





We do not only talk about service – we offer it!

As a service provider, DSI offers professional support by experts and the training of installation personnel on site.

Tysons Corner,
Dulles Metrorail Projekt,
Washington D.C., USA

Dear clients, business partners and employees,



Patrik Nolåker, Group CEO

It is a great pleasure and an honor for me to be able to present to you the 19th edition of DSI Info. As the new Chief Executive Officer of the DSI Group, I would like to introduce myself to you, our clients, business partners and employees. I entered this position on March 1st 2012 and am very proud to have the opportunity to develop and strategically lead the DSI Group, a traditional company with roots leading back to 1865, into a successful future.

In 2011 DSI has, once again, reached its targets. Following a phase of consolidation, we have been able to re-enter a growth phase thanks to our dedicated and highly motivated employees. We have also been able to consolidate our globally leading position in our core markets of Construction and Underground.

We will continue to expand our global operative structure in the future. We will continuously improve customer satisfaction and business processes by customer proximity, local service and short decision making processes. In addition, we will work to enhance our long-term reputation as a reliable producer and supplier of quality products and systems by the global exchange of experience and solution oriented research and development.

In our core markets, it is our clear strategic aim to grow both organically – through innovative products especially in Underground (Mining and Tunneling) – and through targeted corporate acquisitions.

We would like to thank you, our clients and business partners, for placing your trust in DSI. You are at the focus of all of our activities. Through a mutually reliable co-operation based on partnership, we will together successfully shape the future.

Join us on a journey around the world to interesting and challenging projects and discover technically innovative and ambitious solutions in this edition of DSI Info.

Discover the new DSI.

Sincerely yours,

Patrik Nolåker
Group CEO

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**APAC/
ASEAN**

Australia

*Mining***DYWIDAG-Systems International**

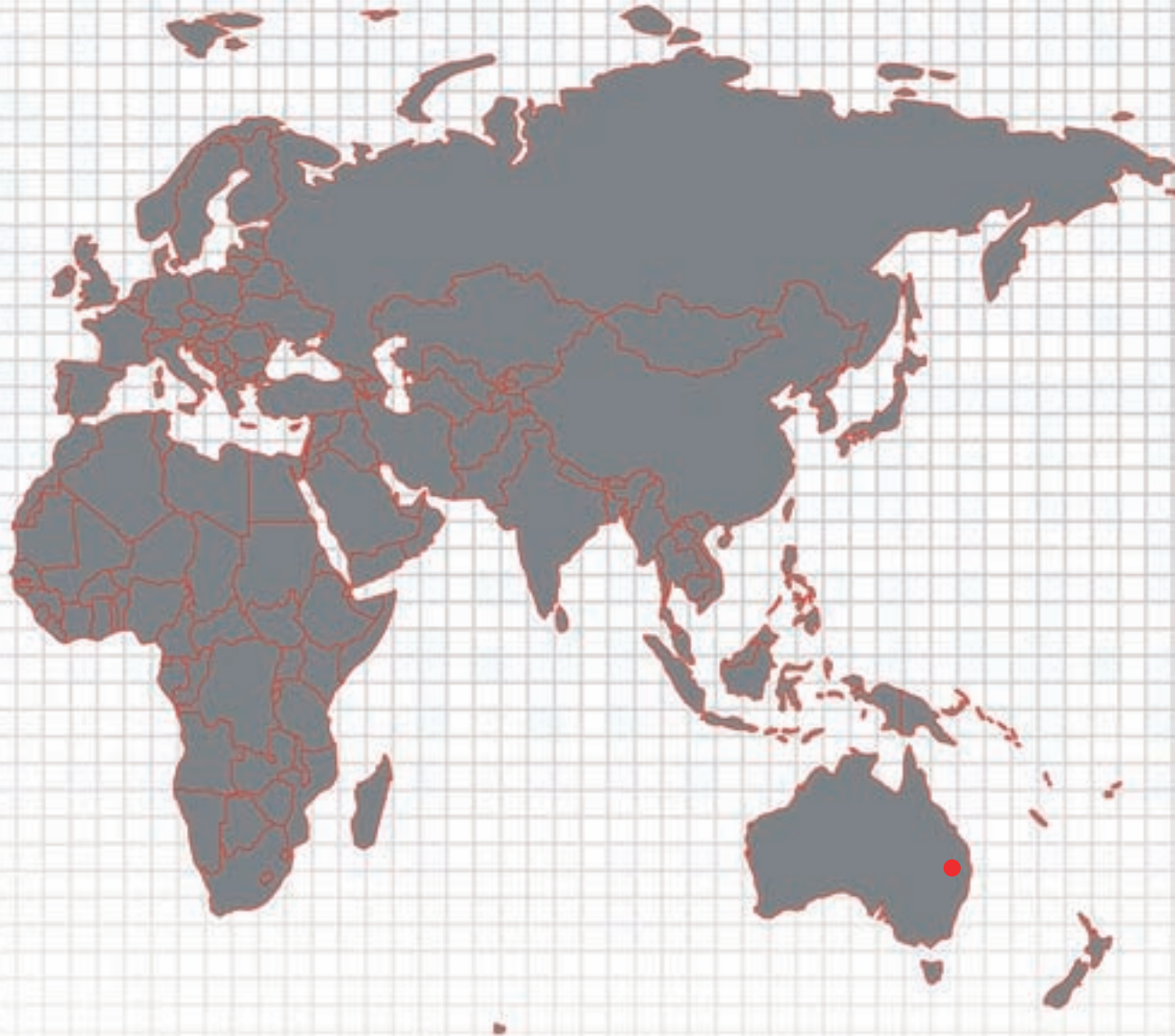
is Australia's largest manufacturer and supplier of technically sophisticated strata reinforcement and support products to the Underground coal and hard rock mining industry.

To optimize client logistics and technical support within Australia, DSI has branch offices and warehouses in Queensland, New South Wales, Victoria and Western Australia. All of these offices are located in the immediate vicinity of the country's major mining regions. Experienced and highly motivated ground support experts keep in continuous touch with their customers and can always support mining operators quickly and competently in meeting new challenges.

Overseas customers benefit from DSI's export facility, which was specifically built to fulfill their requirements. These customers also benefit from our comprehensive technical and logistic services. The company offers a streamlined system of electronic documentation, load planning software, export compliant packaging and a large range of logistic options that are offered by its client oriented export team.

What does DSI offer its customers?

Strata conditions at mine sites and the exploitation of deposits vary greatly from mine to mine. The unique nature of many of the support problems experienced underground requires mine specific solutions. Innovative and often individually tailored solutions have to be developed to solve these problems.



DSI's multidisciplinary teams always cooperate with mines and mining engineers in order to develop optimum solutions. DSI develops prototypes for testing in its own laboratories and conducts extensive field trials to provide the best products and solutions for its customers' needs. New products and differentiated strategies are delivered with comprehensive training to operators by skilled staff to ensure the solution is all inclusive – whenever and wherever required.

Key competence - service and support

The stabilization of mines only works when all elements are adequately designed and correctly installed. As efficient ground support is a product of all the elements working together, strata reinforcement testing is carried out by the same team that develops and manufactures the ground support systems.

This is the only way to ensure that all components of the system work together perfectly. Our technical service is backed by a local team of engineers who have immediate access to the latest worldwide technology through DSI's global network. Underpinning this service is an R & D department which has been continually improving underground safety and productivity since the early 70's. Furthermore, DSI also supports and funds several mining research projects with Australian universities.



Bennetts Green



New Product Developments DSI

EziTen Ø 23.5mm Flexi-Bolt

OVERVIEW

The EziTen cable bolt is an evolution of the DSI Hi-Ten cable bolt. By utilising a DSI Strand Locker we combine a barrel and wedge supported 23.5mm cable with a threaded tensioning system. Pretension of the cable is obtainable with a regular bolting machine by using a 56mm AF dolly (no special hydraulic tensioner required). The pre-tension is a result of the torque applied by the tensioning dolly onto the large nut. The strand locker unit is pre-tensioned to the cable at DSI to the required length and shipped ready to install with a compatible dome plate.

MAIN ADVANTAGES

- no specialised hydraulic tensioner unit required for installation
- quick and simple installation
- consistently short tail lengths
- EziTen is delivered assembled ready to install



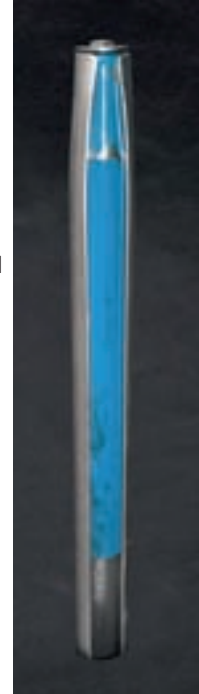
MAIN ADVANTAGES

- resin anchored bolt
- eliminates potential damage from protruding bolt threads
- shear pin breakout system

Hyperthane Friction Bolt Ø 47mm

OVERVIEW

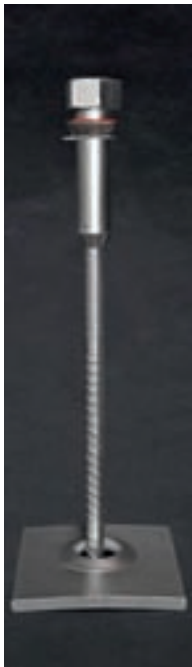
DSI Hyperthane Friction Bolts are an improved point anchoring Ø47mm friction bolt. The fundamental principle of the system is to enhance point loading in the toe. Unlike grout or cement, the Hyperthane insert is made from a highly elastic material and will not fracture if the bolt buckles. This ensures that the Hyperthane Bolt will hold load before and after ground movement. The bolts are manufactured from high strength steel tube with urethane insert at the toe and a slot along its entire length. A ring is welded on the outer end to hold a dome plate to the surface.



MAIN ADVANTAGES

- ultimate load is achieved immediately on installation (no curing time required)
- no extra operator training required as drilling and insertion remains the same
- arrives ready to install
- bolt still functions the same in shear

Manx 24 Bolt



OVERVIEW

Named after the tailless cat, Manx bolts eliminate the threaded bar protruding beyond the tensioned nut on a rock bolt. Developed and patented in 2006 in a 16mm rib bolt version to reduce tire damage in underground roadways, the bolt features a tensioning assembly that contracts as it is rotated tight.

The Manx system is now available in Ø24mm bar, providing the tensile strength found in our AX bar rock bolts. These bolts are available in right and left hand drive versions to suit both coal and hard rock applications.

DCP Ten Double Corrosion Protected Flexi-Bolt

APAC/
ASEAN

Australia

Mining



OVERVIEW

The DCP cable bolt is the flexible cable version of a tried and proven solid DCP bolt. By utilising a barrel and wedge supported $\varnothing 23.5\text{mm}$ cable with a patented DSI grout bell, the resin anchored cable can be post grouted via the top down method. The barrel and wedge is pre-tensioned to the cable bolt at DSI and shipped ready to install with a compatible dome plate.

MAIN ADVANTAGES

- a sleeve of HDPE encases the cable from the resin boundary down to the grout bell providing a barrier to combat the effects of corrosion
- the HDPE sleeve has deformations to improve load transfer at the cable to rock interface when fully grouted
- top down grouting is achieved by pumping through the side of the grout bell and up the inner side of the HDPE sleeve allowing grout to flow from the top down the outer annulus.
- the grout bell assembly collar and segmented wedge can sustain collar loads of between 52 and 55 tonne
- the DCP-Ten is delivered preassembled with barrel and wedge ready for installation

HEA (High Energy Absorption) Mesh

OVERVIEW

Where ground conditions are rock-burst prone and challenging, HEA mesh by DSI provides improved surface containment with the addition of pre-laced wire strand. In dynamic conditions where an excavation surface deforms, the strata loading is effectively transferred to all bolts and tendons, with a strong connection between the bolts and mesh offered by the HEA mesh installation.

HEA mesh has the ability to allow large deformations whilst maintaining a high load capacity. This “yield-ability” of HEA mesh to absorb energy in dynamic and repeated loadings can complement yielding reinforcement as an element in a complete



dynamic system. The HEA mesh is manufactured in collaboration with the Australian Centre for Geomechanics, University of Western Australia.

MAIN ADVANTAGES

- superior containment of rock bursts
- Jumbo specific for rapid installation
- reduced shotcrete requirement
- deformation plus strength for superior performance

OSRO Strap

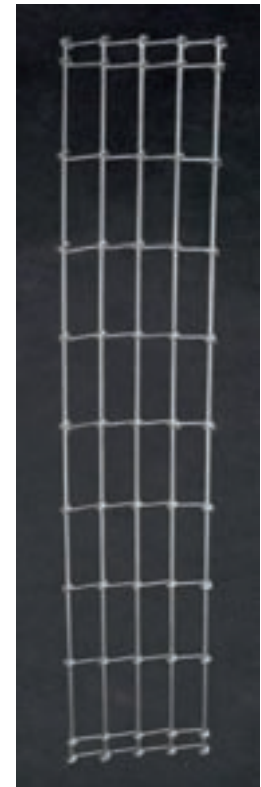
KEY FEATURES

- dynamic yielding alternative to W-strap
- flexibility in encompassing supports
- 10mm gauge wire strength
- easy to handle
- aperture: 170x60mm

GENERAL FEATURES

Commonly used when surface support is required in environments with ongoing deformation or seismically active. The strand is able to slip under load conditions through the cross wires to distribute load over several bolts. This may provide a large surface confinement to loose rock that can form between bolts.

The DSI - OSRO strap's ability to yield whilst retaining capacity is through the use of cross wires tightly “pig tailed” around heavy gauge longitudinal strands combined with an alternate three loop two loop welded intersection sequence. This configuration lessens the risk of tearing away surface support from bolt collars, gives rigidity for installation, and provides containment plus the flexibility to encompass several support connections.



DSI supplies Specialty Systems for Australia's largest Infrastructure Project

APAC/
ASEAN

Australia

Tunneling



The city of Brisbane is Australia's third largest city and is continuing to grow even larger. In order to cope with ever increasing traffic congestion in the north of the city, three large infrastructure projects are currently under construction (Brisbane Airport Link, Northern Busway and Airport Drive Connection). DSI Australia Civils participated in two projects: Brisbane Airport Link and Northern Busway.

The Brisbane Airport Link is a road tunnel that will link the city center with the airport. At a length of approx. 6.7km, the toll tunnel will be Australia's longest road tunnel after its completion, which is scheduled for mid-2012. It is anticipated that the tunnel will be used by 95,000 vehicles per day and will facilitate a quick connection from the city center to the north.

The tunnel consists of two separate tunnel tubes running at a depth of up to 30m and accommodating three lanes each. A combination of drilling and blasting, road headers and TBMs were used for tunnel excavation. The tunnel walls are sealed with a PVC sheet membrane on top of which the cast-in-situ concrete lining was placed using 10 and 12m long slip forms. In the transition areas such as the passages to underground stations, the tunnel lining consists of shotcrete.

The second project, the widening of the Northern Busway, will also connect the city center with the northern districts. The new double lane section will only be used by buses to ensure faster transportation independent of road traffic. Near the airport, the Northern Busway will be connected to the Brisbane Airport Link.

The Northern Busway runs underground for a length of 1.5km in a separate tunnel.

Up to 17 road headers were used for the new tunnel structures – more machines than had ever been used for any other Australian project. Both of the TBMs used were the largest of their kind ever operated in Australia.

DSI Australia supplied the following products for both projects:

- over 50,000 temporary Posimix AX Bolts
- over 7,000 temporary CT Bolts
- over 21,500 double corrosion protected (DCP) DYWIDAG Rock Bolts for temporary and permanent use
- approx. 18,500m of Rock Bolts
- over 3,500 Fiberglass Bolts
- AT Pipe Umbrellas
- over 2,500m of PANTEX Lattice Girders



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Owner City of Brisbane, Australia
General Contractor Joint Venture BrisConnections, consisting of: Macquarie Capital Group, Thiess, John Holland, Arup and PB, all of them Australia

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

DSI Scope Supply of approx. 50,000 Posimix AX Bolts, 7,000 CT Bolts, 21,500 DCP DYWIDAG Rock Bolts, 18,500m of Rock Bolts, 3,500 Fiberglass Bolts, AT Pipe Umbrellas and 2,500m of PANTEX Lattice Girders

DSI Australia is honored at Premier's Export Awards in Sydney

At the 2011 New South Wales Premier's Export Awards held in Sydney, DSI Asia Pacific received a Highly Commended Award for Export in the Large Advanced Manufacturer category.

The awards are an annual event that aims to recognize excellence in the export of goods and services by New South Wales business. The awards acknowledge the important contribution of businesses to the economic development of the region.

The award that was given to DSI is recognition for its high production efficiency and the safe and economic handling of its products during transport and shipping. Furthermore, DSI was also given an award for its efficient handling of accompanying documentation processes in export operations.

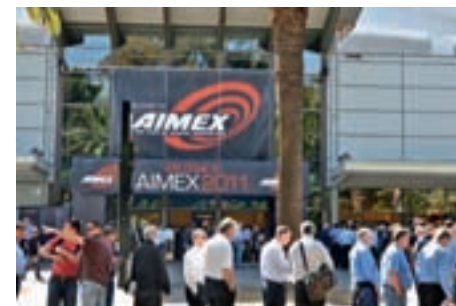
According to Peter Mace, the General Manager of the Australian Institute of Export, the winners of the

New South Wales Premier's Export Awards are role models for other businesses. They represent a cross section of industry sectors in New South Wales that are successful on the world stage thanks to their efficient operational sequences.



Steve Mackaway and Kate Anderson, DSI Australia

AIMEX Exhibition, Sydney, Australia September 6-9, 2011



AIMEX was the largest and most important trade fair for mining in the Asia/Pacific region in 2011. In comparison to 2007, the number of visitors increased by more than 40% to almost 17,000 trade professionals.

Exhibition space was increased by more than 20%, and more than 1,300 international experts visited the trade fair. The organizers attributed the strong interest in AIMEX 2011 to the very positive growth of the Australian mining industry. According to experts, the attractiveness of investment in Australia's mining industry will not diminish over the next 10 years.

More than 600 exhibitors (2007: 500 exhibitors) showed recent developments in mining on 45,000m² of space. As the largest and leading Australian producer of ground support products in mining, DSI Australia was represented at their own booth.

DSI presented several new products to the interested expert public. These included

- the Hyperthane Friction Bolt
- the EziTen Flexi Bolt and
- the HEA Mesh System.

The next AIMEX, which DSI will also participate in, will be held from September 1st to 4th 2015 in Sydney.



5.5km long Thirra Tunnel for the Albania-Kosovo Highway secured by DSI Systems

Once completed, the new Albania-Kosovo Highway will link Kosovo with the seaport of Durres on the Adriatic Sea, crossing Albania. The travel route will then be much easier and shorter, thus significantly contributing to increasing trade and tourism in this area of northern Albania.

On the Albanian side, 1,858m high Mt. Runes divides the planned highway section between the towns of Rreshen and Kalimash. Engineers decided to guide the new highway through the mountain in a 5.5km long double tube tunnel. Tunneling work for the Thirra Tunnel started in May 2007 from all four portals simultaneously.

In its production facility in Pasching near Linz in Austria, DSI produced anchor systems and rock support for the Thirra Tunnel and supplied them to the site in accordance with project progress. The support systems were continuously adjusted in the plant to suit new requirements. During excavation work, changing rock conditions were repeatedly encountered in five different zones. This required a huge amount of flexibility and quick recalculation and adjustments of the support systems that were needed.

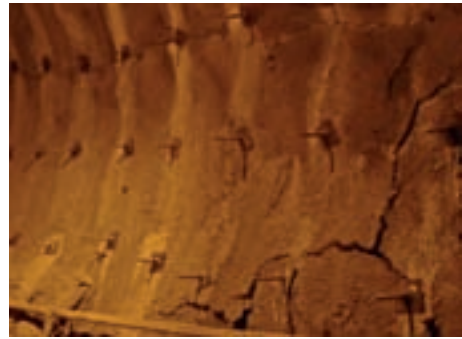
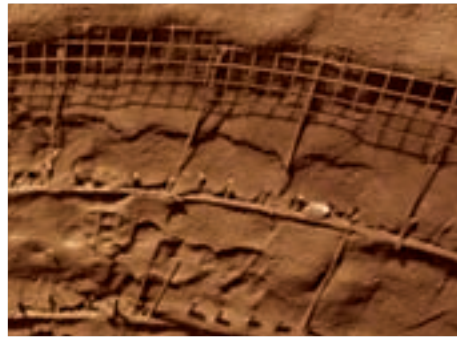
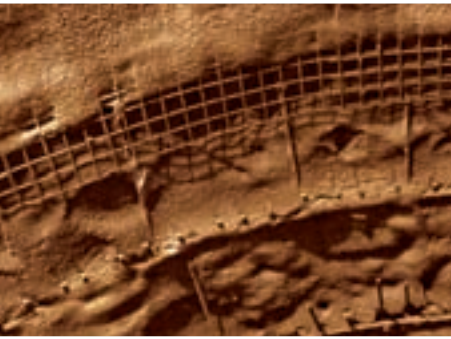
The characteristics of the IBO - Self-Drilling Anchor System – quick and safe application due to drilling, installation and grouting in a single operational step – constituted a huge advantage for the project team. The changing rock conditions also required an ad hoc adjustment of the anchor lengths, which could be done any time using the included couplers.

Immediate support in the excavation area was achieved using 95/30/20 PANTEX Lattice Girders. The PANTEX Lattice Girder stiffeners (also known as “spiders”) reduce local buckling lengths of the bars and, in addition to a high normal and bending moment resistance, provide an assured transfer of the normal forces prior to the application of shotcrete. The complete integration of the PANTEX Lattice Girders in the shotcrete lining results in a tunnel lining that significantly reduces ground deformations and prevents the ingress of water.

The Thirra Tunnel was opened to traffic in July 2010.



Support of Tunnel Lining using IBO - Self-Drilling Anchors and PANTEX Lattice Girders



Owner Government of Albania
General Contractor Joint Venture
Bechtel/ ENKA
Engineer Egis Route, France;
Geoconsult, Austria

DSI Unit DYWIDAG-Systems
International GmbH, Austria
DSI Scope Supply of IBO -
Self-Drilling Anchors R32,
PANTEX Lattice Girders





DYWI® Drill Anchors and AT-Pipe Advance Work for Algiers Metro

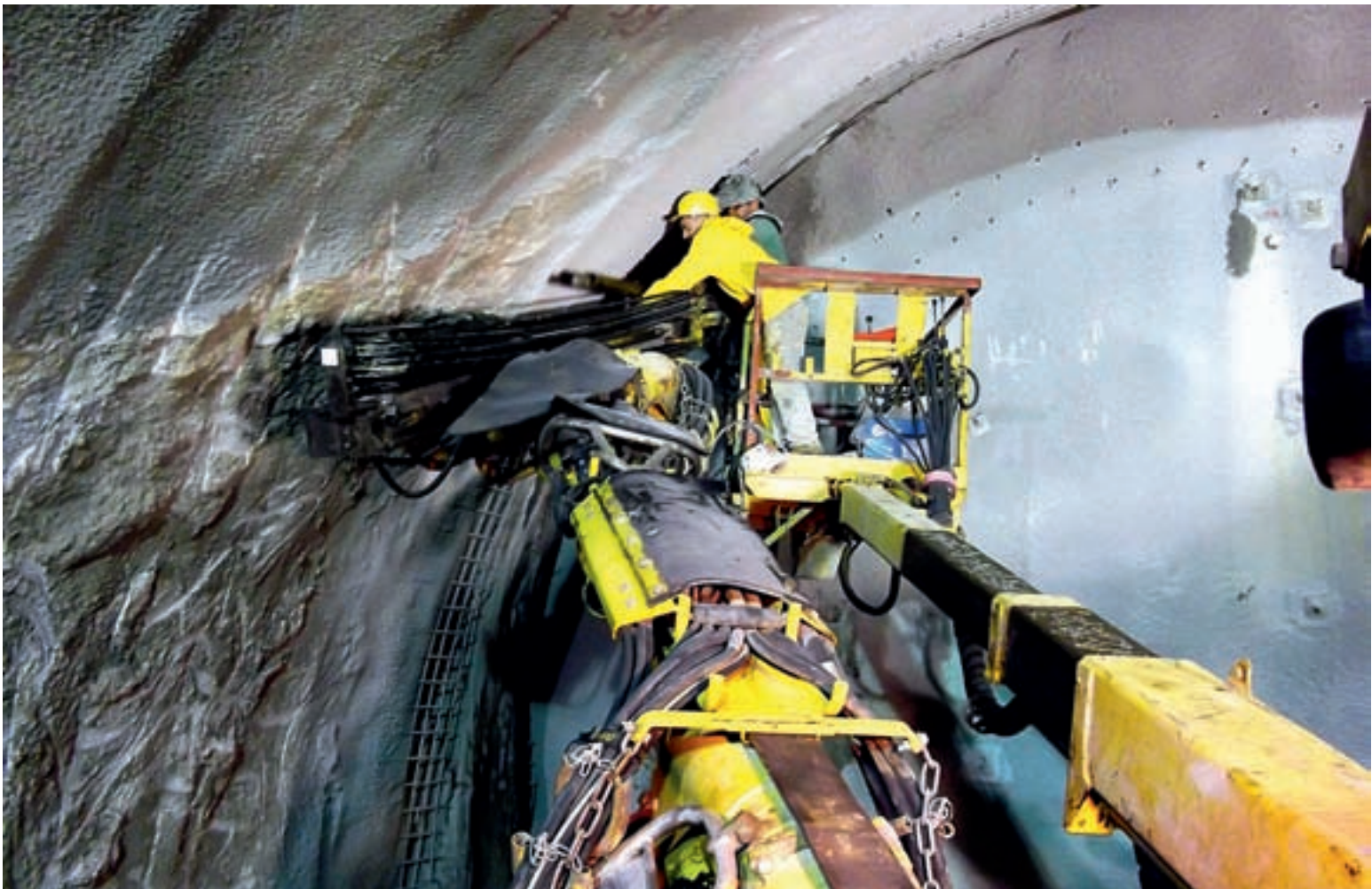
The network of Algiers Metro was extended by an additional 4km between July 2008 and January 2012. Construction work mainly included a 2.7km long tunnel, four new subway stations, an approx. 300m long bridge across the motorway and a river undercrossing.

The 2.7km long tunnel runs through clayey sands and sandy clays, marl, interstratified sandstone and unconsolidated rock. Due to the widely varying geological conditions and the relatively short tunnel sections, the tunnel for the Metro was built using the New Austrian Tunneling Method (NATM). As the excavation work was carried out using excavators, the team was able to react quickly and flexibly to changing ground and stability conditions by adapting support systems in accordance with the concept of NATM. The tunnel was stabilized using steel mesh and shotcrete immediately after excavation. This process led to a high loading

capacity in the ground with only small relaxation processes.

The dimensions of this project were impressive. With a full cross section of 88m², more than 1,200t of steel and approx. 17,000m³ of shotcrete were used during tunnel construction. For stabilizing tunnel advancement, DSI Austria supplied R32-280 DYWI® Drill Anchors including the complete range of accessories such as drill bits, couplers, nuts and anchor plates. Especially in the sandy clays, the self-drilling DYWI® Drill Anchor proved to be the best solution due to the fact that the injection anchor can be drilled into non-stable boreholes without a casing.

The length of the anchor rods consisting of special hollow bars with cold rolled outside threads could be modified as needed using couplers. Thanks to matching types of drill bits, the DYWI® Drill Self-drilling Anchors were adapted to the different rock and soil conditions quickly and flexibly during tunnel advancement.



Umbrellas Stabilize Tunnel



The easy operation principle, which remains the same even in different rock and soil conditions, and the time-saving installation procedure due to simultaneous drilling, installation and grouting also proved to be significant advantages during this project.

In addition, DSI supplied the AT-Pipe Umbrella System with an exterior pipe diameter of 88.9mm and a wall thickness of 6.3mm as a pre-support element in the partly soft and subsidence prone ground conditions. The use of the AT-Pipe Umbrella System offers the following principal advantages:

- reduction of subsidence due to ground improvement and load distribution
- increase of stability and safety by ground improvement ahead of the tunnel face
- ground support in the open span in the face region



The quick and easy installation of the self-drilling pipe umbrellas and the accurate alignment of the pipe umbrellas during drilling, which was carried out using a conventional drilling rig available on site, repeatedly proved of value during the use of the AT - Pipe Umbrella System in Algiers Metro.

In addition, the self-drilling AT - Drainage System AT-118/DR was successfully used for dewatering the surrounding ground parallel to construction.

The extension of Algiers Metro was successfully completed in January 2012.



Owner EMA (Entreprise Metro d'Alger), Algeria
General Contractor Joint Venture ENSITRANS, consisting of STRABAG International GmbH (DYWIDAG International GmbH), Germany, Cosider TP, Algeria and Trevi S.p.A., Italy
Engineers SYSTRA, France

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Production and supply of DYWI® Drill Anchors, R32-280, AT-Pipe Umbrella System AT-89, AT-Drainage System AT-118/DR

DYWI® Drill Hollow Bars now produced





Due to the increased demand for the high quality DYWI® Drill Hollow Bar System, DSI opened a new production facility for hollow bars in Pasching, Linz at the beginning of 2011.

Production capacity in Pasching was considerably increased by two new assembly lines. The new facility exemplifies the success of the product line and demonstrates the commitment to this DSI System in Pasching. The strategic investment ensures the future growth of this business division.

The DYWI® Drill Hollow Bar System is a self-drilling anchor, soil nail and pile system that is successfully used in Geotechnics as well as in Tunneling and Mining.

With this investment, the DSI Group is well positioned to meet both the current and future growing demand for high quality hollow bar systems that have been successfully installed for many decades.

The fully automated production facility corresponds to recent safety and environment requirements and includes a comprehensive enlargement of the plant's own quality assurance system.

The production facility is divided into two independent assembly lines. On the first assembly line, hollow bars in all standard diameters such as 32mm, 38mm and 51mm are produced with minimum changeover times. The second assembly line is there to flexibly produce special orders and is also designed to produce larger diameters when necessary.

The strategic focus of DSI Austria is on the development, production and supply of high quality products and systems for Tunneling and Mining. These systems stand for quality and reliability and are globally marketed with the brand name ALWAG Systems. They are well-known and favored in markets around the world.



EMEA

Austria

Tunneling

ALWAG Systems Stabilize Austria's

The Koralm Tunnel is the most important part of the Koralm Railway running from Graz to Klagenfurt in Austria. The construction of the new high-speed line will significantly increase transportation capacity in Austria and will shorten travel time between Graz and Klagenfurt from three to one hour.

With a total length of approx. 32.8km, the tunnel will be the longest railway tunnel in Austria and one of the longest traffic tunnels in the world after its completion. Two and a half km of the tunnel's 20km long main section are being constructed as two single rail tunnels using the New Austrian Tunneling Method (NATM). The remaining section is excavated using TBMs. The tunnel will have a maximum overlay of approx. 1,200m. The tunnel tubes have an axis-center distance of approx. 40m, an interior radius of 3.95m and a breakout area of approx. 82m² each.

In order to carry out an in-depth analysis of the geological and hydrogeological conditions as the basis for the main excavation, approx. 130 exploration wells as well as a 10km long exploratory tunnel system were excavated in advance. DSI had previously participated at the construction of the Paierdorf Exploratory Tunnel, which will be used as an air shaft after completion of the Koralm Tunnel.

DSI is supplying specialized tunneling systems for section KAT I, the first, approx. 5.5km section in the east. The double tracked section is being built as a double tube, 1,961m long shotcreted tunnel using a combination of blasting and excavation.

The prevailing ground is characterized by sediments consisting of unconsolidated rock, sand and silt with underlying layers consisting of unconsolidated silt and sandstone.

