

**DYWIDAG-SYSTEMS  
INTERNATIONAL**



***DSI***  
***UNDERGROUND***



## Dear clients, business partners and employees,

it is a pleasure and an honor for us to present the 23<sup>rd</sup> edition of our DSI Info to you.

In **Underground**, with the acquisition of Jennmar's businesses in Europe and Latin America in February 2016 and the acquisition of 50% of Jennmar Jinning, now trading as Rocbolt Technologies Jinning, we have been able to successfully close **a series of acquisitions for DSI's Underground Division**. Over the past months, we concentrated on a successful integration of the new businesses and employees and have strategically realigned our organization by creating the two new Divisions, DSI Construction and DSI Underground. We would like to take this opportunity and welcome all new employees to our company.

These acquisitions are important milestones for us that sustainably strengthen our product

portfolio and service offering for our customers as well as strengthening DSI's presence **as a global market leader** in international Mining and Tunneling markets.

In **Construction**, our strategic aim is to grow organically in our core markets with innovative systems. Recent achievements include the development and patenting of fully removable anchor systems. This includes the QuickEx<sup>®</sup> System for DYWIDAG Strand Anchors with a new, patented end anchorage system that ensures the full removal of the strands. Simultaneously, we also developed a new temporary Bar Anchor with a fully removable steel tendon. Both removable anchor systems have been very successfully introduced in the market.

Another important project for our R&D departments was the development of a system

for the permanent monitoring of post-tensioning forces in bridges, dams, wind towers and buildings that are located in seismically active areas. For this purpose, we developed the DYNA Force<sup>®</sup> Sensor System that ensures a continuous, lifelong monitoring of post-tensioning forces in structures. The anchor forces can be transferred and evaluated manually, automatically and by remote control via wireless LAN.

In all these activities, you as our customers and business partners are always at the center of our plans and actions; so join us on what we hope will be an exciting and inspiring journey through this new edition of DSI Info.

Sincerely yours,

**Michael Reich**  
Group CEO DSI Underground



**Nick Moses**  
Acting Group CEO DSI Construction



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# DSI Construction – Always one Step ahead in Technology

DSI continuously invests in the development of special construction systems that are both innovative and sustainable. We proactively use the challenges that accompany Industry 4.0 brings with it as a chance in order to secure the sustainability of our company with new ideas and concepts.

05.2015

+++ Montreal, Canada +++

One of the largest infrastructure projects in the last 40 years starts in Quebec, Canada. Construction of the new, 3.4km long Champlain Stay Cable Bridge across the St Lawrence River, for which DSI supplies all stay cables.

12.2015

+++ Bolingbrook, USA +++

DYWIDAG-Systems International USA Inc. extends its strategic partnership with Gerdau Long Steel North America until 2022

11.2014

+++ Regente Feijó, Brazil +++

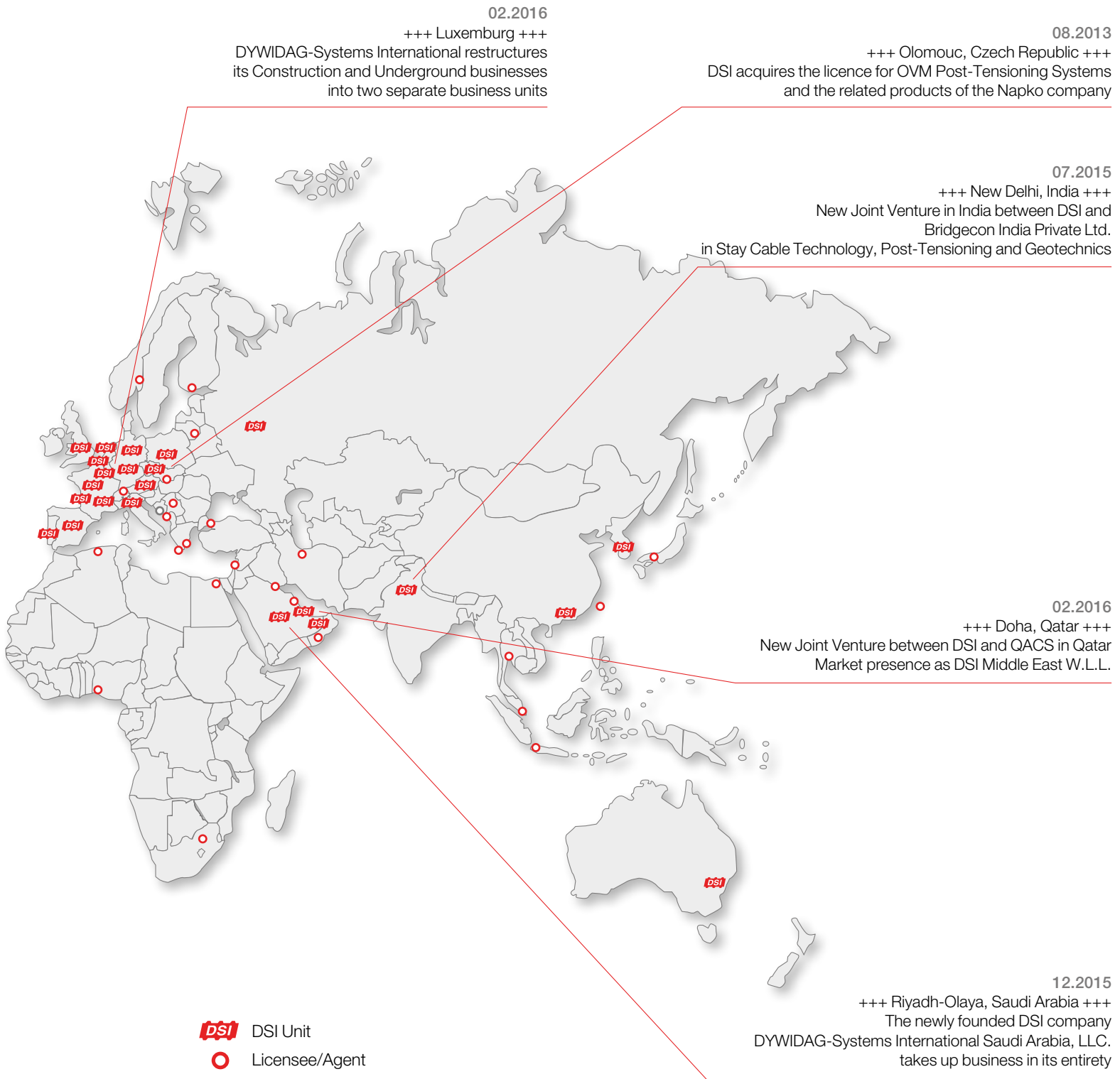
DSI acquires the Prepron company – a specialist for Post-Tensioning Systems in Brazil  
New market presence as DSI-Prepron

02.2016

+++ Sao Paulo, Brazil +++

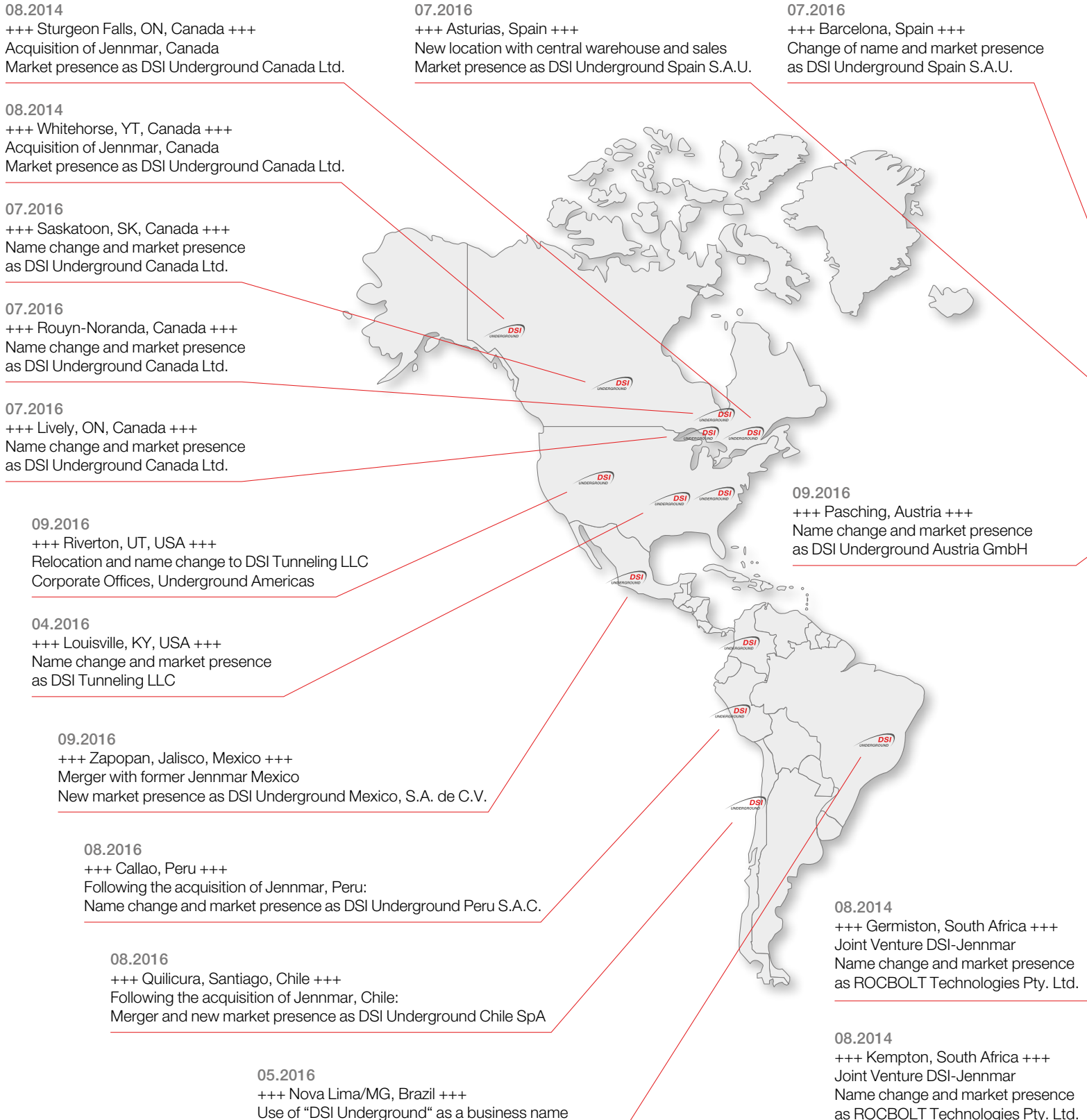
Protendidos DYWIDAG Ltda. and DSI extend their strategic partnership with Bardella S.A. Brazil until 2021

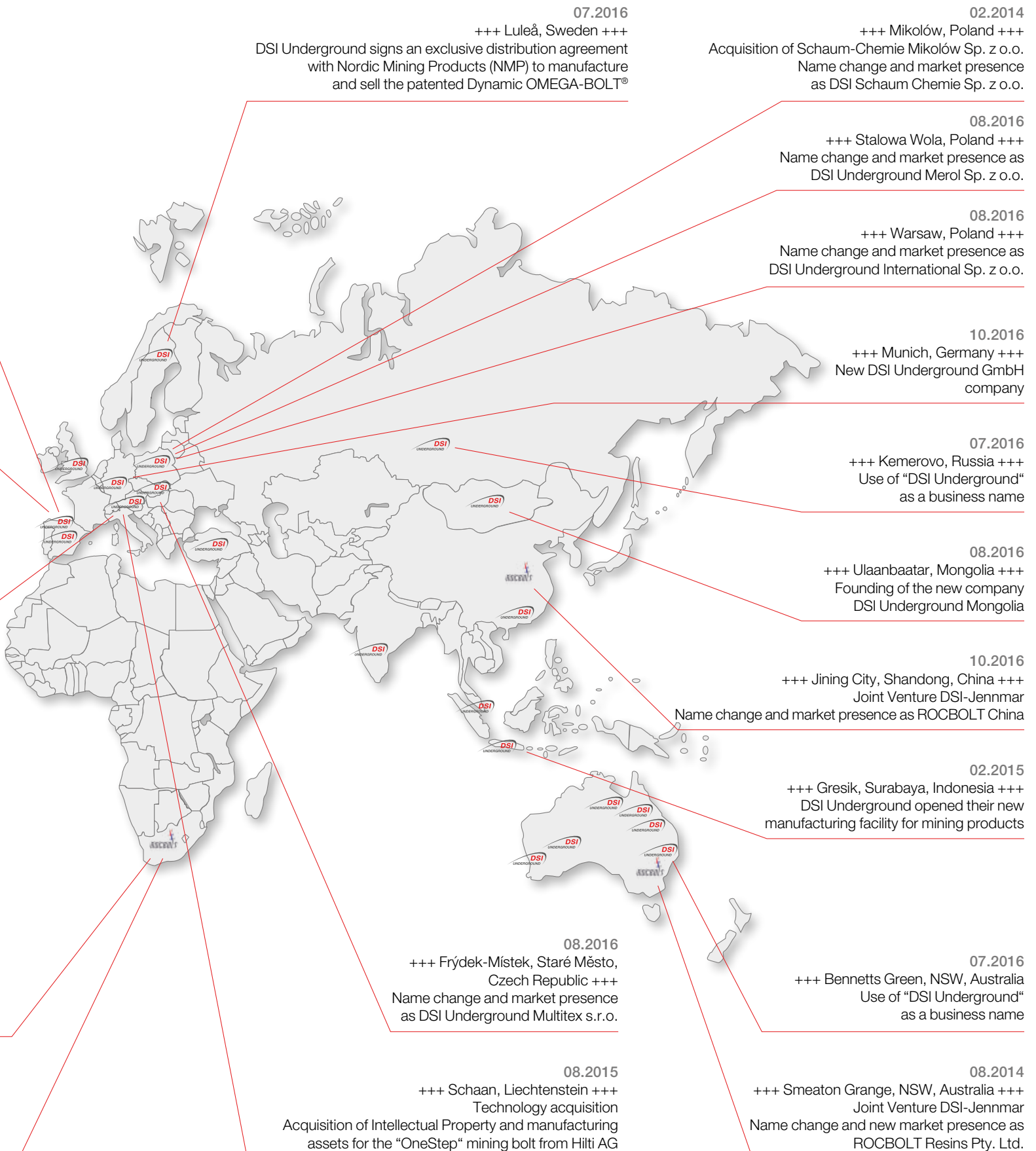




# DSI Underground has never been stronger

Early in 2016, DSI successfully completed the acquisition of Jennmar's international businesses. This was followed by a consolidation and a merger of the Jennmar businesses with the local DSI Underground units. Today, DSI Underground is as strong as never before and is focused on new target markets that will open up further growth opportunities.









