tendons were also used to transport the heavy precast concrete segments from the field factory to the bridge. In addition, short bar tendons were used for temporary tensioning of the concrete precast segments on the bridge deck.



Owner National Road Authority, Brazil

General Contractor Joint Venture Consorcio Ponte de Laguna, consisting of Camargo Corrêa S.A., Aterpa M.Martins and Construbase Engenharia Ltda., all of them Brazil

Contractor Joint Venture Consorcio Ponte de Laguna, consisting of Camargo Corrêa S.A., Aterpa M.Martins and Construbase Engenharia Ltda., all of them Brazil

Design Enescil Engenharia de Projetos, Brazil

Design Lifting Gantry Berd S.A., Portugal

Engineering Enescil Engenharia de Projetos, Brazil

DSI Unit Protendidos DYWIDAG Ltda., Brazil

Protendidos DYWIDAG Scope Production, supply, technical support

DYWIDAG Products 30,600m of Ø 32 DYWIDAG Bar Tendons;
860m of Ø 36mm DYWIDAG Bar Tendons

The Atlântica Wind Park: DSI supplies Wire EX Post-Tensioning Tendons for Brazil's tallest Wind Towers

C PFL Renováveis, a subsidiary of the largest private energy company in Brazil, recently built a wind park near the town of Palmares do Sul in the southern part of the federal state of Rio Grande do Sul. Acciona Windpower supplied the towers and turbines for the new park in southern Brazil.

In the beginning, the Atlântica Wind Park consisted of four wind power stations with a capacity of 30MW each that were put into operation successively from November 2013 to June 2014. At first, the erection of a total of 60 80m tall, 2MW capacity towers was planned.

CPFL Renováveis altered the plan and built the country's 40 highest wind towers each with a height of 120m and a capacity of 3MW – the largest capacity that has been achieved in Brazil so far. The wind towers consist of prefabricated concrete elements, and the rotors have lengths of 116m.





CPFL Renováveis has leased the wind park for a duration of 20 years – the Brazilian government assigned the right of use during an energy auction in 2010. Including the new Atlântica Wind Park, CPFL Renováveis now operates 20 wind parks with a total operating performance of 719MW. The parks are located in the federal states Rio Grande do Norte, Ceara and Rio Grande do Sul.

Since the wind towers in Atlântica Wind Park are exposed to high dynamic loads during operation, they were post-tensioned using external Wire EX Tendons. For the 40 wind towers, DSI supplied a total of 28,000m of prefabricated Wire EX 66 Post-Tensioning Tendons that

were supplied coiled and ready to be installed to the jobsite. 6 Wire EX 66 Tendons in lengths of 120m were used per wind tower. The Wire EX Tendons were installed by experienced DSI technicians.



Operator CPFL Renováveis, Brazil
General Contractor Acciona Windpower, Spain
Engineering Airton, Brazil

DSI Scope Production, supply, installation
DSI Products 28,000m of Type 66 Wire EX Post-Tensioning Tendons

Fast Construction Progress with DYWIDAG Bars: Allianz Parque Stadium, São Paulo

The old home of the traditional soccer club **Sociedade Esportiva Palmeiras – the Palestra Itália Stadium in São Paulo – was expanded into one of the largest multifunction arenas in Brazil for the 2014 Soccer World Championship and the 2016 Olympic Games.**

The modern arena with the new name Allianz Parque will include shopping facilities, restaurants and a convention center.

The stadium is designed for 45,000 seats under roof as well as up to 12,000 seats in the open air.

As time schedules were tight, precast concrete beams that were secured with DYWIDAG Bar Tendons were used during the construction of the new stadium. Protendidos DYWIDAG supplied approximately 650m of Ø 36mm DYWIDAG Bars and accessories to support the beams of the lower luxury boxes that will be fixed on the upper raker beams of the main concrete structure.

Additionally, approximately 3,700m of Ø 32mm DYWIDAG Bars and accessories were supplied to create a tight connection between the precast beams. Construction of the new Allianz Parque Stadium began in October 2010 and was finished in the first quarter of 2014 – on time for the centennial of the Sociedade Esportiva Palmeiras soccer club.