DSI supplied the following products for stabilizing the excavation:

- PANTEX Lattice Girders PS50/20/30, PS70/20/30 and PS95/26/34
- SN Anchors, 250kN, Ø 25mm
- DYWI® Drill Hollow Bars R32, 250kN, R32, 280kN, R38, 500kN and R51, 550kN
- AT – Power Set Self-drilling Tube Spiles, 52 Ø x 4.5mm
- Steel Spiles, Ø 26 and 36mm.

Construction of section KAT I started at the end of 2008 and is scheduled for completion in July 2013.



Longest Railway Tunnel

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Underground



EMEA

Austria

Tunneling



Owner ÖBB Infrastruktur Bau AG, Austria
Contractor W&F Ingenieurbau AG, Austria
Engineers Projektgemeinschaft Koralmtunnel, consisting of Geoconsult, Bernard Ingenieure, Basler&Hoffmann, Lombardi, Ingenieurbüro Maidl and Werner Consult, all of them Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Supply of PANTEX Lattice Girders, PS50/20/30, PS70/20/30 and PS95/26/34, SN Anchors, 250kN, Ø 25mm, DYWI® Drill Hollow Bars, R32, 250kN, R32, 280kN, R38, 500kN and R51, 550kN, AT – Power Set Self-drilling Tube Spiles, Ø 52 x 4.5mm and Steel Spiles, Ø 26 and Ø 36mm

60th Geomechanics Colloquy in Salzburg

October 13–14, 2011

The 2011 Geomechanics Colloquy in Salzburg was the most successful ever. More than 1.000 expert visitors from 25 countries and 57 exhibitors participated in the event. Continuing its long and successful tradition, the 60th Geomechanics Colloquy in Salzburg was characterized by lively discussions relating to recent developments in tunneling.

This time, sessions dealt with measurement engineering and geotechnical measurements, the avoidance of failures and criteria for selecting the most appropriate tunnel construction method. The lecture category “Current Major Projects” included a presentation of the Reisseck II pumped storage power station in Carinthia, which incorporates ALWAG Systems supplied by DSI.

As the Geomechanics Colloquy provides a discussion forum between site managers, planners, engineers and construction companies in tunneling, it is the most important annual professional event for DSI Austria in the German-speaking region of Europe.



EMEA

Austria

Tunneling

Successful Extension of Bosruck Tunnel

The 5.5km long Bosruck Tunnel runs from Upper Austria to Styria and is part of the A9 Pyhrn Motorway, one of the most important connections to South East Europe. The existing two-way traffic east tunnel, which has been operational since 1983, leads through very difficult rock formations. This results in tunnel deterioration that has been made worse by continuous moisture expansion in the area of the Hasel Mountains, which is why an overall repair of the tunnel was necessary.

The groundbreaking for the construction of the west tunnel took place on December 4th 2009, and the second tunnel will be opened to two-way traffic in 2013. Afterwards, the old east tunnel will be repaired over a period of approximately 1.5 years, and both tunnels will be fully operational by 2015.

The construction of the second tube for the Bosruck Tunnel and the A9 Pyhrn Motorway poses a special challenge from a tunneling point of view. On the one hand, water inflow in the existing tube and in the ventilation and escape galleries is very high and can be up to 300l/sec during snowmelt. On the other hand, geological conditions are extremely difficult, especially in those areas of the Hasel Mountains that consist of gypsum, salt and clay and are both swelling and water soluble.

In the sections of the west tunnel tube that are located close to the portal, short tunnel sections of 133m in the South and 60m in the North had already been driven during construction of the east tunnel in the 1980's. The section of the west tunnel that still needs to be driven is approximately 5,233m long. Due to widely varying rock conditions, the tunnel cross sections will range from 103m² (flat bottom slab) to 129m² (circular section). The northern tunnel section rises to the up-station at an inclination of 0.5%, and the decline in the direction of the south portal is 0.8%. The maximum overlap of the tunnel roofs is approx. 1,150m and is reached in the carbonate level of the Bosruck Tunnel.

Tunnel driving is carried out using the conventional tunneling method (blasting, mechanical heading) in accordance with the Austrian Tunneling Method using calotte driving and subsequent tunnel floor and bench driving from both portals. Depending on the rock conditions encountered, stabilization is carried out using shotcrete, steel mesh, steel arches and appropriate anchorages.

For stabilization during tunnel advancement, DSI Austria was awarded a contract by the Joint Venture Alpine Bau GmbH – Alpine BeMo Tunnelling GmbH to produce and supply DYWI® Drill Hollow Bar Anchors and R32 Self-Drilling Spiles in lengths of 6 to 10m, Bst 550 Concrete Steel Spiles, ERB 240 OMEGA-BOLT® Anchors, SN Anchors, PANTEX Lattice Girders and AT-LSC Lining Stress Controllers.





Owner ASFINAG, Austria
General Contractor Joint Venture Alpine Bau GmbH – Alpine BeMo Tunnelling GmbH, Austria
Engineering Ingenieurbüro Laabmayr & Partner ZT GmbH and ILF – Beratende Ingenieure, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Supply of DYWI® Drill Hollow Bar Anchors and R32 Self-Drilling Spiles, Concrete Steel Spiles, OMEGA-BOLT® Anchors, SN Anchors, PANTEX Lattice Girders and AT-LSC Lining Stress Controllers

Successful Technical Cooperation Leads to Supply Contract for Mining Products

EMEA

Bosnia-
Herzegovina

Mining

The Durdzevik brown coal mine is located near the city of Tuzla in eastern Bosnia. As brown coal has been produced there since 1936, the mine is considered to be historical. Today, the annual output is some 550,000 - 600,000t of brown coal.

Mining is carried out in open pit mines as well as underground. However, plans for the future concentrate on underground mining, which requires constant investment in this sector. Brown coal seams are currently being developed at a level of 250m below ground.

DSI was originally contacted by the mining company for technical support related to the rehabilitation of a central adit. For the reprofiling of an important adit, DSI developed a concept for the installation of 2,000mm long R32-210 and R32-250 IBO anchors together with Tuzla Technical University. This successful cooperation for restoring the safety of the adit provided the basis for future teamwork.

Since then, DSI has provided mining systems for the driving and support of new galleries and shafts for the Durdzevik underground brown coal mine. DSI is now supplying \varnothing 25mm SN Anchors with corresponding \varnothing 28mm resin cartridges in lengths of 500mm each as well as 24 OMEGA-BOLT® Anchors in lengths of 240cm and 270cm.

An additional supply contract for high quality mining products has already been agreed upon with the mining company.



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Owner JP RMU Durdzevik,
Bosnia-Herzegovina

DSI Unit DYWIDAG-Systems
International GmbH, Austria

DSI Scope Supply of Rebar Rock
Bolts and resin cartridges,
OMEGA-BOLT® Anchors

AT-Pipe Umbrella Support System allows safe Driving of Omis Tunnel

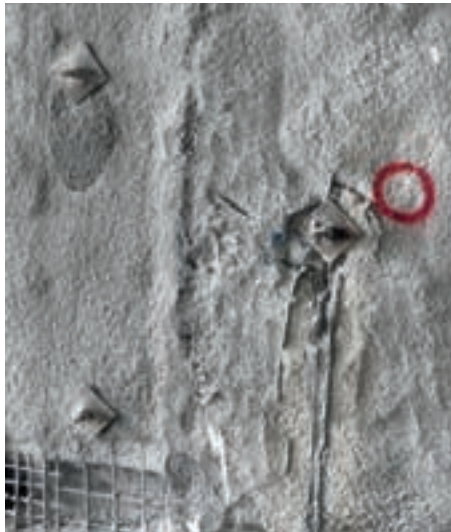
The most important route between the Croatian seaports of Split and Makarska is the D8 National Road. This road was built very near to the shoreline of the Adriatic Sea in the 1960s. Today, the road finds itself in the middle of numerous towns which have grown in the last decades. Due to continuously increasing traffic volume, the government decided to expand this coast road and to construct spacious bypasses for several towns.

A critical part of this infrastructure upgrade project was the construction of a 1,471 m long tunnel as part of the bypass of the town of Omis, some 25km south of Split.

Due to the comparatively small depth of cover at the tunnel location, it was necessary to start with a pipe umbrella support at the portal. DSI supplied its reliable 114mm AT-Pipe Umbrella Support System, which provided the protection and safety for the first tunnel driving work.

Tunneling was carried out mechanically using excavators and shotcrete in accordance with the New Austrian Tunneling Method (NATM). For further tunneling work, DSI supplied DYWI® Drill Hollow Bar Self-Drilling Anchors in lengths of 3,000mm each to secure the heading face. However, the geology encountered often required short-term recalculations of the necessary anchoring forces. Hence, different types of DYWI® Drill Hollow Bars were used. The DYWI® Drill Hollow Bar System is designed for differing rock mass conditions: The DYWI® Drill Hollow Bar drill bit design and diameter can be easily and flexibly adjusted. Various types maintain the basic dimensioning of the required anchoring forces. Eventually, necessary functional adjustments of the required anchor lengths can be carried out easily using the appropriate couplers.

The opening of the new of Omis bypass tunnel is scheduled for the end of 2012.



Owner Hrvatske ceste d.o.o.
(Croatian Highway Authority), Croatia
General Contractor Vijadukt
Zagreb, Croatia
Engineer IPZ d.o.o. Zagreb and
IGH d.o.o. Zagreb, Croatia

DSI Unit DYWIDAG-Systems
International GmbH, Austria
DSI Scope Supply of R32, R38,
and R51 DYWI® Drill Hollow Bar,
AT - Pipe Umbrella Support Systems



EMEA

Germany

Tunneling

The Jagdberg Tunnel: ALWAG Systems

The A4 motorway links central Germany with Poland and is one of the most important East-West axes in Europe. The section between Magdala and Jena-Goeschwitz is no longer able to accommodate the current traffic volume of more than 50,000 vehicles per day. Due to many steep grades and a large number of sharp curves along the motorway, traffic flow is considerably obstructed by slow-moving trucks.

In May 2008, construction began on an 11.8km long section that will be widened to six lanes. In order to protect the ecologically sensitive Leutra valley, the section was designed to include a 3km tunnel. The Jagdberg Tunnel consists of two parallel tubes with three lanes each. With a maximum overburden of approx. 134m, the tubes have an axis-center distance of approx. 35m and cross sections of 125-155m².

The 3,074m long northern tube was excavated using mining techniques over



stabilize East-West Motorway Axis

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Underground

EMEA

Germany

Tunneling

a length of 3,042m. 10m of the tunnel tube at the eastern portal and 22m at the western portal were built using the open cut tunneling method. The 3,070m long southern tube was excavated using mining techniques over a length of 2,930m. 10m at the eastern portal and 130m at the western portal were built using the open cut method.

The tunnels were driven by drilling and blasting in accordance with the New Austrian Tunneling Method (NATM). Both tubes were driven in opposite directions with an advancing crown with advance rates of up to 9m a day.

The driven sections were immediately stabilized using anchors and steel reinforcement encased in gunite. Final reinforcement was provided by a 40-50cm thick inner concrete lining. The particularly sensitive area around the southern tube that was close to the slope and in proximity of the portals required additional spiles for reinforcement ahead of the tunnel face in order to effectively stabilize weathering pockets in the prevailing red sandstone.

In addition, there were several tectonic fault zones in the middle of the tunnel for which DSI Austria supplied high quality ALWAG Systems. Among other products,

AT - System AT-139 Pipe Umbrellas in lengths of up to 15m were used for reinforcement ahead of the tunnel face. The AT Pipe Umbrella System provides an effective support of the tunnel wall and distributes loads longitudinally in the region of the face.

In order to achieve an optimum adaptation to the tunnel geometry, DSI also supplied PS70/22/32, PS95/22/32, PS130/26/34 and PS 130/22/32 PANTEX Lattice Girders. By using the lattice girders, ground deformations of the surrounding rock mass were minimized and the impermeability of the gunite lining was considerably improved.

Additionally, Ø 25mm, M26 SN Anchors and R32 and R38 DYWI® Drill Hollow Bars were installed in the tunnel. The scope of delivery also included Ø 32 GEWI® Bars, ERB 240 OMEGA-BOLT® Expansion Anchors and Ø 28mm Rebar Spiles in lengths of 8m.

The motorway section, which is currently the largest motorway construction project in the federal state of Thuringia, is scheduled for completion by mid-2013 and will considerably improve traffic flow in the region.



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Owner Ministry for Transportation, Construction and Town Development, represented by the free state of Thuringia
Client DEGES (Deutsche Einheit Fernstraßenplanungs- und Bau GmbH)
Contractor JV Tunnel Jagdberg, consisting of Baresel GmbH, ALPINE BeMo Tunnelling GmbH and Kirchhoff Leipzig Straßenbau GmbH & Co. KG, all of them Germany
Engineering BUNG AG beratende Ingenieure and Müller + Hereth Ingenieurbüro für Tunnel- und Felsbau GmbH, both Germany

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Supply of AT - System AT-139 Pipe Umbrellas, PANTEX Lattice Girders, SN Anchors, DYWI® Drill Hollow Bars, GEWI® Bars, OMEGA- BOLT® Expansion Anchors and Rebar Spiles

DYWI® Drill Hollow Bars and PANTEX Lattice Girders secure Driving of the Sten Tunnel

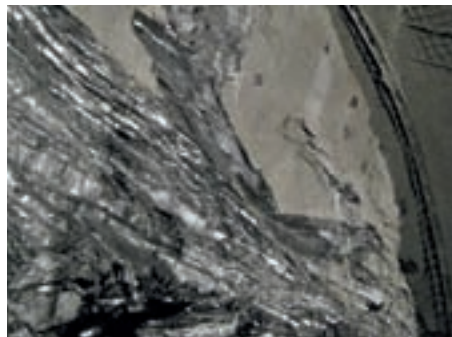
Skofja Loka, a town some 25km northwest of the Slovenian capital of Ljubljana, looks back on a long tradition. First mentioned in historical records in 973, the town was rebuilt after a major earthquake in 1511. Even today, the town is largely conserved in this style and ranks amongst the most significant medieval cities of the area. The construction of a 3.9km long bypass was chosen to shield the many medieval buildings and the inhabitants from the steadily increasing traffic volume.

Key projects on this bypass are several bridges as well as the 613m long Sten Tunnel. Attached to the actual tunnel, there are galleries on both sides, extending the total tunnel structure to 712m. Tunnel driving was performed by drill-and-blast and using excavators in accordance with the New Austrian Tunneling Method (NATM).

DSI supplied R32 DYWI® Drill Hollow Bars together with the required injection pumps for the starting gallery and the initial support. In addition, DSI provided three 70/30/20 PANTEX Lattice Girders. The girders were installed in combination with shotcrete for the immediate support in the excavation area along the entire length of the portal. In contrast to standard steel sections (solid-web girders), PANTEX Lattice Girders are entirely integrated in the shotcrete lining, avoiding porous zones and shotcrete spray shadows.

The owner decided to also use DYWI® Drill Hollow Bars for the support of the tunnel because their characteristic application as injection anchors without the need for casing makes them very suitable especially for non-stable boreholes. The self-drilling installation is done using the anchor bar as a drill rod with a single-use drill bit. According to the requirements during installation, the anchor lengths can easily be extended using couplers.

Work on the new Sten Tunnel was successfully completed mid-2012.



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Owner Direkcija Republike Slovenije za Ceste, Slovenia
General Contractor Primorje d.d. Ajdovscina, Slovenia
Engineer Geoport, Slovenia
Supervisor DRI d.o.o. (DDC d.o.o.), Slovenia

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Supply of R32 DYWI® Drill Hollow Bars and injection pumps, 70/30/20 PANTEX Lattice Girders

Koza Gold Underground Mining Operations rely on high quality DSI Anchor Systems for Gold Mining

The first noteworthy and economically exploitable gold reserves in Turkey were discovered in 1989. With the founding of the Koza Gold Operations Company in 2005, a Turkish company was established to produce gold in that country for the first time.

The most important site of Koza Gold Operations - and the very first gold mine in Turkey - is the Ovacik mine in West Anatolia close to the city of Bergama some 100km north of the sea port city of Izmir. The gold ore body is bedded in two quartz veins in andesitic volcanic rock. The mined ore is almost free of sulphurous minerals and barely contains any heavy metals.

Koza Gold Operations also emphasizes underground gold production in the Mastra mine in the north-east of Turkey near the Black Sea, close to the city of Gumushane. This area is well known for its metallogenic zone. Hence, it has developed into a typical mining region. Gold has been produced from the Mastra mine since 2008.

DSI, as a system supplier for high quality strata control products for the mining industry, supplies the Ovacik,

Mastra and Cukuralan gold mines (the last of which is being developed) with Friction Bolts, OMEGA-BOLT® Anchors, Cable Bolts and the required accessories.



Owner KOZA Altin Isletmeleri A.S.,
Turkey

DSI Unit DYWIDAG-Systems
International GmbH, Austria
DSI Scope Supply of Friction Bolts,
OMEGA-BOLT® Anchors, Cable
Bolts and Accessories

Copper Mines in Turkey seismically

In Turkey, mining activities have been known from the early days of human history. Today, mining continues to be an economically important industry sector for the country. At present, Turkey is mainly exploiting gold, lead, zinc, chromate, coal, and iron. But there are also significant deposits of copper and pyrite concentrate that are being mined (pyrite concentrate is a byproduct of copper mining and contains a high proportion of sulfur). One of the major producers for these two products is the Eti Bakir A.S. mining group., which is part of Cengiz Holding.

Eti Bakir mines copper in two similar mining regions. The Küre Mine of Eti Bakir is located in the northwestern part of Turkey, near the city of Kastamonu, close to the Black Sea. The Murgul Mine is operated in the far northeast of Turkey, close to the town Murgul in the province of the city of Artvin.

The Küre Mine includes three open-pit mines as well as one underground mine. Here, more than 250 employees mine copper exceeding 1 million t run off mine and pyrite concentrate exceeding 90,000t per year.

The Kastamonu region is geographically located in one of the most seismically active regions of the world – due to the North-Anatolian fault stretching below the north of Turkey and the Marmara Sea as far as Greece.

Hence it was mandatory for the mining company to find a flexible bolt system suitable to secure underground working galleries in seismically active mining regions.

DSI recommended the OMEGA-BOLT® Anchor System to the mining group. After several test installations and comprehensive load tests, OMEGA-BOLT® Anchors quickly convinced the customer of their viability to solve the existing problem. The characteristic flexibility of the OMEGA-BOLT® to continually conform to



secured by DSI products

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Underground

EMEA

Turkey

Mining



changing conditions of the installation ground as well as its ability to link multiple weak strata layers reliably secures the seismically active rock. DSI currently supplies OMEGA-BOLT® Expandable Friction Bolts to the Küre mines which are continuously installed in the shaft and galleries during tunnel driving. Moreover, DSI provides pumps and additional equipment for the installation of OMEGA-BOLT® Anchors in the mines.

Eti Bakir also operates the Artvin Murgul Mines in the far northeast of Turkey, where they annually remove more than 2.7 million t of runoff copper and 75,000t of pyrite concentrate. For these mines, DSI supplies an extensive range of mining products for the efficient safety of the galleries such as split sets, OMEGA-BOLT® Anchors and cable bolts together with pumps and cable bolt tensioners.



Owner Eti Bakir A.S. (Cengiz Holding), Turkey

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Supply of OMEGA-BOLT® Anchors 120, SS39 split sets, cable bolts; pumps and cable bolt tensioners





Over the last few years, demand for raw materials has once again experienced a strong increase. This trend is impacting the mining industry in South Africa and in the adjacent countries that possess abundant raw material resources. The growth in Africa's mining industry is additionally strengthened by a high demand for raw materials from China and India which results from strong economic expansion in those countries. Traditionally, the mining industry in South Africa is the most developed in the region because the country is the world's largest platinum group metals producer and the most important exporter of coal to Europe.

In Zimbabwe, the government has recognized the importance of the mining industry for the country's economy. Zimbabwe possesses very large mineral deposits, with gold being the most important raw material of the country. In addition, chromium, asbestos, nickel, copper, iron ore, vanadium, lithium, tin and platinum are mainly extracted in hard rock mining.

In Botswana, there has also been a very positive trend in the mining industry within the last years. Botswana is the world's largest producer of gem diamonds, and the mining industry is mainly focused on the extraction of raw diamonds in hard rock mining. In addition, the extraction of copper, nickel, salt, potash, coal, iron ore and silver is growing.

Activities in Botswana and Zimbabwe

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Underground

EMEA

South Africa

Mining



DSI is one of the largest and leading producers of products and systems for mining in South Africa. DSI South Africa strongly focuses on research and development, the production and the just in time supply of products and systems for stabilizing advance sections in underground mining. DSI puts great importance on optimizing its production processes because they represent an important success factor. As a result, production schedules can be readily modified in order to quickly respond to the changing needs of its customers.

DSI South Africa offers its clients

- production of technically refined and economic products and systems
- supply and technical support by experienced technicians and engineers on site
- just in time delivery and logistics
- high security through best quality

As a system supplier, DSI offers a large range of mining products: friction anchors, expansion anchors, resin roof bolts, fully threaded and unthreaded rebar bolts, double corrosion protected (DCP) bolts, cable bolts, deformed and

flat anchor plates and a complete range of accessories.

The products and systems are centrally produced in Johannesburg and are directly supplied to the clients by truck. Clients include BHB Billiton, Xstrata, Exxaro, De Beers, Anglo American Thermal Coal, Anglo American Platinum, Bombela Construction, Sasol, CMI Joint Venture and a large number of smaller and medium sized mining operations.

Clients' demand for high quality innovative products and solutions both from South Africa and from neighboring countries is steadily increasing. Consequently, DSI is going to strategically expand its export activities into the important neighbor countries such as Botswana and Zimbabwe in accordance with the slogan **"RELY ON DSI"**.



DYWI® Polymer Rock Dust System enhances Safety and Productivity in Underground Mining

Improving the application of inert rock dust to reduce the risk of coal dust explosions has become a central topic in underground mining in the last few years. The efficient reduction of respirable dust concentrations in the mine atmosphere is another important issue, as respirable dust can cause health problems.

In order to meet these requirements, DSI Underground Systems Inc. USA has widened its product range by the addition of the DYWI® Polymer Rock Dust System, which has been developed by DSI and is now successfully used in underground coal mining.

The performance of the new system aides customers in meeting the current requirements of MSHA (Mining Safety Health Administration) in terms of inert rock dust application in underground coal mining and also reducing respirable rock dust in the mine atmosphere.

The DYWI® Polymer Rock Dust System combines wet dusting technology and polymers to ensure the effective application of inert rock dust along with reducing respirable dust. The system can be applied at rock dust thicknesses of a range between approx. 0.5mm and 40mm (0.02" - 1.6") and typically dries within 24 to 48 hours, depending on the mine air velocity and humidity.



The compact size of the equipment ensures that it can be easily transported in underground mines using standard means of transportation such as wheel loaders or overhead monorail systems.

The DYWI® Polymer Rock Dust System can be easily operated by two people and the coal surface can be sprayed during continuous shift operation. A typical batch operation provides approx. 75m (250ft) of roof and rib coverage, depending on mine height and width.

The hydraulically powered air compressor provides 30%-50% more coverage per batch by improved dispersion of the product via the air assist spray nozzle.



Advantages of the DYWI® Polymer Rock Dust System:

- easy to batch and spray
- quick troubleshooting
- one stop shop service for the concentrate and application equipment (DSI is the manufacturer of the equipment)
- operating at low pressures improves application and end user safety
- patent pending system
- approx. 75m (250ft) of roof and rib coverage in only 15 - 20 minutes
- aides customers in meeting current requirements for rock dust application in underground coal mining
- dusting operations can be carried out while the production unit is under operation – no shut down periods
- cost effective and easy operation

Tunneling Systems and Machine Dulles Corridor Metrorail Project



The Dulles Corridor Metrorail Project is a 5.25 billion Dollar project that is being built to create a high-capacity local traffic system in the Dulles Corridor near Washington D.C. and to reduce traffic congestion in the region. The project is owned by the Metropolitan Washington Airports Authority (MWAA) and includes the extension of Washington D.C.'s Metrorail System by 37km (23mi) to Dulles airport.

The work is divided into two phases. Phase 1 is the construction of an 18.8km (11.7mi) section from East Falls Church to Wiehle Avenue and includes four stations: Tysons Corner, Tysons Central 123 and 7 as well as Tysons West. Construction began in March 2009 and is scheduled for completion in 2013.

Phase 2 includes the extension from Wiehle Avenue to Ashburn in the eastern part of Loudoun County. With this alignment, Reston's city center, Dulles Airport and Route 606 will be closely linked to Dulles Corridor.

The hills in the Tysons Corner area through which the tunnel passes consist of mica schist that contains large amounts of quartz, phyllonite, gneiss and graywacke. Furthermore, gravel-like deposits and silt were found in the area of the planned tunnel alignment. Due to the difficult geological conditions and the very shallow soil cover in some areas, advance work was carried out mechanically using excavators and a shotcrete lining support in accordance with the principles of the New Austrian Tunneling Method (NATM).

Technology for Tysons Corner,

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Underground

North America

USA

Tunneling

For the construction of the 510m long double tube tunnel, DSI Underground Systems, USA and DSI Austria supplied a large amount of innovative products and systems as well as comprehensive site support services. DSI Underground Systems, USA's scope included the supply of technical equipment such as Hany Mixers and injection pumps, breathing gear as well as lubricants and accessories. Furthermore, DSI Underground Systems manufactured and supplied the necessary lattice girders and underground steel supports that ensure an immediate support of the tunnel wall in the excavation area and are entirely integrated in the shotcrete lining during installation.

In order to support the active work area at the heading, DSI Austria supplied the innovative ALWAG Systems AT-114 Pipe Umbrella pre-support system. As the soil cover above crown was only 2.13m (7ft)

at the tunnel portal, a double injection pipe umbrella was installed by a conventional drill rig. The double pipe umbrella consisted of 57 self-drilling tubes in lengths of 17.35m (57ft). The center to center distance at the mouth was 0.5m (19.69") and the outer diameter was 114.3mm (4.5"). The installation procedure was finished by carrying out the grouting work with a special cement suspension. 12.8m (42ft) of tunnel were advanced in each pipe umbrella section. The remaining part of the pipe umbrella served as an abutment ahead of the face to transfer the loads during stress redistribution. A single pipe umbrella with 27 elements was enough for the sections further inside the tunnel that had a larger overburden. Casing tubes with a total length of 45km (28mi) were successfully installed in both tunnel tubes.

The use of two AT-Automation Units was another innovative solution for this project. They were assembled on a standard underground drilling rig (Atlas Copco EC218) that made the automated installation of the AT-Pipe Umbrella System possible. The AT-Automation Unit offers the following advantages:

- time-saving pipe umbrella installation
- cost reduction due to the faster installation process of a complete pipe umbrella
- cost and time reduction thanks to a smaller saw tooth profile
- higher occupational safety
- reduction of staff requirement and downtime

As DTP's Senior Mining Engineer Frank Jenkins comments, "In this technically challenging tunnel, we appreciated the close technical support, the hands-on mentality and the service DSI's employees supported us with".



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Owner Southern Nevada Water Authority (SNWA), USA
General Contractor Vegas Tunnel Constructors – Joint Venture, consisting of Impregilo, Italy, and S.H. Healy, USA
Project Design Arup, USA
Geotechnical Consulting Brierley Associates, USA

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

DSI Scope Supply of AT-114 Pipe Umbrella Systems, AT-Automation Units, underground steel supports, anchor bolt systems, lattice girders, lubricants and accessories, breathing gears, Hany Mixers and injection pumps





Tunneling Machines and Ground Support from a Single Source,

The eastern side of San Francisco Bay is densely populated. The residents of this region, who commute between Oakland and San Francisco, use Highway No. 24 for their daily journey to work. This highway, which is becoming increasingly congested, runs through the Caldecott Tunnel underneath the Berkeley Mountains between Oakland and Orinda.

The first two double lane tunnel tubes date back to the Thirties and the third tunnel tube was built in the Sixties. The middle tube is opened for one direction at a time depending on the main flow of traffic. At approx. 160,000 vehicles per day, this system creates long bottlenecks in the direction that can only use one tube. A fourth tube will bring relief for this situation so that there will be two tunnel tubes per direction beginning in 2014.

The prevailing geology with its many different soil conditions and four major and three minor fault zones poses many challenges for the stabilization of tunnel excavation work. A large active fault zone that could cause an earthquake of 7.4 on the Richter scale at any time is located in the immediate vicinity of the project. Consequently, the approx. 1,000m long tunnel has to be built absolutely earthquake proof. That is why a double lining which requires complex stabilization methods is being created. In addition, the complete tunnel is endangered by potential gas leakages. This means that all of the equipment used for tunneling must be explosion proof.

Excavation is carried out with a road header in accordance with the New Austrian Tunneling Method (NATM). As an authorized dealer of Aker Wirth in the United States, DSI supplied a Type T3.20 Wirth road header. The machine's electrically powered drill boom covers an advance area of approx. 7x9m.



Caldecott Tunnel



Once a defined length of excavation has been reached, the ground support products consisting of lattice girders, spiling and IBO and glass fiber reinforced (GRP) anchors and shotcrete are installed. The lattice girders, which are supplied by DSI, are fully integrated into the lining so that porous zones and shotcrete spray shadows can be avoided. This minimizes ground deformations and significantly enhances the impermeability of the shotcrete lining. In addition, DSI supplied DYWIDAG THREADBAR® for spiling, IBO Self-Drilling Anchors, Type ALWAG Systems and GRP anchors for stabilizing the excavation area. Once the excavation work has been completed, the shotcrete lining is covered with a waterproof membrane. Afterwards, the final cast-in-place concrete lining is built. The Caldecott Tunnel's fourth tube is scheduled for completion in mid-2014.

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Owner CALTRANS (Californian department of transportation), CCTA (Contra Costa Transportation Authority) and ACTC (Alameda County Transportation Commission), all of them USA

General Contractor Tutor-Saliba, USA

Contractor Sylmar, USA

Subcontractor FoxFire Constructors, USA

Design Jacobs Associates, USA

Construction Management

Parsons Brinkerhoff / Gall Zeidler Consultants JV, USA

Consultants Brierley Associates, USA

DSI Unit DSI Underground Systems Inc., USA

DSI Scope Supply of lattice girders, DYWIDAG THREADBAR®, IBO Self-Drilling Anchors and GRP anchor systems, a Type T3.20 Aker Wirth Roadheader, spare parts and service and Condat fire proof hydraulic fluids

Lake Mead Intake Tunnel No. 3 stabili

Hoover Dam in Lake Mead supplies 90 % of the water for Las Vegas. However, during the last 9 years, the United States' southwest and especially the Las Vegas area in the state of Nevada have experienced a significant drought. As a result, Lake Mead's surface level has decreased by approx. 35m to 338m above sea level over the last 9 years.

The Las Vegas valley is currently fed by water from two underwater intakes located east of Saddle Island. If the water level sinks another 18m, intake No. 1 will no longer be usable. The second intake would be dry if the water level sank to 305m above sea level. In addition, Hoover Dam's electric generating capacity would be reduced.

The owner of the power plant, Southern Nevada Water Authority (SNWA), announced the necessity of a third intake years ago. This project is characterized by technically challenging parameters such as diverging soil conditions (sedimentary and volcanic rock), the tunnel depth with high water pressures and the size and depth of the underwater intake structure at the end of the tunnel. Due to the complexity of the project, SNWA decided to undertake the work as a Design-Build Project. The Joint Venture of Vegas Tunnel Constructors has assigned Arup USA with the lead design and Brierley Associates with geotechnical consultancy during the project.