***DSI***  
***UNDERGROUND***



## Special Grout for Rock Consolidation: DSI Australia supplies the Pajingo Gold Mine with DYWI® Grout

In December 2015, the Jandam 700 Grouted Sill Pillar Project commenced at the Pajingo Gold Mine. The mine, which is operated by Evolution Mining, is located in Queensland in northeastern Australia. For this project, the pillars that had been left to support the mined drifts underground had to be consolidated using grout in order to ensure the stability of the galleries and permit future excavation work.



After several months of negotiations, DSI Australia was awarded a contract for grout supply thanks to the professional proposal put forward by the Ground Consolidation Team. For this project, DSI supplied 200 x 1,200kg bulker bags of DYWI® HY Grout, which is a high yield, low strength product that can be mixed at different water to powder ratios, producing different yield factors.

DSI also assisted with the installation of the special grout and formed a Joint Venture with

Bolt Up Mining, who provided 4 employees (2 per shift) to carry out the work on site.

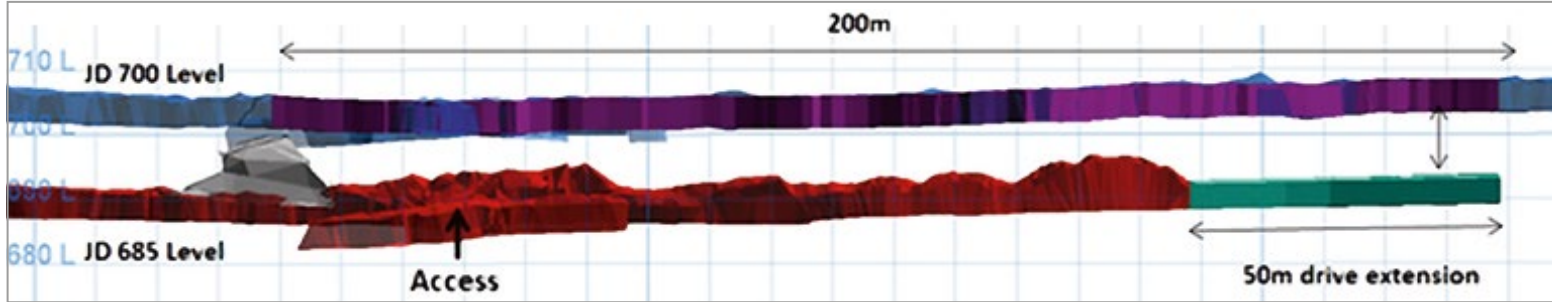
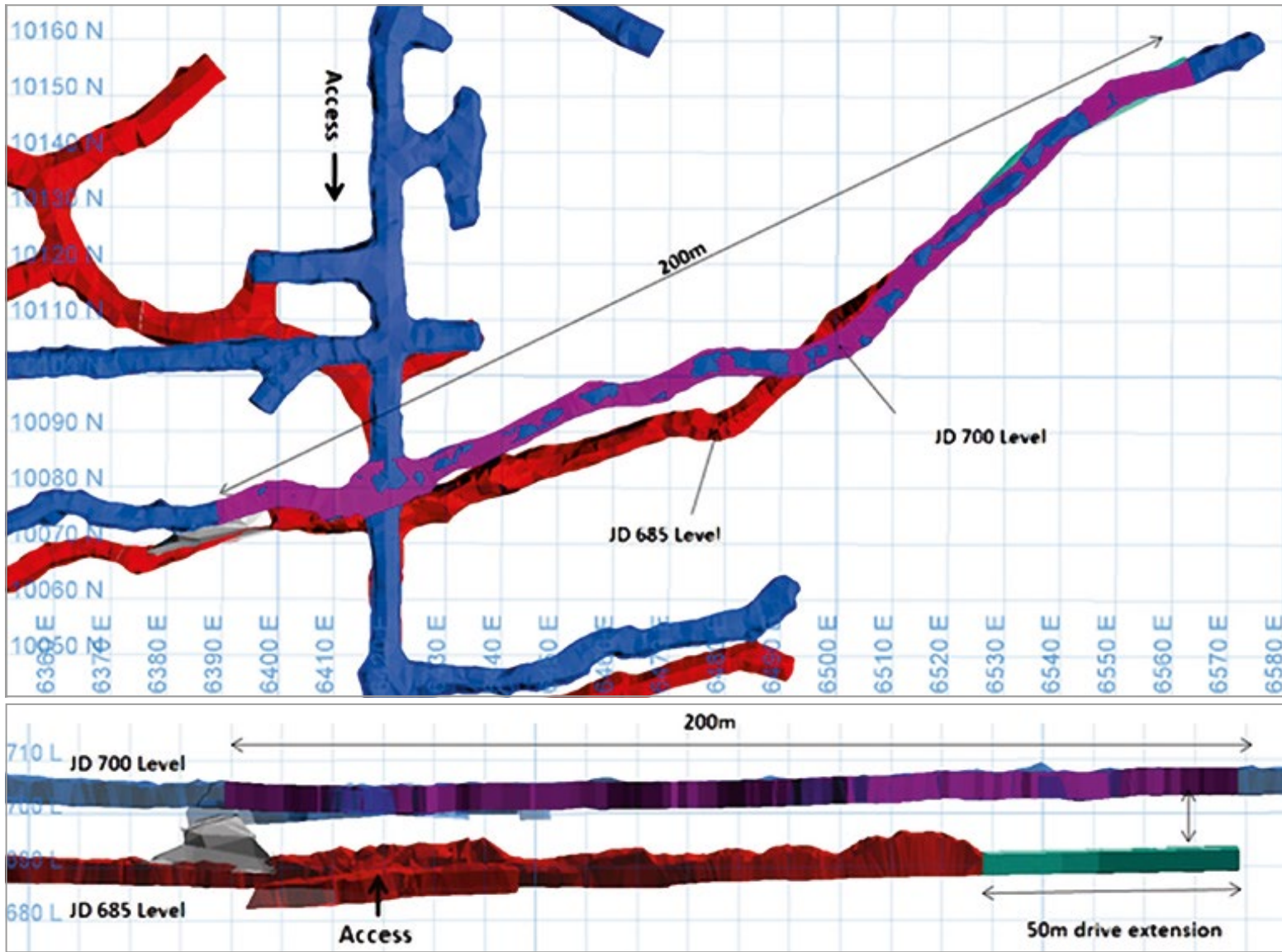
The plan was to grout the Jandam 700 pillar from below at the Jandam 685 level using the special grout. The process included drilling SDA rods from below through the roof and into the pillar to be consolidated. The lengths of the SDS hollow rods were extended to 10m using couplers. Afterwards, the DYWI® HY Grout was pumped up through the strata to percolate

down through the loose fill for consolidation and strengthening.

28 days later – after the complete curing strengths were achieved – the strata below was scaled out to recover an old high grade ore body.

This project is extremely relevant to DSI Australia due to the fact that it is the first large scale grout supply and application project for the company.





It therefore also demonstrates the widening of DSI's business activities in injection chemicals. In this area, DSI offers high quality special grouts and resins that are used for underground rock consolidation. The special grouts specifically designed for mining are produced in Australia and can be provided in 20kg and 1,200kg bags.

**Owner**  
 Evolution Mining Ltd, Australia  
**Contractor**  
 Bolt Up Mining Pty Ltd, Australia

**DSI Unit**  
 DYWIDAG-Systems International Pty. Ltd., Australia  
**DSI Scope**  
 Production, supply, application of the product  
**DSI Products**  
 240,000kg DYWI® HY Grout



## Delivering Ground Support Cost Efficiencies: The DSI-PEAK Resin Bolting System

In 2015, DSI Australia released the new DSI-PEAK Resin Bolting System to the underground coal mining market. This new system increases mining efficiency through improved ground stability without major changes to equipment or operational practices.



The DSI-PEAK System promotes the positive attributes of resin bolting methods while minimising potential technical deficiencies.

The system characteristics include: improved resin mixing reliability, reduced gloving, reduced resin pressures, robust pre-tensioning, reduced installation times,

high fracture toughness and the ability to re-tension the bolt after installation.

The system is a product of all its elements working in concert; that is, the resin matched to the bolt, the increased annulus and the plate size along with the un-encapsulated section of bolt to provide a solid beam in the

roof of the mine. Each piece of the bolting system is matched and therefore is sold only as a complete system. The feedback from all mines currently using the system has been positive without exception: They have seen considerable improvement in strata control, paired with benefits in operation efficiency and reductions in secondary support.





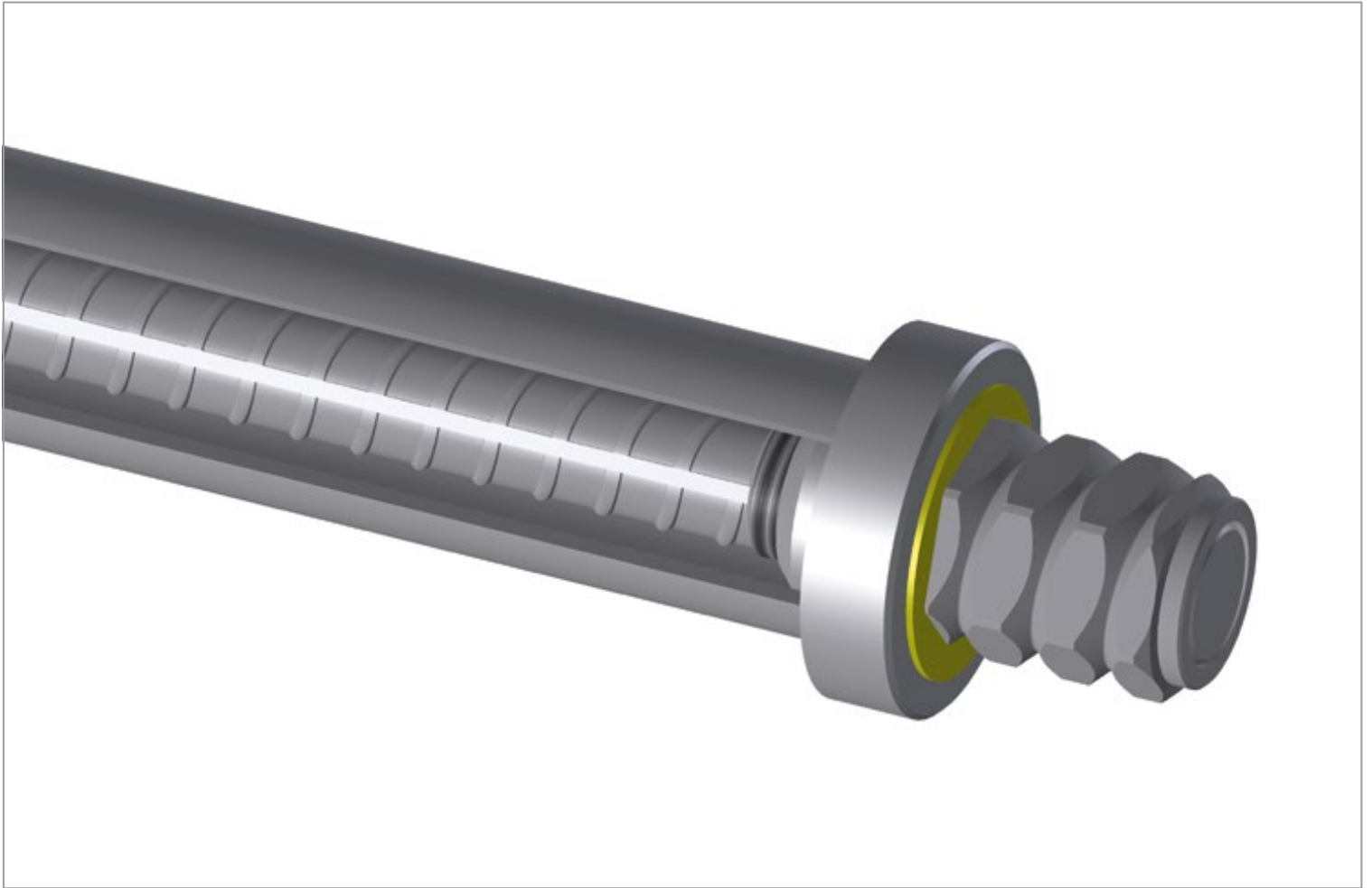
DSI is currently working on a model that will quantify the reductions in annualised spends on ground support consumables by 5% – the data that have been collected so far suggest a reduction of this magnitude.

The fact that more and more Australian coal mines are convinced by the advantages

of the new resin bolting system speaks for itself. DSI is continuously working on further developments of this novel system in order to increase the already substantial advantages the system provides for its customers.

## The Kinloc Bolt: Value Added thanks to Customized Solutions

At the end of 2014, in association with a number of customers, DSI determined that there was a need for a higher capacity bolt that basically replicated the performance of an inflated bolt but without the complexity surrounding installation. The Kinloc Bolt System is a mechanically operated, point anchoring friction bolt.



The DSI patented system permits anchor installation using standard equipment. Installation is fast and ensures immediate, high load-bearing capacity.

In addition to the load transfer capacity of the friction bolt, a high capacity rock bolt down the middle of the friction bolt acts as a point anchored bolt. This delivers a very “stiff” system with high shear strength.

During initial testing in late 2014, DSI adapted its existing load testing equipment to manage the higher capacity achieved by the Kinloc Bolt.

A customer in Western Australia was so convinced by the product that he moved from the trial to a full conversion to the new Kinloc System on their drives shortly after the testing phase had started.

Since then, DSI has continuously developed the Kinloc Bolt in close cooperation with its customers so that the system now offers additional features and benefits. One of these features relates to a retention device for the inner bar of the Kinloc Bolt that is now part of the system. In the event of the inner bar breaking due to excessive load or shear, the bar cannot fall out of the roof with the plate thanks to the standard ECS (Event Capture System).