Owner Sociedade Esportiva Palmeiras, Brazil
General Contractor WTorre S.A., Brazil
Subcontractor TLMix Construções Ltda., Brazil
Architect Edo Rocha Arquiteturas, Brazil
Design Cesar Pereira Lopes S/C Ltda., Brazil

DSI Unit Protendidos DYWIDAG Ltda., Brazil
Protendidos DYWIDAG Scope Design, production, supply, technical support
DYWIDAG Products 650m of Ø 36mm DYWIDAG Bars and accessories;
 3,700m of Ø 32mm DYWIDAG Bars and accessories

Hidroituango: DYWI® Drill Hollow Bars for Colombia's largest Hydroelectric Power Plant

149

Construction

South America

Colombia

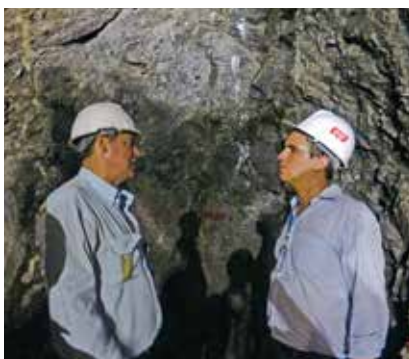
Slope
Stabilization

In 2010, construction began on the largest hydroelectric power plant in Colombia's history – the Hidroituango Power Plant. The power plant is located near the town of Ituango, approx. 171km north of Medellín, and is expected to be completed by mid-2019.

A 79km long barrier lake with a capacity of 2,720 million m³ and a 225m high dam are being built for the Hidroituango project. The power plant will produce energy with 8 turbines in a 23m wide, 50m high and 240m long main cavern.

By 2022, Hidroituango will presumably reach its maximum installed power of 2,400MW, thus covering up to 20% of the Colombian demand for electricity.

The first part of this major project included construction of the various access roads and the surface infrastructure in order to permit access to the main dam and the tunnels for the hydroelectric power plant. In this area, Ø R32 and R38 DYWI® Drill Hollow Bars supplied by DSI Colombia were used for slope and face stabilization purposes in combination with shotcrete and mesh. One challenging construction step was the application of the DYWI® Drill Hollow Bar System for the reinforcement of an area close to the river, the stability of which was endangered by high water flow levels.



DSI Colombia provided both design-related and on-site support for this project during which the DYWI® Drill Hollow Bar System was successfully used for the first time.



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Owner EPM, Colombia

General Contractor CCC Ituango consortium, consisting of: Camargo Correa S.A., Brazil, Concreto S.A. and Coninsa Ramón H S.A., both Colombia

Consulting Engineers Ingetec, Colombia

Designer Integral, Colombia

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

DSI Scope Production, supply, technical support

DYWIDAG Products Ø R32 and Ø R38 DYWI® Drill Hollow Bar System

Slope Stabilization in difficult Terrain: Use of *GEWI*® Bar Anchors in Santiago de Chile

During the last few years, demand for living space has increased considerably in Santiago de Chile. Because of the mountainous terrain and the danger of earthquakes, the stabilization of foundations and the anchoring of slopes are important design and construction considerations.

In the popular district Lo Barnechea, demand for flats increases by approx. 3.4% per year. The foundation soil in Lo Barnechea is clayey and argilliferous and contains sand and gravel. From time to time, the water that is naturally stored in underground cavities escapes forming currents.



Furthermore, high seismic activity and constant earth movements require the use of reliable and durable systems.

To stabilize a slope in a development area, DSI Chile supplied 62 passive and permanent Ø 32mm *GEWI*® Bar Anchors in lengths of 8m as well as 39 permanent Ø 32mm *GEWI*® Bar Anchors in lengths of 10m with accessories and mesh.

Drilling was carried out using a hydraulic hammer, with drill bits having to be exchanged every 1,200m.

The *GEWI*® Bar Anchor System with single corrosion protection supplied by DSI could be installed quickly and without any problems even in this difficult and moist soil.

For the first time, the contractor, FLESAN ANCLAJES, used high quality *GEWI*® Bar Anchors instead of

more commonly used strand anchors or bars with low yield capacity loads. FLESAN ANCLAJES was very satisfied both with the *GEWI*® Bar Anchors that were supplied and with the technical support provided by experienced DSI employees on site.



Contractor FLESAN S.A., Chile

DSI Unit DSI Chile Industrial Ltda., Chile

DSI Scope Production, supply, technical support

DYWIDAG Products 62 passive Ø 32mm *GEWI*® Bar Anchors;
39 Ø 32mm *GEWI*® Bar Anchors with single corrosion protection; mesh

The Presidente Ibáñez Bridge: DYWIDAG Bar Tendons Stabilize Chile's longest Suspension Bridge

The 210m long Presidente Ibáñez Bridge in the Aysén region of southern Chile is the country's longest suspension bridge and has been declared a national memorial. Completed in 1966, the bridge crosses the Aysén River and is a historic monument for the architectural style that was typical for public construction projects during the 1960s. The structure connects the region's largest harbor, Puerto Chacabuco and the regional capital of Coyhaique with the rest of the country, thus continuing to fulfill an important transportation function even today.