The new intake tunnel will be accessible via a 170m deep, \varnothing 9.1m shaft. The shaft is excavated by drilling and blasting with a subsequent



zed using DSI Rock Support Products

cast-in-place concrete lining. Extensive probing and advance grouting is necessary for the construction of the shaft. The access shaft is widened to a cavern at its bottom in order to permit the assembly of a Tunnel Boring Machine (TBM) and serve as a 137m long starter tunnel for the machine. The TBM has an excavation diameter of 7.22m, and the approach shaft has a length of 4.8km. The tunnel will be lined with precast concrete segments sealed by gaskets.

The intake tunnel is mainly located in tertiary sedimentary rock of the Muddy Creek Formation, and excavation must progress through a large number of fault zones. As a result, large amounts of water will be encountered during advancement.

According to the geotechnical baseline report, the single shield TBM (Type Mixshield) will also realize two sections in fully shielded mode. This means that comprehensive grouting and ground treatment will be necessary.

Consequently, the fully shielded machine is equipped for probing and ground improvement ahead of the TBM. Two drill rigs are located inside the shield for face positions. The third drill rig is located behind the ring erection area for periphery positions. If necessary, a fourth drill rig can be mounted on the erector.

DSI Underground Systems supplied high quality rock support products such as steel ribs and anchor systems. Additionally, DSI supplied the Type AT-114 Pipe Umbrella System, which is used for stabilizing the starter tunnel

ahead of the tunnel face. On the whole, ten 14m long pipe umbrellas were installed with 16 bores each for additional support of the TBM starter tunnel. The AT Pipe Umbrella Systems ensures a reduction of subsidence due to ground improvement and optimized load distribution.

As authorized dealer for Condat Lubricants in the USA, DSI also supplied various types of machine grease and hydraulic liquids that are needed for running the TBM as well as accessories and spare parts for the Hany Mixers and Injection Pumps. The completion of this infrastructure project, which is of great importance for Las Vegas, is planned for 2015.



Owner Southern Nevada Water Authority (SNWA), USA
General Contractor Vegas Tunnel Constructors – Joint Venture Impregilo, Italy, and S.H. Healy, USA
Project Design Arup USA
Geotechnical Consultants Brierley Associates, USA

DSI Unit DSI Underground Systems Inc., USA

DSI Scope Supply of steel ribs, anchor systems, AT-114 Pipe Umbrella Systems, machine grease and accessories, breathing gears, Hany Mixers and Injection Pumps



Safe Deep Mining with DSI Products: Turquoise Ridge Mine

North America

USA

Mining



With 26 operating mines and additional global mining projects, Barrick Gold Corporation is one of the world's largest gold producers. In 2010, the company produced a total of 7.8 million ounces of gold.

Barrick Gold Corporation is the 75% owner and operator of the Turquoise Ridge Mine in the Potosi Mining Area in Nevada, USA. Since the ore is mainly located in calciferous sediments and unstable zones, mine development is being carried out using the underhand cut-and-fill method, with excavation and fill from the top downward.

This method is the most flexible exploitation method used in deep mining. The ore is removed in several horizontal drifting slices. Directly afterwards, the void is filled with waste material from the mine's mineral processing plant and stabilized with cement in order to create a load-bearing roof under which the excavation can be continued.

In some areas of the long term development areas of Turquoise Ridge Mine, the surrounding rock mass was so unstable that filling of cavities with cement was not enough to stabilize the heading.

For efficiently stabilizing these areas, the operator asked DSI Underground Systems Inc. to supply PANTEX Lattice Girders which proved to be the best solution for the prevailing conditions because they ensure comprehensive and immediate support in the excavated area.

Furthermore, the lattice girders can be easily shaped and adjusted to the excavation geometry of the adit. Since August 2010, Turquoise Ridge Mine has been keeping two to three different sizes of PANTEX Lattice Girders in stock in their supply yard so that the owner can react quickly to changing ground conditions.



Owner Barrick Gold Corporation,
USA

DSI Unit DSI Underground Systems
Inc., USA

DSI Scope Supply of PANTEX
Lattice Girders in different sizes

Safety in Mining with DSI: Marlin Mine

Marlin Mine is located approx. 300km north-west of Guatemala City in the western highlands of Guatemala. It is the country's first big mining project in two decades. The operator, Montana Exploradora de Guatemala, S.A., is a 100% subsidiary of the Canadian mining company Goldcorp.

Since December 2005, gold and silver ore has been mined both in open pit and underground mining and processed directly on site at the Marlin Mine. In 2009, the mine produced a total of 274,900 ounces of gold and 4,156,500 ounces of silver.

The use of a large number of cable bolts was necessary to ensure future mine development and expansion. Experienced DSI employees trained the mine's crews both during locally held seminars and in application training directly on site.

Through comprehensive on-site training, DSI was able to competently convey the critical factors for the successful performance of cable bolts to the workers and the operator of Marlin Mine.

Thanks to DSI's high quality products, Marlin Mine is well prepared for its future ore extraction process.



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Owner Montana Exploradora de Guatemala, S.A.

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

DSI Scope Supply of friction bolts, cable bolts and cable tensioners; technical assistance and on-site training



Gold Mine profits from DSI Products and Services: El Limon Mine



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Owner B2Gold Corp, Nicaragua

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

DSI Scope Supply of welded wire mesh, friction bolts and cable bolts; technical supervision and instruction, training of the miners

The Limon Gold Mine is located in the north-west of Nicaragua, approx. 100km north of the capital of Managua and at a distance of 20km from the Panamericana highway system that runs from north to south over the entire American continent.

With 95% of the shares, B2Gold is the majority owner of the mine – the remaining 5% is owned by Inversiones Mineras S.A., a company that represents unionized miners in Nicaragua. The Limon Mine is operated both as an underground and open pit mine. In 2010, the mine produced approx. 40,000 ounces of gold.

B2Gold is currently carrying out explorations in order to make new gold deposits accessible and to increase the mine's gold production.

DSI's Mexican branch, DS International S.A. de C.V., in Zapopan, Jalisco was awarded a contract by B2Gold to supply the complete range of needed mining products. The product range includes welded wire mesh, friction bolts, cable bolts and accessories.

A major part of the support DSI offers to its client is onsite product testing, training of the miners and support for the efficient installation of the products.

Thanks to the comprehensive services provided, the customer is able to take full advantage from the mining products supplied. On site, the miners receive important information regarding the safe performance and capacity of the rock bolts as well as information on specific borehole tolerances that permit an optimized use of friction bolt load-bearing capacity.



ALWAG Systems Contribute to Chile's Energy Supply

In the Chilean Andes, approx. 150km south of Santiago de Chile, a new hydropower plant is currently under construction that will significantly improve the energy supply of the entire region: La Confluencia power plant. La Confluencia is being built as a turnkey project by a joint venture consisting of Hochtief AG and Tecsa SA.

The run-of-river power plant has a capacity of 158MW and is being built at an elevation of 1,430m. The water inflow to the power plant is mainly determined by snowmelt. In contrast to the region's existing hydropower plants, this plant will also operate at full capacity during the dry season in order to supply energy to the complete system.

La Confluencia is being built between both the Tinguirica and Portillo rivers. Two main inlet areas and five secondary inlets collect the water from both river valleys and direct it into a catchment with a daily capacity of 1.2 million m³.

In order to divert the water from the main inlets to the power plant, 20km of tunnels are being excavated. Two horizontal tunnels will direct the water to an approx. 360m long vertical pressure shaft. From here, the water will flow through a high pressure tunnel to the two turbines in the power plant.

Excavating the tunnels makes up the better part of the construction work for this project. Excavation is being carried out simultaneously from both portals in blasting and drilling advance with consecutive ground support and at advance rates of approx. 9m per day. The Portillo Tunnel has a cross-sectional area of nearly 33m², whereas the shorter Tinguirica Tunnel features a cross-sectional area of nearly 37m². The 95m high surge shaft, which is being built as a watertight shaft for diminishing water surge pressure in the piping, has a cross section of more than 200 m².



The geology in the region includes tuff and breccias with hematitic and arcillic alterations, and unconfined compressive strength ranges between 80MPa and 120 MPa. Tunneling is made difficult especially because the Andes are characterized by sedimentary and volcanic rock with strongly differing intermediate layers. Consequently, rock conditions cannot be predicted: in addition to the main rock classes of III-V, classes I-II were also expected but not encountered during excavation. Furthermore, excavation was made difficult by groundwater - particularly so in the El Manzano area.

For stabilizing tunnel advancement, the general contractor awarded a contract to DSI Chile for the supply of approx. 350,000m R32 IBO Self-drilling Anchors, 25,000m \varnothing 1.2m ventilation ducts and 11 injection pumps. In addition, DSI Chile supplied approx. 500m of AT-114 Pipe Umbrellas and approx. 1,500m AT-89 Pipe Umbrellas. Construction work on this important infrastructure project began in October 2007 and was completed at the end of 2011.



Owner Tinguirica Energia, a joint venture consisting of Pacific Hydro, Australia and SN Power, Norway

General Contractor Joint venture Hochtief-Tecsa, consisting of Hochtief AG and Tecsa SA, both Chile

Contractor Geocontrol, S.A., Chile

DSI Unit DSI Chile Industrial Ltda., Chile

DSI Scope Supply of approx. 350.000m R32 IBO Self-drilling Anchors, 25,000m \varnothing 1.2m ventilation ducts, 11 injection pumps, approx. 500m of AT-114 Pipe Umbrellas and approx. 1.500m of AT-89 Pipe Umbrellas

APAC/
ASEANNew
CaledoniaCommercial
Buildings

GEWI® Piles for one of the World's largest

The Koniambo Nickel project in New Caledonia in the South Pacific region is a large scale project in which nickel is being mined using the open pit method and directly processed in a smelter on site. With an estimated reserve of approx. 80-100 Mio. t of high quality nickel, the deposit is one of the world's largest nickel deposits.

The approx. US\$3.85 billion development is being managed by the Koniambo Nickel SAS joint venture. The Société Minière du Sud Pacifique, a company acting on behalf of the regional government of New Caledonia, holds 51% of the mine's shares and Xstrata Nickel, the world's fourth largest copper producer, holds the remaining 49%.

The Engineering, Procurement and Construction project Management services (EPCM) contract was awarded to



Mines in the South Pacific Region

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New
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Buildings



a joint venture between Hatch and Technip. A total of 7 million m³ of earth was excavated and 75,000m³ of reinforced concrete were used for the project. Construction work also included a new nickel smelter with an annual production capacity of 60,000t of ferrous nickel alloy.

DSI Australia worked closely with the General Contractor during the preliminary design of the pre-stressed permanent anchors and micropiles for the metallurgical plant and the power station. Thanks to the excellent co-operation between the parties, the products needed could be delivered quickly from Australia. Additional products were supplied from DSI's competence centers in Dagneux, France and Koenigsbrunn, Germany.

In total, DSI Australia supplied 100 11.8m long \varnothing 63.5mm GEWI[®] Micropiles and over 1,040 Permanent Double Corrosion Protected (DCP) \varnothing 63.5mm GEWI[®] Anchors.



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Owner Xstrata Nickel,
New Caledonia
General Contractor JV, consisting
of Hatch and Technip, France

DSI Unit DYWIDAG-Systems
International Pty. Ltd., BU Civils,
Australia
DSI Scope Supply of 100 \varnothing 63.5mm
GEWI[®] Micropiles as well as of
1,040 Permanent DCP \varnothing 63.5mm
GEWI[®] Anchors





APAC/
ASEAN

Japan

Bridges

Uratakao Bridge: State of the Art Post-Tensioning for an Expressway Bridge

A new four-span bridge is currently being built in Tokyo between the Takaosan Tunnel and the junction of the Ken'o-do and Chuo-do expressways: The Uratakao Bridge. The structure was constructed as a continuous prestressed concrete/steel rigid frame bridge and completed at the end of 2011.

Uratakao Bridge is characterized by several technological features, including the use of ultra-high strength strands for the superstructure and high-strength steel bars for the bridge piers.

In addition, demanding adaptations of the main girders to differing deck widths were necessary in order to adapt the bridge to existing structures.

Sumitomo participated in the construction of Uratakao Bridge. Internal and external tendons with epoxy coated and filled ultra-high strength strand was used to ensure the load-bearing capacity of the main girders against large seismic movements. MA 12-15.7mm DYWIDAG Strand Tendons were used for internal post-tensioning.

The external tendons were anchored to the precast girders on one end and to the steel girders on the other end. The MC 19-15.7mm DYWIDAG Post-Tensioning System was used for external post-tensioning.

In addition, Sumitomo supplied VC 19-15.2mm and MC 19-15.2mm DYWIDAG Tendons with epoxy coated strand as well as DYWIDAG Tendons with epoxy coated and filled ultra-high strength strand.

Since ultra-high strength strand had never been used for the construction of an expressway bridge before, the post-tensioning system including the anchorages had to be subjected to various performance verification tests, all of which were successfully completed.

In fact, $\varnothing 15.7$ mm epoxy coated and filled ultra-high strength strand performs better than conventional $\varnothing 15.2$ mm strand. With an elongation at ultimate performance that is equivalent to that of conventional strand, stress resistance of ultra-high strength strand is approx. 20% higher and load resistance approx. 28% higher than those of standard strand. Thanks to the epoxy coating, the strands have excellent anti-corrosion and



anti-fretting properties. The epoxy coatings are also effective as a counter measure to stress corrosion.

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Owner Central Nippon Expressway Company, Japan
General Contractor Joint Venture, consisting of Kajima Corporation and Hazama Corporation, both Japan
Architect Chodai Corporation and IDEA Consultants, both Japan

DSI Unit Sumitomo Electric Industries Ltd., Japan
Sumitomo Scope Supply of MA 12-15.7mm, MC 19-15.2mm and 15.7mm and VC 19-15.2mm and 15.7mm DYWIDAG Post-Tensioning Systems with epoxy coated strand

DYWIDAG Strand Tendons Stabilize Shishihara Viaduct No. 2

The Shishihara Viaduct No. 2 in Japan crosses motorway 52, which links the prefectures of Shizuoka and Yamanashi on Japan's main island of Honshu. The viaduct is an 8-span continuous box girder bridge with strutted wing slabs. The bridge is 579m long, with a maximum span length of 79m.

The bridge was constructed using the cantilever method. As the bridge spans a deep gorge, it had to be erected with the help of 200t crawler cranes. Up to six form travelers were necessary for construction work: two large form travelers for the wider segments and four mid-size form travelers for the standard segments.

The 12S15.2 MA DYWIDAG Strand System was used for the longitudinal post-tensioning of the bridge deck. Pre-grouted 1S28.6 Prestressing Strands were used for edge beam reinforcing and for the strut anchors. Sumitomo also supplied pre-grouted 1S21.8 Prestressing Strand for the transverse post-tensioning of the deck slabs and the longitudinal tensioning of the cantilever deck slabs.

In order to increase durability, minimize work related to grouting and make future maintenance work easier, the post-tensioning system that was used was the 19S15.2 MC DYWIDAG Strand System with epoxy coated and filled strands.

Since the opening of the new section, travelers have been rewarded with an exceptional view of famous Mount Fuji and the region's tea plantations and tangerine orchards.



Owner Central Nippon Expressway Company Limited, Japan

General Contractor Obayashi Corporation, Japan

Architect Obayashi Corporation, Japan

DSI Unit Sumitomo Electric Industries Ltd., Japan

Sumitomo Scope Supply of 12S15.2MA DYWIDAG Strand Tendons with bare strands and of 19S15.2MC DYWIDAG Strand Tendons with epoxy coated and filled strands

Environment Protection Thanks to Construction: The Matoba Viaduct in



The New Tomei Expressway is a motorway located on the south-eastern coast of Honshu, Japan's main island. The new expressway is being built parallel to the existing Tomei motorway.

At one of the junctions of the New Tomei Expressway, the Matoba Viaduct is being constructed over the Matoba River. This river is one of Japan's most important biotopes for fireflies. In order to minimize the impact of construction work on this habitat, the cantilever erection method with precast segments was used for the construction of the Matoba Viaduct.

Thanks to this method, construction work that usually is done on site (such as the assembly of steel frames and the casting of concrete) could be carried out elsewhere so that work on site was kept to a minimum and the habitat was protected.

The segments were prefabricated in a casting yard in the earthwork area behind the bridge abutment using the match-cast method. In this method, the segment that has just been concreted is used as a bulkhead formwork for the next segment, which insures that the joints fit together precisely.

The short line match cast method facilitated the time and space saving production of the bridge superstructure elements in stationary formwork. The segments were lifted out of the formwork after concreting and curing and positioned as new match cast elements in front of the formwork.

The core cross section of the main girder was used for the installation of the segments from the cantilever. Thus, weight can be reduced to approx. 80% of the weight that has to be supported when the entire cross section is used during cantilever erection.

Cantilevered Japan



Consequently, both installation costs related to the erection girders as well as the amount of material needed were minimized.

For post-tensioning the viaduct, Sumitomo supplied external 19S15.7 MC DYWIDAG Tendons with epoxy coated and filled ultra-high strength strands. The strands are coated with high quality epoxy in order to increase the corrosion resistance and durability of the tendons.

Tensile strength and yield strength of ultra-high strength strands are approximately 20% greater than those of conventional strands. As breaking loads and yield point loads are approx. 28% higher than those of conventional 19S15.2 Strand Tendons, fewer tendons were needed so that the segments of Matoba Viaduct are lighter than those of conventional bridges.

Construction of the Matoba Viaduct started in April 2009 and was successfully finished in August 2011.



Owner Central Nippon Expressway Co., Ltd, Tokyo Branch, Hamamatsu Construction Office, Shizuoka, both Japan

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

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

Sumitomo Scope Supply of the 19S15.7 MC DYWIDAG Strand Post-Tensioning System

DYNA Grip® System for South Korea's



South Korea's first stay cable bridge to feature a curved layout is currently being built near the city of Gwangyang, in the southern part of the country. Sae Poong Bridge is part of Gwangyang's new bypass National Road No. 2 and will considerably improve the region's traffic flow.

The 875m long stay cable bridge, which was designed by the Daelim Consortium, has a total of three vertical pylons that are centrally placed in the cross-section of the superstructure. The pylons have heights of 86.7, 101 and 88m, with the middle pylon being the tallest at a height of 101m. The individual

spans measure 85 + 220 + 220 + 85m. The bridge deck is 23.9m wide and is designed to accommodate two lanes in each direction. The bridge deck is being built on falsework from the approach structures to the side spans. In the main span area, the bridge deck is being built using the cantilever construction method.

In July 2008, DSI was awarded the contract to supply all of the stay cables needed for this major project. The main stay cables that were used are 64 Type DG-P55 and 26 Type DG-P61 DYNA Grip® Stay Cables.

Due to the curved layout, the construction geometry of Sae Poong Bridge is very complex.

first Curved Stay Cable Bridge

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Korea

Bridges

The stay anchorages at the bridge deck follow the curve; thus, the cable forces include a horizontal component at the pylon anchorage introducing lateral bending moments. In order to compensate for these bending moments, the pylons are laterally stayed using transverse stay cables. All in all, DSI supplied 12 Type DG-P12, 8 Type DG-P37 and 4 Type DG-P61 DYNA Grip® Stay Cables for this purpose. In addition, DSI supplied 6 Type DG-P19 DYNA Grip® Stay Cables that will act as tiedown cables to prevent lifting of the bridge deck at the abutments. Within the scope of the construction of Sae Poong Bridge, DSI developed two innovative solutions that we would now like to present to you.



Clevis Anchorage

Due to the fact that the transverse stay cables are positioned at a very steep angle to the pylon, they had to be anchored to the outsides of the pylons using special Clevis Anchorages that were newly developed by DSI (cf. DSI-Info 17 article on p. 114). These transverse stay cables are completely preassembled on site, including the strands. As the strands will no longer be accessible after installing the clevis anchorage, their wedges were hydraulically power seated in order to prevent slipping during lifting and subsequent stressing. Afterwards, the clevis anchorage, which features an inside thread, was threaded onto the anchor block instead of the usual ring nut. As these components weigh up to 1,000kg, a turning device had to be designed and supplied by DSI. For final assembly, the transverse cable was lifted by a crane and anchored to the gusset plate at the upper part of the exterior of the pylon using a pin. The first fatigue test for the new clevis anchorage was carried out successfully in accordance with fib Bulletin 30 for Type DG-P61 DYNA Grip® Stay Cables at the Technical University of Munich in 2009.



Slim Sheathing

Another special feature of this project is the slim HDPE sheathing used by DSI. This feature had been requested in the project specifications in order to reduce the lateral wind load on the cables, which in turn allows for the use of a slimmer pylon and results in savings that carry all the way down to and include the

foundation. DSI used these small diameter slim ducts for the first time on the Sae Poong Bridge. Thus, the outer diameter of the ducts for Type DG-P61 cables was reduced from 225mm to 200mm and from 200 to 180mm for Type DG-P55 cables. DSI developed a new installation method and new equipment in order to accommodate the demanding conditions caused by the smaller diameter and subsequent high degree of filling of the sheathing.

Construction work on this special major project began in August 2009 and is scheduled for completion in July 2012.



Owner Iksan Regional Construction & Management Administration, South Korea

General Contractor Daelim Consortium, South Korea

Design Chung Suk Engineering, South Korea

Consulting Daelim Industrial Co., LTD & Envico Consultants Co., LTD, both South Korea

Subcontractor for Stay Cable Installation BNG Consultants

DSI Unit DYWIDAG-Systems International GmbH, Headquarter Operations, Germany
DYWIDAG-Systems Korea Co. Ltd., South Korea

DSI Scope Supply of 64 Type DG-P55 DYNA Grip® Stay Cables, 26 Type DG-P61 DYNA Grip® Stay Cables, 6 Type DG-P19 Stay Cables, 12 Type DG-P12 DYNA Grip® Stay Cables, 8 Type DG-P37 Stay Cables and 4 Type DG-P61 Stay Cables as well as of Clevis Anchorages; assembly instruction on site

DYWIDAG Tendons Link new University Campus



Tendons over Pier Support

also involved in the construction and supply of the precast long bed supporting structures and the design and supply of the precast segment forms. Additionally, Utracon performed the epoxy application work (to the segment joints) and temporary stabilization of the precast segments using lifting frames.

The Post-Tensioning Systems used were 7-0.6", 12-0.6", 15-0.6", 19-0.6" and 22-0.6" DYWIDAG Strand Tendons with MA Anchorages.



Production of Precast Elements

The National University of Singapore (NUS) is currently building a new University Town (UTown) which is hoped will help graduates prepare for living and working in a world of fast changing cultural complexity.

This new UTown, however, is separated from the existing Kent Ridge Campus by a very busy expressway, the Ayer Rajah Expressway (AYE). In order to connect the two campuses across the AYE, a 290m long viaduct was constructed by the university. The bridge structure has one vehicle lane per direction, a sheltered pedestrian walkway and a bike lane.

The side spans of the bridge were built via cast in situ method. However, as the 100m main span across AYE did not have a consistent radius of curvature, incremental launching was not possible.

After analyzing various options, the main contractor, Sato Kogyo (Singapore) Pte Ltd., decided to construct the main span using a modified precast segmental method.

Typically, the box girders of the main span were 15.35m wide, with depths varying from 5.0m at the support to 2.0m at mid span. After the side spans had been constructed, cast in situ cantilever hammer heads were cast from both supports, each projecting 6.9m and 9.6m from their respective piers. The remaining section of the main span was then subdivided into 29 precast concrete segments which were cast in a nearby yard.

The supply and tensioning of the precast concrete segments was carried out by DSI's licensee in Singapore, Utracon Structural Systems Pte Ltd. Besides post-tensioning, Utracon was



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Owner National University of Singapore, Singapore
General Contractor Sato Kogyo (S) Pte Ltd, Singapore
Architect DP Architects, Singapore
Consulting Engineers TY Lin International Pte Ltd, Singapore

DSI Unit Utracon Structural Systems Pte Ltd., Singapore
Utracon Scope Supply and installation of 7-0.6", 12-0.6", 15-0.6", 19-0.6" and 22-0.6" DYWIDAG Strand Tendons with MA Anchorages

More Mobility and Safety with Utracon: Jurong East Modification Project

The Jurong East Modification Project (JEMP) is part of a program by the Land Transport Authority that aims at upgrading public transportation in Singapore. After the completion of JEMP and the purchase of additional trains, the capacity of the North-South and East-West Lines will be significantly increased. In addition, during peak periods, more connections will be offered to shorten waiting times and avoid overcrowded trains.

Construction also involved building two new 2.5km long rail tracks: The North & East Bound line, and the South Bound line.

The piers of the new elevated railway were built using a combination of cast in place concrete and precast prestressed segments supported on pot bearings. The individual spans of the viaducts range in length from 29.1m to 40.5m, with all the precast segments erected using mobile cranes.

Five of the spans for the South Bound line had to be installed over existing railway lines. Because the spans in this area were large, ranging from 50.5m to 70.5m, the precast segmental construction method was used for this purpose.

Utracon Structural Systems Pte Ltd, a DSI licensee since 1998, was the Post-Tensioning specialist for this project. Bonded DYWIDAG Post-Tensioning Systems were installed in all the precast prestressed beams and in the precast segments. In addition, DYWIDAG Bar Tendons were used for stressing some cast in place crossheads. Utracon supplied 7-0.6", 12-0.6", 19-0.6" and 22-0.6" DYWIDAG Strand Tendons with MA Anchorages as well as \varnothing 47mm DYWIDAG Bars for this project.

Besides carrying out the post-tensioning work, Utracon was also involved in the erection and temporary stabilization of the precast segments. Each of the 94 precast segments weighed between 35t and 55t, with the piers also built out of precast segments. In those areas where the new elevated railway spans across an operational railway line, the precast segments could only be erected between 1am and 4.30am.

In order to comply with the authority's health and safety regulations, all precast segments were temporarily stabilized by three independent mechanisms prior to stressing. Stabilization was achieved by a combination of post-tensioning bars and steel truss supports, where each level

was designed to carry the full weight of the segment independently.

To facilitate the epoxy gluing of individual segments and the execution of the post-tensioning work, an elaborate double decker steel cage was designed that was supported by the overhanging steel truss. In addition, each working platform of the steel cage was equipped with independent safety catch devices to ensure that there would be no danger for train commuters. Following the erection of each individual segment, the entire steel cage and the steel truss were moved forward using hydraulic jacks.



Viaduct spanning across a Railway Line in Operation



Launching of a Segment



Working above a Railway Line in Operation



Owner Land Transport Authority, Singapore

General Contractor Sato Kogyo (S) Pte Ltd, Singapore

Architect Land Transport Authority, Singapore

Consulting Engineers YWL Engineering P.L., Singapore

DSI Unit Utracon Structural Systems Pte Ltd., Singapore

Utracon Scope Supply and installation of 7-0.6", 12-0.6", 19-0.6" and 22-0.6" DYWIDAG Strand Tendons with MA Anchorages as well as \varnothing 47mm DYWIDAG Bars

EMEA

Albania

Slope
Stabilization

Permanent DYWIDAG Anchors stabilize first Motorway Connection between Albania and Kosovo

The 170km long Albania-Kosovo Motorway is the largest road infrastructure project to have ever been built in Albania. After its completion, the four lane section will be the first motorway connection between Albania and Kosovo, connecting the port of Durres in Albania with the Kosovan city of Pristina and Pan European Corridor 10.

The new motorway connection will reduce total travel times by several hours and will not only boost tourism in Albania, but also economic relations between Albania and Kosovo.

The most difficult part of the motorway was the approx. 61km long section between the Albanian towns of Rreshen and Kalimash, which was divided into three construction stages. In addition to a tunnel, 27 bridges had to be built in mountainous terrain.

DSI was involved in the first part of this section – the 19km long contract section from Rreshen to Reps.

An 11m high and 110m long anchor wall had to be built 14km north of Rreshen in order to stabilize the slope next to the

motorway. The embankment situated above the retaining wall is 17m high and was stabilized using the Terramesh mesh system.

DSI supplied a total of 110 8-0.62" Double Corrosion Protected (DCP) DYWIDAG Strand Anchors in lengths of 23m with bond lengths of 7m and free lengths of 16m for the anchor wall. The permanent anchors were supplied to a partner company in Croatia.

Subsequently, the anchors were delivered to Albania by a Croatian civil engineering company and installed on site in two rows of 55 anchors each. Construction work at the retaining wall was carried out from the 15th of December 2010 to the 1st of February 2011. Three to four DYWIDAG Strand Anchors were installed per day.

In order to ensure a safe installation within the planned schedule, experienced DSI technicians provided on-site training for the correct use of the tensioning jacks and the tests that had to be carried out.



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Owner Departments of Transportation of Albania and Kosovo, Albania and Kosovo

Contractor Bechtel-Enka JV, consisting of Bechtel, USA and ENKA, Turkey

Subcontractor WERKOS d.o.o. – OSIJEK, Croatia

DSI Units DYWIDAG-Systems International GmbH, Austria; DYWIDAG-Systems International GmbH, BU Geotechnics, Germany

DSI Scope Supply of 110 8-0.62" Double Corrosion Protected (DCP) DYWIDAG Strand Anchors; technical assistance on site

GEWI® Piles used for Important Train Connection from Munich to Verona

The rail connection between Munich and Verona is one of the principal routes between Germany and Italy and is one of the main transportation corridors in Europe. During the expansion of the rail section, several tunnels had to be built through the Unterinn Valley near Kufstein in Austria.

The approx. 2km long section H2/2 was constructed using the sheet piling trough construction method. As the tunnel floor is located approx. 13m beneath the ground water table, the underwater concrete was protected against uplift with GEWI® Piles in addition to anchoring the sheet pile wall using DYWIDAG Strand Anchors. The section was divided into 18 troughs, an excavation providing the connection to an existing tunneling section and an escape shaft.

Compression-loaded Double Corrosion Protected (DCP) GEWI® Piles had to be installed in the excavation pit in order to transfer the structure's loads safely to the deeper rock layer. Drilling depths ranged from 8m to 17.5m, with the GEWI® Piles installed 2m into the rock.

The 15m wide troughs were constructed continuously: After driving the sheet pile walls, excavating, drilling the anchors and underwater excavation, the GEWI® Piles were installed into the underwater concrete. Afterwards, water in the excavation was pumped out, the floor was concreted and the formwork carriage was driven through. Finally, isolation and covering work was carried out and the sheet pile walls were built.

The installation of the DYWIDAG Strand Anchors was carried out using cased borehole hammer drilling at drilling depths of up to 22m in mainly sandy gravel with individual sand layers and drilling obstructions such as old tree trunks that measured up to 2m in diameter. The anchors were temporary strand anchors with 3 to 9 strands and planned loads of up to 1,200kN.

The GEWI® Piles in the troughs were sunk by pile driving. A cable dredger was used to drive a lance through a drilling vibrator into the soil, the GEWI® Pile was



installed and grouted, and the lances were withdrawn. The casing was lead through apertures in a staging that was placed over the sheet pile walls. Due to the high pile loads of up to 1,600kN, driving depths had to be 20m. Combined with the previous excavation of 15 to 16m, driving lances were up to 40m long.

Despite unfavorable conditions and bad weather, work was completed on time. Even in critical areas, for example when drilling directly underneath an embankment, installation work was carried out without any problems.

All in all, approx. 26,485m of anchors were drilled and 1,394 anchors with 3 to 9 strands were installed. In addition, approx. 22,000m of driven GEWI® Piles were used to guard against uplift, which corresponds to a total number of 1,730 piles. The project also required approx. 5,685m of drilled compression GEWI® Piles (180 piles). Collared tube injections were carried out on an area of approx. 50m³, and approx. 50m of DM1200 grout piles were installed. Construction work on this major project started in June 2008 and was successfully completed in October 2010.