Additional tests completed by the Western Australia School of Mines (WASM), the well-respected industry testing authority, confirmed the excellent performance of the Kinloc System in terms of point anchor load and dynamic capacity. These tests have led to a second-generation bolt: The Kinloc Indie. In this product, the inner bolt works independently of the friction bolt. This allows the inner bar to elongate by up to 200mm,

allowing for dynamic adaptations to ground movements.

Today, many mines trust the Kinloc Bolt, which significantly enlarges the existing friction bolt family. The Kinloc Bolt is only one of many examples showing that the close cooperation between DSI and mine operators leads to product innovations that afford true value.



## The OneStep Mining Bolt: A Premium Ground Support Product for individual Requirements

In July 2015, DSI entered into an agreement with Hilti AG, Schaan/Liechtenstein to acquire intellectual property and manufacturing assets for the “OneStep” mining bolt.



OneStep is a self-drilling mining bolt which combines the drill head, drill steel, bolt and adhesive resin in a single unit. It offers a unique value proposition since drilling the hole, retracting the drill steel, resin capsule insertion, bolt insertion and setting of the bolt can be done in one single step. This permits faster installation cycles and better installation quality as well as ensuring that the highest safety levels are achieved.

The OneStep has developed a strong position in both development applications around rib support and also in Long Wall moves. Currently, a local

manufacturing unit for the OneStep Bolt is being established at DSI Australia that will reach its full manufacturing capacity in the 4<sup>th</sup> quarter of 2016.

DSI has consciously decided to go against the trend of off shore manufacturing in countries with low priced production conditions and is creating additional jobs and a more manageable and responsive supply chain for customers in Australia.

With this development, DSI sends a clear signal in the development of new and innovative products even if the market space

is currently stagnating. The ultimate aim is for the OneStep to become a primary strata support product and an important part of DSI's Mining product portfolio. The OneStep Bolt integrates itself into the high quality offerings of DSI that are focused on providing customers with unique and tailored systems.

The new mining bolt will be fitted with resin cartridges that are locally produced by DSI in Australia and that were included in the offer in 2015. As a resin anchor, the OneStep now provides longer shelf life through the use of DSI's own resin cartridges.



Adam Rainer, who was previously employed by Hilti and was the driver of the OneStep Bolt development, has joined the DSI Team in Newcastle, Australia as Product Manager for OneStep. He will ensure that the OneStep Bolt will be developed into an even more performant system.

OneStep represents an important addition to DSI's product portfolio targeting the premium bolt segment. The product has already proven itself by significantly increasing productivity with several customers.

DSI is planning is to optimize the supply chain of the product and promote OneStep through the well established distribution network of the DSI Group. This acquisition confirms DSI's continuous interest in technically advanced solutions to make Underground Mining safer and more efficient.



## The Rohtang Tunnel: Ground Support Products by DSI Underground for one of the World's highest Mountain Passes

At an elevation of 3,980m, the Rohtang Pass in the Himalayas in India is one of the world's highest drivable mountain passes. The only connecting road from the north Indian federal state of Himachal-Pradesh to the Ladakh border region is impassable for 4 - 6 months every year during winter.



In order to create a year-round connection, construction of the new Rohtang Pass Highway Tunnel located approximately 3,100m above sea level started in 2010.

The 8.8km long, horseshoe-shaped, two-lane tunnel includes two 4m wide lanes and two 1m wide sidewalks. Underneath the carriageway, an emergency gallery is integrated into the tunnel cross section. The maximum cover of the Rohtang Tunnel is almost 1,900m.

Due to several fault zones and strongly squeezing rock conditions, the tunnel is being conventionally excavated in accordance with

the New Austrian Tunneling Method (NATM) using sectional heading. The tunnel is being exclusively driven from the two portals, south and north, using simultaneous heading in crown and bench/invert as well as rapid ring closure.

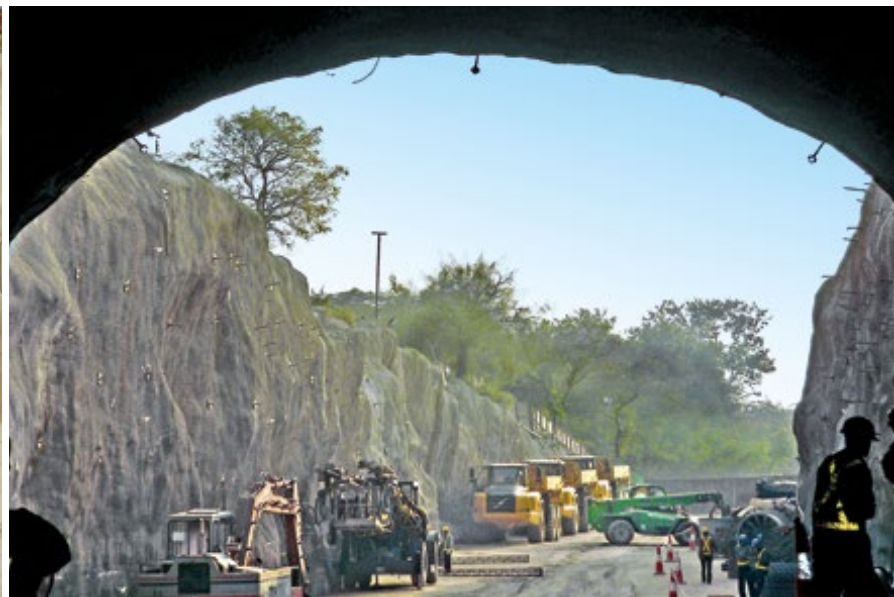
DSI Underground Austria has extensive long-term experience in the development, production and supply of high quality ground support products for tunneling that are also installed in difficult conditions in high alpine areas in Europe. Especially in these areas, the fast & safe installation of ground support products and their functionality have

highest priority. As one of the world's highest mountain passes, the Rohtang Tunnel was a new challenge for DSI Underground.

Important ground support products for stabilizing tunnel excavation included rock anchors, fiber-reinforced shotcrete etc. – depending on the different excavation classes including the occasional requirement for additional steel arches.

For this unique project, DSI Underground mainly supplied the following systems from its wide product range:





- POWER SET Hanger Bolts
- POWER SET Self-Drilling Friction Bolts
- DYWI® Drill Hollow Bar Anchors
- LSC™ Elements (Lining Stress Controllers)
- AT 76-DR Drainage System
- GRP Anchors

Because very difficult geology was encountered in some areas, 2 complete, 15m long Type AT – 76 and AT – 114 pipe umbrellas were additionally installed in the south drive. The pipe umbrellas were installed using two AT – Pipe Umbrella Automation Units that were also produced and supplied

by DSI Underground. Furthermore, DSI supported the project with a supervisor on site.

Currently, DSI Underground is also supplying OMEGA-BOLT® Expandable Friction Bolts that are continuously installed in accordance with construction progress. This system is very suitable for use in the difficult geology of the Rohtang Tunnel because it immediately reaches its full load bearing capacity over the entire installed bolt length and reliably maintains its support capacity even when undergoing deformations.

#### Owner

Border Roads Organisation, India

#### General Contractor

M/s STRABAG AG - Afcons Joint Venture, consisting of STRABAG AG, Germany and Afcons Infrastructure Limited, India

#### Engineering

SMEC, Australia

#### DSI Unit

DSI Underground GmbH, Austria

#### DSI Scope

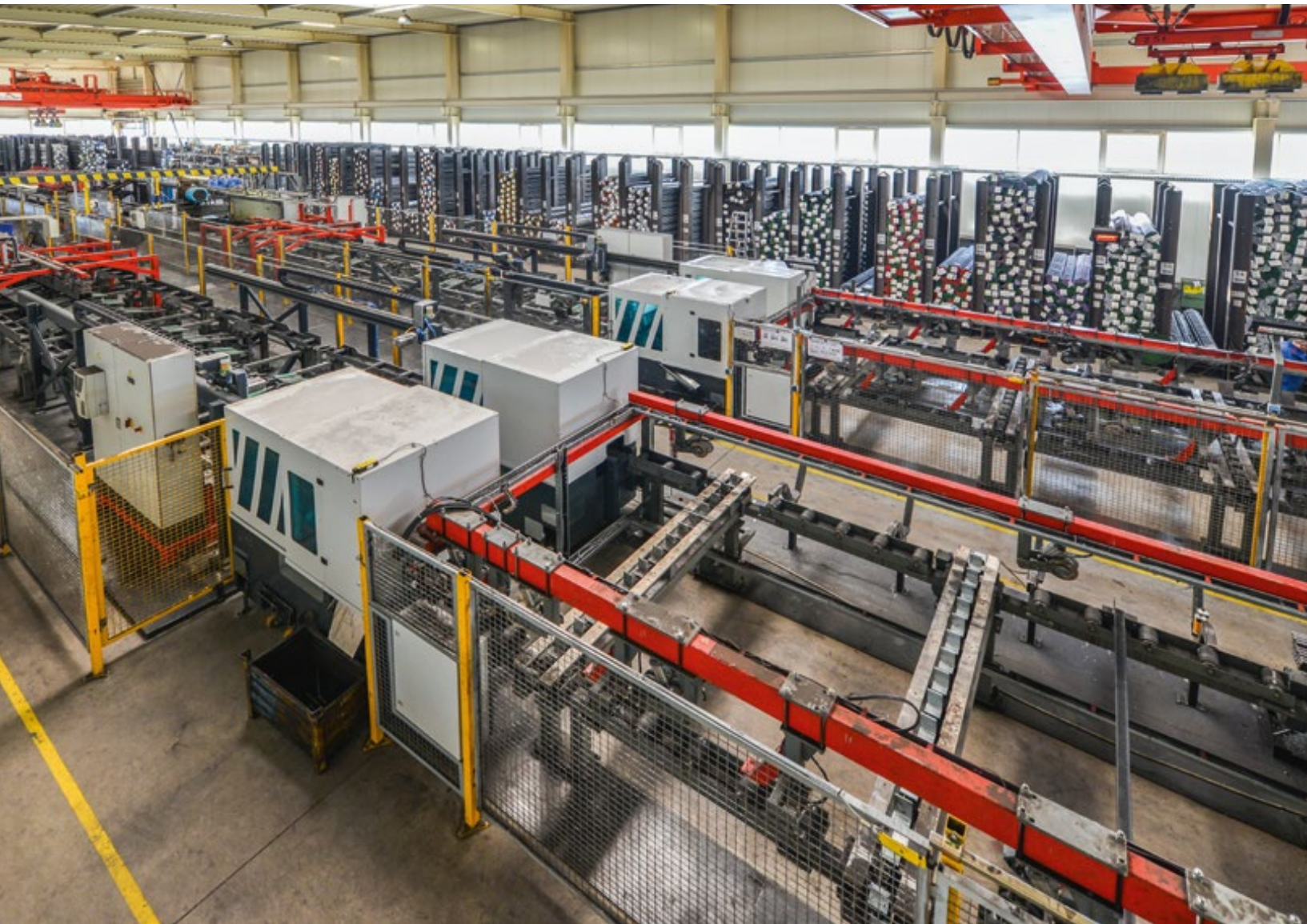
Production, supply, technical support, supervision

#### DSI Products

POWER SET Hanger Bolts, POWER SET Self-Drilling Friction Bolts, DYWI® Drill Hollow Bar Anchors, LSC™ Elements (Lining Stress Controllers), AT 76-DR Drainage System, GRP Anchors, pipe umbrella systems, Type AT – 76 and AT – 114, 2 AT – Pipe Umbrella Automation Units, OMEGA-BOLT® Expandable Friction Bolts



## Major Orders of more than € 46 Million in Tunneling for DSI Underground Austria



### **Semmering – Koralm – Brenner: In Austria, people are talking about the Decade of Major Railway Tunnels.**

In 2012, construction of the 27.3km long Semmering Base Tunnel started, which is scheduled for completion in 2026. The tunnel has an average longitudinal gradient of 8.4‰, and trains will pass through this tunnel at speeds of up to 230km/h.

The second major project is the 32.9km long Koralm Tunnel. In addition to the Koralm

Tunnel, other significant tunnels such as the approximately 2.1km long Stein Tunnel and the approximately 6km long Granitztal Tunnel Chain are being advanced. This major project will be opened to traffic in 2023.

The third and largest project is the construction of the Brenner Base Tunnel (BBT). Including the existing bypass around Innsbruck, the Brenner Base Tunnel has a total length of 64km between Innsbruck, Austria and Franzensfeste, Italy. This mega project will be opened to regular train traffic in 2026.

Currently, the last major orders have been assigned for the construction of the Semmering Base Tunnel. DSI Underground Austria is proud of the fact that the joint ventures and clients of all three major projects have decided to use high quality DSI Systems! The bidding process was fierce, but DSI Underground succeeded in acquiring all three “projects of the century”. Based on the three major projects, DSI Underground Austria is expecting a stable DSI business in Austria for this year and the years to come.





To enhance its strong market position sustainably, DSI Underground, Austria is now focusing even more strongly on international tunneling projects.

A short while ago, DSI Underground, Austria successfully acquired the first smaller tunneling projects in India and is currently in the bidding phase for a large number of international infrastructure projects in Tunneling.





## Short Distances with DSI: Supply of Ground Support Products for the Granitztal Tunnel Chain in Austria

The 130km long Koralmbahn is currently the largest project for extending Austria's railway network. The new section establishes a direct connection from Graz to Klagenfurt, reducing travelling times in this area from 3 hours to 1 hour.



After the Koralm Tunnel, the approximately 6.1km long Granitztal Tunnel Chain is the Koralmbahn's second longest tunnel system. The tunnel chain is located in the 7.8km long section between St. Andrae and Aich that is being built by a Joint Venture consisting of Implenia and Hochtief Infrastructure.

The tunnel chain consists of three sections – a tunnel in the Granitz Valley that is being built using the open cut method, and two bored tunnels. The Deutsch Grutschen Tunnel is 2,556m long and the Langer Berg Tunnel has a length of 2,929m. Both tunnels are being built with 2 single track tunnel tubes each and are connected via the 597m long enclosure in the Granitz Valley.

Between the double tubes of both tunnels, crosscuts are being built approximately every 500m. The excavation of the two tunnels will create approximately 1.3 million m<sup>3</sup> of excavation material, 800,000m<sup>3</sup> of which will be re-used for building the tunnels.