The Presidente Ibáñez Bridge was built on reinforced concrete foundations and features two 25m high metal piers that support eight suspension cables per side. On both sides of the main support cables, 22 vertical hangers connect the main suspension cables to the bridge deck. These hangers support the stiffening girders and cross beams that carry the reinforced lightweight concrete deck slab.

In order to maintain the bridge, comprehensive repair measures were carried out a few years ago. Within the scope of the repair work, the corroded coating of the complete bridge was replaced, new guide rails were installed and large level differences were evened out on the deck at both ends of the bridge. Furthermore, the elastic confinement of the main cables was renewed, and the tar that had been used was replaced by polyurethane foam.

Within the scope of further reinforcement measures, DSI Chile was asked to reinforce four vertical hangers in the middle of the bridge deck. For this purpose, DSI supplied 16 Ø 32mm DYWIDAG Post-Tensioning Bars that were installed at each of the hangers in question in a supporting structure that was additionally fixed to the bridge deck.



Four DYWIDAG Bar Tendons were arranged vertically around each of the hangers. This structure permits a reliable transfer of loads from the hangers to the DYWIDAG Bar Tendons.

The DYWIDAG Bars were post-tensioned using four 110 MP jacks connected via a manifold to a

central hydraulic pump ensuring an even distribution of pressure to all four jacks. In addition, DSI supplied 24 short Ø 32mm DYWIDAG Bar Tendons that were horizontally installed into the new supporting structure and post-tensioned to 600kN using a torque wrench.



Owner Ministerio de Obras Públicas, Chile
Engineers Poul Mondorf Ing. Civil, Chile

DSI Unit DSI Chile Industrial Ltda., Chile
DSI Scope Production, supply, rental of equipment
DYWIDAG Products 16 Ø 32mm DYWIDAG Bar Tendons;
24 short Ø 32mm DYWIDAG Bar Tendons

Quality from the very Beginning: DSI Peru supplies DYWIDAG Bar Tendons for Lima Metro

The Lima Metro, which was originally known as “Tren Eléctrico” (electrical train), is a light rail system that connects southern Lima with the city center. After beginning construction in 1986, the city railway included more than 32 cars and seven stops along a 9.2km section on Line No. 1. Nevertheless, construction work was suspended for nearly 20 years due to a lack of demand and unfavorable economic conditions.

In 2009, the Ministry of Transportation (Ministerio de Transportes y Comunicaciones) resumed construction and finished the first section of Metro de Lima’s Line 1 within a record time of one and a half years. The present section now has a total length of 21.48km and leads to Lima’s city center. During this construction phase, DSI Peru had supplied the consortium with DYWIDAG Bars and accessories for the construction of the Metro de Lima’s viaducts.



Afterwards, the second section leading to San Juan de Lurigancho in the city’s north-east was put out to bid, and the joint venture “Metro de Lima” consisting of Odebrecht Perú Ingeniería y Construcción and Graña y Montero was awarded the contract to build the project.

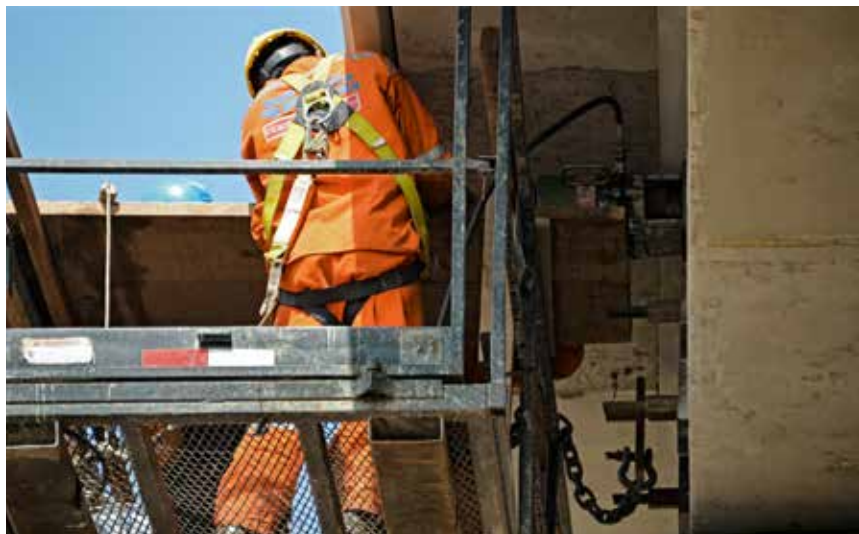
The second section of Line 1 runs through the three districts Cercado de Lima, El Agustino and San Juan de Lurigancho on a 12.4km long viaduct. The second, approx. 13km long section will include 10 stops, a 270m and a 240m long bridge as well as four power stations and a turnaround area.