Owner ÖBB Infrastruktur Bau AG, Vienna, Austria

Client Strabag AG Dir. IE, Linz, Austria

Contractor ZÜBLIN Spezialtiefbau Ges.m.b.H., Vienna, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Supply of 1,394 DYWIDAG Strand Anchors with 3 to 9 strands and of 1,910 GEWI® Piles

DSI supplies Monostrand Post-first Ultra High Performance Concrete

In 2008, construction on an exceptional bridge project began near the town of Voelkermarkt in Carinthia, Austria: The Wild Bridge. The new bridge was built to relieve the town of the heavy traffic that is directed towards the local optomechanics company "Wild".

Above the main span, the approximately 157m long Wild Bridge consists of a post-tensioned UHPFRC truss frame arch with a hollow box girder section and a wall thickness of only 6cm. A concrete quality of C 165/185 was used for the bridge's arch. The delicate bridge construction spans the Muehlgraben valley at a height of approx. 40m with two



Wild Bridge is the world's first arch bridge carrying a street to be built using UHPFRC (Ultra High Performance Fibre Reinforced Concrete). As the grain structure of Ultra High Performance Concrete is significantly tighter than in normal concrete, and as the resulting density is higher, construction elements can be designed to be very slim and light. The higher density and the tight grain structure of UHPFRC result from a high proportion of finely graded additives that are adjusted in terms of grain size in order to perfectly fill the cavities between the larger grains.

parallel arches, the open spans of which measure nearly 70m each.

Both arches consist of six up to 16m long bars and 8 joints at the inflection points. The precast segments were produced in a precast yard and the bars were connected to the joints. For the external post-tensioning between the bars and the joints that was necessary for assembly, DYWIDAG Monostrands by DSI Austria were installed in the precast yard. These monostrands were detensioned once the main post-tensioning and the folding of the arches had been carried out.



Tensioning Systems for the World's Street Bridge

The UHPFRC precast elements for the arches were assembled on site using the segment folding method to form three segments per half-arch and stabilized using external DYWIDAG Monostrand Tendons running through cavities in the segments.

The monostrands were diverted in what is known as the bridge's knee joints in concreted, saddle formed steel ducts. On the outline, 28 monostrands were arranged in the first, 24 in the second and 20 in the third segment to achieve concentric post-tensioning in the arch bearing structure.

The post-tensioning tendons were inserted from above using a tower crane and were simultaneously pulled from below using pulling cables. Installation and tensioning of the tendons in the crest area using deviation was made difficult by limited space in the arch's interior.

The correct insertion of the monostrands during segment assembly was difficult because DSI's technicians were unable to climb into the arch. During assembly, the technicians had to be careful to ensure that the monostrands did not get caught at the joints of the deviation ducts and that the PE duct for the strands was not damaged. Finally, DSI's on site technicians decided to use pulling cables that had a total length of approx. 4,800m. These pulling cables were installed in advance and firmly tensioned and fixed using a drawstring stopper so that the segments could be coupled quickly.

After their insertion, the strands were post-tensioned from above using tensioning jacks. The monostrand tendons can be easily replaced at any point of time even after the bridge's completion.

DSI supplied and installed a total of 144 external 6-1 (150 mm²) DYWIDAG Monostrands for this project. In addition, DSI developed special anchorage heads that were successfully tested in advance in the laboratory of TU Graz.

The world's first street bridge to consist of Ultra High Performance Concrete was completed at the end of August 2010 and has already received three awards.



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Owner Kommunalgesellschaft
Völkermarkt GesmbH, Austria
General Contractor STRABAG AG,
Austria
Architect Univ. Dipl.-Ing. Dr. techn.
Lutz Sparowitz, Austria
Engineering S+W Wörle Sparowitz
Ingenieure, Austria
Consulting Dipl.-Ing. Welf
Zimmermann, Austria

DSI Unit DYWIDAG-Systems
International GmbH, Austria
DSI Scope Supply, installation and
post-tensioning of 144 external 6-1
(150 mm²) DYWIDAG Monostrand
Post-Tensioning Tendons

Inspection of PZ Anchors in Bischofshofen



For decades, DSI has been a recognized partner and leading system supplier of geotechnical products and systems both for private and for public clients. Highly qualified engineers, technicians and business people support clients with specific know-how, commitment and the willingness to perform.

This commitment to service was demonstrated by DSI Austria's response to a special request received from the road and bridge construction department Strassen- und Brueckenmeisterei Hallein, Austria.

In the summer of 2011, blasting work was carried out near federal road B311 between Bischofshofen and Zell am See, near Klamm. A tied back anchor wall, built in 1986 to protect the federal road, is located in this area.

The anchors in the wall were supplied by the company Polensky und Zöllner. The Strassen- und Brueckenmeisterei Hallein asked DSI experts to measure the tensioning force of several of the permanent anchors that are also known as PZ anchors.

DSI engineers studied the problem and determined the exact geometry of the existing anchorage devices. During this process, they concluded that the use of

standard tensioning jacks was impossible due to the special anchor type.

A stressing chair had to be individually modified so that a DYWIDAG tensioning jack could be accurately assembled on it.

The inspections included random lift-off tests of several permanent anchors. Load cells with over 1,000kN were later installed on two of the PZ anchors. For this purpose, DSI engineers lengthened the existing anchor bolt using a special M56 tensioning spindle. With this accomplished, the anchors could be destressed, inspected and re-tensioned to 1,000kN.

The inspection was carried out in close co-operation with and to the full satisfaction of the Strassen- und Brueckenmeisterei Hallein.



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Owner Strassen- und Brueckenmeisterei Hallein, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Inspection of the tensioning force at the permanent anchors, adaptation of the tensioning equipment, technical assistance

GEWI® Plus Anchors and GEWI® Plus Piles stabilize Suspension Bridge in Soelden

Since August 2011, a new pedestrian suspension bridge links the two districts of Wildmoos and Pitze in the municipality of Soelden. Tourists are also pleased with this project because the suspension bridge crosses a 35m deep gorge and makes a new hiking trail accessible.

The specialists of Hoch-Tief-Bau-Imst (HTB), who had been assigned this task, met unusual challenges due to partly extreme conditions. The construction and assembly of a 55m long bridge into a rock with an overhang in only 2 months' time required a high degree of precision and experience.

The anchor points were placed in classical climbing manner by rope and with the help of a helicopter. For tying back the suspension cables in the rock, DSI Austria produced and supplied double corrosion protected (DCP) GEWI® Plus Anchors. A total of 200m of \varnothing 57mm GEWI® Plus Anchors with average anchor lengths of 14m were produced and supplied with accessories for fixing and anchoring the suspension cables.

In addition, \varnothing 57mm pressure loaded GEWI® Plus Piles in average lengths of 6m were installed at the foundation points of the abutments. DSI produced and supplied a total of 100m of DCP GEWI® Plus Piles for those abutments.

As a preparative measure for bridge assembly, a cable winch had to be set up especially for the project. Once all anchor points had been successfully placed and the suspension cables had been anchored, the bridge was placed element by element. Afterwards, the bridge was secured using special cables. Subsequently, the railing was mounted and a final report was written.

After only 2 months of construction, the technically sophisticated bridge was opened on August 26th 2011.



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Owner Municipality of Soelden and Ötztal Tourismus, Austria
General Contractor Hoch-Tief-Bau-Imst (HTB) Ges.m.b.H, Austria
Engineers Ingenieurbüro Brandner, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Supply of DCP GEWI® Plus Anchors and GEWI® Plus Piles

145m long DYWIDAG Strand Anchors stabilize Railroad Bridge in Dalaas

The rail connection between Innsbruck and Bregenz, also known as Arlbergbahn, runs across the approx. 111 year old Muehltobel Bridge. During routine inspections, the Austrian railway company Österreichische Bundesbahn AG (ÖBB) discovered that the high gypsum percentage of the Maehrenalpe Mountain had caused displacements that endangered the bridge. Consequently, the railway bridge had to be further stabilized.

The engineering company Geotek suggested installing additional strand anchors for stabilization that were to be anchored in a newly erected anchor beam located at the bridge abutment. According to the geotechnical report, the stable layer in the slope was situated at a depth of approx. 130m, which posed a unique challenge during the project. A special construction company drilled the necessary boreholes at both abutments through the 6m strong reinforced concrete up to a depth of 145m.

DSI was the only company that was technically able to produce a total of six 8-0.62" double corrosion protected (DCP) DYWIDAG Strand Anchors in lengths of 151m, to place them on a special drum and transport them to the construction site. Once DSI had been awarded the contract, the six DYWIDAG Strand Anchors were produced at DSI's production plant in Koenigsbrunn near Augsburg.

The installation of the anchors posed an additional challenge. As the anchors had to be installed at an incline of only 10%, there was a risk of the strand anchors getting stuck during insertion. The professional partners on site flushed the boreholes thoroughly so that the permanent strand anchors could be pushed in up to a length of 145m without any problems. Afterwards, the bond lengths were grouted for a length of 25m.

After a curing time of one week, the first Permanent DYWIDAG Strand Anchor was tensioned in the presence of employees of Cottbus Technical University. Initially, the anchors were tensioned to more than 1,200kN, and afterwards, anchoring was carried out at a working load of 700kN.





DSI produced and supplied the exceptionally long DYWIDAG Strand Anchors on drums to the site just in time. Furthermore, DSI experts also supported the construction site during the installation of the anchors and during grouting and provided the necessary equipment and expert personnel for tensioning.

Thanks to the seamless co-operation of all partners, the project was completed on time and to the full satisfaction of the client.



Contractor gk Construction, Austria
Drilling Company Greuther, Switzerland
Engineers Geotek, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Production and supply of 6 double corrosion protected (DCP) 8-0.62" DYWIDAG Strand Anchors; rental of technical equipment, technical assistance during installation and anchor tensioning



Vienna's new Central Station: DSI Increased Mobility

In Austria's capital, construction work has begun on Vienna's new central station. This major project will create a completely new district and a huge hub for public transportation. In a few years' time, more than 1,000 trains and 145,000 people will be passing through Vienna's new main station.

Beginning in mid-September 2008, the old train station known as Suedbahnhof is being rebuilt and enlarged by new buildings on a total area of approx. 109ha. Construction work also includes 100km of new rail tracks as well as bridge structures with a total area of approx. 30,000m².



Austria contributes to

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Construction

EMEA

Austria

Excavation

DSI's subsidiary near Pasching/Linz also participated in the construction work for this major project. For stabilizing the excavation of the new buildings for the train station, DSI Austria supplied approx. 10,000 pieces of \varnothing R32 DYWI® Drill Hollow Bar Anchors with ultimate loads of 250kN to 360kN

in partial lengths of 300 and 400cm with drill bits, couplers and other system accessories.

As a self-drilling anchor system with continuous exterior thread, the DYWI® Drill Hollow Bar Anchor can be simultaneously drilled and grouted without any casing into poor or unstable soils. Thanks to the continuous thread, the drill rod can be cut, coupled or extended at any point along its length.

In addition, DSI Austria supplied approx. 2,000m of temporary 3,4 and 5-0.6" DYWIDAG Strand Anchors in lengths of 12-15m. Due to their elasticity, DYWIDAG Strand Anchors are very robust. They are easy to install due to their relatively light weight and their optimized system components.

After its completion in 2015, the new train station will not only permit efficient traffic connections, but also upgrade the adjoining district with a modern shopping center, new offices and a new hotel.



Owner ÖBB (Federal Austrian Railway), Austria
General Contractor Grund- Pfahl- und Sonderbau GmbH and Porr GmbH, both Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Supply of approx. 10,000 \varnothing R32 DYWI® Drill Hollow Bar Anchors with accessories and approx. 2,000m of temporary 3,4 and 5-0.6" DYWIDAG Strand Anchors



DYWIDAG Post-Tensioning Systems Stabilize Major Projects in Brussels

In Brussels, two major projects are currently under construction that will create a faster, more efficient link to Belgium's international airport. One of these projects will improve the northern access to Brussels Airport. It is part of a Flemish government stimulus package and is the first PPP (Public Private Partnership) to have ever been undertaken in Belgium.

Within the scope of this project, comprehensive work was carried out on the E19 Motorway between the town of Vilvoorde and Brussels Airport. Several additional on ramps and exits were built, and three of the streets adjacent to E19 were completely reconstructed. A viaduct was built from the existing bridge over E19 that extends over the three adjacent streets, creating a direct link to Brussels Airport for freight traffic.

The second project is known as the Diabolo Project because it consists of two intersecting triangular junctions, thus bringing to mind the juggling toy bearing the same name. Within the scope of this approx. 540 Mio. € project, which is being built by the Belgian railway company Infrabel, a new rail track is being constructed that will link the airport to Brussels and Antwerp. The new direct link will relieve traffic congestion on the roads around the airport and is planned to be used by 40% of all travelers to the airport by 2015.

A railway tunnel was built from the airport towards Brussels for the Diabolo Project. The new rail track also includes a section that runs above ground and, like the viaduct for freight traffic, crosses both E 19 and the adjacent streets Haachtsesteenweg, Luchthavenlaan and Bataviastraat.

DYWIDAG-Systems International Belgium did the post-tensioning work on the five bridge segments for both projects. Within four months, a total of 300t of Bonded MA, St 1860, 150mm², 31-0.62" DYWIDAG Strand Tendons were installed.



Additionally, MA 19, 13 and 9-0.62" DYWIDAG Strand Tendons were used. The transverse post-tensioning of the bridge decks, which were exceptionally slim, required an additional 30t of Unbonded DYWIDAG Monostrand Tendons.

DYWIDAG-Systems International Belgium is proud to have contributed to one of the largest infrastructural projects in Belgium.



Owner Infrabel and Flemish Government, Belgium

General Contractor THV Dialink, Belgium

Architect Technum, Wayss & Freytag Ingenieurbau AG, Germany (Northern Access)

Engineers Technum, Wayss & Freitag Ingenieurbau AG, Germany (Northern Access)

Unit DYWIDAG-Systems International N.V., Belgium

Scope Supply, installation, tensioning and grouting of 300t of 31-0.62", 19-0.62", 13-0.62" and 9-0.62" DYWIDAG Strand Tendons, MA Anchorages and bond head anchorages as well as of 30t of Unbonded DYWIDAG Monostrand Tendons

DYWIDAG Strand Tendons for Belgian Turbo Roundabout

EMEA

Belgium

Bridges



Two of Belgium's main arterial roads, E314 and A13/E313, meet at the Lummen junction, approx. 37km north-west of Maastricht. The intersection dates from the early seventies and was built as two highways crossing at different levels. An oval roundabout provides for the interchange of traffic between the two highways, and the junction also has exits to the nearby industrial estate.

The busy intersection is considered to be dangerous and causes traffic jams of approx. four hours per day. While the two main axes of the highways intersect without any problems thanks to the bridge structure, traffic wanting to change highways depends on the roundabout. There are four points of conflict where fast traffic from the highway must give priority to the slower traffic on the roundabout.

Since an expansion of the exit lanes on E313, which was carried out in 2003, brought only little improvement, construction work began to create a lasting solution for the junction. In the preparatory phase, the roads leading to the industrial estate were replaced by separate access and exit roads on the A13.

Work on the roundabout itself started in May 2008 and is scheduled for completion in 2012. The old structure is replaced by what is known as a turbo roundabout. In this special kind of roundabout, the number of lanes changes, and waiting times can be considerably shortened by directing traffic into their respective lanes at an early stage. Two new levels and eight bridges are being built at the roundabout.

Total cost is estimated to be approx. 40 million Euros.

DYWIDAG-Systems International Belgium supplied the prestressing systems for two of the roundabout's bridges. DYWIDAG-Systems International Belgium installed a total of 90t of 19-0.62" DYWIDAG Strand Tendons with MA Anchorages and Bond Head Anchorages. Additionally, DYWIDAG-Systems International also carried out the tensioning and grouting works. In order to limit friction loss in the curved decks, the 21 DYWIDAG Strand Tendons with 19 strands each were installed in the ducts before the concrete was poured.



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Owner Flemish Government, Belgium

General Contractor JV, consisting of Jan De Nul Group and Betonac N.V., Belgium

Architect Department of Mobility and Public Works, Flemish Government, Belgium

Engineers Department of Mobility and Public Works, Flemish Government, Belgium

Unit DYWIDAG-Systems International N.V., Belgium

Scope Supply and installation of 90t of 19-0.62" DYWIDAG Strand Tendons with MA Anchorages and Bond Head Anchorages

Slender Structure for Funder Bridge with DYWIDAG Systems

Denmark is the land of 1,400 islands, which is why most of the country's bridges cross water. However, in order to close the approx. 12km long gap in the east-west highway connection in the center of Denmark, a solution had to be found for the environmentally protected valley of the Funder Stream. With a length of 724m, the structure that was built at that location is now Denmark's longest bridge that does not cross a major waterway.

As the nature reserve had to be protected to the greatest possible extent, the bridge was constructed using the incremental launching method with flying shores. Since the layout of the bridge axis includes a constant circular arc as well as a spiral curve, bridge construction was carried out using the patented match cast method.

With its two separated superstructures consisting of precast concrete box girders, the bridge has a very slender appearance. The constant span lengths of 85m were separated into 42.5m long segments for incremental launching. During launching, the precast concrete box girders rested on flying shores in addition to the 35m high piers.

Both the flying shores and the launching formwork were transversally relocated in order to launch the superstructure for the carriageway leading in the other direction.

The deck slab was concentrically post-tensioned with 12 Ø15.7mm 15 strand DYWIDAG Strand Post-Tensioning Tendons. Eight 12 strand DYWIDAG Strand Post-Tensioning Tendons were used per bottom slab. In addition, four bottom slab tendons per section had to be anchored to the bottom slab pilaster strips. Five additional 19 strand DYWIDAG Tendons were used in each longitudinal girder and overlapped in the area of the supports so that they could accommodate the additional loads after the removal of the flying shores as well as the traffic load.

Spanning the Funder river bed was a special challenge because flying shores were not allowed in the nature reserve. In order to divide the span length in half, an A shaped steel trestle was built over the river bed. For accommodating the horizontal shear force that could not be transferred to the piers from both arms of the trestle, DYWIDAG Post-Tensioning Tendons were tensioned for bypassing the forces between the bottom joints of the piers and post-tensioned against



them before launching the superstructure. The stabilized A trestle was also transversally relocated for constructing the second superstructure using DYWIDAG Tendons.

Denmark's longest bridge that does not cross a major waterway was successfully completed at the end of 2011.



Photos reprinted courtesy of Juhlufffoto and TPA/Beutler, Denmark

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Owner Kingdom of Denmark, Vejdirektoratet Skanderborg (motorway administration)
General Contractor Joint Venture DYWIDAG Bau GmbH, Germany, and Züblin Scandinavia A/S, Denmark
Design Gimsing & Madsen A/S, Denmark
Planning K+S Ingenieurconsult GmbH & Co. KG, Germany

DSI Unit DYWIDAG-Systems International GmbH, BU Post-Tensioning, Germany
DSI Scope Supply, installation, post-tensioning and grouting of prefabricated SUSPA Systems Tendons, approx. 980t, 19-0.62", 15-0.62" and 12-0.62", MA Anchorages and Bond Anchorages

The Kliplev Sønderborg Motorway: DSI contributes to Denmark's first PPP Project

An approx. 25km long highway section was built in the south of Denmark in 2010/2011. This section now links the harbor and the industrial city of Sønderborg with the central European north-south highway E45 via a highway interchange near the town of Kliplev, enhancing the economic development of the entire region.

The Kliplev Sønderborg Motorway was built by the STRABAG joint venture KMG (Kliplev Motorway Group) and is the country's first highway to be constructed as a PPP project (Public Private Partnership). The total investment cost for the new motorway section amounted to 148 Million Euros. The project includes a total of seven interchanges, 18km of by-roads as well as numerous bridges and municipal road underpasses.

KMG used highly innovative construction methods for this project in order to ensure that future maintenance requirements will be minimized. As a result, the 13 new bridges were planned with minimized material in terms of bearings, joints and other construction elements. Thanks to these preventions, KMG estimates to be able to reduce the project's life cycle cost by more than 40% compared to existing Danish highways.

DSI supplied a total of 180t of St 1860, 150 mm² SUSPA Systems Bonded Strand Post-Tensioning Systems for this important infrastructure project. The well-proven MA 19-0.62" Strand Post-Tensioning System was successfully used for post-tensioning the 13 bridges.

In addition to the manufacture and supply of the post-tensioning systems, DSI's scope also included installation as well as post-tensioning and grouting on site. Work on this project began in 2006. The opening of the bridge for traffic is scheduled for the early summer of 2012.

Based on the positive experiences during the construction of this new section, Denmark is currently considering using the PPP model for future road construction projects.



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Owner Danish Road Directorate, Denmark

General Contractor STRABAG joint venture KMG (Kliplev Motorway Group) / DYWIDAG Bau GmbH, Denmark

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

DSI Scope Supply, installation, post-tensioning and grouting of prefabricated 19-0.62" SUSPA Systems Strand Tendons, MA Anchorages and Bond Anchorages

Rehabilitation of a Dry Dock using DYWIDAG Systems

The French company DCNS, which is active in ship construction around the world, recently repaired one of its dry docks in its yard in Lorient, Brittany.

Dry dock No. 3 was originally built between 1912 and 1920 and is principally used for the repair and maintenance of ships. The basin is 206m long, 36m wide and 14.70m deep. As the lock gate of the dry dock no longer complied with modern requirements, DCNS decided to build a new gate.

First, the contractor SEMEN TP had to seal all the joints, creases and gaps around the old lock gate so that the gate would be able to resist the exterior water pressure. On the horizontal side of the joint, the sill had to be waterproofed and the weathered concrete had to be rehabilitated. Consequently, the cavities under the sill were grouted in several steps.

Construction work was carried out on dry ground, protected by the old gate that served as a cofferdam.

After dismantling the old reinforced concrete sill, a new cross bar was concreted on the floor parallel to the old gate. For reinforcing the bar, boreholes were drilled in the dry dock at distances of one meter between holes. DSI supplied a total of 32 \varnothing 75mm DYWIDAG Bar Anchors. They were installed at distances of 1m in a row, anchored at a depth of 8m into the slate bed underneath the sill and the concrete was subsequently grouted.

Stress monitoring devices were installed on the permanent anchors, and the data provided by these devices was continuously read and evaluated. Additional empty sleeves for possible future anchorages were included in the horizontal bar – these would have been used if the stress monitoring had shown a

need for action. After the installation and tensioning of the DYWIDAG Bar Anchors, the anchor heads were permanently concreted into the new cross bar.

At the same time, the side walls of the dry dock were reinforced in the area in which the new lock gate was to be installed. The old inner lining of the dry dock had to be removed in this area before reinforced concrete bracket connections were installed on both sides of the gate.



Dry Dock with old Lock Gate



Installed DYWIDAG Bar Anchors



Position of the new Cross Bar



New Lock Gate



Anchor with Sensor Unit

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Owner DCNS, Lorient, France
Contractor SEMEN TP, France

DSI Unit DSI-Artéon, France
DSI Scope Supply of 32 \varnothing 75mm DYWIDAG Bar Anchors, of 6 \varnothing 40mm DYWIDAG Bar Anchors and of 33 preassembled \varnothing 40mm DYWIDAG Bar Anchors, rental of equipment, post-tensioning work, technical assistance

EMEA

France

Hydro- & Marine Structures

Afterwards, core holes were drilled into the outer walls. Subsequently, a total of 33 double corrosion protected \varnothing 40mm DYWIDAG Bar Anchors that were preassembled and supplied by DSI were used to connect the bracket connections to the anchor wall. Finally, the side walls were reinforced using 6 \varnothing 40mm DYWIDAG Bar Anchors.

DSI continuously supported the contractor just in time by comprehensive calculations and by supplying all of the measuring instrumentation. Thanks to the excellent co-operation of all partners involved, this exceptional project was completed to the full satisfaction of the owner.



Reinforcement of the Outer Walls for the new Lock Gate

DYNA Grip® System Stabilizes France's in Lille

A new football stadium is being built in the city of Lille in order to create sufficient capacity for the European Football Championship, which will be held in France in 2016. Completion of the stadium is planned for July 2012.

The flexible use of the stadium is ensured by a special lifting platform at the northern end of the pitch underneath which there is an event arena with additional galleries for nearly 30,000 visitors.

The movable roof of the stadium is carried by two main lattice girders that are connected to two transverse girders consisting of steel lattice formwork. Additional movable transverse girders are placed on the main girders, permitting the opening and closing of both halves of the roof in a mere 30 minutes.

The two longitudinal main girders have a span of approx. 205m and a height of 16m. The bottom chords of these steel lattice girders contain five tendons each in order to increase their load carrying capacity and limit deflection. These tendons are located between the bottom

chord plates and anchored at the joints. Two tendons with 55 strands each are installed along the entire length of the bottom chords, and three tendons with 37 strands each strengthen the middle section of the bottom chord.

Of particular note are the two ends of the girders, where the bottom chord is deviated upwards at the last joint, and the tendons are deflected by approx. 15°. For this purpose, DSI developed a special deviation saddle in which the 55 PE coated strands are guided individually. The deviation saddle consists of an exterior galvanized steel tube containing individual embedded PE tubes. The cavity between the steel tube and the PE tubes is filled with ultra high performance grout. The prefabricated deviation saddle is placed in an additional curved steel tube that is welded to the steel girder.

The principle of individual strand deviation makes it possible to replace both individual strands or the complete deviation saddle. Similar deviation saddles have already been used for stay cable or extradosed bridges.



first Movable Stadium Roof

77

Construction

EMEA

France

Commercial Buildings



However, in these cases, a load change may not result in a relative displacement of the strands in relation to the saddle. In the case of the Lille stadium, such a relative displacement with minimum friction is explicitly required. The displacement results from the change of forces in the tendon due to the flexible opening of the roof.

In order to determine friction and to prove the durability of the strand PE sheathing as well as the load-bearing capacity of the deviation saddles, a comprehensive testing program with up to 10,000 load cycles was successfully carried out in DSI's test laboratory in Unterschleissheim. The tests were performed in close coordination with the owner and supervised by the Universität der Bundeswehr München.

HDPE-coated, galvanized, waxed and PE sheathed 0.62" strands with a nominal tensile strength of 1860N/mm² were used for this major project. DSI supplied 8 deviation saddles for 55 strands and a total of 20 Type DG-P 37 and DG-P 55 DYNA Grip® Anchorages that are usually used for stay cable or extradosed bridges.



All of the tendons are equipped with DYNA Force® Sensors that make it possible to continuously monitor the strand forces. For this purpose, a total of 38 DYNA Force® Sensors were installed at defined strands near the anchorages. These sensors are connected to several multiplexers and a readout unit in the roof command room of the stadium.

DSI has been able to successfully prove the versatility of the DYNA Grip® system in this major project. The Lille stadium shows that tendons can not only be used in classical prestressed concrete construction, but also for pure steel structures.



Owner Communauté Urbaine de Lille Métropole, France

General Contractor Elisa (Eiffage Lille Stadium Aréna), France

Contractor EIFFAGE Travaux, France

Subcontractor Eiffel, France

Architect Pierre Ferret; Valode & Pistre, both France

Consulting Engineers Iosis, Arcora, Froclum, all of them France

Consulting Socotec, France

Engineers Greisch, Belgium

DSI Unit DSI-Artéon SAS, France

DSI Scope Supply of 0.62", St 1860 Stay Cable Strands, 8 deviation saddles for 55 strands, 6 Type DG-P 37 DYNA Grip® Anchorages and 4 Type DG-P 55 DYNA Grip® Anchorages as well as DYNA Force® Sensors

Technique Béton supplies Quality Products for new Soccer Stadium in Lille

EMEA

France

Commercial Buildings

France has been intensively preparing for the 2016 European Soccer Championship. A total of eleven stadiums are being expanded or newly built in order to accommodate the millions of visitors expected for the European Championship.

The stadium north of Lille is one of the new construction projects. It is designed for approx. 50,000 spectators and will also be used for local soccer club matches and for other events once the European Championship is over.

One of the special features of the stadium is its environmental friendliness: Thanks to two wind generators and a photovoltaic system, the stadium generates its own energy. The total cost for this construction project is approx. 282 million Euros, 44% of which is financed by the metropolitan region of Lille and the region of Nord-Pas-de-Calais.

Technique Béton has already participated in the construction of several stadiums including the stadiums in Saint Denis, Montpellier and Le Mans. As the company is able to supply products promptly and can adapt them to suit project specifications thanks to its local presence throughout France, Technique Béton was awarded a contract to supply high quality products for the new soccer stadium in Lille, the adjoining hotel and the motorway approach.

Technique Béton supplied the concrete and plastic spacers for the new structures. In order to permit an easy releasing of the concrete and to respect the environment, Technique Béton supplied the vegetable mould release agent Biodem® SI1, which is more than 60% biodegradable. The release agent was used for more than 300,000m² of formwork.

Until now, more than 168t Mastar® special mortar have been used for anchoring the stadium tiers. This mortar achieves a compressive strength of 50 MPa within 24 hours.

Ravalchoc® AL self-leveling mortar was used for the floor of passageways in the stadium.

Technique Béton is proud of the fact that its high quality products have contributed to the construction of the new stadium in Lille.

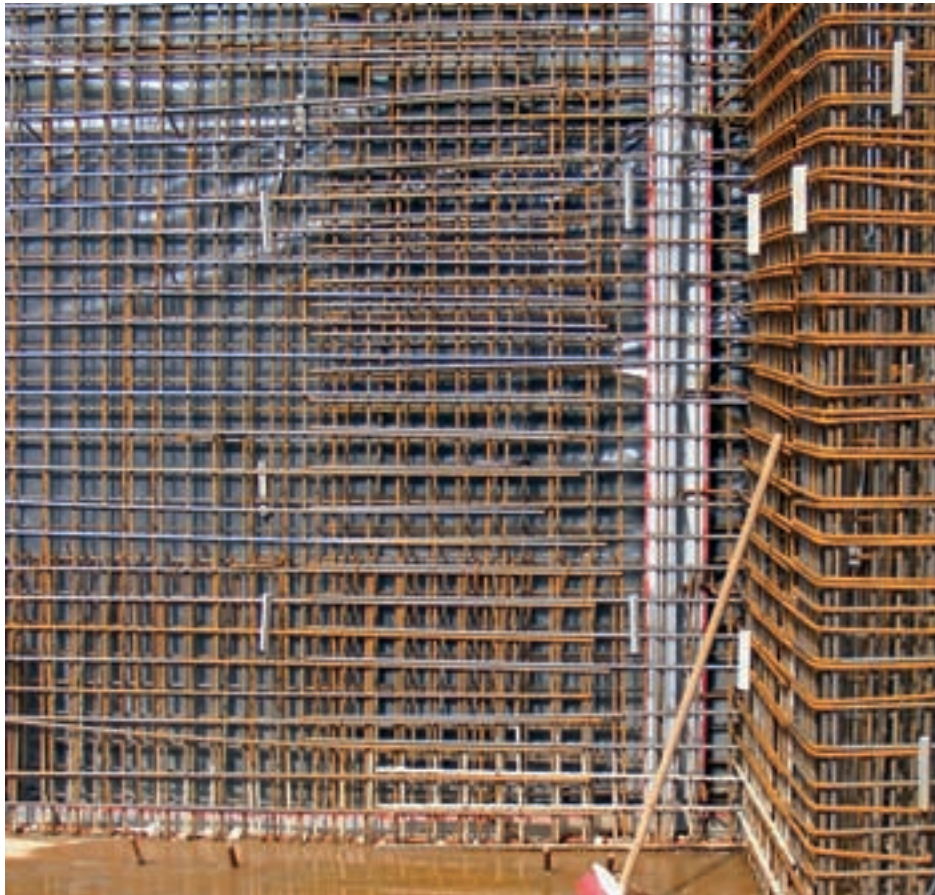


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Owner Communauté Urbaine de Lille Métropole, France
General Contractor Elisa (Eiffage Lille Stadium Aréna), France
Contractor EIFFAGE Travaux, France
Subcontractor Eiffel, France
Architects Pierre Ferret; Valode & Pistre, both France
Consulting Engineers Iosis, Arcora, Froclum, all of them France
Consulting Engineers Socotec, France
Engineers Greisch, Belgium

DSI Unit Technique Béton, France
Technique Béton Scope Supply of concrete and plastic spacers, Biodem® SI1, Mastar®, Ravalchoc® AL

DSI supplies contec Systems for German Printing Office



The Bundesdruckerei is a German government printing office that develops identification products and systems. In addition, the company produces official documents such as passports or drivers licenses and prints currency and stamps. Apart from the Federal Republic of Germany, the company's clients include private mail service providers, patent offices and banks.