The geology near the Langer Berg Tunnel is characterized by tectonic fault zones and highly changing formations so that a flexible and adjustable construction method was required. The tender stipulated that the excavation had to be carried out in accordance with the New Austrian Tunneling Method (NATM) because the use of a Tunnel Boring Machine (TBM) would have involved unacceptable risks.

The mountain ridge near the Deutsch Grutschen Tunnel consists of Neogene and unconsolidated Miocene sediments. According to a cost estimate, tunnel driving in this area was also more economical using the NATM in comparison to a TBM.

DSI Underground Austria as a system supplier produced and supplied all of the ground support products that were required to stabilize advancement, including OMEGA-BOLT® Expandable Friction Bolts, SN Anchors, the DYWI® Drill Hollow Bar System, AT – Tubespile™, Ø 38 x 4 mm tube spiles, and POWER SET Self-Drilling Vacuum Tube Spiles.





In particular, the AT – Drainage System was predestined for deep reaching drainage in highly variable formations. The system consists of an inner steel tube which is wrapped with a PVC-drainage pipe.

It can be employed temporarily as well as semi-permanently during drainage work parallel to tunnel advances. The AT – Drainage System is characterized by a rapid length adaptation achieved by piece-by-piece installation, with a simple lengthening of the drainage tubes also being possible in limited space at all times. Another important feature of the system is the high directional accuracy of the drainage drilling.

DSI supplied the Type AT – 76-DR Drainage System, T32 x 3,000mm AT – Drilling Rods, R32 shanks and R32-T32 transition pieces.

To provide immediate support in the open span area, DSI produced and supplied 3 bar, Types P50/20/30, P70/20/30, P95/25/30 as well as P130/25/30 PANTEX Lattice Girders including welded-on nut pairs, 1m long spacers and tilting bases with 3 struts. Excavation at the northern portal near St. Andrae was begun on April 24<sup>th</sup> 2015, and the tunnel chain is scheduled for completion in 2020.

#### Owner

ÖBB-Infrastruktur AG, Austria

#### General Contractor

Joint Venture, consisting of Implenia AG and Hochtief Infrastructure Austria, both Austria

#### Construction Site Management

Joint Venture, consisting of IL – Ingenieurbüro Laabmayr & Partner ZT GesmbH, IGT Geotechnik und Tunnelbau Ziviltechniker G.m.b.H. and iC consulenten Ziviltechniker GesmbH, all of them Austria

#### DSI Unit

DSI Underground GmbH, Austria

#### DSI Scope

Production, supply

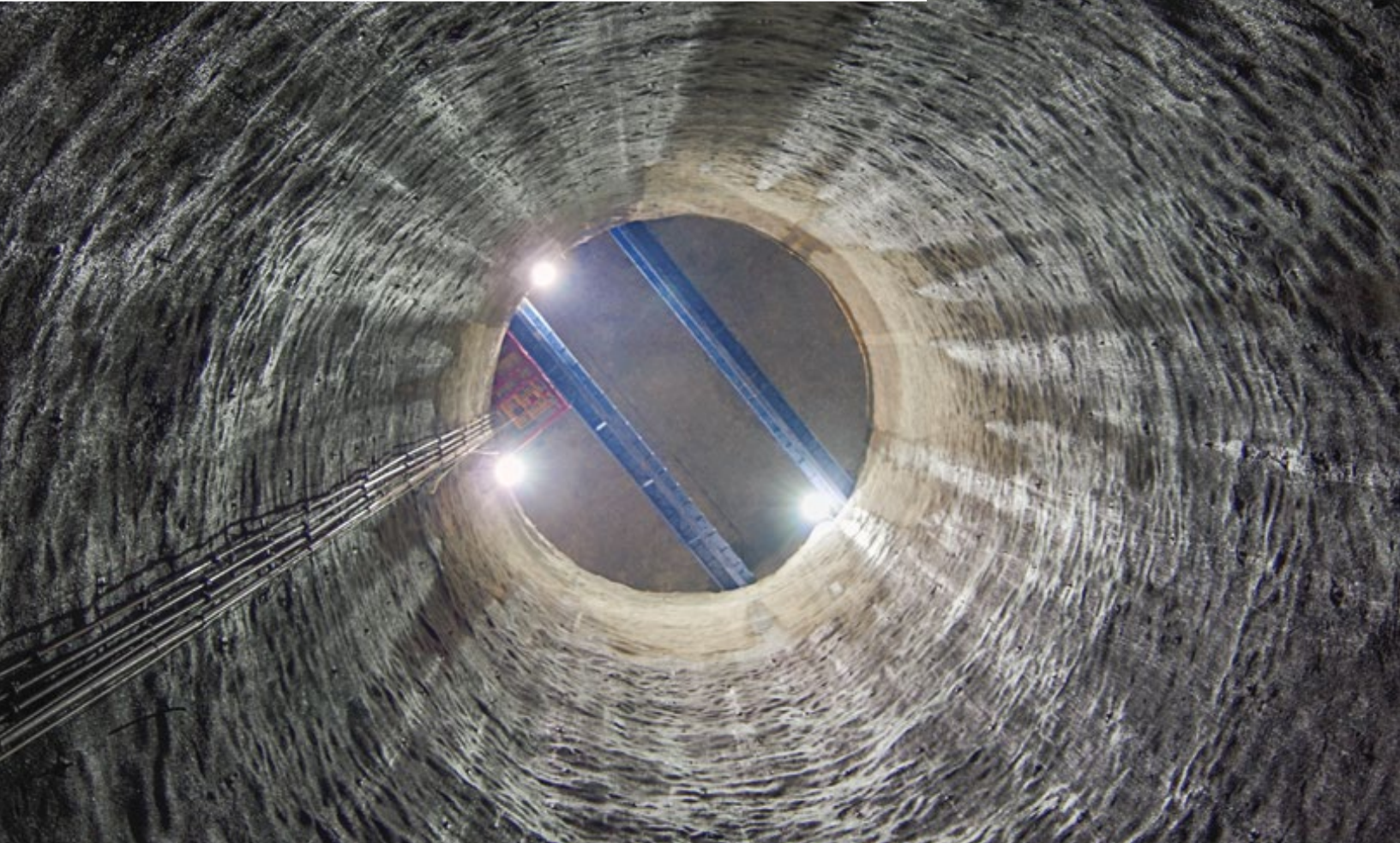
#### DSI Products

OMEGA-BOLT® Expandable Friction Bolts, SN Anchors, DYWI® Drill Hollow Bar System, AT – Tubespile™, Ø 38 x 4 mm tube spiles, POWER SET Self-Drilling Vacuum Tube Spiles; Type AT – 76-DR Drainage System; 3 bar, Types P50/20/30, P70/20/30, P95/25/30 and P130/25/30 PANTEX Lattice Girders



## Flexible Energy Generation: DSI supplies Ground Support Products for Obervermuntwerk II at a Height of 1,700m

At the rear of the Montafon Valley in Austria, a modern pumped storage power station is being built at an elevation of 1,700m: The Obervermuntwerk II. The power plant benefits from the height difference of 300m between the 2,030m high Silvretta Reservoir and the 1,743m high Vermunt Reservoir.



Within a few seconds, the power plant can react to fluctuations in the power network that are caused by regenerative energies such as wind or solar energy. When there is excess capacity, the water is pumped back into the Silvretta Reservoir and can thus be re-used for generating energy.

After its completion that is scheduled for the end of 2018, the pumped storage power station will have a generating capacity of 360MW. It includes two Francis turbines and

2 main pumps with a capacity of 180MW each. The power plant is being built underground and is designed as an extension of the existing Obervermuntwerk I that has been operational since 1943.

The new cavern power plant consists of an intake structure in the Silvretta Reservoir, a penstock shaft, a head race tunnel, a double chamber surge shaft and a pressure tunnel with subsequent distributing pipelines towards the power plant cavern.

The existing, 3.3km long, surface pressure pipe line of Obervermuntwerk I is being replaced by an underground water conductor system that will be shared by both power plants. The pressure tunnel is being built as a pipe gallery.

On the 1,700m high jobsite – the highest of a total of 5 construction areas – concrete is being produced on site. Mainly rock excavation material is used for concrete production.





All of the excavation work is being carried out using conventional blasting; the only exception is the surge shaft, where a shaft is first being constructed using the raise boring method.

For the construction of the different tunnels and the excavation of the caverns, DSI Underground Austria produced and supplied the complete range of required ground support products.

This mainly included OMEGA-BOLT® Expandable Friction Bolts, SN Anchors, the DYWI® Drill Hollow Bar Anchor System, BST 550 steel spiles, lagging sheets, PANTEX 3-bar Lattice Girders and 57.5mm Ø GEW® Bars.

**Owner**

Vorarlberger Illwerke AG, Austria

**General Contractor**

Joint Venture OVW II, consisting of Porr AG, Jäger Bau GmbH, G. Hinteregger & Söhne Baugesellschaft m.b.H. and ÖSTU-STETTIN Hoch- und Tiefbau GmbH, all of them Austria

**DSI Unit**

DSI Underground GmbH, Austria

**DSI Scope**

Production, supply, technical support

**DSI Products**

OMEGA-BOLT® Expandable Friction Bolts, SN Anchors, DYWI® Drill Hollow Bar Anchor System, BST 550 steel spiles, lagging sheets, PANTEX 3-bar Lattice Girders, 57.5mm Ø GEW® Bars



## The Tunnel du Chambon: POWER SET Bolts stabilize important Connection between Grenoble and Briançon

The Tunnel du Chambon in France, which was opened in 1935, is an important connection between Grenoble and Briançon. The tunnel forms part of the Route Départementale 1091 and is located above Lake Chambon. In the spring of 2015, a landslide was detected in this area that had caused cracks in the tunnel lining and invert despite its having moved only a few centimeters per year. On April 10<sup>th</sup> 2015, the tunnel had to be closed as a consequence of the damage caused by the rock movements.



As the population of the Haute-Romanche Valley was completely cut off by this closure, an emergency route was built on the opposite lake shore that was opened in November 2015. However, this road is only able to accommodate approximately 700 vehicles per day. A long-term solution was urgently required to prevent further damage to the region's economy as a result of the tunnel closure.

Stabilization of the areas in question was not economically and technically feasible so that the decision was made to build a new tunnel structure that will make a wide-ranging, 500m long detour around the landslide. The new bypass tunnel will be excavated from the

inside of the existing tunnel and will then open out into a smaller, existing tunnel. In total, the Tunnel du Chambon will be lengthened by 240m, so that it will have a total length of 990m.

To stabilize advancement, DSI France produced and supplied Type PS 50, 300kN, 4m long POWER SET Self-Drilling Friction Bolts including 200/200/12 anchor plates. The patented POWER SET One-Step Bolt System ensures a safe and easy installation as well as immediate load-bearing capacity. Furthermore, the system is characterized by its high flexibility in regard to changing rock conditions.

**Owner**  
Conseil départemental de l'Isère,  
France  
**General Contractor**  
Eiffage S.A., France  
**Contractor**  
Groupement TPGE0/DELUERMOZ,  
France

**DSI Unit**  
DSI France SAS, France  
**DSI Scope**  
Production, supply  
**DSI Products**  
Type PS 50, 4m long POWER SET  
Self-Drilling Friction Bolts



## Construction of the Pforzheim Tunnel: DSI supplies Ground Support Products for the Karlsruhe-Muehlacker Train Section

Built in 1860, the double track Pforzheim Tunnel on the train section between Karlsruhe and Muehlacker no longer meets modern performance requirements and is in urgent need of repair. As a rehabilitation would have been too complex, a new, double track tunnel is now being built parallel to the existing tunnel. The new tunnel runs to the west of the existing structure at a maximum distance of 26m. The old tunnel will be shut down and backfilled once the new structure has been completed.



With a track distance of 4m instead of the previous 3.64m, the new, 909m long tube fulfills current safety regulations and has a modern escape and rescue concept. Furthermore, the new tunnel will have an invert that prevents the ingress of ground water. The new tunnel has a maximum cover of 40m and an excavated cross section of 130m<sup>2</sup>. Since the precut is hard to access from the Pforzheim side, the tunnel is being continuously excavated from the town of Ispringen.

The tunnel is being advanced in accordance with the New Austrian Tunneling Method (NATM). Due to the special geological requirements and due to the existing buildings near the tunnel, a road header is being used. Advancement is progressing with calotte driving followed by bench and invert excavation.

As the in-situ soil consists of shell limestone – i.e. unconsolidated soil – along the first 300m, an excavator is used for advancement in this area. In the other areas in which rock and bedrock prevail, the tunnel is excavated using a rotary cutter. During advancement, the tunnel is first stabilized using a shotcrete lining. Afterwards, a cast-in-place concrete lining is installed.

To stabilize excavation work, DSI Underground Austria supplied DYWI® Drill Hollow Bar Anchors and Self-Drilling Spiles in addition to other products. The self-drilling ground support products are a sound and efficient alternative to time-consuming cased drilling installation methods and products. For the drainage work around the excavation, DSI also supplied the proven AT – 76-DR Drainage System.

**Owner**  
DB Netz AG, Germany  
**Contractor**  
Baresel GmbH, Germany  
**Engineering**  
WBI GmbH, Germany

**DSI Unit**  
DSI Underground GmbH, Austria  
**DSI Scope**  
Production, supply  
**DSI Products**  
DYWI® Drill Hollow Bar Anchors and  
Self-Drilling Spiles, AT – 76-DR Drainage  
System



## The Klokova Tunnel: Ground Support Products by DSI Underground for Greece's new North-South Connection

Ionian Odos, which is also known as Aftokinitodromos 5, is a new, 196km long north-south motorway connecting northwestern Greece with the Peloponnes Peninsula.



This project also includes the construction of 24 bridges and 4 tunnels. One of the tunnel structures that had to be advanced is the 2,950m long Klokova Tunnel north of Patras. The double tube tunnel is being excavated using the conventional drill and blast method.

To stabilize advancement in the unstable rock layers in which limestone, sand and conglomerates prevail, DSI Underground

Austria produced and supplied several ground support systems such as rock anchors for immediate support of the open span area in the prevailing fault zones.