DSI Peru is in continuous contact with the planning department of Consorcio Tren Eléctrico and is supporting the general contractor on technical issues regarding the use of DYWIDAG Bar Tendons that are both used for the temporary stabilization of precast girders and as permanent tendons. The following products have been used for this project:

- Ø 32mm DYWIDAG Bar Tendons for the temporary stabilization of the precast girders on the pier bearings. In addition, several intermediate walls near the platforms were struted with permanent DYWIDAG Bar Tendons. In each of the 10 stations, the precast girders were fixed on each of the pier supports using four permanent DYWIDAG Bar Tendons that were horizontally placed and tensioned to 590kN in order to accommodate the expected dynamic alternating loads.
- DYWIDAG Bar Tendons, Ø 36mm: To eliminate tension in the concrete and for structural reinforcement, the two outer faces of the pier abutments were reinforced using Ø 36mm vertical DYWIDAG Bar Tendons that were tensioned to 740kN.

DSI Peru is proud to have contributed to the successful construction of this important infrastructure project.



Owner Ministry of Transportation (Ministerio de Transportes y Comunicaciones), Peru
General Contractor Joint Venture Tren Eléctrico, consisting of Odebrecht Perú Ingeniería y Construcción and Graña y Montero, both Peru

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

DSI Scope Technical support, supply

DSI Products DYWIDAG Bar Tendons, Ø 32 and 36mm



Imprint

Published by

DSI Holding GmbH
Destouchesstrasse 68, 80796 Munich, Germany
Phone +49-89-30 90 50 200
E-mail info@dywidag-systems.com
www.dywidag-systems.com

Design and Editorial Content

DSI Holding GmbH
Marketing Department
Chief Editor
Gerhard Kahr
Editor
Christine Ritz

Revision

Ron Bonomo
Naperville, Illinois, USA

Design, Layout, Typesetting and Picture Editing

d-formen.de, Volker Heise
Solingen, Germany

Printing

Holzer Druck und Medien
Weiler im Allgaeu, Germany

Picture Credits

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This publication is printed in English (13,000 pcs.)
and German (3,000 pcs.)

DSI Holding GmbH

Destouchesstrasse 68
80796 Munich, Germany
Phone +49-89-30 90 50 200
E-mail info@dywidag-systems.com
www.dywidag-systems.com

North America*Construction*

DYWIDAG-Systems International USA Inc.
320 Marmon Drive
Bolingbrook, IL 60440, USA
Phone +1-630-739 1100
E-mail dsiamerica@dsiamerica.com
www.dsiamerica.com

North & South America*Underground*

DSI Underground Systems Inc.
9786 S Prosperity Road
West Jordan, UT 84081, USA
Phone +1-801-973 7169
E-mail dsiunderground@dsiunderground.com
www.dsiunderground.com

South America*Construction*

PROTENDIDOS DYWIDAG Ltda.
Itaim Bibi
Rua Iaiá, 150 – 10º andar - Cj.102
04542-060-São Paulo/SP, Brazil
Phone +55-11-21 31 37 00
E-mail vendas@dywidag.com.br
www.dywidag.com.br

APAC*Underground & Australia Civils*

DYWIDAG-Systems International Pty. Ltd.
25 Pacific Highway
Bennetts Green, NSW 2290, Australia
Phone +61-2-49 48 90 99
E-mail dsi@dywidag.com.au
www.dsiminingproducts.com/au

EMEA

Construction, Post-Tensioning Systems
DYWIDAG-Systems International GmbH
Max-Planck-Ring 1
40764 Langenfeld, Germany
Phone +49-2173-79 02 0
E-mail suspa@dywidag-systems.com
www.dywidag-systems.de

EMEA

Construction, Geotechnical Systems
DYWIDAG-Systems International GmbH
Germanenstrasse 8
86343 Koenigsbrunn, Germany
Phone +49-8231-96 07 0
E-mail geotechnik@dywidag-systems.com
www.dywidag-systems.de

EMEA

Construction, Concrete Accessories
DSI-Holding France
12-14, rue des Cressonnières
Z.I. Nord
95500 Gonesse, France
Phone +33-1-34 45 90 45
www.dsi-accessories.com

EMEA

Underground, Tunneling
DYWIDAG-Systems International GmbH
Alfred-Wagner-Strasse 1
4061 Pasching/Linz, Austria
Phone +43-7229-61 04 90
E-mail office@dywidag-systems.at
www.dsi-tunneling.com

EMEA

Underground, Mining
DSI Schaum Chemie sp. z o.o
ul. Podleska 72
43-190 Mikołów
Poland
Phone +48-32-355 90 81
E-mail biuro@dsi-schaumchemie.pl
www.dsi-schaumchemie.pl

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