The Bundesdruckerei site in Berlin includes several industrial buildings dating back to different construction periods. In order to create room for a security center, a data processing center and a visitors' center as well as for offices, production and logistics, a new building complex was constructed that is divided into three different parts. The new buildings consist of a combination of prefabricated reinforced concrete elements and cast-in-place concrete. Impermeable floor slabs were a bid

requirement for all three parts of the new complex.

In co-operation with BATEG, the contractor, DSI Porta Westfalica, developed a concept for the waterproofing method. The transition between the two parts of the building was especially difficult. DSI designed and produced a special solution that required the installation of 30m of the modified contec Old/New System.

For concrete placement, which was carried out in sections, DSI Porta Westfalica supplied a total of 1,200m of contaflexaktiv ACF 125 bentonite coated working joints. In addition, 170m of recostal® 2000GTF aktiv forming units as well as 295m of recostal® 1000F aktiv forming units were used for several working joints.

DSI also supplied 80m of grout tubes and expanding seals, contec-combiject 2000, as well as 1,500m of injection tubes.



Owner Bundesdruckerei GmbH, Germany
General Contractor BATEG Ingenieurbau GmbH, Germany
Architect Aukett + Heese, Germany

DSI Unit DYWIDAG-Systems International, BU Concrete Accessories, Germany
DSI Scope Supply of 30m of the contec Old/New System, 1,200m of Type ACF 125 working joints, 465m of forming units, 80m of grouting tubes and expanding seals and 1,500m of injection tubes

Attractive Center for UNESCO World Heritage Site: Quartier 17, Stralsund



Photos reprinted courtesy of PST Grundbau GmbH, Germany

The Hanseatic city of Stralsund on the Baltic Sea was an important center of trade in the 14th and 15th centuries and was declared a UNESCO World Heritage Site in 2002 because of its fully conserved medieval townscape. Until recently, the town center was characterized by a large vacant land area located near the town hall square that was the result of a plane crash in World War II.

In 2010, construction began on Quartier 17, a new apartment and retail center complex that will close the gap in the townscape and make the town center more attractive. The construction project is one of the largest inner-city projects of the federal state of Mecklenburg-Vorpommern and is scheduled for completion in summer 2012.

In addition to restaurants, offices and retail space, the area will also include a medical center and modern apartments. The 24 new buildings in Quartier 17 are being architecturally adapted to the surrounding medieval houses.

A secant pile wall with approx. 3,000m of Ø 0.9m bored piles was built to stabilize the 100m long, 50m wide and



10m deep excavation. The piles were installed into firm ground at depths of up to 12m. In addition, a 600m² soldier pile retaining wall with wood and gunite lagging was built.

DSI supplied a total of 320 temporary DYWIDAG Strand Anchors with 4 strands each to the General Contractor PST Grundbau GmbH that were used to tie back the walls. The strand anchors were installed in one to two layers into the retaining walls.

Despite the fact that direct delivery to the construction site by heavy trailer trucks was impossible due to the narrow alleys in the town center, the installation of the DYWIDAG Strand Anchors was successfully completed on schedule.

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Owner TLG Immobilien GmbH, Germany
Contractor PST Grundbau GmbH, Germany

DSI Unit DYWIDAG-Systems International GmbH, BU Geotechnics, Germany
DSI Scope Supply of 320 temporary DYWIDAG Strand Anchors with 4 strands each

Accelerated Bridge Construction: Talbruecke Enzenstetten, Fuessen

The A7 Motorway crosses Germany from North to South, forming an important part of the European arterial road network. Since September 1st 2009, you can drive non-stop on the A7, from the Danish border to the Fuessen-Reutte border crossing in Austria.

Until then, a 16.2km long segment at the southern end, just before the border between Nesselwang and Fuessen, had been missing to complete the 962km long motorway. In this scenic area of the alpine upland, an optimized integration of the motorway into the scenery while at the same time protecting the environment were of paramount importance.

The planners achieved this goal by tunneling and bridging ecologically sensitive areas.

One of the environmentally sensitive areas, the Enzenstettener Brunnenmoos, is a valuable habitat that was protected by a new, 557.7m long motorway bridge. This unstable and subsidence prone spring fen constituted a special challenge. Consequently, the bridge had to be as light as possible, which is why it was originally planned as a steel structure. In order to accelerate construction and finally provide relief from through traffic for local residents, a short-term decision was made to build a concrete bridge instead. This resulted in more complicated foundations, but the considerably shortened construction time more than compensated for this issue. The 6 span hollow box girder prestressed concrete bridge with spans of 55 to 120m now rests on post-tensioned V-shaped pylons.

The large open spans of the bridge in relation to the desired, relatively low height posed problems for the designers. In addition, the Brunnenmoos underneath the bridge was not to be affected under any circumstances by the construction work. Consequently, the bridge was built using the free cantilever method with a launching nose because this permitted an optimum achievement of both requirements. A single cell hollow box girder approx. 15m wide and 3.5m high was erected for each driving direction. DSI produced and supplied the longitudinal tendons necessary for the comprehensive post-tensioning of the bridge superstructure from their nearby plant in Koenigsbrunn.



A total of 592 12-0.62", 15-0.62" and 19-0.62" strand tendons with corresponding plate anchorages were installed and post-tensioned as interior post-tensioning in the deck and floor slabs. In addition, the External Prestressing System with 66 Prestressing Steel Wires was used as external tendon 52 times in the box girder. The DSI scope also included the installation, the tensioning and the grouting of all tendons.

DSI is proud to have contributed to the rapid completion of this important arterial road with its efficient post-tensioning system.



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Owner Federal Republic of Germany, Motorway Authority South Bavaria, Germany

Contractor JV consisting of Adolf Lupp GmbH + Co KG, and Glass GmbH, both Germany

Planning Konstruktionsgruppe Bauen Kempen AG, Germany

Architekt Karl + Probst, Germany

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

DSI Scope Supply and installation of 52 External Prestressing Tendons with 66 Prestressing Steel Wires, Type SUSPA Systems, 96 Tensioning Tendons, 12-0.62"; 484 Tensioning Tendons, 15-0.62"; 12 Tensioning Tendons, 19-0.62"

EMEA

Germany

Special

Internal Unbonded Longitudinal Post-Ten

The German road network is dominated by its civil engineering structures. Up to 40% of the cost of motorway construction is related to structures such as bridges, tunnels, retaining walls and noise barriers.

Due to ever increasing traffic volume and limited financial resources on one hand and higher demands in terms of environmental sustainability on the other hand, requirements for civil engineering structures will considerably increase in the future. With its developments in the area of internal unbonded post-tensioning using restressable and replaceable tendons, DSI is answering the need for quality as well as for durable structures with low and easy maintenance.

Unbonded internal post-tensioning is used in bridge construction – both in box girders and in massive T girders. State of the art post-tensioning of box girders combine external transverse unbonded post-tensioning tendons inside the hollow box and bonded internal tendons in the deck and floor slabs. Unbonded internal post-tensioning can replace bonded internal post-tensioning both in box girders and massive T-beams. The advantages of the unbonded method are factory assembly, less weather dependency during installation, restressability, replaceability, better damage detection and thus better maintenance in general.

The bridge leading over the Kleine Lauer consists of two separate double-webbed T-girders reaching a total length of 273m with eight 35m long internal spans and 31.5m long end spans. For the first time, internal unbonded tendons were used for post-tensioning a

bridge that is erected in sections and incorporates overlapping tendons.

The structure has a maximum clearance of 12m. Pilaster strips that are located on both sides of the beams above the piers allow the statically even transfer of loads as well as accessibility to all anchorages. The unbonded internal SUSPA Type Tendons that were used had a tensioning force of $P_{m0,max} = 2,430\text{kN}$ for 54 $\varnothing 7\text{mm}$, St1470/1670 post-tensioning strands and $P_{m0,max} = 2,970\text{kN}$ for 66 $\varnothing 7\text{mm}$, St1470/1670 post-tensioning strands. Seven post-tensioning tendons and one empty duct were installed per superstructure in the standard range. If necessary, a tendon can be inserted into the empty duct for optional reinforcement at a later date. Due to the overlap connection above the piers, a minimum of 10 post-tensioning tendons are located there, in the area of the highest stress.

In September 2010, a replacement test was carried out using scientific monitoring. The aim of the test was to prove the installation quality of a post-tensioning tendon that had been inserted at a later time as well as the restoration of the appropriate corrosion protection on the project site. For this purpose, an empty duct running across two spans with a length of 84m and three tendon high points was fitted with an extra tendon as well as 23 temperature sensors before concreting the bridge deck. The replacement was carried out after the completion of the structure and post-tensioning of all tendons.

First, the extra tendon was detensioned and pulled from the duct while at the same time simultaneously inserting a cable. Afterwards, the corrosion protection material that had



sioning for the Kleine Laber River Bridge



remained in the duct was removed using a bead chain and a brush chain, and the new tendon was inserted together with a preassembled stressing anchorage. This procedure was followed by the installation of the fixed anchorage and application of the tensioning load. Afterwards, the tendon was sealed, and the non grouted volume in the tendon was measured using the Volumess system in order to be able to compare it to the volume after grouting.

For grouting, the corrosion protection material was heated to more than 100°C and grouted starting from the stressing anchorage. Simultaneously, negative pressure was applied from the fixed anchorage. The temperature of the corrosion protection material inside the duct was measured by the sensors along the complete length, both during the operation and during the subsequent cool down. This way, progress could be followed along the length of the tendon. Afterwards, the completeness of the tendon grouting was demonstrated by comparing the volume of the injected material with the previously measured cavity volume and by endoscopic inspection at the tendon high points.

The replacement test with scientific monitoring at Laber Bridge has shown

that a tendon can be replaced and corrosion protection can be re-established on site. The results obtained and the ensuing design principles will help to meet the ever increasing requirements of prestressed concrete bridge construction.



Repair of the Koehlbrand Bridge Stay Cable System

The Koehlbrand Bridge is a structural steel stay cable bridge with a main span of 325m and two side spans of 97.5m each. The 88 fully locked stay cables are anchored at the bridge deck and at two 98m high pylons.

The superstructure consists of a hollow box girder with slightly slanted webs. It is 17.8m wide and crosses the harbor area on Hamburg's Elbe island Wilhelmsburg at a maximum height of 58m.

During the course of regular inspections by the Hamburg Port Authority (HPA), damage to the stay cable coating that made repair work necessary were repeatedly found. During the most recent inspection, coating and corrosion damage were found on eight stays. Consequently, the owner decided to carry out comprehensive repair on the bridge.

As the Koehlbrand Bridge represents the most important connection to the Hamburg harbor, closing of the bridge for the planned repair work was ruled out. Due to the stay cables' alignment and geometry, scaffolding would have been a complicated and cost intensive alternative for accessing the bridge stays.

As a result of the positive experiences during the repair of the Kehl-Strasbourg Bridge (cf. DSI-Info 17, S. 28-29), the owner contacted Alpin Technik and Ingenieurservice GmbH and DSI. The two companies presented a proposal that was accepted after internal assessment. In order to test the suitability of the method as well as the DYNA Protect® System under difficult conditions on the Koehlbrand Bridge, the assignment for the first section was made in 2009 for the eight stays with the worst damage. These stays have diameters between 65mm and 120mm and a maximum length of 164m. On the whole, approx. 290m² of stay cable surface had to be protected.

Due to the good results achieved in the work on the first section, the owner decided to also assign Alpin Technik Leipzig with the corrosion protection of the remaining 80 stay cables as well as with the accompanying services (visual and magnet inductive tests).





DYNA Protect® Corrosion Protection System

The corrosion protection system consists of two layers of butyl rubber tape, each of which is wrapped around the stay at an overlap of 50%. The total thickness of corrosion protection is approx. 2.6mm and therefore five or six times as much as a coating. In the overlap area between the single layers, the butyl rubber compound adheres by cold amalgamation that is caused by an interdiffusion of the rubber molecules. This creates a locked, tube like and mechanically robust wrapping that is practically impermeable to water vapor and oxygen.

The complete contract was awarded in September 2009. Following visual and magnet inductive tests of the stay cables, the stays were wrapped, with DSI supplying the necessary corrosion protection system - DYNA Protect®.

Both for the corrosion protection of new, fully locked stay cables and for the replacement or strengthening of the corrosion protection of existing stays, a wrapping with butyl rubber tapes offers the following significant advantages compared to conventional coating:

MATERIAL

- practically impermeable for water vapor and oxygen
- long lasting material and color

SYSTEM

- based on the DENSO corrosion protection technology that has been field-approved for decades
- robust system thanks to a layer thickness of approx. 2.6mm and to exterior polyethylene carrier foil
- formation of a tube like, dense coating due to self-acting cold amalgamation of the corrosion protection tapes in overlapping areas
- no complicated surface preparation methods such as abrasive blasting are necessary
- positive visual design aspects due to the colored external polyethylene carrier foil
- adaptation to stay cable deformations thanks to the elastic and plastic characteristics of the wrapping
- tolerates the discharge of stay cable filling additive without any flaking or crack formation
- nearly maintenance free



Owner Hamburg Port Authority (HPA), Germany

Contractor repair works Alpin Technik und Ingenieurservice GmbH Leipzig and DYWIDAG-Systems International GmbH, both Germany

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

DSI Scope Supply of the corrosion protection system DYNA Protect®, consulting during repair works

GEWI® Plus Piles prevent Settlement during Power Plant Construction: Wilhelmshaven

The city of Wilhelmshaven in Northern Germany has the deepest deep water harbor in Germany. Here, the company GDF Suez Energie Deutschland has been building a modern black coal-burning power plant since 2008.

The location is well suited for coal-fired power plants because ships with a capacity of up to 100,000t can be unloaded in the harbor in order to supply the power plant quickly with the high volume of coal needed for its operation. When completed in 2012, the new power plant is expected to reach an efficiency of 46%, which is very high for coal-burning power plants.

One of the difficulties encountered during construction was the fact that the load-bearing capacity of the soil on the construction site was comparatively low and that the pipelines that had to be installed for cooling the plant were absolutely sensitive to settlement. Consequently, a complex deep foundation had to be designed and built to support the cooling pipe system.

After winning the bid process, DSI was awarded a contract to produce and supply a total of 283 Ø 75mm GEWI® Plus Piles. The GEWI® Plus Piles, which were designed for the expected loads, were coupled and installed in lengths of 33m. The piles had a total weight of 325t. The upper part of the GEWI® Plus Piles with a segment length of 18m that were produced by DSI were supplied to the site including the double corrosion protection system. In addition to the piles, DSI also supplied all of the accessories such as couplers, anchor plates and lock nuts.

Construction work had to be carried out under difficult logistical conditions. As all works had to be carried out within the power plant's premises, there was very little storage space for the GEWI® Plus Piles.

Furthermore, installation had to be partly undertaken at night.

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Owner GDF Suez Energie Deutschland AG, Germany
Client Neidhardt Grundbau GmbH, Germany

Contractor JV Kraftwerk Wilhelmshaven, consisting of Max Bögl Bauservice GmbH und Co. KG and Heitkamp Ingenieur- und Kraftwerksbau GmbH, both Germany

Subcontractor Demler Spezialtiefbau GmbH + Co. KG, Germany

Consulting Engineers Inros Lackner AG, Germany

Engineers Axel Christmann Ingenieurtechnik GmbH, Germany

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

DSI Scope Supply of 283 GEWI® Plus Piles, Ø75 mm, couplers, anchor plates and lock nuts



Prefabricated DYWIDAG Tendons for busy highway interchange - Neufahrn

The Neufahrn interchange is one of the major traffic interfaces north of the city of Munich in southern Germany. At this location, the north-south traffic circling Munich meets the west-east tangent.

Moreover, most of the traffic to and from the prospering Munich airport has to pass through the Neufahrn interchange. Currently, approximately 25,000 vehicles use the interchange per day. Recent forecasts indicate that the traffic volume will grow to 38,000 vehicles per day by 2020.

Based on these studies, it was considered absolutely necessary to increase the capacity of what is now a bottle neck. In total, five new bridges have been constructed and five existing bridges have been improved since the start of construction in 2009.

The center piece of the extension of the Neufahrn interchange is an elevated, two-lane crossing that leads across the very busy A9 highway, guiding traffic from the east and the airport in the southerly direction onto the A9.

The crossing consists of three reinforced concrete bridges at a height of up to 15m over the interchange. The loads are transferred to the ground by large abutment piers via drilled piles. 2,500m² of concrete were used to construct the abutment piers for the three bridge structures.

For the improvement and extension of the Neufahrn interchange, DSI supplied approx. 227t of Type SUSPA Systems prefabricated tendons with MA Anchorages, bond head anchors and couplers.

Moreover, DSI installed all tendons, 22-0.62", grade 1860, 150mm², and carried out the post-tensioning and grouting work for the various bridge structures according to DIN 1045-1 and DIN FB 102.

Work at Neufahrn interchange was successfully completed by the end of 2011.



Owner Highway Authority South Bavaria, Germany

General Contractor Hentschke Bau GmbH, Xaver Riebel Bauunternehmung GmbH, both Germany

Engineering SSF Ingenieure GmbH, Germany

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

DSI Scope Supply, installation, stressing and grouting of prefabricated 22-0.62" Type SUSPA Systems Tendons, MA Anchorages, bond head anchorages, and couplers



GEWI® Piles ensure Skiing Pleasure

Germany's highest mountain, the 2,962m high Zugspitze, is a very popular destination for tourists from around the world during the summer.

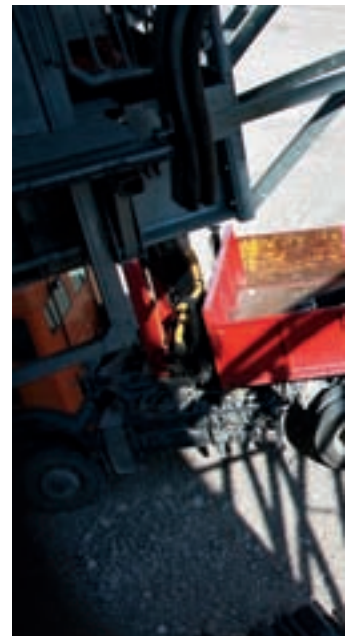
In order to enhance the attractiveness of the Zugspitze for winter tourism, a new tunnel and a new cable car are being built that will link the relatively small skiing resort on the Zugspitzblatt with the Ehrwalder Alm ski resort located below.

The 16 individual foundations needed for the construction of the new ski lift were constructed using Ø 40 and 50mm GEWI® Piles. The double corrosion protected (DCP) GEWI® Piles in lengths of 6.0m were brought up the mountain using the Zugspitzbahn AG's rack railway and then transported to the construction site by truck. 4-6 GEWI® Piles were used for each of the pillar foundations.

DSI supplied approx. 8t of DCP GEWI® Piles for the construction of the new cable car. In addition to the piles, DSI also supplied the necessary accessories such as couplers, anchor plates and nuts.

Due to the large variations in geology, each individual pillar foundation was tested by a geologist after blasting in order to determine the appropriate diameter and length of the GEWI® Piles.

Installation was complicated due to the fact that water is very scarce on the Zugspitzblatt. As drilling had to be carried out without water, the drill rigs had to be thoroughly cleaned every two days because of the large accumulation of dust. In addition, the water needed for grouting the GEWI® Piles had to be transported to the site in 1m³ barrels.



on Germany's highest Mountain

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Construction

EMEA

Germany

Foundations



The skid loader used for the drilling work could not be used in two particular locations because there was not enough flat space for positioning the loader. One of the Zugspitzbahn's walking cranes was used instead to drill in these areas.

As the temperatures on the Zugspitze are 20°C lower than in the valley even during the summer, the installation and grouting of the DCP GEWI® Piles had to be completed before the first snow fall.



Owner Bayerische Zugspitzbahn
Bergbahn AG, Germany
General Contractor Häsch Georg
GmbH, Germany

DSI Unit DYWIDAG-Systems
International GmbH, BU
Geotechnics, Germany
DSI Scope Supply of Ø 40 and
50mm DCP GEWI® Piles and
accessories



DSI stabilizes Talbruecke Bergen along



During an inspection of the Talbruecke bridge in Bergen, which was built in 1937 on the A8 Motorway south-east of the town of Chiemsee, considerable damage was detected on the bridge.

As a comprehensive repair of the bridge would not have made sense either economically or technically, a new bridge with two separate superstructures is being built 11.63m north of the old structure. The new bridge will include two lanes per direction at first, but is designed for a future widening to 6 lanes.

The new bridge has a longitudinal gradient of 4.4% practically along its entire length of 364m and reaches a height of 35m at its highest point. The bridge axis is in a straight line between the abutments and then merges into a curve with a clothoid parameter of $A = 600\text{m}$.

The structure is supported by accessible hollow box abutments and massive H piers that are 2.2m thick each and widen to 7m at the pier table.

The piers, which are built using climbing formwork, evenly broaden at an inclination of 35:1 towards their foundations. The foundations rest on drilled piles in those areas where the load cannot be transferred directly into the soil.

The bridge features spans of 45+ 60+ 80+ 65+ 60 +54m and a width of 38.5m between the guard rails. The two separate bridge superstructures with their overall height of 4.5m rest on the two abutments and 5 piers each.

The superstructures consist of post-tensioned box girders that were launched in segments in lengths of 16.3 to 30.5m. Due to the longitudinal gradient of 4.4%, the superstructures had to be stabilized by what is known as a hydro incremental launching facility during launching at the eastern abutment. The launching facility was equipped with additional strand jacks.

The superstructures were post-tensioned both internally and externally.



the A8 Motorway to Salzburg

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Construction

EMEA

Germany

Bridges



For stabilizing the superstructures during construction, centralized post-tensioning in the bonded areas was sufficient.

The eccentrically placed tendons that will accommodate traffic loads were only installed after completion of the two superstructures.

For the longitudinal tensioning of the new bridge, DSI supplied approx. 500t of 19-0.62" Strand Tendons, St 1860, 150 mm², with MA Anchorages (passive and active anchorages) and Type SUSPA Systems Couplers. Approx. 83t of Type SUSPA Systems 4-0.62" Monostrand Tendons, St 1860, 150 mm², with MER and MEF Plate Anchorages were needed for the transverse tensioning of the superstructures. In addition, DSI supplied approx. 117t of Type SUSPA Systems Tendons, Wire-EX 66 for external prestressing, St 1470/1670 with anchorages. All of the prefabricated tendons were produced in Langenfeld and installed, tensioned and grouted by DSI on site.

Total cost for the construction of the new bridge and the demolition of the old structure amounted to approx. 37.6 mio. €. Construction at the new bridge began in May 2010 and is scheduled for completion in June 2014.



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Owner Federal Republic of Germany, represented by the building authority of the Federal State of Bavaria, Germany

Client Highway Authority South Bavaria, Germany

General Contractor JV Talbrücke Bergen, consisting of Max Bögl Bauservice GmbH und Co. KG and Max Aicher GmbH und Co. KG, both Germany

Engineers Haumann + Fuchs Ingenieure AG, Germany

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

DSI Scope Supply, installation, tensioning and grouting of approx. 500t of Type SUSPA Systems 19-0.62" Strand Tendons, approx. 83t of 4-0.62" Monostrand Tendons and of 117t of Wire-EX 66 Tendons

GEWI® Plus Tie Bars Support Crucial Retaining Walls after Tunnel Collapse



Recently, **GEWI® Plus Tie Bars (Tie Rods)** were extensively used for reconstructing a precast tunnel in Gerrards Cross, a town located approx. 32km outside London. In order to create space for a supermarket with parking for 300 cars, an innovative solution was chosen which featured the covering of the existing railway line with precast tunnel segments. New fill up to the original ground level was placed to create additional surface area and make use of what is known as air rights.

When the fill material for the new building ground was placed around the newly formed tunnel profile, the tunnel collapsed due to uneven stresses on the pinned joints of the tunnel segments. An approaching train engineer was able to stop his passenger train just in time before reaching the collapsed tunnel.

In order to achieve a stable and safe solution for the reconstruction of the enclosure, two lines of contiguous bored piles were driven on each side of the tunnel to act as retaining walls and tied back to anchor pile walls on the upside of the railway cut slopes.

As the stiffness of the tie bars used to tie the rail facing walls back was of primary concern given the close proximity to the live railway, the designers chose to use **GEWI® Plus Tie Bars**.

The robust tie bars proved to be the ideal choice for the contractor because they can be adjusted to the correct length by either adjusting the nut at the termination point or adding a coupler and additional section of bar. All in all, DSI supplied 108 \varnothing 57.5mm **GEWI® Plus Tie Bars** in lengths of 14 to 18m as well as 60 \varnothing 43mm **GEWI® Plus Tie Bars** in lengths of 12 to 16m.

To accommodate the angled anchorages, DSI fabricated articulating wedge bosses with articulations consisting of **GEWI® Plus** domed nuts. Due to the fact that the diameter of the dome allows the use of anchor plates with larger through holes, greater articulation is ensured. Thanks to the articulating anchorages, construction time was significantly reduced. A total of 336 anchor plates with angle compensation wedge bosses and hi-load domed nuts were used for the project.

As long term settlement of the fill was predicted, settlement ducts consisting of large diameter corrugated sheathing were employed on each of the tie bars. The tie bar is laid along the base of the settlement duct and fill is placed around the duct in layers and compacted. Over the course of time, the fill consolidates and settles without affecting the stressed tie bars, which are free to float within the settling duct.

If settlement ducts were not used, the tie bar would be subject to catenary bending. This would put additional loads on the walls and potentially lead to shearing of the tie bars at the bearing plates.

The durability of the tie bars was ensured through sacrificial corrosion allowance. The corrosion rate of the steel diameter is determined throughout its complete service life, and the bar is produced in a larger diameter so that corrosion can occur without compromising the tie bar's design load.

After the **GEWI® Plus Tie Bars** had been installed and stressed to their respective working loads by DSI, the collapsed tunnel was removed and the new tunnel lining reinforced at the crown pin joint. Afterwards, the tunnel was over-clad with a 600mm reinforced concrete deck, and 200,000t of fill were placed over the tunnel. The supermarket on the enclosure recently opened for business.



i

Owner Tesco Stores Limited and Network Rail, both Great Britain
Contractor Costain Group PLC, Great Britain
Engineering Peter Brett Associates LLP, Great Britain

DSI Unit DYWIDAG-Systems International Ltd., Great Britain
DSI Scope Supply and installation of 108 \varnothing 57.5mm **GEWI® Plus Tie Bars**, 60 \varnothing 43mm **GEWI® Plus Tie Bars** and 336 Anchor Plates with Wedges and Domed Nuts

DSI stabilizes Sidehill Cut at Great Britain's central Freight Terminal

The Daventry International Rail Freight Terminal (DIRFT) is a freight depot and logistics center that is centrally located between Birmingham and London and directly linked to the European continent via the Channel Tunnel. DIRFT is in immediate proximity to Great Britain's most important motorway and railway links and is one of the most important freight terminals in the country.

The area, which was originally established in 1997, is being expanded by a total of 54ha on which several bridges, streets and railway tracks will be built in addition to warehouses and industrial buildings.

Due to the grade separations between the incoming rail lines, access for road freight and hard standing areas, a number of retaining walls were required. One of the largest retaining walls consisted of a contiguous pile wall, tied back with permanent DYWIDAG Tie Bars (Tie Rods).

The permanent tie bars consisted of 50mm GEWI® steel threadbars in lengths of 12-22m with couplers, domed nuts and countersunk bearing plates.

At the dead end, the tie bar was anchored in a deadman consisting of a precast bearing pad embedded in the ground beyond the active wedge zone.

At the live end, the tie bars were terminated on short length galvanized waler beams to ensure that the load in the tie bar was spread between two piles in the contiguous wall.

Durability of the tie bars was ensured through the incorporation of sacrificial corrosion allowance. This mechanism allows for sufficient section of steel to enable corrosion to occur without compromising the steel section required to fulfill the design load of the tie.



Owner DIRFT, Great Britain
Contractor Volker Fitzpatrick Ltd., Great Britain

DSI Unit DYWIDAG-Systems International Ltd., Great Britain
DSI Scope Supply of 65 No. Ø 50mm GEWI® Tie Bars and accessories

Widening of the M1: Great Britain's Largest Soil Nailing Project supplied by DSI

The M1 motorway in Great Britain links London with the North of the country. The motorway, which was built in the 1950's, is one of the most important connections in the country and is heavily overburdened.

Consequently, the motorway is now being widened north of London between interchanges 10 and 13, between Luton and Milton Keynes. Construction work is being carried out on the hard shoulders so that they can be used as additional lanes during peak hours.

For stabilizing the motorway embankments, DSI supplied 17,000 Type R38 DYWI® Drill Hollow Bar Soil Nails in lengths of 6-10m and with a total length

of 150,000m as well as Ø 25mm GEWI® Soil Nails for the clay areas. All the soil nails are top bar galvanized with formed bearing plates and domed nuts for angle compensation.

The engineer chose to use hollow bars because they allow simultaneous drilling and grouting and ensure that grout is placed at all points within the ground as drilling is advanced.

DSI worked closely with the drilling contractor in order to design the most suitable drilling equipment that could reach over the embankments. Furthermore, DSI consulted with the contractor on the selection of rotary percussive top hammers (drifters) to ensure correct rotation speeds (120 RPM) and blow rates of the hammer (400-600 BPM).



Galvanized Type R38 DYWI® Drill Hollow Bars



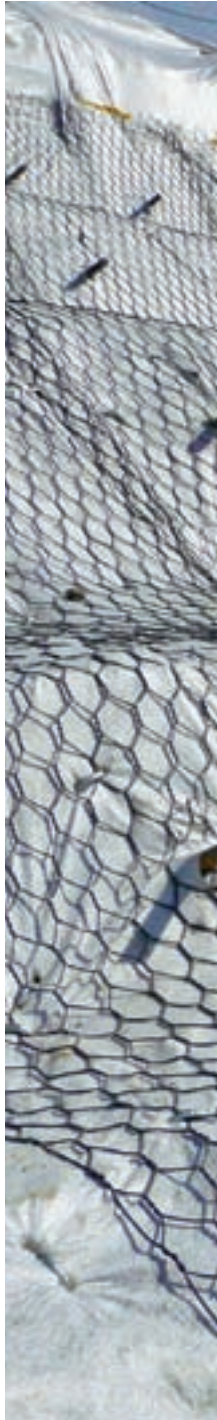
Short and Long Soil Nails



Excavator with Drill Boom



Retroflush Drill Bits





EMEA

Great Britain

Slope
Stabilization

DSI also tested the soil nails and worked up a testing method for the hollow bars with the designers. In this method, which has become known as the long and short nail testing method, tests are applied to sacrificial soil nails, and the resulting design load is calculated by taking the load of the short nail away from that of the long nail. Thanks to this method, bond stress in the stable zone can be quantified.

Construction work was carried out from February 2010 to September 2011 on only one lane at a time in order not to cause any disruptions to traffic in the area.