For immediate temporary support, DSI produced and supplied 4.0m to 4.5m long OMEGA-BOLT® Expandable Friction Bolts. Bonding forces between the friction bolt and the rock mass are caused by form closure

and friction transfer between the borehole wall and the rock bolt that is expanded by hydraulic pressure. OMEGA-BOLT® Anchors reach immediate full load bearing capacity over the entire installed bolt length and were especially well suited for use in the Klokova Tunnel thanks to their low sensitivity against vibrations caused by blasting work.





**Owner**  
 Joint Venture Nea Odos S.A.,  
 consisting of GEK-TERNA, Greece,  
 Ferrovial S.A. and ACS Actividades  
 de Construcción y Servicios, S.A.,  
 both Spain  
**General Contractor**  
 GEK-TERNA, Greece  
**Contractor**  
 GEK-TERNA, Greece

**DSI Unit**  
 DSI Underground GmbH, Austria  
**DSI Scope**  
 Production, supply, technical support  
**DSI Products**  
 DYWIDAG Rock Bolts, 4.0m to 4.5m long  
 OMEGA-BOLT® Expandable Friction Bolts



## John Hart Generating Station Replacement Project: System Solutions for difficult Ground Conditions in an Access Tunnel

The John Hart Generating Station in Campbell River on Vancouver Island in Western Canada has been operating since 1947. In 2014, a large-scale modernization project was initiated that includes the construction of an underground powerhouse and associated facilities.



Upon completion, expected in 2018/2019, the facility will have an increased installed capacity of 132MW featured by 3 new turbines. Besides an increase of structural safety against potential earthquakes, the visual impact of the hydro station will be reduced by removing the 3 current surge towers and wood stave penstock lines. One key element of the project is the L20 main access tunnel, which provides truck access

to the 40m high and 94m long by 20m wide underground power house.

In May 2015, weak ground was encountered about half way through the tunnel. As later confirmed, this zone was part of an ancient riverbed traversing the previously excavated basaltic formation likely deposited by an ancient glacier. These features are sometimes referred to as buried valleys.

As opposed to the original ground support concept employed using poly reinforced shotcrete, lattice girders, and CT-Bolt™ combination rock bolts, excavation and support of this weak ground zone required additional measures. Bolstered by technical support from DSI and various tunnel expert teams, a contingency excavation and ground control concept was developed within a short period of time.





Among other things, this concept included a double layer of the AT – 139 Pipe Umbrella Support System, DYWI® Drill spiles and face bolts as well as a heavy-duty set of 3-bar PANTEX Lattice Girders. The pipe umbrella support system used features a so-called squeezed connection type, which allows a safer and faster completion of installation work besides an increased load-bearing capacity. By using an AT – Automation Unit,

operational effectiveness and occupational health and safety were improved further on.

Within a few weeks' time, all required ground control systems were designed and transported to the remote project site. Afterwards, excavation works were successfully accomplished.

#### Owner

British Columbia Hydro and Power Authority (BC Hydro), Canada

#### Design Builder

SNC-Lavalin Inc.

#### Civil Contractor

Aecon/SNC-Lavalin Inc. Joint Venture (ASL JV), Canada

#### Subcontractor Tunneling

Frontier-Kemper Constructors ULC/ASL Joint Venture (FK/ASL JV)

#### Consulting

BeMo Tunnelling GmbH, Austria,  
ILF Consulting Engineers, USA

#### DSI Unit

DSI Tunneling LLC, USA

#### DSI Scope

Design, production, supply, technical support

#### DSI Products

3-bar PANTEX Lattice Girders, AT – 139 Pipe Umbrella Support System, AT – 139 Automation Unit, DYWI® Drill Spiles and Rock Bolts, CT-Bolt™ Combination Rock Bolts



## Innovations in Mining: DSI Underground develops efficient Cable Bolt Systems

Cable Bolts are routinely used for underground roof support in coal, metal and non-metal mines. Since cable bolts in Mining are long, single-section multi-strand tendon supports, they are very suitable for use in deep boreholes and where mining heights restrict the use of long solid-bar style rock bolts.



DSI Underground is aware of the important role of these ground support products in Underground and is therefore continuously developing its product offer in this area.

Recently, DSI Underground tested and approved new cable bolt systems: Square Head Cable Barrels, Threaded Tensionable Cable Bolts and new Indented Strand Cable Bolts.

### DSI Square Head Cable Barrels

The new DSI Square Head Cable Barrels permit bolt installation and resin-mixing with conventional installation tools. Numerous Square Head Barrel Cable Bolts have been tested in the lab and in-the-mine to verify performance. The 1-1/8" Square Head meets ASTM Rock Bolt Specification requirements.

### DSI Threaded Tensionable Cable Bolts

Tensionable ground support systems

provide additional roof rock reinforcement in thinly laminated mine roof conditions. Furthermore, Threaded Tensionable Cable Bolts permit the utilization of longer, single-section ground support systems in reduced mine opening heights. The new DSI Threaded Tensionable Cable Bolts have recently been successfully tested and approved at a DSI Underground customer mine in North America. In addition to product application, the test installation also demonstrated the immediate roof compression and the excellent product performance of the new cable bolt.





### DSI Indented Strand Cable Bolt

Most high-strength cable is smooth and requires cable “bulbs” or other deformations for proper anchorage in the drill hole. The new DSI Indented Strand Cable Bolt has small deformations along the length of the cable strand that provide stable anchorage in resin or grout.

The small deformations perform similarly to deformations along the length of bulbed or otherwise deformed rebar bolt systems.

The Indented Strand Cable does not require the extra manufacturing step for “bulbing” the cable, thus minimizing manufacturing costs. DSI Underground has conducted both laboratory and in-mine tests that proved the performance of the anchorage and the assembled cable bolt. Since the DSI Indented Strand Cable Bolt is not bulbed, bolt installations are easier with faster resin systems; the non-bulbed indented strand cable also makes installing the cable bolts easier with older, higher viscosity resin.

Taking into account manufacturer’s dates on the packages, customers are therefore able to utilize older resin inventory that would have created bolt installation problems with bulbed cable bolts.

## The Caquende Hydroelectric Power Plant in Brazil: The AT – Pipe Umbrella System demonstrates its Efficiency and Safety

Near the town of Bonfim in the Federal State of Minas Gerais northwest of Rio de Janeiro, a new 4MW hydroelectric power plant is being built on the Macaúbas River: The PCH Caquende.



Once completed, the power plant will feed approx. 18,500MWh of electricity per year into the power supply system. The PCH Caquende consists of 3 horizontal Francis turbines that are operated at an influx rate of 7m<sup>3</sup>/s of water. The concrete dam that forms part of the power plant reaches a maximum height of 2.5m and is 60m long.

Within the scope of construction work, a 350m long single tube inlet tunnel is being excavated. Since the tunnel portal is located in an unstable zone, the Type AT – 76 Pipe Umbrella System was used for pre-support.

Due to the self-drilling installation process, the AT – Pipe Umbrella Support System decreases deformations and increases the stability and safety in the working area.

DSI Underground Brasil supplied the complete AT – 76 Pipe Umbrella System on short notice for the construction of the PCH Caquende. The required system components included the AT – Starter Unit with drill bit, AT – Extension Tubes, injection valves in the injection drillings, several AT – Drilling Adapters, the required drill rods and AT – Grouting Caps.

The pipe umbrella tubes were installed piece by piece and overlapped using conventional drill booms with rotary-percussive rock drills. The general contractor was very satisfied with the fast, self-drilling installation of the pipes and their high directional accuracy during installation. Furthermore, DSI Underground Brasil's specialists supported the jobsite personnel during the professional installation.





**Owner**  
Macaúbas Energia Renovável  
Ltda, Brazil  
**General Contractor**  
Construtora Ocmx Ltda., Brazil  
**Consulting Engineers**  
Construtora Sofisa, S. A., Brazil

**DSI Unit**  
DSI Underground Brasil, Brazil  
**DSI Scope**  
Production, supply, technical support  
**DSI Products**  
Type AT – 76 Pipe Umbrella System  
with accessories



## BULLFLEX® Support Pillars prove their Load-Bearing Capacity: Successful Tests at the NIOSH Laboratory

BULLFLEX® Support Pillars have been developed as a special supporting member featuring an excellent load-bearing capacity. Their main fields of application are auxiliary standing support, artificial pillars, and corner slumps, as well as repair work in overstressed or fault zone areas. Other applications include the rehabilitation of visitor mines or the construction of bulkheads or dams.



The BULLFLEX® system consists of patented textile groutable hoses made of high-strength fabric, which are subsequently filled with a cement-bonded building material. BULLFLEX® Support Pillars are used wherever a fast support solution is required. Due to their active setting load and immediate load transfer, support pillars, which are also referred to as pumpable cribs, work like a strong hydraulic prop that can be left in position as a permanent standing support. Besides, the BULLFLEX® system has an active pre-loading feature and a higher safety support factor

compared to conventional supplementary standing support systems.

Recently, improved BULLFLEX® Support Pillar versions were developed that had to be tested in terms of load-bearing capacity. Due to the high load-bearing capacity levels featured by BULLFLEX® Support Pillars, only a few testing laboratories are able to conduct load testing on pillar samples. One laboratory with long-term experience in testing and evaluation of standing support systems is the Pittsburgh Research Laboratory of the National Institute

for Occupational Safety and Health (NIOSH) in the USA.

The testing program was developed by DSI in cooperation with the partner and supply firm BuM Beton- und Monierbau GmbH, Herten, Germany. In May 2015, 5 Type 25-29" (63.5-73.5cm) BULLFLEX® Pillars with a height of approximately 2.5m (8ft) and 5 Type 20-23" (51.0-58.5cm) BULLFLEX® Pillars with a height of approximately 2.1m (7ft) were prepared as test samples in Germany and shipped to Pittsburgh.





In June 2015, load tests were conducted on those 10 samples. Type 20-23" BULLFLEX® Support Pillars showed an average load-bearing capacity of approximately 580 kips (2,580kN). Pillars type 25-29" had an average load-bearing capacity of approximately 950 kips (4,225kN).

In November 2015, a second series of load tests was conducted on similar samples to verify both the support capacities and an improved yielding ability of the BULLFLEX® Pillars.

The successful performance evaluation of BULLFLEX® Support Pillars now forms the basis for a technical document that allows design firms and clients a fast and flexible choice of additional standing support systems wherever required.





**DYWIDAG-SYSTEMS  
INTERNATIONAL**



## DYWIDAG GRP Anchors stabilize Slopes along Coramba Road in New South Wales

The scenic area between the town of Dorrigo and the seaport Coffs Harbour in New South Wales, Australia, is a magnet for tourism. Coramba Road, which links both towns, is especially popular with motorcyclists because of its breathtaking scenery.



Unfortunately, due to the high average rainfall, this area is prone to ground movements that have repeatedly damaged the road. As a result, the New South Wales Government has commissioned the upgrade of a number of roads in the northern New South Wales area. In this program, past and potential slip areas will be stabilized and protected from future damage caused by excessive rainfall.

In 2014, a part of Coramba Road 5km east of Dorrigo was also marked as a potential slip area. To stabilize this region, DSI Australia supplied DYWIDAG GRP Anchors that were ideal for this project because of their ease of handling and long design life.

The soil nails that were supplied by DSI were drilled and installed by the subcontractor Ground Stabilisation Systems. DSI supplied a total of 1,477m of 25mm Ø DYWIDAG GRP Anchors and 2,024m of 32mm Ø DYWIDAG GRP Anchors as a full system including steel hex nuts, dome plates, grout tubes and centralizers.

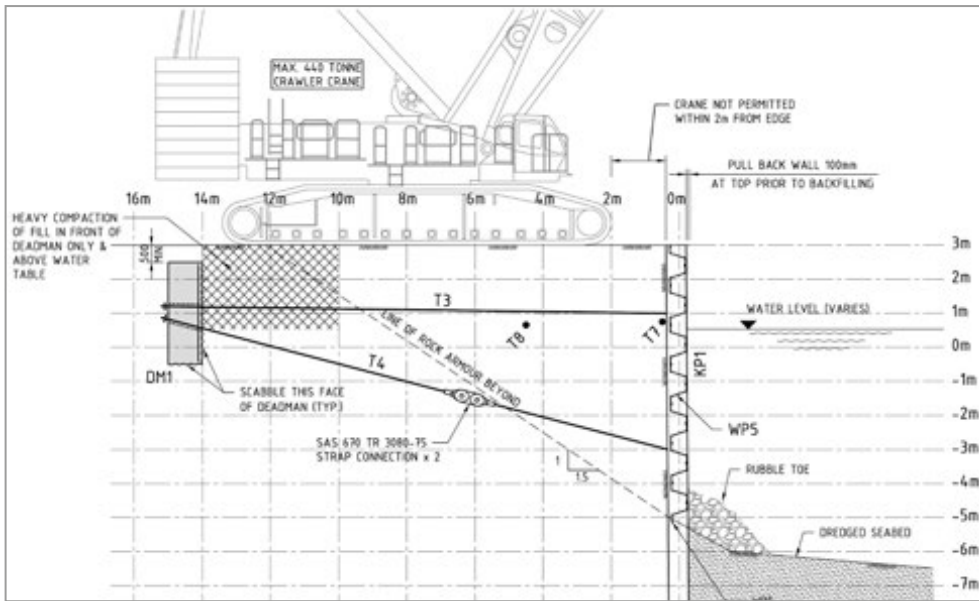
**Owner**  
Coffs Harbour City Council,  
Australia  
**General Contractor**  
Earthtec, Australia  
**Contractor**  
Earthtec, Australia  
**Subcontractor**  
Ground Stabilisation Systems Pty. Ltd.,  
Australia  
**Consulting Engineers**  
Coffey, Australia

**DSI Unit**  
DYWIDAG-Systems International Pty. Ltd.,  
BU Civils, Australia  
**DSI Scope**  
Production, supply, technical support  
**DYWIDAG Products**  
1,477m of 25mm Ø DYWIDAG GRP Anchors  
and 2,024m of 32mm Ø DYWIDAG GRP  
Anchors including accessories



# GEWI® Tie Rods permit the Use of a 450t Crawler Crane: The BAE Systems Facility in Henderson

South of Perth, in southwestern Australia, BAE Systems Australia operates a 14.5ha facility specializing in the construction and repair of commercial and military vessels. The facility is located in the shipyard of the Australian Marine Complex in Henderson.



Recently, BAE Systems expanded this facility by constructing a 75m long, land backed wharf section. For this purpose, 22,500m<sup>3</sup> of sediment had to be excavated from the port basin. Work included the driving of king piles, the installation of fabricated steel wall panels, rock armor and dead man anchors that were tied back to precast concrete blocks behind the sheet pile wall. The dead man structure ensures a safe tieback of the sheet pile wall so that heavy machinery will be able to drive on this area.

To tie back the sheet pile wall safely, DSI Australia supplied a complete 63.5mm Ø GEWI® Tie Rod System consisting of a total of 164m of GEWI® Steel, turnbuckles, welded eye pieces, couplers, hex nuts and bearing plates.

Thanks to the expansion of this wharf section, BAE will be able to undertake dual crane lift loading and unloading of barges utilizing their new 450t crawler crane.

**Owner**  
BAE Systems Australia Ltd,  
Australia  
**General Contractor**  
MARINE & CIVIL PTY LTD, Australia  
**Consulting Engineers**  
Peritas Group, Australia

**DSI Unit**  
DYWIDAG-Systems International Pty.  
Ltd., BU Civils, Australia  
**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
63.5mm Ø GEWI® Tie Rod System



## Light and stable Structures: DYWIDAG Post-Tensioning Tendons for Tower Two at Collins Square in Melbourne

Currently, one of the largest commercial construction projects in Australia is under construction at the centrally located Collins Square in Melbourne's Western Precinct. It involves the construction of a large block of buildings that includes 6 towers and a renovated, historical warehouse that will accommodate offices, retail facilities and restaurants on an area of over 250,000m<sup>2</sup>.



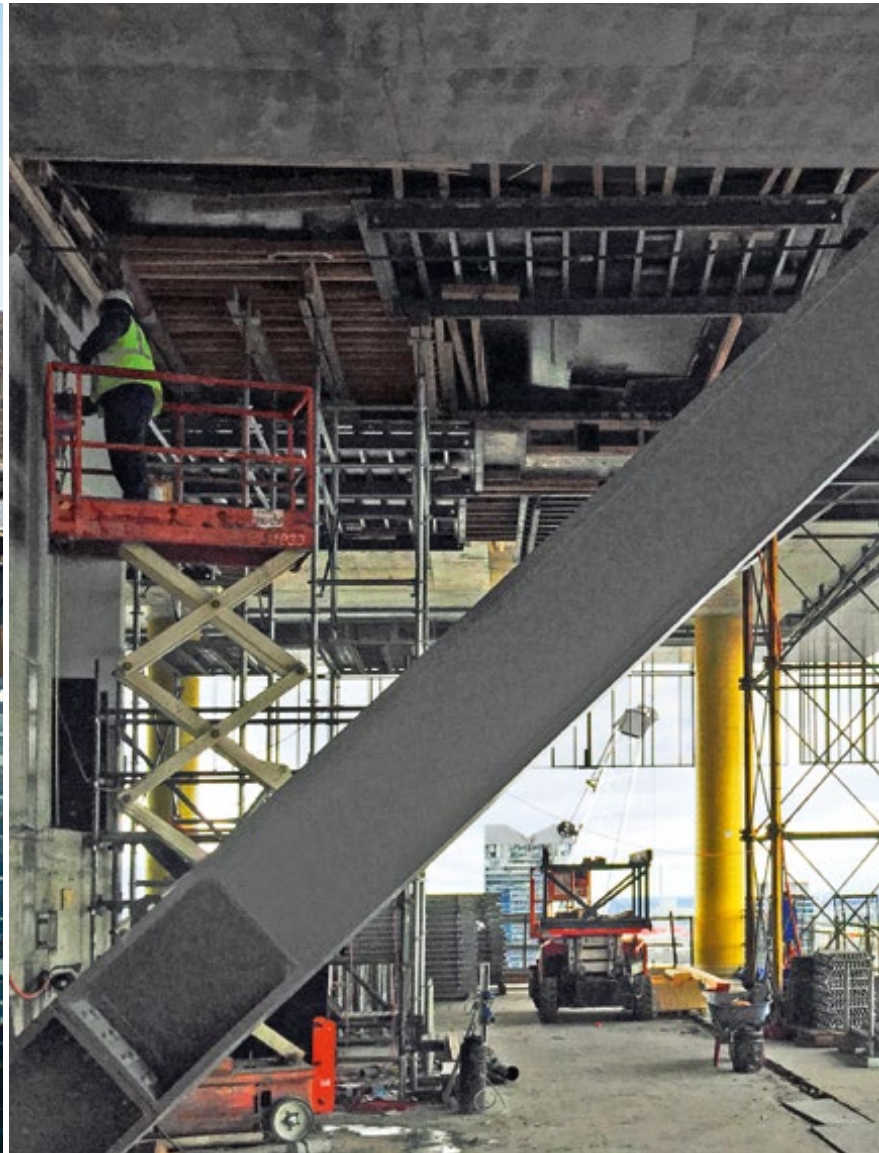
DYWIDAG Strand and Bar Post-Tensioning Systems were used in levels 26 and 27 of the 39 story high Tower Two at 727 Collins Street. The contractor, Form 700, together with its partner company Postenco, designed an alternative solution for the complicated structural design of both levels. In order to comply with the design of the architects, no columns could be used in the façade of level 26 on one side of the building.

As there are 12 more stories above level 27, not having these columns in the façade created structural instability that was initially solved with passive reinforcement.

As an efficient and light-weight alternative, Postenco proposed active post-tensioning using eight 57mm Ø DYWIDAG Bar Tendons and DYWIDAG Strand Tendons with Type 6837 MA Anchorages.

The large steel “triangles” on level 26 were tensioned back to the central core of the building using DYWIDAG Bar and Strand Post-Tensioning Tendons. In total, 8 Fep 1,050N/mm<sup>2</sup> DYWIDAG Bar Tendons with nuts, couplers and plates were cast into the floor and the walls of the core. The DYWIDAG Strand Tendons were installed in the heavy beams on level 27, tying back the steel triangles of level 26.





All 37 strands in one cable were installed parallel to prevent entangling and friction of the individual strands in each cable bundle. Due to limitations in stressing space and maximum weight restrictions, stressing was carried out using a monostrand jack. In total, 10 DYWIDAG Strand Post-Tensioning Tendons were used. DSI not only supplied the necessary DYWIDAG Post-Tensioning Tendons, but also supported the contractors

in the correct use of the post-tensioning systems. The DYWIDAG Post-Tensioning Systems were installed, stressed and grouted by the subcontractor Postenco.

**Owner**  
Walker Corporation, Australia  
**General Contractor**  
Brookfield Multiplex, Australia  
**Contractor**  
Form 700, Australia  
**Subcontractor Post-Tensioning Works**  
Postenco Pty. Ltd., Australia  
**Architects**  
The Buchan Group and akin creative, both Australia

**DSI Unit**  
DYWIDAG-Systems International Pty. Ltd., BU Civils, Australia  
**DSI Scope**  
Production, supply, technical support  
**DYWIDAG Products**  
10 DYWIDAG Strand Tendons with Type 6837 MA Anchorages and eight 57mm Ø DYWIDAG Bar Tendons



## DYWIDAG Strand Tendons for flowing Road Traffic: New Viaducts in Brunei

In the sultanate of Brunei on Borneo Island, 57 new road construction projects will be built that will provide for more safety in road traffic and ease congestion on the existing roads.



This also includes a new flyover in the district of Gadong in the country's northeast that is located 5km from the capital Bandar Seri Begawan. Thanks to the new bridge at the Jalan Gadong/Jalan Telanai Junction, traffic will flow uninterrupted on Jalan Gadong Road.

In addition, a new set of traffic lights will be installed for right-turning vehicles at Jalan Telanai Road.

The flyover is a three-span bridge consisting of 27m + 36m + 27m spans. 13, 36m long prestressed precast concrete (PSPC) I-girders

and 26, 27m long PSPC I-girders were required for the spans.

In the 39 PSPC girders, the DSI licensee Utracon supplied and installed 104 Type 15-0.62" DYWIDAG Strand Tendons and 78 Type 19-0.62" DYWIDAG Strand Tendons including anchorages and accessories. In total, 55.86t of Type 0.62" Strand were needed for the ducted tendons. Utracon also carried out the stressing work on all DYWIDAG Post-Tensioning Systems and supplied the girder steel molds and the required casting yard equipment.

### Project Information Jalan Telanai

#### Owner

Jabatan Kerja Raya Negara, Brunei

#### General Contractor

Haji Adinin and Sons (B) Sdn. Bhd., Brunei

#### Contractor

Ley Choon EWC Sdn. Bhd., Brunei

#### Consulting Engineers

Petar Perunding Sdn. Bhd., Brunei

#### DSI Licensee

Utracon Overseas Pte Ltd., Singapore

#### Utracon Scope

Supply, installation, technical support, supervision

#### DYWIDAG Products

104 Type 15-0.62" DYWIDAG Strand Tendons,  
78 Type 19-0.62" DYWIDAG Strand Tendons  
including anchorages and accessories;  
molds and casting yard equipment





In the district of Bukit Beruang that has considerably grown within the last few years, another new bridge was built at the Persimpangan Lebuhraya Tutong Telisai/Jalan Perumahan Bukit Beruang Junction to relieve traffic.

The 4 lane viaduct consists of two spans, each 30m long and 23m wide. The reinforced concrete deck is supported by 13, 30m long PSPC T-girders.

Each of the girders was post-tensioned using two Type 15-0.62" and one Type 19-0.62" DYWIDAG Tendons. In total, the construction of the new flyover in Bukit Beruang required 52 Type 15-0.62" DYWIDAG Strand Tendons and 26 Type 19-0.62" DYWIDAG Strand Tendons with a total strand tonnage of 44t. Utracon also provided the steel formwork for casting the T-beams.

**Project Information Bukit Beruang**

**Owner**  
Jabatan Kerja Raya Negara, Brunei  
**General Contractor**  
Surati Construction Sdn. Bhd., Brunei  
**Subcontractor**  
Hunt Concrete Industries Co. Sdn. Bhd., Brunei  
**Consulting Engineers**  
Jurutera Tempatan Sdn. Bhd., Brunei

**DSI Licensee**  
Utracon Overseas Pte Ltd., Singapore

**Utracon Scope**  
Supply, installation, technical support, supervision  
**DYWIDAG Products**

52 Type 15-0.62" DYWIDAG Strand Tendons,  
26 Type 19-0.62" DYWIDAG Strand Tendons with anchorages and accessories; formwork



## DYNA Grip® Stay Cables for Gujarat's first Extradosed Bridge: The 3<sup>rd</sup> Narmada Bridge

In the district of Bharuch in the federal state of Gujarat in northwestern India, National Highway 8 crosses the Narmada River. The motorway is one of the country's most important connections linking Delhi with the economic center of Mumbai and other economically important cities.



In order to provide relief from the heavy traffic congestion which often occurs in this area, the 3<sup>rd</sup> Narmada Bridge is being built. It will include 4 lanes and a pedestrian crossing and will be used together with the existing bridge that will remain in service.

The new, 1,344m long and 20.8m wide bridge consists of two 96m long side spans and eight 144m long main spans. The structure will be the first extradosed bridge in the federal state

of Gujarat and will have the country's longest spans. Each of the center spans consists of 38 3.55m long precast concrete hollow box girder segments.

At each of the pylons, there are two stay cable planes consisting of 6 stays arranged in a fan pattern that support the bridge deck. In total, DSI-BRIDGECON supplied and installed 216 27.5 - 70m long DYNA Grip® Stay Cables with a strand tonnage of 500t. 36 Type DG-P31,

36 Type DG-P37, 72 Type DG-P43 and 72 Type DG-P55 Stay Cables were used for this purpose.

The stay cables were anchored at the bridge deck using DYNA Grip® Anchorages and at the pylons using the DYNA® Link Anchor Box System. In this system, the fact that the stay cable anchorages are located outside permits slender pylon shapes because the interior of the pylon does not need to be accessible.





In addition, DYNA Force® Sensors were installed in order to permit long-term monitoring of the forces acting on the stay cables.

The 3<sup>rd</sup> Narmada Bridge is the first project in which DSI-BRIDGECON has installed the DYNA Grip® System and the DYNA® Link Anchor Box System.

**Owner**

National Highway Authority of India, India

**General Contractor**

Larsen & Toubro Limited, India

**Consulting Engineers**

Precast Bridge Tech. Co., Ltd., Thailand

**Consulting**

Joint Venture, consisting of Yogma Engineering co., Ltd., Korea and Feedback Ventures Pvt., Ltd., India

**Subcontractor**

DSI-BRIDGECON India Pvt. Ltd., India

**DSI-BRIDGECON Scope**

Design, supply

**DYWIDAG Products**

216 Type DG-P31, DG-P37, DG-P43 and DG-P55 DYNA Grip® Stay Cables, DYNA® Link Anchor Box System, DYNA Force® Sensors



## The Chenab Bridge: DYWIDAG Systems stabilize impressive Slopes for the World's highest Railway Bridge

Traveling around the mountainous region of Jammu and Kashmir in northern India has always been difficult. In order to considerably shorten travel times, the Indian Government decided to build a new, 345km long railway route from Jammu to Baramulla.



Photos reprinted courtesy of Grips India, India

This project also includes a new, 1,315m long railway bridge across the Chenab River near the town of Katra. Once completed, the bridge, the 469m long main span of which reaches a height of 359m above the River Chenab, will be the world's highest railway bridge.

As the bridge has a design life of 120 years, the General Contractor needed a proven, reliable system for stabilizing the Chenab Valley's massive slopes that have angles between 43° and 77°.

Furthermore, the system was also required to be earthquake-resistant. DSI proposed its double corrosion protected (DCP) DYWIDAG Bar Anchor System consisting of WR DYWIDAG Bars, which is known around the world for its quality and reliability.

Due to the fact that the construction site is located in one of the most remote and difficult to reach parts of India, DSI together with its partners decided to produce the DYWIDAG Anchors in a field factory directly on site using high-quality materials in order to

ensure the highest possible quality. This way, the permanent corrosion protection can be applied in the close vicinity of the site, and the corrosion protection applied on the DYWIDAG Systems is not exposed to damage during the long road transport to the site. In addition to the supply of the DYWIDAG Rock Anchors including accessories, the scope of DSI and its Indian partner company also included the supervision of on-site production, the installation and the stressing of the bar anchors as well as the supply of the necessary equipment.