Owner UK Highways Agency, Great Britain

Engineers URS Scot Wilson, Great Britain

General Contractor JV Costain Carillion, consisting of Costain Group PLC and Carillion PLC, both Great Britain

Drilling Contractor Bachy Soletanche Carillion Piling JV, consisting of Bachy Soletanche Limited and Carillion PLC, both Great Britain

DSI Unit DYWIDAG-Systems International Ltd., Great Britain

DSI Scope Supply of 17,000 Type R38 DYWI® Drill Hollow Bar Soil Nails and of Ø 25mm GEWI® Soil Nails; soil nail testing



Benched Face

New Connecting Road in Sittingbourne enhances the Region's Economic Development

EMEA

Great Britain

Slope
Stabilization

Many inhabitants of the town of Sittingbourne in Southern England have been waiting for it for a long time: The new key transport link Sittingbourne Northern Relief Road between the Eurolink Industrial Park and the A249 trunk road.

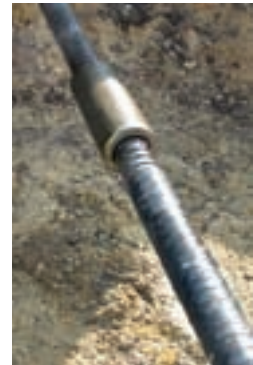
Previously, traffic had to wind its way through the narrow streets, low bridges and complicated one-way systems of Sittingbourne's center. Thanks to the new relief road across Milton Creek, traffic can now flow to the industrial park directly, which considerably enhances the area's economic attractiveness.

DSI were consulted with early in the project to develop a suitable tie bar (tie rod) solution for the sheet piled walls along the banks of the river and in the proximity of the new bridge. Given the high traffic loads on the approach roads and in the proximity of the bridge abutments, a high capacity tie bar solution was required. Consequently, the decision was made to use \varnothing 63.5mm GEWI® Tie Bars in lengths of 8-16m with an ultimate strength of 2,217kN. Thanks to their continuous thread, the bars can be cut and coupled at any point.

This was a key requirement for the contractor, as the final alignment of the sheet piled walls could only be determined once the piles were driven.

The GEWI® System used also incorporated DSI's heavy duty clevis anchorages, which allow articulation at both faces. The robust clevis ensures full load capacity of the bar and offers ease of installation. In order to make installation even easier, DSI also designed special cleat plates.

For effective corrosion protection, sacrificial corrosion allowance was applied to the entire tie, in conjunction with Denso wrapping of the GEWI® Tie Bars and clevises.



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Owner Kent County Council, Great Britain
Contractor Jackson Civil Engineering Group Ltd., Great Britain
Engineers Jacobs Engineering Group Inc., Great Britain

DSI Unit DYWIDAG-Systems International Ltd., Great Britain
DSI Scope Supply of \varnothing 63.5mm GEWI® Tie Bars and Clevis Connections



DYWIDAG Post-Tensioning Systems Stabilize Italy's longest Motorway

The 754km long A1 from Milan to Naples is Italy's longest motorway. The highway was originally completed in 1964 in order to stimulate the Italian economy after World War II. As the A1 was no longer able to cope with ever increasing traffic volume, the owner, Autostrade per l'Italia, began the widening of the Variante di Valico section, which runs through the Apennines.

This mountainous section is where the Aglio Bridge is located, crossing the Barberino di Mugello River at a height of 90m. The 598m long bridge consists of three 148m long main spans and of two 77m long side spans.

Both the piers and the bridge deck consist of self-consolidating concrete (SCC), which features excellent mechanical properties and ensures that the structure will be highly impermeable. The bearings necessary for the piers and the joints in the bridge deck were reduced to a minimum in order to keep both construction and maintenance costs as low as possible.

The 38.5m to 78m high piers rest on foundations that are 22 to 31m deep and 15m in diameter. The superstructure was simultaneously built outward from the four pier tables by the classical cantilever construction method using form travelers.

The width of the bridge superstructure ranges from 19.7m to 22m and includes four traffic lanes and one emergency lane.

DYWIT supplied 150 mm² St1860 MA Bonded DYWIDAG Strand Tendons with 27, 22 and 9 0.62" strands for the longitudinal post-tensioning of the Aglio Bridge.



The segments have differing lengths ranging from 3.35m at the main piers to 4.70m in the center of the span.

The depth of the segments measure 7.5m at the pier tables and diminish to 3m in the center. Starting from the four pier tables, one segment was poured every two weeks.

DYWIDAG Strand Tendons with 3 and 4 0.62" strands and MA anchorages were used for transverse post-tensioning. A total of 673t of strand was installed. Vertical post-tensioning was carried out using 95t of 36WR DYWIDAG Bars.



Owner Autostrade per l'Italia S.p.A., Italy
General Contractor TOTO Costruzioni Generali S.p.A., Italy
Engineers SPEA Ingegneria Europea S.p.A., Italy

DSI Unit DYWIT S.P.A., Italy
DYWIT Scope Supply of 3, 4, 9, 22 and 27-0.62" DYWIDAG Strand Tendons with MA anchorages and of Ø 36mm DYWIDAG Post-Tensioning Bars; rental of equipment, technical assistance

DYWIDAG Tendons facilitate Permanent Crossing of a Torrent in the Dolomites

In 1997, a mudslide of exceptional intensity resulted in the collapse of the bridge over the Rudavoi torrent.

In order to replace this important part of Federal Road No. 48 between the towns of Cortina d'Ampezzo and Misurina as quickly as possible, the bridge was temporarily replaced by a Bailey bridge with 39m spans.

As the bridge was temporary, it had a limited load capacity and had to soon be replaced by a permanent viaduct. The new bridge is situated downstream of the Bailey bridge and has a higher clearance so that future mudslides can flow underneath the new bridge without causing any problems. The viaduct is 180m long, 11.5m wide and features a curve radius of 140m. The bridge has a main span of 100m and two side spans of 40m each.

The post-tensioned bridge deck, with a thickness ranging from 1.5 to 8m, rests on 5m high piers that were erected with a spacing of 100m. The bridge was built in three sections. The first section was 70m long and was constructed using falsework at the first pier. Once concrete had cured, the same falsework was mirror inverted and used at the other pier.





A temporary pier as well as temporary side foundations were needed for the remaining 40m in the middle of the bridge in order to erect the falsework for the bridge superstructure formwork. The longitudinal prestressing of the bridge in accordance with construction progress was of great importance for statics because the prestressing systems had to accommodate the loads caused by the bridge's 140m radius.

For the longitudinal prestressing of the bridge deck, DYWIDAG supplied DYWIDAG Strand Tendons with fixed R couplers with 2,700kN load bearing capacity. DYWIDAG Strand Tendons with 1,750kN load bearing capacity were installed for the transverse prestressing of the bridge piers.

On the whole, 103t of 19-0.6" and 12-0.6", St 1670/1860 DYWIDAG Strand Tendons were used. The installation of the DYWIDAG Tendons was carried out successfully from June 2010 until November 2010.



Owner Province of Belluno, Italy
General Contractor Monti S.P.A., Italy
Consulting Engineers Inco S.P.A., Italy

DSI Unit DYWIDAG S.P.A., Italy
DYWIDAG Scope Supply of 103t of 19-0.6" and 12-0.6", St 1670/1860 DYWIDAG Strand Tendons

Westrandweg Motorway in Amsterdam



Photos reprinted courtesy of fotomix.nl and Ineke Key Fotografie, Netherlands

Overview

The Westrandweg, a 10km long motorway that will considerably improve traffic flow and connect the second Coen Tunnel with the junction of the A5 and A9 motorways near Rasdorp, is currently under construction in the West Harbor Area of Amsterdam. The major part of the Westrandweg is being built at ground level, but the motorway also features various elevated crossings with streets, canals and railways. The most spectacular crossing is the so called KW 520 - a more than 3km long viaduct constructed at a height of 12m above ground level that will be the longest viaduct in the Netherlands after its completion. KW 511 is another special bridge: It is the viaduct with the longest precast box girders ever used in the Netherlands.

Design of the KW 520 viaduct

The two bridge decks of KW 520 are 27.5m wide, accommodating 2 traffic lanes with additional emergency lanes each, and consist of ten precast pre-stressed concrete box girders.

These girders are supported by transverse cantilever beams at the top of columns which are cast in situ. The foundation is based on piles, and the span between columns is 44m. The columns are 6m wide, and the cantilever part of the beams is almost 11m long. Thirteen 19 strand $\varnothing 15.7\text{mm}$ St 1860 N/mm² DYWIDAG Tendons were installed in order to provide sufficient load capacity for the beams. The tendons included 6819 MA stressing end anchorages and bond-head non stressing anchorages.

Spanbeton, the market leader for precast pre-stressed segments in the Netherlands, developed a new type of precast box girder for this project. These PIQ girders have wide flanges on both sides at the bottom. Consequently, one bridge deck could be built with eight 2.8m wide girders in the middle and two smaller girders at both sides. The standard girders are 42m long and weigh approx. 145t. The girders are only 1.45m high, which makes the two viaducts very slender.



Transport of the Girder



Placing the Box Girders



Launching Gantry

beats Records

A 0.3m thick and 1m wide concrete deck was cast in place between the precast girders. In order to provide excellent stability for the bridge deck, eight precast segments per bridge were transversely post-tensioned using 28 8 strand, \varnothing 15.7mm, St 1860 N/mm² DYWIDAG Tendons.

Construction Methods for KW 520

In order to be able to complete one new bridge span per week, six casting forms were used for the transverse cantilever beams. The reinforcing steel cages with the transverse tendons were prefabricated in a yard nearby and installed in the formwork using cranes. After concreting, the tendons were stressed in three stages:

- partial pre-stressing two days after casting in order to allow the removal of the scaffolding and formwork
- approx. one week later, 10 tendons were stressed to 100% to allow the installation of the box girder at one side of the column
- after the girders had been installed on one side, the remaining three tendons were stressed to their final tension force, and the box girders for the next span were placed

At their manufacturing plant in Koudekerk, Spanbeton cast two new PIQ girders per day that were transported on special trucks to a temporary storage yard in Amsterdam the same night. A special launching gantry was necessary for placing the girders in the bridge spans. Thanks to this construction method, the bridge could be built quickly, and disturbances of the city traffic were reduced to a minimum.

The weekly construction cycle was as follows:

- Tuesday: installation of the PIQ girders
- Wednesday: installation of formwork, reinforcement and tendon ducts for the cast in situ parts of the bridge deck
- Thursday: pushing of the strands and installation of the SD Plate Anchorages for the transverse tendons
- Friday: casting of the deck elements located between the girders
- Monday: tensioning of transverse tendons



SKK Girders for KW 511 Viaduct

For the construction of the KW 511 viaduct, Spanbeton pushed the development of the SKK precast box girders even further, reaching a record length of 61.75m. The girders are approximately 1.2m wide and 1.85m high and weigh approx. 160t. Transportation of these girders by truck from the plant in Koudekerk to Amsterdam was spectacular. 25 girders were placed in two days using heavy mobile cranes. DSI installed, stressed and grouted 70 \varnothing 15.7mm St 1860 N/mm² transverse tendons with 9 strands each. Thanks to the exceptionally long girders, the Ringvaart Canal only had to be closed to ship traffic for 5 days.

Final remarks

In a very successful co-operation between Van Hattum en Blankevoort, Spanbeton and DSI, economically attractive structural solutions were developed for this challenging construction project. The Westrandweg Motorway is scheduled for completion at the end of 2012. DSI is proud to have contributed to new developments concerning slender precast concrete viaducts with large spans.



101

Construction

EMEA

Netherlands

Bridges

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Owner Rijkswaterstaat (Dutch department for traffic, public construction and waterways), Netherlands

Contractor Joint Venture Westpoort, consisting of: Van Hattum en Blankevoort, KWS Infra and Boskalis, all of them Netherlands
Precast Girders Spanbeton, Netherlands

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

DSI Scope Supply, installation, stressing and grouting of \varnothing 15.7mm St 1860N/mm² DYWIDAG Strand Tendons

GEWI® Piles stabilize Important Motorway Connection in the Netherlands

The A4 motorway is an important link between Amsterdam and Den Haag. Currently, the two lane section between Burgerveen and Leiden is being widened in order to eliminate the traffic bottlenecks that regularly occur in this area.

The widening of the A4 motorway also includes the construction of two aqueducts. The first aqueduct is located at the “Ringvaart” waterway. This new structure was built and completed at the end of 2010 next to an existing aqueduct.

DSI Netherlands supplied approx. 1,500 GEWI® Piles for this part of the project.

At present, construction work is underway on the first part of the second aqueduct at the “Oude Rijn” River. The current bridge over the river will be replaced by two aqueducts. In this area, the A4 highway will run beneath the ground surface for a distance of approx. 1,440m.

In total, DSI supplied approx. 8,500 GEWI® Piles in lengths of 14.5m to 29m to prevent uplift of the highway due to groundwater pressure.





Two anchor plates were installed on the *GEWI*® Piles after the piles had been installed. One of the anchor plates was placed at the underwater concrete floor by divers. After the excavation had been pumped dry, the second anchor plate was installed on the construction floor.

Construction work began in 2009 and is scheduled for completion in 2013.



Owner Ministry of Transport, major projects department, Netherlands

General Contractor JV A4 Burgerveen – Leiden, consisting of BAM Civiel, BAM Wegen, VTN Verkeers- & Besturingstechniek bv and Van Oord, all of them Netherlands

Subcontractor BAM Speciale Technieken, Netherlands

Engineering BAM Infraconsult bv, Netherlands

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

DSI Scope Supply of 10,000 *GEWI*® Piles with 20,000 Anchorages

Rotterdam, Netherlands: DYWIDAG Strand Anchors stabilize Europe's



With a total area of 105km², Rotterdam Harbor in the Netherlands is Europe's largest port. The harbor

consists of several port areas extending from Rotterdam city center to the North Sea along a distance of 40km.

In order to maintain the harbor's leading position in the future, construction work started at Maasvlakte 2 in September 2008. Maasvlakte 2 is the western extension of the harbor in the North Sea, which is being constructed by reclaiming land through spraying on sand. The new terminal will also include a 1.15km long deep sea quay with water depths of up to 20m, which will make Rotterdam the only harbor in Europe able to accommodate container ships of the newest generation.

The front wall of the new feeder quay wall is constructed as "combi wall" using Ø1.2m steel piles and sheet piles. A 3.25 x 7m large concrete sleeve is positioned on top of the combi wall.

DSI assisted with the design of the sheet pile wall and supplied and installed the DYWIDAG Strand Anchors that were needed for horizontally tying back the quay wall. The unbonded DYWIDAG Strand Anchors consist of 20 greased and HDPE coated 0.62" strands equipped with two MA 6822 anchorages with helices and protection caps to prevent the ingress of sea water.

Inside the concrete sleeve of the quay wall, the HDPE trumpets of the DYWIDAG Strand Tendons are connected to a Ø 140mm HDPE tube. In the transition from anchor length to free length, the HDPE duct is protected by an extra Ø160mm HDPE tube. Special curved deviator saddles are used to prevent sharp bending and damage to the strand tendons in case of soil settlements of the reclaimed sand behind the front wall.

In total, 360 strand tendons were installed in the 1.15km long deep sea quay wall at distances of 3.1m.

largest Harbor

Depending on the soil quality, the DYWIDAG Strand Anchors are between 40 and 45m long. The anchors were tensioned in two steps to 50% and 100% of their tension force and injected with cement grout afterwards.

Due to their flexibility, their ease of handling and long service life, the horizontal strand anchors proved to be the optimum solution for the quay wall of the new container terminal. In addition, the tendon length can be adapted to suit on site requirements, and the tendons can be tensioned to accurately defined forces. Even if the quay wall were to deform at sometime in the future, the DYWIDAG Strand Anchors can be restressed.



Owner Havenbedrijf Rotterdam N.V.
(Port of Rotterdam), Netherlands

General Contractor PUMA JV, consisting of
Koninklijke Boskalis Westminster N.V. and
Van Oord N.V., both Netherlands

Subcontractor Quay Walls BAVO JV,
consisting of BAM Civiel B.V. and Van Hattum
en Blankenvoort, both Netherlands

Architect Quay Walls BAM Infraconsult B.V.,
Netherlands

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

DSI Scope Supply and installation of
360 unbonded horizontal DYWIDAG Strand
Anchors (500t) with MA Anchorages

105

Construction

EMEA

Netherlands

Hydro- &
Marine
Structures

Monostrand Systems fulfill Special Requirements: Wodnik Hotel



As the polish town of Torun, located approx. 180km North West of Warsaw, has preserved its medieval center, it has been declared a World Heritage Site by UNESCO and is very popular with tourists today.

Although the town has a population of approximately 200.000, some of Poland's biggest and most important companies are located there; as a result, the town is also frequently visited by many business travelers.

In order to create sufficient capacity for both the 1.5 Million tourist visitors per year and for people travelling on business, a new four star hotel was recently built. The "Wodnik" Hotel is designed as a comfortable, modern conference center.

One of the project's main challenges was the architect's request for the largest conference room to be built without intermediate supports. The second challenge was that the conference room had to be located on the ground floor and that another two floors were to be built above it.

The only way to fulfill the architect's request was to design and build the conference room ceiling as a prestressed concrete structure. DSI supplied more than 12t of Unbonded 6-1 Monostrand with SK6 and SF6 Anchorages. The 34 x 22m large ceiling could only be built without supports thanks to the use of Monostrand Tendons.



Owner L&P Sp. z o.o., Poland
General Contractor Eiffage Budownictwo Mitex S.A., Poland
Contractor Eiffage Budownictwo Mitex S.A., Poland
Architect CKK Architekci, Poland
Design Dreibau Polska Sp. z o.o., Poland

DSI Units DYWIDAG-Systems International Sp. z o.o., Poland, DYWIDAG-Systems International GmbH, BU Post-Tensioning, Germany
DSI Scope Supply of more than 12t of Unbonded 6-1 Monostrand with SK6 and SF6 Anchorages

DSI Poland supplies Quality Systems for Pan-European Transport Corridor VI

The A1 Motorway, which is planned as a 570km long North-South connection through Poland, forms part of the Pan-European Transport Corridor VI and will link Scandinavia with the Mediterranean countries once it is finished.

After completion of phase I of the project - the section between Gdansk and Nowe Marzy in the North of Poland - a second, 62km long section of the toll road is now being built from Nowe Marzy to Czerniewicze near Torun.

The second section runs through the administrative districts of Pomerania and Kujavia and Pomerania and includes a total of five intersections, the repair of 14 structures, the demolition of one structure and the construction of 51 new bridges.

DSI Poland was involved in the construction of two of the motorway viaducts and in six of the road viaducts. One of the motorway bridges is the approx. 250m long hollow box bridge WA-102. It is the first bridge in Poland to feature the External Prestressing System with Prestressing Steel Wires. All of the prefabricated tendons were produced, supplied, tensioned and grouted by DSI.

For the second section of A1, DSI Poland supplied 440t of 15-0.6", 19-0.6" and 22-0.6" St 1670/1860 SUSPA Systems Tendons (including more than 130t of Prefabricated Tendons) with K Couplers and MA Anchorages. In addition, more than 40t of the External

Prestressing System with Prestressing Steel Wires EX-66, Type SUSPA Systems were successfully installed. DSI Poland also supplied more than 3t of 36 WR and 40 WR DYWIDAG Post-Tensioning Bars for post-tensioning the launching nose.

Due to the installation advantages of prefabricated tendons, the external prestressing steel wire tendons were completely installed by DSI Poland within only 2 weeks, and post-tensioning and grouting could be successfully completed.



EMEA

Poland

Bridges



Owner Gdańsk Transport Company S.A., Poland
General Contractor Skanska NDI JV, Poland
Contractor Skanska S.A., Poland
Architect Transprojekt Gdański Sp. z o.o.; Transprojekt Warszawa Sp. z o.o., both Poland
Design Transprojekt Gdański Sp. z o.o., Poland; Transprojekt Warszawa Sp. z o.o., Poland; Stähler+Knoppik, Germany

DSI Unit DYWIDAG-Systems International Sp. z o.o., Poland

DSI Scope Production, supply, tensioning and grouting of 440t of Prefabricated Type SUSPA Systems Tendons 15-0.6", 19-0.6" and 22-0.6" with K Couplers and MA Anchorages; 40t of External Prestressing Steel Tendons EX-66, Type SUSPA Systems and 3t of Type 36 WR and 40 WR DYWIDAG Post-Tensioning Bars

DSI supplies Strand Tendons for Poland's largest Sugar Producer

With a domestic market share of approx. 40%, Polski Cukier is the largest sugar producer in Poland. In 2010, Polski Cukier awarded a contract to Chemadex S.A., an experienced general contractor for turn-key industrial buildings, for the construction of a new silo.

The new tank under construction in a sugar factory in Naklo nad Notecia in the northern half of Poland is 34.1m high (excluding the control tower). The silo has 0.32m thick concrete walls, an internal diameter of 45m and a capacity of 50,000t of sugar.

Post-tensioning of the silo began after three weeks of concreting using climbing framework. DSI supplied the Bonded SUSPA Strand System for post-tensioning.

6-7 SUSPA Strand Tendons were used from the foundation up to a height of 19.13m. 6-4 SUSPA Strand Tendons were installed starting at a height of 19.13m up to the upper rim of the silo. On the whole, DSI supplied more than 72t of St1860, \varnothing 15.7mm Strand Tendons as well as 176 MA 6-7 Anchorages and 116 MA 6-4 Anchorages. Post-Tensioning was carried out from April 2010 to May 2011.

Thanks to the excellent co-operation with the general contractor, DSI Poland has already signed a contract for another silo project that will be built in August 2011.



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Owner Polski Cukier S.A., Poland
General Contractor Chemadex S. A., Poland
Architect Chemadex S. A., Poland

DSI Units DYWIDAG-Systems International Sp. z o.o., Poland;
 DYWIDAG-Systems International GmbH, BU Post-Tensioning, Germany

DSI Scope Supply, installation, post-tensioning and grouting of 72t of SUSPA Systems Strand Tendons, St1860, \varnothing 15.7mm, with MA Anchorages

Prefabricated Tendons accelerate Construction Progress on Wroclaw's new Ring Road

Wroclaw's city center has been adversely affected by ever increasing traffic volumes. In order to relieve congestion on the arterial roads in the city, Poland's road construction authority decided to build a new, 35.4km long section of A8 with two lanes in each direction.

On a 26km long section, the new motorway will run through Wroclaw's north-western outskirts, diverting transit traffic around the city.

Due to its importance both for the city itself and for the infrastructure of the entire region, this project was declared the most important investment for Wroclaw until 2012. The construction of the ring road is divided into three sections.

In co-operation with DSI Germany, Nauen, DSI Poland participated in the construction of the largest of these sections. Among other things, this section consists of two motorway bridges: The 370m long WA-20 and the 1,597m long WA-22A.

Prefabricated Type SUSPA Systems Tendons were installed in the superstructures of both bridges using a movable scaffolding system. On the whole, DSI supplied more than 2,000t of Prefabricated Strand Tendons with K Couplers and 7-0.6", 9-0.6", 12-0.6" and 19-0.6" MA Anchorages.

Thanks to the use of prefabricated tendons that were preassembled in the factory and supplied to the site coiled on drums, the tendons could be installed easily and quickly into the 38m long bridge segments of motorway WA-22A in only six days. The DSI scope included the production, supply, installation, tensioning and grouting of the tendons.



Uncoiling of Prefabricated Tendons and Installation in the Formwork



Prefabricated Type SUSPA Systems Tendons on a Drum



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Owner GDDKiA (road construction authority), Poland

General Contractor JV, lead by STRABAG Sp. z o.o., Poland; Partners: DYWIDAG Bau GmbH, Germany; Heilit+Woerner Budowlana Sp. z o.o., Poland

Contractor DYWIDAG Bau GmbH, Germany

Architect JV, lead by: Profil Sp. z o.o., Partner: BBKS-Projekt Sp. z o.o., Mosty Wroclaw S.C., Mosty Katowice Sp. z o.o., all of them Poland

Design BBKS-Projekt sp. z o.o., Mosty Katowice sp. z o.o., Mostopol sp. z o.o., all of them Poland; Stähler und Knoppik, Leonhard, André und Partner, Kinkel + Partner GmbH, all of them Germany

DSI Units DYWIDAG-Systems International Sp. z o.o., Poland;

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

DSI Scope Supply of more than 2.000t of Prefabricated SUSPA Systems Tendons with K Couplers and 7-0.6", 9-0.6", 12-0.6" and 19-0.6" MA Anchorages

Extending Europe's Energy Supply: stabilize LNG Tanks

The seaport of Sagunto, located approx. 30km north of the city of Valencia, has grown to be one of the most important Spanish ports for the importation of liquid natural gas (LNG) into Spain. In line with the political goals of the European Union, Sagunto's LNG plant contributes significantly to the expansion and diversification of Europe's energy supply.

The first two LNG tanks were built between 2003 and 2005. Planning and construction of the third LNG tank was begun shortly after the two first tanks had been completed. Construction work on the fourth LNG tank began in 2008 and was successfully completed in June 2011. The LNG plant in Sagunto has a capacity of approx. 600.000 m³.

All four of the tanks were constructed by the UTE Ampliación Regasagunto joint venture consisting of



DYWIDAG Post-Tensioning Systems

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Construction

EMEA

Spain

Tanks

Cobra, Sener – Spain, Toyo Kanetsu KK – Japan and DYWIDAG International GmbH – Germany. As was the case during the construction of the previous tanks, DYWIDAG-Sistemas Constructivos (DSC) was awarded the contract for producing, supplying and installing all of the post-tensioning systems.

Each tank has a height of approx. 52m. The inner diameter measures 74m, and the wall thickness varies between 60cm and 120cm. Like the previous tanks, the fourth tank was also post-tensioned using 19-0.62" DYWIDAG Strand Tendons with Multiplane Anchorages. 12 horizontal DYWIDAG Strand Tendons were installed in the floor slab, 178 tendons were installed in the exterior wall and 18 tendons were used in the ring beam.

The bottom slab was circumferentially post-tensioned with tendons anchored in 6 buttresses rotated by 60 degrees. In the ring beam and in the outside wall, the DYWIDAG Strand Tendons were anchored in 4 buttresses placed at 90° centers. Vertical post-tensioning was accomplished by 80 U-shaped 9-0.62" DYWIDAG Strand Tendons.

This Post-Tensioning System, also known as a loop tendon system, consists of two vertical tendons that are connected by an 180° arc at their bottom ends and anchored by MA-Anchorage in the ring beam at their top ends. The 650t of DYWIDAG Strand Tendons that were supplied for the fourth tank complied with EN-14620 requirements regarding cryogenic applications.

Additionally, DSC supplied Ø25, 28 and 32mm GEWI® Post-Tensioning Bars with accessories such as couplers and nuts for cryogenic and standard applications. The tensioning bars were used as splices in the construction joints and in the assembly access openings that had to be closed following installation.

In total, DSC supplied the following products for all four tanks:

- 640 anchorages for DYWIDAG Strand Tendons with 9 strands, Ø 0.62"
- 1,664 anchorages for DYWIDAG Strand Tendons with 19 strands, Ø 0.62"
- 28,500m of Ø 80mm galvanized and corrugated duct
- 102,332m of Ø 100mm galvanized and corrugated duct
- 122,850m of GEWI® Bars (Ø25, 28 and 32mm)
- 4,240 GEWI® Couplers
- 8,480 GEWI® Lock Nuts



Material supply for the fourth tank started at the end of 2009, and installation work began in April 2010. The placing, tensioning and injection of all tendons – excluding those located at the assembly access openings of the tanks – was successfully completed with only two teams in less than five months.



Owner SAGGAS, Spain

General Contractor JV UTE Ampliación Regasagunto, Spain, consisting of: Cobra, Sener, all of them Spain, Toyo Kanetsu KK, Japan and DYWIDAG International GmbH, Germany

Consulting Engineers DYWIDAG International GmbH, Germany

DSI Unit DYWIDAG Sistemas Constructivos S.A., Spain

DSC Scope Supply and installation of 650t of Ø 0.62" DYWIDAG Strand Tendons with 9 and 19 strands, GEWI® Bars and accessories, rental of equipment

DYNA Grip® Stay Cables carry new Landmark of the Andalusian Town of Albox



The town of Albox in Almería, southern Spain, now features a new landmark: A stay cable bridge crossing over the Rambla, a mostly dry river bed.

The new bridge has a length of 112m, a width of 13.5m and spans of 23+64+24m. The bridge deck is supported by a total of 11 stay cables that are anchored to a 27m high pylon.

Five stay cables are attached to the front of the pylon, and six stay cables are grouped in pairs at the back of the pylon. All of the stays are inside HDPE ducts.

DSC produced and supplied DYNA Grip® Stay Cables for this project. All in all, five Type DG-P 31, four Type DG-P 37 and two Type DG-P 55 Stay Cables were installed. The Y 1860 S7, 0.62" strands that were used for the stay cables were galvanized, waxed and sheathed.

DSC also supplied eight 27-0.6" DYWIDAG Tendons for prestressing the bridge deck. DSC installed all of the stays and tendons using an experienced team. The DYNA Grip® Stay Cables were stressed using the patented Conten system. Thanks to the red color of the stay cable ducts, Albox's new bridge is visible from afar as the town's new landmark.



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Owner Albox County, Spain
General Contractor Detea, Spain
Consulting Engineers ACL Estructuras, Spain

DSI Unit DYWIDAG Sistemas Constructivos S.A., Spain
DSC Scope Supply and installation of 11 Type DG-P 31, 37 and 55 DYNA Grip® Stay Cables as well as of eight 27-0.6" DYWIDAG Tendons

New Stay Cable Bridges in Toledo Increase Mobility

Recently, two new, aesthetically pleasing pedestrian bridges were built in the city of Toledo in Spain. Buenavista Bridge links the district of Buenavista with a new urban development around the Beatriz Hotel, and Benquerencia Bridge connects a residential area and an industrial area. Both bridges cross two very busy ring roads.

Despite their completely different geometries, both pedestrian bridges were built using the same construction method. In both cases, the stay cables were installed using an innovative system that did not require the use of a crane. The stays, which had previously been assembled to their total length on site, were raised with the help of an auxiliary steel rope and a winch. Thanks to this method, the traffic on the ring roads beneath the bridges was not obstructed.

The coupled \varnothing 30-56mm DYWIDAG Structural Bars that were used as stay cables are hot dip galvanized and between 30 and 80m long. In order to make the bridges look elegant and modern, the DYWIDAG Structural Bars are lead through white HDPE ducts. The stay cables were installed and stressed in only 2 weeks on both bridges, with work carried out at night.

In addition to the stay cables, DSC also supplied \varnothing 25mm and \varnothing 32mm GEWI® Bars that ensure a stable connection of the bridge pylons with the foundation. Thanks to efficient work cycles, both bridges were successfully completed within a mere five months from February to June 2011.



Owner Toledo County, Spain
General Contractor Sogeosa S.A., Spain
Consulting Engineers Estudio A.I.A., Spain

DSI Unit DYWIDAG Sistemas Constructivos S.A., Spain

DSC Scope Supply and installation of \varnothing 30-56mm DYWIDAG Structural Bar Stays and of \varnothing 25mm and \varnothing 32mm GEWI® Bars



Underwater Post-Tensioning: Al Khalij Power Plant

EMEA

Libya

Hydro- &
Marine
Structures

As Libya's only energy supplier, the state-run company **GECOL (General Electricity Company of Libya)** generates electrical power for the entire country. Since Libya's energy demand is steadily increasing, a new steam power plant is being built 20km west of the town of Surt. The **Al Khalij Power Plant** consists of four conventional steam turbines with an output of 350MW each that are fired with natural gas and oil. The power plant is cooled with sea water.