So far, DSI has already provided over 10,000m of DYWIDAG bars, mainly 40 WR and 47 WR. All systems were supplied in different lengths, including bearing plates, anchor caps, nuts, ducts, and corrosion protection compound. In addition, for force monitoring, the DYNA Force® System was supplied for its first Geotechnical application in India.

Slope stabilization was carried out in layers of 3-5m from top to bottom. After excavating each section, the boreholes for the DYWIDAG Rock Anchors were drilled.

The anchors were installed and grouted using cement mortar following stressing. For additional stabilization, steel fiber reinforced shotcrete was applied to the slopes to conclude the project.

DSI is proud to contribute reliable systems to this important major project.

**Owner**  
Konkan Railway Corporation Ltd.,  
India  
**General Contractor**  
Afcons Infrastructure Ltd., India  
**Consulting**  
Scott Wilson & Co. Ltd., Great Britain,  
Scott Wilson India Pvt. Ltd, India  
**Engineering**  
WSP Consulting, Finland, Leonhardt,  
Andrä und Partner Beratende Ingenieure  
VBI AG, Germany

**DSI Units**  
DYWIDAG-Systems International GmbH,  
GBU, Germany, Grips India, India  
**DSI and Grips India Scope**  
Production, supply, engineering services  
**DYWIDAG Products**  
10,000m of DCP DYWIDAG Bar Anchors,  
40 WR and 47 WR, including accessories,  
DYNA Force® System, equipment



## The Kuningan Flyover in Jakarta: Cantilever Erection for efficient Construction Progress

The Kuningan Intersection in Jakarta, Indonesia is an important traffic hub that connects different business districts with several embassies and the airport. For many years, considerable traffic jams have occurred at this junction. An attempt to solve the problem by building a conventional cast in place viaduct on the north side of the intersection in 2002 was unsuccessful.



Thanks to the new, 680m long and 9m wide Kuningan Flyover on the south side that was opened in December 2015, the situation has finally improved. The flyover was built using precast concrete segments and the balanced cantilever construction method. The General Contractor decided to use two different construction methods in order to reach the target schedule and to minimize traffic interruption during construction. The precast segmental concrete box girder for the 6 approach spans was erected using lifter frames, and the 160m long main span was built using the balanced cantilever method and DYWIDAG Form Travelers.

PT Delta Systech Indonesia was awarded the contracts for post-tensioning work, segment erection and engineering services. In a joint venture with Utracon Structural System Pte Ltd., Singapore, PT Delta Systech used 2 sets of static standard lifter frames for mounting the precast segments for the hollow box girder using the balanced cantilever method.

In cooperation with DYWITECH Taiwan, PT Delta Systech Indonesia also used 4 DYWIDAG Form Travelers for the cast in place balanced cantilever part of the bridge.

A total of 78t of Types 15-0.6" and 19-0.6" DYWIDAG Strand Tendons were needed for post-tensioning the precast concrete elements and the cast in place balanced cantilever bridge spans. PT Delta Systech supplied and installed the post-tensioning systems including Types MA 6815 and MA 6819 Anchorages. Furthermore, DYWIDAG Bar Tendons were used for temporary stressing in order to stabilize the segments during erection work and form traveler operation.

#### Owner

Dinas Bina Marga  
Pemprov DKI Jakarta,  
Indonesia

#### General Contractor

PT Nindya Karya (Persero),  
Indonesia

#### Consulting Engineers

PT Delta Global Struktur,  
Indonesia

#### Consulting/Site Supervision

PT Perentjana Djaja, Indonesia

#### Engineering

PT Delta Systech Indonesia,  
Indonesia

#### DSI Licensees

PT Delta Systech Indonesia,  
Indonesia, Utracon Structural  
Systems Pte Ltd., Singapore and  
DYWITECH Co. Ltd., Taiwan

#### PT Delta Systech, Utracon and DYWITECH Scope

Development, supply, installation,  
engineering services, technical support,  
supervision

#### DYWIDAG Products

78t of Types 15-0.6" and 19-0.6"  
DYWIDAG Strand Tendons,  
DYWIDAG Bar Tendons, 2 lifter frames,  
4 DYWIDAG Form Travelers



## The Permata Hijau Flyover in Jakarta: Road Safety with DYWIDAG Post-Tensioning Systems

The Permata Hijau Flyover in Jakarta, Indonesia is 544m long and 10m wide. The flyover is one of several infrastructure projects that the Jakarta Provincial Government has initiated to improve traffic flow in Jakarta. Furthermore, thanks to the new viaduct, road traffic no longer has to cross the Jakarta-Serpong railway tracks directly. The viaduct was built in only one year and was officially opened in January 2016.



PT Delta Systech Indonesia was the subcontractor for post-tensioning work, the erection of the hollow box girder segments and engineering services. To erect the precast segments using the balanced cantilever method, PT Delta Systech Indonesia cooperated with DSI's Singapore licensee Utracon Structural System Pte Ltd. using 2 sets of static lifter frames and one special movable lifter frame. The static lifter frames were used to lift the segments in the side spans, and the movable lifter frame was used for the segments of the main span located above the railroad.

The movable lifter frame is designed for erection work in cases in which only one side of the segment supply area can be accessed. The lifter is able to move above the pier tables so that precast segments can be positioned in both directions. In the case of the Permata Hijau Flyover, the supply of the precast segments was prohibited in the active rail road track area. The special lifter frame was used for the first time for a bridge construction project in Indonesia.

The special lifter frame has 2 control cabins at the front and at the rear and is equipped with 16 large tires that are moved simultaneously by remote control. The lifter is powered by an electrical motor and has a hydraulic system with a maximum capacity of 65t. Thanks to the special lifter frame, the segments can be erected faster, cleaner and more reliably. Furthermore, when using this equipment, traffic flow does not have to be interrupted.

The segmental box girders of the bridge were post-tensioned using internal Type 15-0.6" and 19-0.6" DYWIDAG Strand Tendons and Type MA 6815 and MA 6819 Anchorages. In total, PT Delta Systech supplied and installed 105t of Type 0.6" Strand. Furthermore, DYWIDAG Bar Tendons were used for the temporary stressing and stabilization of the segments during erection work.

#### Owner

Dinas Bina Marga  
Pemprov DKI Jakarta,  
Indonesia

**General Contractor**  
Lampiri-Multi-Brantas KSO,  
Indonesia

**Consulting Engineers**  
PT Delta Global Struktur,  
Indonesia

**Consulting/Supervision**  
PT Intimulya Multikencana,  
Indonesia

**Engineering**  
PT Delta Systech Indonesia,  
Indonesia and Utracon Structural  
Systems Pte Ltd., Singapore

#### DSI Licensees

PT Delta Systech Indonesia,  
Indonesia and Utracon Structural  
Systems Pte Ltd., Singapore

**PT Delta Systech and Utracon Scope**  
Supply, installation, engineering  
services, technical support, supervision

**DYWIDAG Products**  
Type 15-0.6" and 19-0.6" DYWIDAG  
Strand Tendons, DYWIDAG Bar Tendons,  
2 static and 1 movable lifter frames



## Efficiency with DYWIDAG Strand Tendons: The Gunkai-gawa Bridge on the New Tomei Expressway in Japan

The New Tomei Expressway on Japan's main island of Honshu connects Japan's 3 largest cities with each other. Located between the cities of Toyota and Okazaki in the Aichi Prefecture, the Gunkai-gawa Bridge also forms part of this route.



The 740m long, 7 span bridge was built as a continuous rigid frame box girder using prestressed reinforced concrete. The bridge is a rigid frame structure with only two bearings, thus eliminating the need for complex intermediate bearings.

The superstructure of the Gunkai-gawa Bridge was built taking advantage of light weight concrete construction.

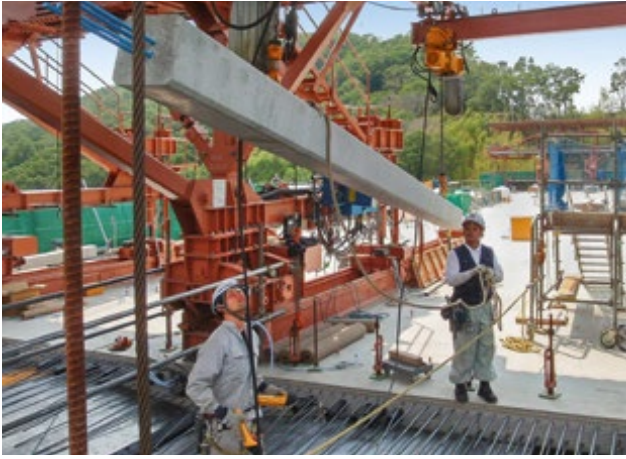
For this purpose, high-strength concrete was used in some parts of the girder in order to reduce slab and web thicknesses.

Additionally, 650t jacks were used near both end piers in the hollow box girder in order to transfer horizontal loads before closing the girder at the center span. This way, the bending moment acting on the end piers was reduced.

This method allows a more compact design of the end pier foundations, minimizing adverse environmental impact in the area of the jobsite. Furthermore, the method was the most economic approach.

Caisson foundations were constructed for all bridge piers. In some cases, an angle cut cylinder earth retaining method was adopted in order to reduce the excavation area.





The cross section of the main girders is around 15m wide and was realized as a single-cell box girder section with an extended slab reinforced by struts. To reduce the number of external tendons in the narrow box girder, DSI licensee Sumitomo supplied high-strength Type 19S 15.7 MC DYWIDAG Strand Tendons.

The main girders were constructed with Type 12S 15.2 MA DYWIDAG Strand Tendons using

the cantilever method. The maximum span of the Gunkai-gawa Bridge is 124m long. Both Type 19S 15.7 MC DYWIDAG Strand Tendons and Type 12S 15.2 MA DYWIDAG Strand Tendons were used for post-tensioning. Type 1S 21.8 pre-grouted DYWIDAG Tendons were used for transverse post-tensioning.

**Owner**  
Central Nippon Expressway Co., Ltd, Japan  
**General Contractor**  
Sumitomo Mitsui Construction Co., Ltd, Japan  
**Architect**  
Sumitomo Mitsui Construction Co., Ltd, Japan

**DSI Licensee**  
Sumitomo (SEI) Steel Wire Corp., Japan  
**Sumitomo Scope**  
Supply, technical support  
**DYWIDAG Products**  
Types 19S 15.7 MC, 12S 15.2 MA and 1S 21.8 DYWIDAG Strand Tendons



## The Tamwe Flyover: DYWIDAG Post-Tensioning Systems for Yangon's longest Viaduct

In Yangon (Rangoon) in southern Myanmar, several viaducts are being built that will enhance traffic flow. One of these viaducts is the Tamwe Bridge that will connect three of the city's most congested roads by a Y shaped intersection.



At a length of 1,477m, the Tamwe Flyover will be Yangon's longest viaduct. The flyover has a foundation consisting of reinforced concrete bored piles and is designed for loads of up to 75t.

The viaduct's 11.2m cantilever pier heads were post-tensioned using DYWIDAG Strand Tendons. In total, Utracon supplied and installed 114 Type 19-0.6" DYWIDAG Strand Tendons and 12 Type 37-0.6" DYWIDAG Strand Tendons including anchorages and

accessories with a total strand tonnage of 22.3t. To make the construction of the long cantilevering elements easier, Utracon also suggested a suitable construction method and solutions for the formwork system that was used.

Thanks to the close cooperation with the General Contractor, Utracon was able to successfully install the DYWIDAG Strand Post-Tensioning Systems despite the congested reinforcement with small interstices.

**Owner**  
Yangon City Development  
Committee (YCDC), Myanmar  
**General Contractor**  
Shwe Taung Development Co., Ltd,  
Myanmar  
**Consulting Engineers**  
P.T. Waagner-Biro Indonesia,  
Indonesia

**DSI Licensee**  
Utracon Overseas Pte Ltd., Singapore  
**Utracon Scope**  
Supply, installation  
**DYWIDAG Products**  
114 Type 19-0.6" DYWIDAG Strand  
Tendons and 12 Type 37-0.6" DYWIDAG  
Strand Tendons including anchorages and  
accessories



# The Sule Square Project in Myanmar: DYWIDAG Post-Tensioning Systems for a modern Office Tower

In Yangon (Rangoon), Myanmar's industrial center in the south of the country, demand for office space is continuously rising. The Sule Square office tower that is being built near the famous Shwedagon Pagoda in the city center is one of the projects that are currently under construction.



In Myanmar, post-tensioning systems have been rarely used up to now. The Sule Square project is currently the tallest building that has been built using post-tensioning systems. The General Contractor chose to use DYWIDAG Post-Tensioning Systems because of their flexibility and the possibility to create long spans.

The Sule Square Complex consists of a 6,000m<sup>2</sup> shopping center with restaurants, a 5 storey car park and a 15 storey, 30,000m<sup>2</sup> office building. DSI's licensee Utracon was awarded the contract to supply and install the

Types 12-0.5" and 20-0.5" DYWIDAG Strand Post-Tensioning System. The tendons were used to stress 4.7m cantilever beams and 12m long girders.

In total, Utracon installed 818 Type 12-0.5" DYWIDAG Tendons and 186 Type 20-0.5" DYWIDAG Tendons including MA Multiplane Anchorages with a strand tonnage of 150.8t in the beams.

The General Contractor was very satisfied with the high standard of technical support provided by Utracon.

**Owner**  
Shangri-La International Hotel Management Ltd., Myanmar  
**General Contractor**  
QingJian International (Myanmar) Group Development Co.,Ltd, Myanmar  
**Architect**  
DP Architects Pte Ltd, Singapore  
**Consulting Engineers**  
Buro Engineering Pte Ltd, Singapore  
**Consulting**  
Alpha Consulting Engineers Pte Ltd, Singapore

**DSI Licensee**  
Utracon Overseas Pte Ltd., Singapore

**Utracon Scope**  
Supply, installation, technical support

**DYWIDAG Products**  
818 Type 12-0.5" DYWIDAG Strand Tendons and 186 Type 20-0.5" DYWIDAG Strand Tendons including MA Multiplane Anchorages



## The DUO Project in Singapore: DYWIDAG Post-Tensioning Tendons keep huge cantilevered Building Elements in Balance

The 26,700m<sup>2</sup> DUO project in Singapore, a joint venture development by the governments of Malaysia and Singapore, is located on Ophir Road in the historical districts of Bugis and Kampong Glam. The main part of this project includes the construction of two high-rise buildings: The 186m high, 50 story tall Residences Tower and the 170m high, 39 story tall Duo Tower.