Four pipelines with intake heads were built in order to feed seawater into the plant for cooling purposes. The pipelines consist of GRP (glass fiber reinforced polyester), and the intake heads consist of reinforced and prestressed concrete. The intake heads are located at a depth of 25m on the sea floor approx. 800 m offshore. The intake heads consist of three parts weighing 50, 113 and 131t respectively that were prestressed using 72 vertical DYWIDAG Post-Tensioning Bars and grouted.

The preparation of the tensioning work included the supply of a 110 Mp tensioning jack as well as special equipment for underwater use. In order to protect the post-tensioning bars from corrosion, the ducts were rinsed with fresh water and sediments and salt water were removed before grouting.

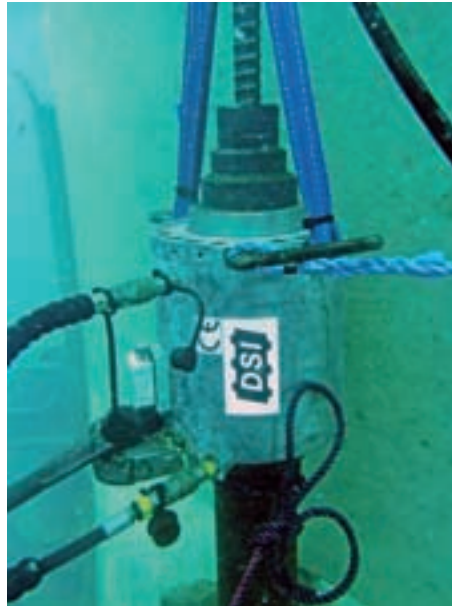
A DSI technician supervised the stressing and grouting operations from a barge on the surface. The divers received the technician's instructions via video and microphone transmission. The tensioning work was successfully completed between July 2010 and the beginning of 2011 according to construction progress.

The unusual working conditions turned this project into a challenge that could be mastered without any problems thanks to the special solution supplied by DSI France.

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Owner General Electricity Company of Libya (GECOL), Libya
General Contractor Geoccean, France
Engineers Bechtel Corporation, Libya

DSI Unit DSI-Artéon SAS, France
DSI Scope Supply, installation, tensioning and grouting of 72 Ø 32mm vertical DYWIDAG Post-Tensioning Bars



Abu Dhabi: Construction of a Bridge from Ras Ghomies to Gaga Island using DYWIDAG Post-Tensioning Systems

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Construction

EMEA

UAE

Bridges



A new bridge is currently being built near the Saudi Arabian border in the United Arab Emirates.

The structure is 520m long and will provide a quick overland connection from Ras Ghomies to Gaga Island.

The bridge has two 3.65m wide traffic lanes, two 2m long hard shoulders and two 1m wide sidewalks. In addition, the 14.3m wide bridge deck is framed by 0.5m wide precast concrete barriers. The 13 spans of the bridge include a total of 104 precast girders with two 27-0.6" strand post-tensioning tendons. The precast T-girders are 39.50m, 39.70m and 40.00m long, 1.90m high and 0.70m wide.

Used for the first time in the United Arab Emirates, plastic ducts with a total length of 8,500m were supplied by DSI. The thick walled PP ducts offer permanent additional corrosion

protection and are especially suitable for use in coastal areas that are subject to aggressive salt water. Thus, the ducts also offer optimum corrosion protection for the tendons in the new bridge.

In addition to the ducts, DSI supplied a total of 416 27-0.6" MA Anchorages as well as the equipment necessary for stressing and grouting. Installation of the post tensioning system was done completely by IGS, DSI's partner company in UAE. Post-Tensioning was completed in May 2011, and the bridge was opened to traffic in July 2011.



Owner DOT - Department of Transportation Abu Dhabi, UAE

Consulting DIWI Consult Emirates, UAE

General Contractor Ghantoot Transport & General Contracting Establishment, UAE

Subcontractor Towers Technology Contracting Co. LLC, UAE

Post-Tensioning Work IGS-Italian Gulf Specialist Contracting LLC., UAE; DYWIDAG-Systems International GmbH, Headquarter Operations, Germany

DSI Unit DYWIDAG-Systems International GmbH, Headquarter Operations, Germany

DSI Scope Supply of 8,500m of PP ducts and 416 27-0.6" MA Anchorages; rental of equipment

DYWIDAG Strand Anchors allow unobstructed Travel on Canada's Highway 63

Canadian Highway 63 crosses the province of Alberta from North to South, through the Athabasca oil sands region near Fort McMurray. Due to the growing oil sand industry, the two lane road had become increasingly overloaded and was expanded by the addition of two lanes in 2006.

In one of the sections of Highway 63 that runs through one of Canada's largest mining areas, long term slope movement was identified. As a result, the owner decided to carry out slope stabilization measures simultaneously with the widening of the section.

During the geotechnical analysis, a deep failure zone was detected on both sides of the highway that had to be stabilized using permanent anchor walls. Due to the steep drop off of the slope, the owner decided to use Double Corrosion Protected (DCP) DYWIDAG Strand Anchors as proposed by DSI. In fact, the installation and coupling of strand

anchors in steep terrain is safer than the installation of bar anchors.

DSI had especially adapted the strand anchors to the extreme weather conditions and also supported the contractor during the onsite tests carried out on the anchors. DSI supplied load cells for the tests to collect the data necessary for fine tuning the anchor forces.

The anchors had to be bonded through three different overburden zones into the prevailing limestone. Since soil conditions along the complete anchor wall were non homogeneous, and the limestone in the soil varied in elevation by up to 7m, it was very difficult to accurately predetermine anchor lengths. Due to the depth of the failure zone, especially long anchors with free lengths ranging from 16 to 31m had to be used.

Initially, the strand anchors were installed at the east side of the Highway.





Photos reprinted courtesy of Beck Drilling & Environmental Services Ltd., Canada

Afterwards, the drilling and installation work was carried out at the three rows of soil anchors on the western wall. All in all, 578 4-0.6" and 12-0.6" DCP DYWIDAG Strand Anchors were installed, tested and tensioned using jacks provided by DSI. The anchors were installed into $\varnothing 225\text{mm}$ boreholes and had design loads ranging from 630kN to 1,180kN. In order to provide additional corrosion protection, the ground anchors were post grouted and fitted with anchor caps at the upper ends.

Despite the difficult access and the fact that work had to be carried out in unfavorable weather conditions during the winter season of 2010/2011, the contractor was able to successfully complete the installation of the ground anchors.



Owner Alberta Ministry of Transportation, Canada

General Contractor Graham Construction, Canada

Contractor Beck Drilling & Environmental Services Ltd., Canada

Subcontractor Beck Drilling & Environmental Services Ltd., Canada

Consulting Engineers Thurber Engineering Ltd., Canada

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

DSI Scope Supply of 578 4-0.6" and 12-0.6" DCP DYWIDAG Strand Anchors, load cells and equipment; technical assistance on site

Fort Edmonton, Canada: First Cable Suspension Bridge stabilized using DYWIDAG Systems

North America

Canada

Bridges

In June 2011, the first cable suspension bridge was opened in the Canadian city of Edmonton, Alberta.

The bridge is located at the south-west corner of Historic Fort Edmonton's park and is part of the city's Ribbon of Green Project. The project's aim is to make the meadows and woods in the river valley accessible to the public.



Construction of the 246m long pedestrian bridge began in August 2008. The bridge has a center span of 138m and features a unique conceptual design with viewing platforms at each pier. It utilizes only two piers that are positioned in the river bed at distances of approx. 30 to 40m from the banks. The piers were built in this manner in order to minimize their impact on nature.

As the upper layers of soil in the river bed did not have enough load-bearing capacity to accommodate the expected loads, the foundations of both bridge piers in the river bed were designed as deep foundations. For this purpose, reinforced concrete caissons were embedded and filled in the river bed at a depth of approx. 12.5m. The dynamic loads of the structure are transferred into the soil above the caissons.

Subsequently, the two piers were erected on the foundations using reinforced concrete up to the height of the bridge deck. The deck was built using the segmental construction method with 3m long reinforced precast concrete panels that were longitudinally tensioned using strand tendons.



Due to the changing weather conditions, it was not possible to use large cranes in the middle of the river to place the precast segments. Consequently, the segments were put in place using temporary post-tensioning tendons across the main span on which a trolley system was used to transport the segments from shore to their final locations.

Above the bridge deck, the two piers consist of divided steel pylons leaning towards each other. At the top of the pylons, two post-tensioned concreted pier caps are located which the two main suspension cables run over. The two main suspension cables run parallel to the bridge deck, accommodate the loads of the vertical hangers and carry the tensile force of the bridge deck. The two main cables are tied back into separate anchor blocks located on shore.

DSI Canada supplied DYWIDAG Bar Anchors, \varnothing 36mm, for the abutments. In addition, DSI supplied and installed all of the post-tensioning systems. This included 12-0.6" to 27-0.6" DYWIDAG Strand Tendons in the bridge deck, DYWIDAG Bar Tendons, \varnothing 36mm for the concreted pier caps and DYWIDAG Bar Tendons, \varnothing 46mm for the anchor blocks at the ends of the main cables.

Thanks to the help and advice of experienced DSI engineers, the Canadian construction team was able to master the unusual challenge without any problems.



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Owner City of Edmonton, Canada
Contractor Alberco Construction Ltd., Canada
Consulting Engineers CH2M HILL, Canada

DSI Unit DYWIDAG-Systems International Canada Ltd., Eastern Division, Canada
DSI Scope Supply of DYWIDAG Bar Anchors, \varnothing 36 mm, DYWIDAG Strand Post-Tensioning Tendons, 12-0.6" to 27-0.6" and of DYWIDAG Bar Tendons, \varnothing 36 and 46mm

DSI supplies DYWIDAG Micropiles for new Wastewater Treatment Plant in Windsor

As is typical in many older Canadian cities, the City of Windsor in south-western Ontario is serviced by a combined sewer system. In this system, a mixture of wastewater and storm water is carried to the treatment plant through a single pipe.

During major storms and heavy rainfall, the pipe system was not able to carry all of the wastewater, and the excess untreated water was directly discharged into the Detroit River.

In order to improve the water quality of the river, a new retention treatment basin for wastewater was built in Windsor. The project included the following structures:

- an underground tank to hold and treat wastewater
- a new collection sewer
- a mechanical building on the river's embankment

The site's location posed some difficulties due to the high water table and weak soft clays that extended to a depth of approximately 30m with highly fractured bedrock underneath.

The foundation of the retention basin had to be designed for the expected pressure loads when filled and for the expected buoyancy forces caused by ground water when empty. The original design specified a deep foundation using screw piles.



However, the piles could not have been produced and supplied on time due to the tight schedule. Consequently, micropiles were chosen in order to save time and cost.

The floor slab was anchored with a total of 155 DYWIDAG Micropiles. The micropiles consisted of \varnothing 57mm DYWIDAG THREADBAR[®] with additional \varnothing 36 mm DYWIDAG Bar Tendons in the bond zone. In total, 5,000m of \varnothing 57mm DYWIDAG THREADBAR[®] and 800m of \varnothing 36 mm DYWIDAG THREADBAR[®] were supplied to the site.

Each DYWIDAG Micropile was designed to carry a design load of

1,920kN in compression and 1,080kN in tension. The load bearing capacity of the DYWIDAG Micropiles was continuously confirmed throughout the project by proof tests. In addition to the micropiles, DSI supplied the complete range of accessories including tensioning jacks as well as the testing equipment.



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Owner City of Windsor, Canada
Contractor EBS Engineering and Construction Limited, Canada
General Contractor PCR Contractors, Canada
Consulting Engineers Stantec, Canada
Engineers Pretium Anderson Waterloo Inc., Canada

DSI Unit DYWIDAG-Systems International Canada Ltd., Eastern Division, Canada
DSI Scope Supply of 5,000m of \varnothing 57mm DYWIDAG THREADBAR[®] and 800m of \varnothing 36mm DYWIDAG THREADBAR[®] with accessories and testing equipment

DSI supplies *GEWI*® Tie Rods for Modern Harbor in the Dominican Republic



Caucedo Harbor near Santo Domingo in the Dominican Republic was opened in 2003 and is one of the most important transit harbors in the region.

The deep water harbor handles both national and international container transportation. At water depths of 13.5 to 15m, the modern harbor can both accommodate RoRo (Roll-On/Roll-Off) traffic and Panamax vessels.

In order to enhance productivity and throughput, Caucedo Multimodal Port just completed phase II of a significant expansion project. Within the scope of the expansion, a new 300m long quay was built which has been stabilized using *GEWI*® Tie Rods.

DSI supplied approx. 2,900m of Ø 63mm *GEWI*® Bars including accessories and clevis anchorages for this project. In addition, cold rolled Ø 75mm DYWIDAG bars with accessories and clevis anchorages were used for the expansion.





The bars were corrosion protected on site using the Denso system by first coating them with Denso paste and then wrapping with greased Densyl tape and Denso Utility isolating tape.

The tie rods were successfully installed from December 2009 to November 2010.

Owner ZFMC (Caucedo Investments) & DP World, Dominican Republic

General Contractor Misener Marine Construction, Inc., USA

Consulting Mouchel Consulting Limited UK, Great Britain

Engineers Lloyd Engineering Inc., USA

DSI Unit DYWIDAG-Systems International USA Inc.,

BU Geotechnics, USA

DSI Scope Supply of approx. 2,900m (9500ft.) of GEWI® Bars, Clevis Anchorages, Tie Rod Accessories



DYNA Grip® Stay Cables relieve Junction in Aguascalientes

North America

Mexico

Bridges

Arch Bridges are often used because of their simple and economic design and are particularly important in Latin America. Due to these advantages, the city of Aguascalientes in central Mexico, which is known for its thermal springs, now includes a new arch bridge.

The new structure is now an efficient access to the city center from the south and relieves one of the most traffic congested junctions in Aguascalientes.

The 700m long bridge leads across José María Chávez Street and consists of an arch structure that supports the roadway with post-tensioned stay cables. In its end section, the bridge was constructed as a traditional bridge resting on columns. The bridge has a maximum incline of 6.5% and employs two lanes on a bridge deck that is 16m wide.

For the two parallel arches with a main span of 150m, DSI supplied a total of 34 galvanized, waxed and PE-coated Type DG-P 19 DYNA Grip® Stay Cables with a total weight of 16t.

Falsework was utilized for the main span of the bridge deck as well as the steel box arch beams in order to stabilize the bridge construction during assembly. Afterwards, the stay cables were individually installed into anchorages located in the steel box girder arch and connected to the steel box girders supporting the bridge deck.



The DYNA Grip® Stay Cables were then anchored and post-tensioned inside the hollow box girder at the anchorage blocks.

The assembly of the stay cables and the tensioning work proved to be difficult because temperatures inside the box girder reached 55°C (130 F). Stressing was accomplished by tensioning individual strands inside the girder using the patented Conten System.



Owner Municipality of Aguascalientes, Mexico
General Contractor Constructora San Marcos S.A. de C.V., Mexico
Architect Constructora San Marcos S.A. de C.V., Mexico
Engineering Ingeniera Sigma, S.A., Mexico

DSI Unit DYWIDAG-Systems International USA Inc., BU Post-Tensioning, West, USA
DSI Scope Supply and installation of 34 Type DG-P 19 DYNA Grip® Stay Cables

Permanent DYWIDAG Strand Anchors for Changuinola Dam

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Construction

North America

Panama

Hydro- &
Marine
Structures



The country of Panama is rapidly developing its economy, requiring ever increasing amounts of electrical power. The new Changuinola Dam, built on the Changuinola River in the northern part of the country, has a capacity of 223 Megawatts or 1,046 GMH energy generation per year, increasing the country's electrical energy generating capacity by 50%. The dam owner is AES, a local subsidiary of the US based company.

Built on roller compacted concrete, the arch dam has a height of 99.2m, a length of 600m and a reservoir level located 165m above sea level.

The left dam abutment was characterized by weak rock that could collapse during reservoir water accumulation. The design engineer decided to stabilize that side by placing a reinforced concrete block tied down to good rock by 43 restressable 12-0.6" DYWIDAG Strand Anchors with double

corrosion protection. Twenty four of these anchors which ranged in length up to 40m had two DYNA Force® sensors installed on their unbonded lengths to monitor anchor loading during the proof test, when water was rising inside the reservoir and during the life of the structure. DSI also provided an anchor uncoiler, a stressing jack assembly and technical assistance for proof testing and anchor load readings.

Readings taken during the filling of the reservoir and building pressure on the dam remained within normal limits, which provided a good indication that the anchors had been installed correctly. The combination of the DYNA Force® Sensor readings and anchor restressability provides the capacity to adjust the load at any time during the life of the structure.

Work on the dam began in October 2007 and was finished in the first quarter of 2011.

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Owner AES Changuinola S.A., Panama

General Contractor Changuinola Civil Works Joint Venture CCWJV, consisting of: E. Pihl & Søn A.S. and MT Højgaard A/S, Denmark; Alstom GmbH, Germany

Anchor Designer MD & G Engineers, South Africa

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

DSI Scope Supply of 43 restressable, double corrosion protected (DCP) 12-0.6" DYWIDAG Strand Anchors as well as 48 DYNA Force® Sensors, equipment and technical assistance

DSI supplies DYWIDAG Tendons for Testing Center

Wind energy is the fastest growing renewable energy industry worldwide. In order to gear the energy mix of the United States more strongly towards the use of wind energy in the future, the Department of Energy decided to build a new testing center in 2007: the Wind Technology Testing Center (WTTC).

WTTC is located in Boston and is the first facility in the United States that can test up to 90m (295ft) long wind turbine blades. The new testing center is of great importance for the research activities of the American wind industry because, until now, turbine blades longer than 50m (164ft) had to be tested in Europe. The facility can accommodate the simultaneous testing of up to three turbine blades according to different criteria such as static loads, fatigue resistance, material properties or quality. Construction work at the WTTC started in October 2009 and was completed in the first quarter of 2011.

The 32 x 12.7m wide and 3.00m (105ft x 41.75ft x 10ft) thick footing was designed to fulfill extremely high requirements. Consequently, 19-0.6" DYWIDAG Strand Tendons were installed longitudinally and transversally and tensioned in addition to the usual mild steel reinforcement. In total, 208 DYWIDAG Strand Tendons were installed in four layers. DSI USA supplied approx. 74,000m (242,595lf) of \varnothing 15mm (0.6") strand and 3,800m (12,400lf) of galvanized \varnothing 100mm (4") duct for this purpose.

Additionally, high strength \varnothing 46mm DYWIDAG Bars were used to strengthen the massive walls of the test stands. DSI USA supplied approx. 110t of post-tensioning bars, 569 anchorages and approx. 6,924m (22,715lf) of \varnothing 65mm (2.5") galvanized duct.

In addition, DSI USA produced and supplied 159 \varnothing 46mm strong floor anchors to serve as future anchor tie-down points in the laboratory during the tests. For a continuous monitoring of the loads during operation, DSI also supplied 25 DYNA Force® Sensors with a readout unit.

Since the bar tendons will be subject to millions of stress cycles during the tests of turbine blades, the DYWIDAG Bar Tendons had to undergo a rigorous dynamic testing program. Nowhere in the United States has this diameter and type of high strength bar been tested to the extent they were tested for the construction of the WTTC. Only after the successful completion of the rigorous testing program could the DYWIDAG Bar Tendons be used for this exceptional project.



Photos reprinted courtesy of LeMessurier Consultants, Inc., USA



USA's largest Wind Technology

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Construction

North America

USA

Commercial
Buildings



Following the owner's guidelines and working closely with the Engineer of Record, DSI USA Engineering developed the test plans, set-up protocol, QA/QC guidelines and managed the testing program through its successful completion. In summary, nine different tests with differing loads, stress amplitudes and numbers of cycles were carried out. The longest test was 10 million cycles at a 1,000kN (240kip) mean load with a stress amplitude of +/- 20N/mm² (+/-3.1ksi).



Owner Massachusetts Port Authority and Massachusetts Clean Energy Technology Center, both USA

General Contractor Turner Construction Company, USA

Architect Architerra Inc., USA

Consulting Engineers LeMessurier Consultants, Inc., USA

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

DSI Scope Supply of 208 19-0.6" DYWIDAG Strand Post-Tensioning Tendons, 110t Ø 46mm DYWIDAG Bar Tendons and 25 DYNA Force® Sensors; rental of equipment

Profitability through Innovation: Structural Repair of George N. Wade Memorial Bridge

North America

USA

Bridges

The 6 lane wide George N. Wade Memorial Bridge over Susquehanna River is an important element of Interstate 81 in Harrisburg, Pennsylvania, USA. The structure is 1,581m (approx. 5,188ft) long and was built between the end of the 60's and the beginning of the 70's.

Within the framework of its comprehensive inspection program, the Pennsylvania Department of Transportation (PennDOT) determined that the reinforcement in the pier caps was no longer able to handle the current traffic load of approx. 32,000 vehicles per day. PennDOT contracted the construction company J.D. Eckman Inc. to carry out comprehensive repair and retrofit of the bridge substructure.

The as-advertised contract documents called for external post-tensioning using ten \varnothing 36mm, GR150 external double corrosion protected (DCP)

post-tensioning tendons per pier cap. At the outer side of each of the pier caps, five tendons were to be installed in order to supplement the existing eight post-tensioning bars that had been installed for reinforcement years ago.

DSI presented a technically proven alternative to the general contractor that only required six \varnothing 46mm, GR150 DCP DYWIDAG Tendons per pier cap. The special solution provided a significant reduction in material and labor costs for the contractor, and ultimately the Owner, PennDOT.

The DSI design included a re-designed end anchorage which facilitated installation. DSI designed rolled (radius bent) steel end cap anchorages that were installed at the ends of the pier caps. Since these anchors are curved, yet the pier caps ends are flat, the space between was filled with an engineered self-consolidating concrete mix to provide proper bearing capacity for the larger diameter bars.

In addition, DSI installed DYNA Force® Sensors on the tendons in order to ensure efficient and reliable long-term monitoring, in place of the as-advertised conventional load cells. The DYNA Force® Sensors allow for force monitoring of the post-tensioning bars at any point of time with the help of a readout box that captures the data. This technology is far superior to traditional load cell tests and also eliminates the need for lift-off testing, which can be cumbersome and expensive.

The repair and retrofit of the pier caps started in autumn 2010. DSI experts first installed and stressed DCP DYWIDAG Tendons on the 34 pier caps accommodating the northbound lanes of traffic. Afterwards, the bar tendons on the southbound lane pier caps were installed and stressed. Repair and strengthening of the piers will be completed in the fall of 2011.



External DCP Pier Cap Strengthening



External DCP Bars with DYNA Force® Sensors



Owner Pennsylvania DOT, USA
General Contractor JD Eckman, Inc., USA

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

DSI Scope Supply and installation of 204 Double Corrosion Protected DYWIDAG-Bar Tendons, \varnothing 46mm and DYNA Force® Sensors; design of end anchorages

Repair of a Water Retention Vault in Chicago

During the construction of a big-box store in the suburbs of Chicago, USA, a water retention vault underneath the parking lot was damaged. The retention system was built according to environmental regulations as a cast in place concrete vault and has a size of approx. 51.2m x 115.8m x 0.76m (168' x 380' x 2.5').

After the vault and parking lot above had been completed, a company performing directional boring accidentally damaged the vault. The exterior vault wall was penetrated by the boring equipment creating a hole, which allowed for further damage to the interior walls.

The contractor engaged DSI to develop a comprehensive plan to repair the damage. An integral component of the repair was the development of an access plan to ensure safe working conditions in such a confined space.

The plan included the very important component of implementation of a temporary air moving system to bring in fresh air along with proper equipment for continuous air monitoring. A special challenge during the execution of the repair work was posed by the limited chamber height of only 0.76m (2.5') and by limited access to the vault.

The damaged vault was holding up the certificate of occupancy for the store. Consequently, the rapid implementation of the repair was of paramount importance and this was treated as an emergency project with the requirement of a very quick response time.

Thanks to excellent planning, this project was completed safely, on time, on budget and with the highest degree of quality.



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Client Novak Construction, USA
General Contractor Novak Construction, USA
Contractor Novak Construction, USA

DSI Unit DYWIDAG-Systems International USA Inc., Structural Repair, USA
DSI Scope Development and implementation of repair and access plan



Memorial Wall at Ground Zero inaugurated September 11th 2011

North America

USA

Excavation

11 Ten years after the terrorist attack on September 11 2001 that caused the collapse of the Twin Towers in New York, work at Ground Zero is still in full swing. Apart from several office towers, a museum is being built underneath the foundations of the destroyed skyscrapers to commemorate the attack.

The area's signature building is an office tower that has been renamed from Freedom Tower to One World Trade Center. With its height of 1.776ft (541.32m), which stands for the year of the Declaration of Independence, the tower will be the highest skyscraper in Manhattan after its completion.

DSI supplied strand anchors for stabilizing the excavations shortly after the attack. DSI USA also supplied DYWIDAG Bar Tendons and Reinforcement Systems for the construction of One World Trade Center.

The FDNY Memorial Wall, located opposite Ground Zero, has already been completed and was dedicated by the American president on September 11 2011. The wall is dedicated to the 343 firefighters of the Fire Department New York who lost their lives during the rescue work.

For stabilizing and tying back the FDNY Memorial Wall, DSI USA supplied 183 epoxy coated, Double Corrosion Protected (DCP) \varnothing 66mm DYWIDAG Bar Anchors in lengths of 15.5 – 34.4m (51 -113ft) with a total weight of 177t as well as 183 anchorages.



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Owner WTCMF - World Trade Center Memorial Foundation, USA

General Contractor E.E. Cruz / Nicholson Construction Company, JV, USA

Architect Handel Architects LLP, Davis Brody Bond, LLP (Associate Architect), both USA

Consulting Engineers Mueser Rutledge Consulting Engineers, USA

Engineering WSP Cantor Seinuk, USA

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

DSI Scope Supply of 183 epoxy coated DCP \varnothing 66mm DYWIDAG Bar Anchors and Anchorages

DYWIDAG Strand Anchors Stabilize Residential Area in the Central Coast Region of California

In the city of Santa Barbara, a large slope stabilization project was carried out to secure a residential area nestled above Sycamore Canyon Road (Highway 154) and to protect the Highway. The \$50 million Sycamore Ranchito Project was divided into seven construction phases to stabilize a sliding hill side.

Seven anchor walls of various heights with integrated drainage systems were constructed. The walls consist of either shotcrete with DCP strand anchors or concrete piles (shear pins) that were tied back with DCP strand anchors spaced at distances of approx. 1.5m (4.9ft). The majority of the strand anchors consisted of nine 0.6" dia. strands and were tested to a load of 1,846kN (415kips) after installation and locked off at a load of 1,388kN (312kips).

The first construction phase included the installation of several hundred DYWIDAG Strand Anchors into an approx. 7.6m (24.9ft) high reinforced shotcrete wall at the top of the slope to arrest the upslope expansion.

The second phase involved the rebuilding of the streets in the upper section. Reinforced \varnothing 91-122cm (3-4ft) concrete shear pins were anchored at depths of approx. 12-35m (39.4-114.8ft) and tied back using 30.5m- 61.0m (100-200ft) long DYWIDAG Strand Anchors. In the southern section, a reinforced shotcrete retaining wall was built and backfilled to decrease the slope gradient.

Within the scope of the third section, the beginning land slide between two other roads had to be stopped. For this purpose, a row of reinforced concrete shear pins were connected to a horizontal tie-beam and tied back using permanent DCP strand anchors.

The sixth phase, which had to be carried out before the fourth and fifth phase, included the stabilization of an active landslide movement in the upper area. The landslide was successfully stopped by installing another concrete shear pin tieback system.

The same system was used for the fourth and fifth construction phases to protect the lower roads from the active



landslide movement. The seventh and last construction phase included the repair and re-opening of the streets in the area as well as landscaping.

Thanks to these measures, the landslide threatening the residential area and the road below was stopped. DSI USA supplied a total of 1,100 permanent 3, 6 and 9 strand DYWIDAG Strand Anchors in lengths of approx. 19.8m - 68.6m (65ft-225ft) as well as the necessary stressing equipment.



Owner Landslide Repair Foundation, USA

General Contractor Condon-Johnson & Associates, USA

Consulting Engineers Cotton, Shires & Associates, Inc., USA

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

DSI Scope Supply of 1,100 permanent DYWIDAG Strand Anchors with 3, 6 and 9 strands; rental of stressing equipment

Permanent DYWIDAG Anchors with DYNA Force® Sensors at new San Francisco General Hospital and Trauma Center

San Francisco General Hospital, the region's central trauma center, required an additional facility that had to be built in accordance with the State of California's current earthquake standards. According to state law, emergency hospitals must be designed and built to remain operational even after a major earthquake.

A new nine story building is under construction between the existing hospital buildings. Two floors of the new structure are located underground and the Trauma Center will be linked to the old complex by a tunnel and a bridge.

150 double corrosion protected (DCP) Ø 46mm DYWIDAG THREADBAR® Anchors were used to tie down the mat foundation to the bedrock with base isolators. The retaining wall built around the excavation required the use of 1,050 permanent double corrosion protected (DCP) Ø 32, 36 and 46mm DYWIDAG THREADBAR® Anchors.

The shoring engineers decided to add 11 DYNA Force® Sensors spread around the wall to the anchors in order to monitor the wall's movement during construction. The sensors were factory installed over the threadbars in the unbonded length and inside the PVC protection sheathing. The sensors were also used to monitor load during cycles loading of the proof or performance test and remained functional during the remaining wall construction as excavation progressed. As expected, the wall movement was insignificant, and the sensors proved themselves as a reliable load monitoring system.

Construction of San Francisco General Hospital began in 2010 and is scheduled for completion in 2015.



Owner The City and County of San Francisco, CA, USA

General Contractor Webcor Builders, USA

Architects Fong & Chan Architects, USA

Shoring Engineer SOHA Engineers, USA

Retaining Wall and Tiedown subcontractor Malcolm Drilling Co., Inc., USA

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

DSI Scope Supply of 1,200 permanent, double corrosion protected (DCP) Ø 32, 36 and 46mm DYWIDAG THREADBAR® Anchors and 11 DYNA Force® Sensors

DYWIDAG Anchor Systems for Retaining Walls of the Sepulveda Pass, I-405 Project, Los Angeles

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Construction

North America

USA

Slope
Stabilization

Interstate 405 is one of the principal highways in Southern California. Heavily traveled by commuters, I-405 has earned its place as one of the busiest freeways in the United States. The Sepulveda Pass section of I-405 serves hundreds of thousands of commuters between major urban centers of the Greater Los Angeles area.

A construction project on this section included adding a High Occupancy Vehicle Lane (HOV) or carpool lane for vehicles carrying more than one person, realigning existing on and off ramps, replacing and constructing a new bridge and several ramp structures, building approximately 29km (18miles) of retaining or sound walls and carrying out road improvements.

The California Department of Transportation (CALTRANS) and the Los Angeles Metropolitan Transportation Authority (Metro) jointly developed this project.

The retaining walls were designed and built by Drill Tech Drilling & Shoring, Inc. and incorporated permanent soil nails along the cut-off of the hills as well as permanent strand tieback walls along Sepulveda Boulevard that were part of the widening project.

Hundreds of Double Corrosion Protected (DCP) DYWIDAG Soil Nails and 500 Permanent 5-0.6" and 7-0.6" DCP DYWIDAG Strand Tieback Anchors were supplied for this project. The City of Los Angeles has requirements for load monitoring of the permanent tieback anchors, and the elasto magnetic DYNA Force® Sensor was the right choice to perform this function.

48 sensors were factory installed over individual strands on the stressing length, inside the corrugated sheathing. They were distributed at different heights of the two tieback wall locations and their lead wires conducted through the anchorage for easy connection to the readout box. They were used for additional load control during the performance/proof test and lock-off load transfer procedure. The walls were more than 350m long, and the lead wires are conducted along the wall length to a main control water-proof cabinet where



multiplexer, modem and batteries are installed together with the readout box. The modem can send daily readings to a remote office location over the internet during the life of the anchor.

The DYNA Force® Sensor System is very easy to install and use, providing a reliable and accurate method to monitor the load of a strand or bar anchor.

Construction work at this major project began in the spring of 2009 and is scheduled for completion in the spring of 2013.

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Owner California Department of Transportation (CALTRANS) Los Angeles Metropolitan Transportation Authority (Metro)

General Contractor Kiewit Pacific Company, USA

Retaining Walls Subcontractor Drill Tech Drilling and Shoring, Inc., USA

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

DSI Scope Supply of Double Corrosion Protected (DCP) DYWIDAG Soil Nails, 500 Permanent 5-0.6" and 7-0.6" DCP DYWIDAG Strand Tieback Anchors and of 48 DYNA Force® Strand Sensors; technical equipment

Comprehensive Strengthening of Roanoke Rapids Dam using DYWIDAG Strand Anchors and DYNA Force® Sensors

Roanoke Rapids Dam is located near the town of Roanoke Rapids in North Carolina, not far from the border with Virginia. The approx. 930m long dam with 24 radial gates and a maximum height of approx. 22m has been operational since 1955. The power plant adjacent to the dam includes four propeller type turbines generating up to 104MW.

Since 1985, the dam has been regularly tested for seepage, pressures acting on the foundation and deformation. From 2006 to 2008, a two-phased investigative program was carried out that included piezometric measurements, load measurements and core hole drilling through the dam into the foundation.

The investigations showed that a long-term alkali-silica reaction (ASR) had lead to an expansion of the concrete and a deterioration of the mortar fraction. In addition, a crack that was up to 2.5cm wide was detected in the dam. The safest and most efficient solution for the comprehensive strengthening of the dam was to grout the crack and install rock anchors across the crack plane.

As calculations indicated that the crack would keep widening in the future, the decision was made to use restressable anchors. This allows for the future adaptation of the anchors to the crack development and to possible ASR alterations. Consequently, the anchors were designed with sufficient free lengths to adjust their load at any time in the future. To repair the dam, DSI USA supplied epoxy coated 30-0.6" DYWIDAG Strand Anchors with re-stressable anchorages for future load adjustment. Their length was between 30m and 40.5m.

In addition, DSI USA supplied 15 elasto magnetic DYNA Force® Sensors that were factory placed over individual strands of five anchors. Three DYNA Force® Sensors were installed per anchor. They were used as an additional load control during the performance/ proof test and lock-off load transfer procedure and for future anchor load monitoring during the life of the structure.



The DYNA Force® Sensor System is very easy to install and use, allowing a reliable and accurate load monitoring of the strand or bar anchor.



Owner Dominion North Carolina Power, USA

General Contractor Brayman Construction Corporation, USA

Engineers HDR/DTA, Inc., USA

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

DSI Scope Supply of restressable, epoxy coated 30-0.6" DYWIDAG Strand Anchors and of 15 DYNA Force® Sensors

Olmos Dam Rehabilitation using Permanent DYWIDAG Strand Anchors, Texas

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Construction

North America

USA

Hydro- &
Marine
Structures



Stressing 20 Strand DYWIDAG Anchors with Tensa 6,800 Jack



Alignment and Stressing of Six Strand DYWIDAG Anchors



Wedge Plate for Restressable 20 Strand DYWIDAG Anchors

Olmos Dam was built in 1928 on Olmos Creek after the city of San Antonio, Texas, USA experienced a major flood disaster during which much of the city was flooded and many people lost their lives.

The dam accumulates and controls water diversion from the entire San Antonio River basin. The straight, concrete gravity dam is about 610m (2,000ft) long, and its crest reaches 17m (58ft) high in some places including 6m (20ft) foundation depth.

A major dam rehabilitation program had to be implemented in order to prevent damage during maximum overflow. This included the installation of 68 Permanent DYWIDAG Tie Down Anchors with six or twenty \varnothing 15.2mm high strength strands with double corrosion protection (DCP) into the bedrock. The dam's spillway was also increased to better handle future inundations.

DSI Long Beach, CA, plant fabricated the anchors with attached grout tubes and wedge plates and supplied them separately from the 1.5mm thick corrugated HDPE anchor sheathing. A very skilled and experienced contractor built a special mobile platform placed on the dam that was able to support and carry the drilling, grouting and stressing equipment along the narrow dam crest. Thus, the contractor was able to drill efficiently, passing strict water pressure tests of the drilled hole and corrugated sheathing. Partly, drilling and anchor installation had to be carried out in very tight spaces.

Strand anchors were inserted inside the corrugated sheathing and lowered into the drilled hole using an uncoiler provided by DSI. Some of the anchorages incorporated load cells for permanent load monitoring. The wedge plates placed over the strands had an external

heavy duty thread allowing for anchor re-stressability and load adjustment if necessary. Performance and proof testing operations were carried out successfully with DYWIDAG jacks supported by special stressing chairs.

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Owner Bexar County, USA
General Contractor Archer Western Contractors Ltd, USA
Geotechnical Contractor (Anchor Installation) The Judy Company Inc., USA
Design Engineer Freese and Nichols, Inc, USA

DSI Unit DYWIDAG-Systems International USA Inc., BU Geotechnics, USA
DSI Scope Supply of 68 DCP DYWIDAG Strand Anchors incl. accessories; rental of equipment

DSI supplies Post-Tensioning Systems for one of the World's longest Self-Anchored Pedestrian Suspension Bridges



In 2011, one of the world's longest self-anchored suspension bridges was built in San Diego, California: The Harbor Drive Pedestrian Bridge.

The 168m long bridge links the Petco Park baseball stadium with the San Diego Convention Center and permits a safe crossing of the multi-lane Harbor Drive as well as several railroad tracks.

The curved structure with a main span of 107.9m (354ft) includes an approx. 40m high pylon that is post-tensioned with DYWIDAG Strand Tendons. Since the pylon features a 60° incline, it had to be tied back using two stay cables. The back stays consist of waxed and PE sheathed 43-0.6" DYWIDAG Strand Cables that were individually stressed using the Conten stressing system and then grouted.

The main suspension cables consist of waxed and PE sheathed 37-0.6" DYWIDAG Strand Cables inside articulated stainless steel pipe segments. These cables extend upward from each abutment to the pylon tip. The main cables were stressed at the abutments with a multi-strand jack and then grouted. To resist unbalanced torsion due to the eccentric hanger supports, lateral forces

acting about 1m above the deck were generated by stressing a 37-0.6" DYWIDAG Tendon that was placed inside a curved heavy wall stainless steel pipe that also acted as part of the bridge railing.

The slender, cast-in-place concrete deck consists of a 1m deep by 3m wide box girder and a 3m overhang slab on one side. It is supported by 34 stainless steel hangers suspended from the main cables. 12-0.6" and 19-0.6" DYWIDAG Strand Tendons with MA Anchorages were used for the longitudinal post-tensioning of the bridge deck.

The extremely complex geometry and extensive use of stainless steel created multiple challenges throughout the design and erection of the cables and the construction of the bridge. DYNA Force® Sensors were necessary during construction in order to monitor loads in the foundation tie-downs, main cables and the back stays throughout the construction process.

Owner City of San Diego, USA
Architect Safdie Rabines Architects, USA
General Contractor Reyes Construction, Inc., USA
Engineers T.Y. Lin International, USA

DSI Unit DYWIDAG-Systems International USA Inc.,
 BU Post-Tensioning, West, USA
DSI Scope Supply, installation, tensioning and grouting of 12-0.6", 19-0.6", 37-0.6", 37-0.62" and 43-0.6" DYWIDAG Strand Tendons incl. anchorages and accessories; DYNA Force® Sensors for load monitoring



DYWIDAG Post-Tensioning Systems Secure tallest Hotel on Guam Island

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Construction

North America

USA/Guam

Commercial Buildings



Experienced DYWIDAG and UTRACON technicians supervised construction work around the clock, installed all tendons and ensured the proper implementation of the sub-contracted works within the given time frame.



Guam is the southernmost and largest island in the Mariana Islands chain in the Western Pacific Ocean and also the largest island in Micronesia. Guam, a US territory, has a population of approx. 175,000. The island's main source of income is tourism, and it is especially popular with Japanese tourists.

The island's main tourist hub, Tumon Bay, features elegant shops and restaurants as well as 21 hotels – including the new Bayview Beach Hotel, which is currently being built and centrally located on the waterfront.

The Project, a five star hotel with 388 rooms and 10 luxurious suites, has a total floor area of approximately 70,000m². The multi-level parking garage provides space for 780 vehicles and will be the largest parking garage in Guam after its completion. The hotel itself is 30 stories tall and has won an award for being the tallest building ever built on the Island.

A joint venture consisting of DYWIDAG and UTRACON was assigned the design, supply and installation of the Bonded DYWIDAG Post-Tensioning Systems for the parking garage and hotel towers. All in all, the joint venture supplied approx. 240t of DYWIDAG 0.6" strand tendons.

The frame construction of the parking garage and the hotel's flat floor slabs were post-tensioned using DYWIDAG Strand Tendons and FA Flat Anchorages. In addition, DYWIDAG Strand Post-Tensioning Systems with Type MA Anchorages were installed in the hotel's beams.

Construction of the Bayview Beach Hotel began in April 2010 and is scheduled for completion in April 2012.

The Owner was very satisfied with the DYWIDAG Post-Tensioning Systems and their advantages and has expressed the intention of using the systems on future projects.



Owner Tanota Partners, Guam, USA
Contractor Inland Builders Corporation, Guam, USA
Subcontractor JV, consisting of DYWIDAG Co. Ltd., Taiwan and UTRACON Structural Systems Pte Ltd, Singapore
Architect O.A. Coloma, P.C. / Dededo, Guam, USA
Consulting Engineers GK2 Inc. Consulting Engineers, Guam, USA

DSI Units DYWIDAG Co. Ltd., Taiwan and UTRACON Structural Systems Pte Ltd, Singapore
DSI Scope Development, supervision, supply and installation of approx. 240t of DYWIDAG Tendons with FA and MA Anchorages

Permanent DYWIDAG Anchors Stabilize

South America

Brazil

Slope
Stabilization

Since the construction of Tancredo Neves International Airport in the city of Confins near Belo Horizonte, Brazil, State Highway MG-010 has been of vital importance for the entire federal state of Minas Gerais.

Consequently, in 2005, the government of Minas Gerais launched the “Linha Verde” project, which will create a modern link between the airport and the city of Belo Horizonte. Since then, extensive construction work has been carried out on the MG-010 Highway.

The construction of a significant retaining wall was part of the project. The wall is located in a section that will improve traffic access to Belo Horizonte and thus also to the administrative district and the new state government building of Minas Gerais.

Excavation for the retaining wall was carried out in alternating sections in order to ensure the stability of the slope. The wall is 245m long and has a total area of 2,050m². The anchors needed for the structure were installed from the top down before applying shotcrete.



Connection to Tancredo Neves Airport

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Construction

South America

Brazil

Slope
Stabilization



For the construction of the retaining wall, Protendidos DYWIDAG supplied approx. 5,000m \varnothing 32mm DYWIDAG Post-Tensioning Bars. A total of 321 permanent St 85/105, double corrosion protected (DCP) DYWIDAG Anchors in lengths between 10 and 18m and with a maximum working load of 350kN were installed in the wall. Construction work on the retaining wall started in January 2010 and was successfully completed in June 2010.

Owner Federal government of Minas Gerais (Governo do Estado de Minas Gerais), Brazil
Contractor Progeo Engenharia Ltda., Brazil
Engineers Progeo Engenharia Ltda., Brazil
Design Engesolo Engenharia Ltda., Brazil

DSI Unit Protendidos DYWIDAG Ltda., Brazil
DSI Scope Supply of 321 permanent DYWIDAG Bar Anchors, \varnothing 32mm, St 85/105



DYWIDAG Bars stabilize Colombia's first Concrete Arch Bridge

South America

Colombia

Bridges



Since the end of 2011, the colonial city of Girón, north-east of Bogotá, can be reached via two new parallel arch bridges consisting of white concrete that are architecturally unique in Colombia and blend harmoniously with the historic townscape.

The Flandes Bridges are located in the province of Santander and replace a temporary bridge over Rio de Oro that was built following the collapse of the original bridge at that location. In addition, the Flandes Bridges are an important part of the motorway connection from Girón to the province's capital of Bucaramanga.

Both arch bridges have a clearance of 90m and each accommodates three traffic lanes and a pedestrian crossing. Due to limited space, the installation of the 36 transverse girders for the bridge

structures was especially difficult. In addition, the drilling work for the pile foundation of the bridge was obstructed by large rock formations in the soil.

DSI Peru supplied the hanger bars needed for both arch bridges. In total, 32 galvanized \varnothing 66mm, GR 150 DYWIDAG Bars in lengths of 7-20m were used as hangers for each bridge.

Included in the contract for the construction of the Flandes Bridge was the widening of the motorway to six lanes for a length of 800m in order to ensure a better connection with the province's capital of Bucaramanga. The section was opened to traffic at the end of 2011.

i

Owner Colombian Department of Transportation, Colombia
Client INCO (Instituto Nacional de Concesiones), Colombia
Contractor Autopistas de Santander S.A., Colombia
Engineering GRISA (Gregorio Rentería Ingenieros S.A.), Colombia
Specialized Subcontractor STUP de Colombia – Installation and tensioning of Threadbars

DSI Unit DSI Peru S.A.C., Peru
DSI Scope Supply of 64 galvanized \varnothing 66 mm, GR 150 DYWIDAG Bar Tendons

DYWIDAG Tendons for Stay Cable Bridge in Peru

Atumpampa Bridge in the department of San Martín in the North of Peru, built as part of an infrastructure project, is one of the country's first vehicular stay cable bridges.

The bridge has a main span of 84m, and the width of the bridge deck measures 7.20m. The stay cables were anchored both at the two inclined, 27m high, double pylons and on the bridge deck itself. The superstructure consists of two massive double T steel beams with varying camber that were reinforced with cross girders to support the 16cm thick concrete deck.

The stay cable anchorages were installed on the exterior steel T girders of the bridge deck. Afterwards, the 12 stay cables were aligned in pairs and installed and tensioned at the anchorages.

The stay cables consist of \varnothing 32mm DYWIDAG Bar Tendons. Both of the slanted pylons were additionally tied back at the abutments using 6 stay cables aligned in pairs on each side.

In addition, 16 \varnothing 36mm DYWIDAG Bar Tendons were installed and tensioned to serve as reinforcement in the horizontal cross girders and as bracing of the pylons.

Furthermore, transverse Double T steel girders were installed at distances of 4m to reinforce the bridge deck. The anchorages were then precisely installed at the anchorage points of the cross girders.

After their installation, the stay cables were tensioned using four hydraulic jacks, working simultaneously at each side of each of the pylons in order to transfer loads evenly. All in all, 24 pairs of stay cables were post-tensioned to accommodate the loads of the bridge deck. Tensioning of the 6 stay cables which were aligned in pairs to transfer loads into the direction of the abutment took place simultaneously. Once tensioning of the shorter stay cables had been completed, the longer stay cables leading towards the middle of the bridge deck were tensioned.

In order to ensure an easy replacement of stay cables in the future, metal ducts leading towards the anchorages were concreted into the pylons. As an additional protection against vandalism and for corrosion protection, the stay cables were inserted in HDPE ducts and post-grouted. The installation of all of the 40 bar tendons was successfully completed by Peruvian employees in a record time of two weeks.

DSI licensee SAMAYCA Ingenieros S.A.C. supplied the tendons and carried out the post-tensioning and grouting of the stay cables. In addition, SAMAYCA provided the detailed design for post-tensioning the stay cables. The stay cables were post-tensioned in June 2009, and the bridge was opened to traffic in August 2009.

Owner Proyecto Especial Huallaga Central y Bajo Mayo, Peru

Contractor General Servicio Industrial de la Marina del Perú S.A. (SIMA), Peru

Subcontractor SAMAYCA INGENIEROS S.A.C., Peru

Engineers Consultor Manuel Villoslada Trujillano, Peru

DSI Unit SAMAYCA INGENIEROS S.A.C., Peru / DSI Unit Central America and Caribbean / DYWIDAG-Systems International USA Inc., BU Post-Tensioning, East, USA

DSI Scope Supply of 212m \varnothing 36mm DYWIDAG Bars, 1,487m \varnothing 32mm DYWIDAG Bars and of accessories

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Fast Connections in Lima: DYWIDAG Bar Tendons Stabilize Arch Bridge

The Ejército Bridge in Lima, Peru, connects the northern districts with the city center and is used by approx. 5,000 vehicles per hour. Due to the high traffic load on all six lanes of this 50 year old structure, the standard queue time for crossing the bridge was approx. 30 to 40 minutes.

As a result, the Lima city council decided to expand the existing bridge by adding two new arch bridges. The new structures were built parallel to the old bridge on its left and right hand sides, increasing the six existing lanes to ten and considerably enhancing traffic flow.

The expansion of the bridge not only shortens driving times for transit traffic to merely two minutes, but also improves travel times for public transport because two of the lanes are exclusively used by city buses.

The two new bridges are 105.05m long and have bridge decks consisting of 200mm reinforced concrete deck slabs and accommodating two 3.5m wide lanes as well as a 1.2m wide pedestrian lane each.

The new structures are steel arch bridges with vertical stays consisting of two \varnothing 36mm DYWIDAG Bar Tendons each that are protected by HDPE tubes. The arches weigh approx. 360t and have a rectangular hollow box girder section and tubular steel cross bracing. During construction work, tower scaffolds were necessary to control the total weight of the arches in 19 different places of the bridges.

DSI Peru supplied 152 GR 150, \varnothing 36mm DYWIDAG Bar Tendons for the arches. The tendons were used for a total of 76 double vertical stay cables – known as hangers – that accommodate the total weight of the bridge deck. 19 hangers were assembled in each of the four bridge arches.

Construction work on the Ejército Bridge began in May 2010 and was completed in December 2010. Since then, the Ejército Bridge, which acts as a feeder for the Panamericana Highway System and for other important major streets in the city of Lima, has considerably improved the situation for Lima's transit traffic.





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Owner City council of Lima (Municipalidad Metropolitana de Lima), Peru

General Contractor Joint Venture COSEI, consisting of COSAPI Ingeniería y Construcción and EIVISAC Ingeniería y Construcción, both Peru

Subcontractor (Installation and Bar Post-Tensioning) Samayca Ingenieros, Peru

Engineers Barriga-Dall'Orto S.A. Ingenieros Consultores, Peru

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

DSI Scope Supply of 152 GR 150, \varnothing 36mm DYWIDAG Bar Tendons for 76 double hangers

Successful DYNA Grip® Fatigue Bending Tests

There are several types of vibrations that can occur in stay cables. Until effective dampening measures are installed, cable vibration can result in high amplitudes and large cable rotations at the anchorage zone. There is very little information about the degradation of the fatigue performance of stay cables that were loaded with severe fatigue bending.

The current design code EN 1993-1-11 requires that flexural effects be taken into consideration in the fatigue design for structures with tension components. Protective measures to minimize the bending stresses within the anchorage areas are to be employed and the actual configuration used should preferably be tested. However, there are no clear regulations on how this effectiveness should be demonstrated and how bending stresses should be limited. Furthermore, neither fib Bulletin 30 nor Setra recommendations provide any values for the limitation of bending stress.

1) DYNA Grip® 2 Million Cycle Fatigue Test at the Technical University of Denmark (DTU)

DTU has designed a new test setup for fatigue bending tests. A test setup with static inclination at the anchorage was chosen to simulate the strand deviation within a full size stay cable anchorage, taking bundling effects and static inclinations into consideration. Following the recommended test setup in fib Bulletin 30, an S-shaped profile was used. Transverse loading at the cable's mid span was created by a hydraulic actuator to simulate the angular deviation of the cable caused by cable vibration or structural deformation. A simplified model of the new test setup is shown in Fig. 1.

Two series of bending fatigue tests were performed on galvanized, waxed and PE-coated 0.62" 7-wire strands with an ultimate tensile strength of 1860MPa. A first test series was carried out with single strands and without any additional elements such as sealing plates or spacers to reduce the bending stresses (Fig. 2). In a second test series, an anchorage corresponding to the current design of the DSI DYNA Grip® System was used (Fig. 3). On the test rig, static inclination angles of up to 3.0° were created at the anchorage, and the single strand specimen was stressed to an axial force corresponding to 45%-60% of the guaranteed ultimate tensile strength (GUTS). After strand stressing and power seating of both wedges, the additional angular deviation was varied from +/- 10mrad to +/- 25mrad in fatigue tests with up to 2x10⁶ load cycles.

The test results were apparent. In the first test series with the simple anchorage that is normally used in Post-Tensioning applications, wire fractures occurred at a very early stage - mostly between 10.000 and 20.000 cycles. Fatigue failure typically occurred at the tip of the wedge.

This area is subject to the highest bending stresses and the strand is notched due to the wedge bite. More importantly, the single strand tests using the anchorage corresponding to the DYNA Grip® System easily passed the 2x10⁶ cycles without any wire breaks.

2) DYNA Grip® 10 Million Cycle Fatigue Test at DTU

Following the first test series, a 10x10⁶ cycle test was conducted on the DTU test rig using single strands fitted with a DYNA Grip® Anchorage including a sealing device without any interruption caused by failures. The static inclination angle of the bearing plates was 3.0°, axial force corresponded to 45% of the guaranteed ultimate tensile strength (GUTS), and the additional angular deviation was +/- 10mrad.

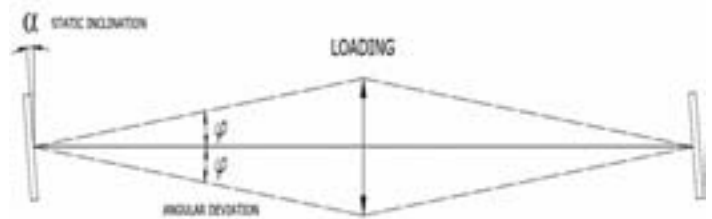


Fig. 1 Simplified Model of an S-shaped Setup with cyclic Midspan Deviation

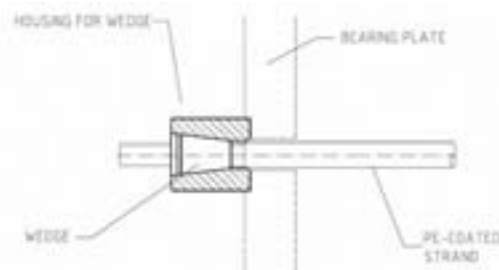


Fig. 2 Simple Monostrand Anchorage

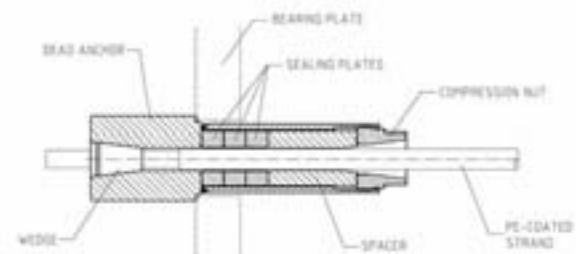


Fig. 3 DSI DYNA Grip® System: Monostrand Anchorage with Sealing and Bending Filter



Test Set-Up at DTU with Clamp

All the test results performed at the DTU show how the DYNA Grip® sealing device influences the fatigue behavior of 7-wire strands.

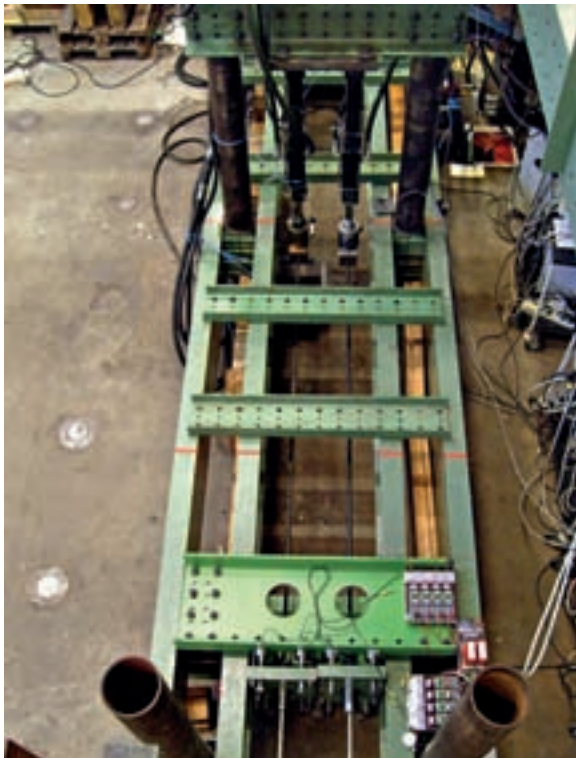
It has to be noted that tests without sealing device had to be stopped at a very early stage due to wire breaks. Strands with sealing devices did not show any problems at any time during the test. Moreover, the strands passed a much higher value of cycles. The tests showed that the sealing unit of the DYNA Grip® System, which consists of an HDPE spacer, sealing plates and a compression plate, is most effective in terms of preventing fatigue caused by bending. An additional guide deviator is unnecessary.

3) DYNA Grip® 10 Million Cycle Fatigue Test at the University of Vienna.

The Type DG P12 DYNA Grip® System was also tested in a new fatigue test facility at the University of Vienna. In contrast to common, hydraulically driven and energy-intensive testing systems, the new test rig uses the systems' eigenfrequency to reach a very high testing frequency with a low level of energy. For 10 million cycles, the attained test frequency of 20.6Hz lead to a testing time of only 5.6 days instead of the normally required 6 months.

The static inclination angle of the installed shim plates was 0.6° , and the cable specimen was stressed to an axial force corresponding to 45% of the guaranteed ultimate tensile strength (GUTS). The stress range between upper and lower load was 200N/mm^2 . The Type DG P12 DYNA Grip® System reached the 10 million cycles without any strand fracture or failure.

In summary, the tests showed that the DYNA Grip® System guarantees long term durability even when submitted to the influences of bending fatigue.



Test Set-Up TU Vienna



Hydraulic Cylinder with mounted Anchorage and Measuring Equipment

Special

Germany
Rwanda

In 2010, the German organization for Geotechnics DGGT celebrated a special anniversary – 60 years of DGGT. Since 1952, DGGT has organized the bi-annual Baugrundtagung, a Geotechnical conference and accompanying geotechnical exhibition.

The principal topics of the last conference, which was held in Munich from November 3rd to 6th 2010, were foundation engineering, soil mechanics, traffic route engineering, geothermal energy, geological engineering, research, development and innovation as well as international projects.

As part of the DSI Group, DSI Germany participated with its own booth at the Baugrundtagung. Products such as DYWIDAG Bar Anchor Systems, Strand Anchors and the GEWI® Pile System were presented to the interested expert public. Furthermore, DSI introduced new technical documentation for the DYWI® Drill Hollow Bar System that also includes the complete range of accessories and the equipment necessary for professional installation on site.

Due to the successful outcome of the event, DSI will also participate at the 32nd Baugrundtagung, which will be held from September 26th to 29th 2012.



DSI Employee actively contributes to Development Aid and Knowledge Transfer in Rwanda



The non-profit organisation Ingenieure ohne Grenzen e.V. (German for “engineers without borders”) offers technical engineering solutions, training and research in developing countries. Thanks to the organization’s decentralized structure, the commitment of many volunteer helpers can be efficiently combined in order to invest in infrastructure as well as water and energy supply projects.

As part of the aid organization’s work, a group of experts in bridge construction and civil engineering both advises regional groups in their activities and undertakes projects on its own. Among other endeavors, this group of experts has already built

two footbridges and one vehicle bridge in rural Rwanda and has held a bridge construction seminar at the technical university in Kigali, Rwanda. Project work is both done individually and in groups during meetings.

As a member of this group of experts, Stefan Wonhoefer, a DSI employee in Munich, has actively contributed to enhancing the infrastructure in Rwanda. Stefan took three weeks of vacation in September 2010 in order to work on different infrastructure projects with other volunteers in Rwanda. DSI supported his stay in Rwanda, during which he carried out maintenance work, by making a product donation. A new bridge project has already been planned for 2012, and bridge construction seminars will be held there on an annual basis.



Meeting Geotechnical Challenges in Brazil: The Prêmio DYWIDAG

For many years, DSI's Brazilian subsidiary Protendidos DYWIDAG has been a member of ABMS, the Brazilian association for ground stabilization techniques and geotechnical engineering. ABMS regularly organizes the COBRAMSEG, a geotechnical congress that aims at improving geotechnical practices in Brazil.

During COBRAMSEG 2010, ABMS cooperated with Protendidos DYWIDAG for a special award: The Prêmio DYWIDAG. Protendidos DYWIDAG awarded a prize to the participant who was able to best predict the load bearing behavior of DYWIDAG bars during a pile test. This particular load test is one of the major challenges the modern geotechnical industry faces, as it is still very difficult to predict interactions between the soil and structures.

Carmine Esposito, manager of Protendidos DYWIDAG, awarded Dirney Cury Filho, a university student at São Paulo's UNIP and an engineer in a geotechnical office, a notebook for his correct prediction of the pile test results. According to Carmine, the DYWIDAG award is "A way to thank ABMS for continuously promoting Brazil's engineering and the country's industry as a whole".



The Winner, Dirney Cury Filho, and Carmine Esposito, manager of Protendidos DYWIDAG



DSI Mining Canada Successfully Certified according to Environmental Management Norm ISO 14001-2004

Special

Canada
Finland



As a subsidiary of the DSI Group, DSI Mining Canada attaches great importance to environmentally friendly products and environmental protection. Within this context, continuous improvement processes that also include environmental issues are particularly important.

The international norm ISO 14001 defines globally acknowledged requirements for companies to promote environment protection. Among other things, these requirements include the definition of an internal environmental policy, an environmental program as well as a corresponding management system for achieving the defined goals.

In order to further reduce its ecological footprint, the DSI unit for Mining in Canada has now successfully implemented the globally recognized environmental program ISO 14001-2004.

DSI started implementing the ISO program in the second half of 2010 and received ISO 14001-2004 certification for its environmental management system in Sudbury in March 2011. Shortly afterwards, the new environmental system was also successfully implemented in the Saskatoon and Rouyn-Noranda divisions.

ITA-AITES World Tunnel Congress, Helsinki, Finland

May 21-26, 2011

More than 1,300 participants from approximately 50 countries met during this year's ITA-AITES World Tunnel Congress (WTC) in Helsinki from May 21st to 26th. In conjunction with the congress, the organizer held a trade show during which a total of 80 exhibitors presented new products and solutions to the interested expert public.

Once again, the WTC was an important international forum for DSI to present itself as a supplier of high quality products and systems to participants of the trade show. Under the brand name of ALWAG Systems, DSI distributes innovative products and systems for Tunneling and Mining. This brand enjoys an excellent reputation in international markets.

During the World Tunnel Congress, DSI was able to strengthen and intensify important contacts with international planners, engineers and universities as well as contractors from all over the world.

In accordance with the guideline **"Local Presence - Global Competence"**, DSI consistently orients itself to meet the

needs of its clients, offering them the advantages of a one stop shop provider with a product range that is adjusted to individual client requirements.

The next World Tunnel Congress will be held in Bangkok, Thailand from May 18th to the 23rd, 2012. DSI will also be represented with its own booth at this important international congress.



Guenther Volkmann and Rok Trotovek, DSI Austria



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