These two asymmetrical towers have concave shapes and include very large cantilevering elements causing a permanent imbalance in the towers. Therefore, the executing companies and engineers had to make sure that both buildings remained stable during every stage of construction.

In order to maintain the permanent balance of the two buildings, the vertical walls of both towers were tensioned to counter the out of balance forces. For this purpose, the engineers had to introduce active prestressing forces at different stages of construction.

In the Residential Tower, the wall had a thickness of 110cm and was therefore wide enough to place large DYWIDAG Strand Tendons into the wall that served as an active anchorage. As the walls in the second tower were only 50cm thick, 75mm Ø DYWIDAG Bar Tendons were used instead.

### **The Residential Tower: Smooth Construction Progress with 140m long DYWIDAG Strand Tendons**

In order to support the overhanging block, large cantilever steel trusses were

placed in the two prestressed walls from levels 30 to 32. These trusses hold both 9 floor slabs below and support 20 floor slabs above. The large steel trusses were anchored in the prestressed wall using 19 75mm Ø DYWIDAG Bar Tendons.

Each wall is prestressed using 6 Type 37-0.6" DYWIDAG Strand Tendons with MA Anchorages, with one additional tendon per wall installed to act as a spare tendon. The DYWIDAG Tendons were installed from basement level 3 up to the 32<sup>nd</sup> floor, thus reaching a total length of 140m. Each tendon has a stressing anchorage at level 32 and a fixed anchorage at basement level 3.

During wall construction, empty ducts were installed for the tendons. The DYWIDAG Strand Tendons were later threaded into the ducts in a single operation when construction progress had reached level 32. During strand installation, the strands were prevented from being drawn down freely by their own weight by temporarily looping the strands around the adjacent walls when feeding them into the ducts.

Timing and the total amount of tensioning forces applied to the tendons at each stage of the stressing operation were crucial as these factors controlled the vertical sway of the tower. Based on a detailed design analysis and on site survey readings, it was determined that 40% of the stressing force had to be applied on reaching level 32, the tendon stress had to be increased to 70% on reaching level 40 and 100% of the load applied when reaching level 50.

Once all DYWIDAG Tendons had been stressed, they were completely grouted in a continuous operation. Due to the length of the tendons, a detailed grouting method statement was prepared by Utracon, with grouting equipment being stationed at strategic locations to ensure that grouting proceed smoothly.

### **The Office and Hotel Tower: Stability through 80m long DYWIDAG Bar Tendons**

Duo Tower, which will include both offices and a hotel, experienced a smaller out of balance load resulting from the overhanging block, as the main building core was designed to hang "only" 11 floor slabs from level 15 to level 25.





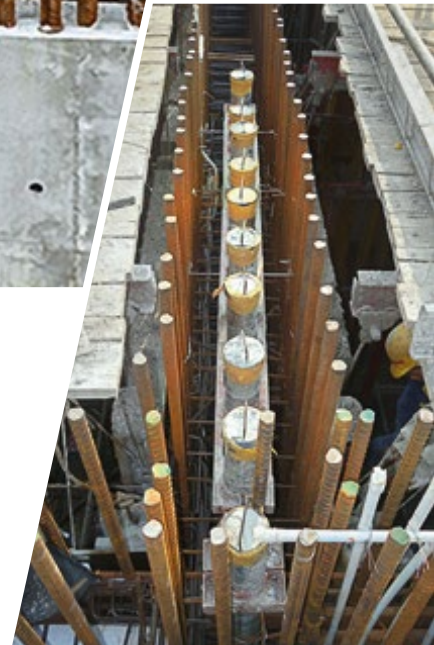
2 level tall steel trusses once again served to support the overhanging block which cantilevers by 9.5m from 3 prestressed walls. The top chords of the huge steel trusses were connected to the walls via post-tensioned beams. 16 75mm Ø DYWIDAG Bar Tendons were used to prestress these beams.

Each of the 3 walls was prestressed using 10 vertical 75mm Ø DYWIDAG Bar Tendons. The DYWIDAG Bar Tendons were only installed from level 10 up to level 25. Weighing 35.9kg/m, the very heavy DYWIDAG Bar Tendons posed a challenge during installation. The individual bars weighing approximately 160kg had to be hoisted into position by tower crane and coupled at every 4.5m casting lift of the wall. The total coupled length of each individual bar tendon was approximately 80m.

As the DYWIDAG Prestressing Bars must not be subjected to any bending, they had to be installed to very strict tolerances. To achieve the +/- 5mm tolerance, an oversized duct and a special template served to guide the installation work. Due to the overhanging forces being lower than in the Residential Tower, all vertical tendons could be fully

stressed in a single operation once floor construction reached level 25. After the stressing operation, the tendons were grouted in a single operation.

In addition to the prestressed walls, the floors from level 2 to level 39 were also designed as post-tensioned slabs. Due to a change in floor layout from the floors designed for office use to the floors designed to accommodate hotel rooms, and due to a change in column and wall orientations, a 250cm thick post-tensioned transfer plate was incorporated at level 25. The transfer plate was prestressed using Type 19-0.6" DYWIDAG Strand Tendons with MA Anchorages.



**Owner**  
M+S Pte. Ltd., Singapore  
**General Contractor**  
Obayashi Corporation, Singapore  
**Subcontractor**  
Utracon Structural Systems Pte Ltd., Singapore  
**Architects**  
Büro Ole Scheeren Group, Hongkong and DP Architects Pte Ltd, Singapore  
**Engineering**  
Beca Carter Hollings & Ferner Pte Ltd., Singapore

**DSI Licensee**  
Utracon Structural Systems Pte Ltd., Singapore  
**Utracon Scope**  
Design, supply, installation, technical support, supervision  
**DYWIDAG Products**  
143t of 75mm Ø DYWIDAG Bar Tendons and 307t of Types 7-, 9-, 12-, 15-, 19-, and 37-0.6" DYWIDAG Strand Tendons with MA Anchorages



## The 2<sup>nd</sup> Suburb Beltway in Seoul: DYWIDAG Bar Anchors contribute to Traffic Relief

The highway network in the metropolitan area of Seoul, South Korea, is a radial network with Seoul at its center. It is connected to national roads and expressways in 5 large suburbs and satellite cities via the Seoul Beltway. In order to react to the rapidly growing population in the suburbs and the ensuing high traffic congestion, the construction of the 2<sup>nd</sup> Suburb Beltway has begun.



This beltway has a total length of 240km and is being built with 4-6 lanes that are divided into 23 construction sections. Construction started in 2013, and the beltway will completely open to the public by 2020. Once completed, Seoul will have a triple ring type road network: The Inside Seoul Beltway, the Suburb Beltway and the 2<sup>nd</sup> Suburb Beltway.

The Incheon-Gimpo section is expected to have a particularly positive influence on urban development and will relieve the existing road network from traffic congestion. This is where the Incheon Tunnel, a tunnel that passes underneath the city center, is located.

In this area, a slope had to be stabilized because of existing soft ground. For this purpose, permanent DYWIDAG Bar Anchors were installed after piles had been placed. The permanent bar anchors were installed in 2 layers, with anchor lengths varying from 12m to 25m depending on ground conditions. A total of 160 GR 950/1,050, 32 mm Ø DYWIDAG Bar Anchors were required for stabilizing the slope.

#### Owner

Incheon Gimpo Expressway Co., Ltd.,  
Korea

#### General Contractor

POSCO Engineering & Construction, Ltd.,  
Korea

#### Contractor

Gyechon Construction Co., Ltd., Korea  
**Engineering**  
Man Maek Engineering Co., Ltd., Korea

#### DSI Unit

DYWIDAG-Systems Korea Co. Ltd., Korea

#### DSI Scope

Supply

#### DYWIDAG Products

160 32 mm Ø, 12 - 25m long DYWIDAG Bar Anchors



## Spectacular Architecture with DYWIDAG Post-Tensioning Systems: The Clearpoint Residencies Tower in Sri Lanka

The current construction boom in Sri Lanka has led to wide spread usage of post-tensioning systems in high rise buildings because these systems make it possible to build extraordinary and seismically resistant designs with long cantilever spans.



DYWIDAG Post-Tensioning Systems were used in the Clearpoint Tower, which will be the tallest vertical garden in Asia after its completion. The use of post-tensioning systems made it possible to build cantilever swimming pools and balconies in the 46 level high building that is being constructed in the Colombo district of Rajagiriya.

The tower includes 5m cantilever balconies surrounding the entire building that required a high load-bearing capacity in order to accommodate the loads of the planned plantings. The tower also features 10 swimming pools extending in 5.1m cantilevers.

Utracon supplied and installed 74t of DYWIDAG Strand Post-Tensioning Tendons in the cantilever beams, flat slabs and walls. The stressed beams enabled the construction of flat girders so that each level has the same floor to floor clear height.

In the cantilever swimming pool slabs, Utracon installed and stressed 30 Type 4-0.6" DYWIDAG Strand Tendons with FA Flat Anchorages. In the cantilever balconies, a total of 328 Type 5-0.6" DYWIDAG Strand Tendons including FA Flat Anchorages and 716 Type 7-0.6" DYWIDAG Strand Tendons including MA Multiplane Anchorages were installed and stressed.

The General Contractor was very satisfied both with the DYWIDAG Post-Tensioning Systems that made it possible to realize the extraordinary architecture of the Clearpoint Tower and with the competent technical support provided by DSI's licensee Utracon.

#### Owner

Clearpoint Residencies (Pvt) Ltd,  
Sri Lanka

#### General Contractor

Milroy Perera Associates (Pvt) Ltd  
und Maga Engineering (Pvt) Ltd,  
both Sri Lanka

#### Contractor

Maga Engineering (Pvt) Ltd, Sri Lanka

#### Architect

Milroy Perera Associates (Pvt) Ltd,  
Sri Lanka

#### DSI Licensee

Utracon Overseas Pte Ltd., Singapore

#### Utracon Scope

Design, supply, installation, technical  
support, supervision

#### DYWIDAG Products

30 Type 4-0.6" DYWIDAG Strand Tendons,  
328 Type 5-0.6" DYWIDAG Strand Tendons  
including FA Flat Anchorages and  
716 Type 7-0.6" DYWIDAG Strand Tendons  
including MA Multiplane Anchorages



## The Lach Huyen Bridge: DYWIDAG Strand Post-Tensioning Systems stabilize Vietnam's longest Sea Crossing Bridge

The new Lach Huyen deep sea port near the city of Hai Phong in the Gulf of Tonkin is one of the most important infrastructure projects that is currently under construction in Vietnam. Lach Huyen will be the first international port in the north of the country and will be able to handle container vessels with capacities of up to 100,000t.



The project also includes the construction of a 15.63km long highway that will connect the eastern districts of Hai Phong with the harbor, Dinh Vu Industrial Park and the expressway to Hanoi. The highway includes 10.19km long and 29.5m wide access roads and the 5.44km long and 16m wide Lach Huyen Bridge.

Lach Huyen Bridge is the longest sea-crossing bridge in Vietnam and one of the longest bridges of its kind in South East Asia.

With four lanes and two emergency lanes, Lach Huyen Bridge both crosses the 500m wide sea canal and the Bach Dang River and Cam River estuaries. Construction work began in February 2015 and is expected to be completed by early 2017.

For the construction of the bridge structure, 500,000m<sup>3</sup> of sand was used to reclaim land for two 26m wide and 4.1km long working platforms. The 88 bridge spans are supported

by pile structures. Each pier is supported by 16 reinforced concrete piles with exterior diameters of 1.3m and lengths of up to 46m.

As a subcontractor, DYWIDAG-Systems International SPP – ASIA Ltd. supplied external, Type 19-0.6" DYWIDAG Strand Tendons with 1,320 MA Anchorages and internal, Type 12-0.6" DYWIDAG Strand Tendons with 2,292 MA Anchorages for Lach Huyen Bridge.





As part of the subcontractor services stipulated by the contract, DSI also provided site supervision and the rental of 20 post-tensioning jacks including hydraulic pumps. This includes 10 HOZ 5,400kN Stressing Jacks that were equipped with a special changing device redesigned to accommodate epoxy coated strand.

In this project, epoxy coated strand produced and supplied by Sumitomo for external

DYWIDAG Post-Tensioning Tendons was used for the first time outside of Japan.

**Owner**  
Socialist Republic of Vietnam, Ministry for Transport, Directorate for Roads, Vietnam  
**General Contractor**  
Sumitomo Mitsui Construction Co., Ltd., Japan  
**Consulting**  
Oriental Consultants Co., Ltd., Padeco Co., Ltd., Nippon Koei Co., Ltd., Japan Bridge & Structure Institute, Inc., all of them Japan

**Subcontractor**  
DYWIDAG-Systems International SPP – ASIA Ltd., Hong Kong  
**DSI Scope**  
Production, supply, supervision  
**DYWIDAG Products**  
DYWIDAG Type 19-0.6" and 12-0.6" Strand Post-Tensioning System with 3,612 MA Anchorages; rental of 20 stressing jacks with hydraulic aggregates



## The new Eibsee Gondola on the Zugspitze Mountain: DYWIDAG Systems for Germany's highest Jobsite

On the highest jobsite in Germany, the Zugspitze Mountain, the new Eibsee cableway is being built parallel to the existing cableway and will ultimately replace the existing system that was built in 1963. With a capacity of 120 people per gondola, the pendulum cableway will be one of the world's largest with a capacity that is three times that of the existing system.



The new, nearly 4.5km long cable car is being built with only one instead of two support towers. At a height of 127m, the support tower is the world's tallest, and the cableway also has the world's longest free span covering 3,213m.

Work is being carried out while the existing cable car is still in operation, and the project is scheduled for completion in 2017. A new ropeway for material transport was built to transport the required construction materials for the new mountain terminal that is located at an elevation of 2,950m. The material is lifted into the different working panels using an erection crane.

For the new mountain station, approximately 1,000m<sup>3</sup> of rock had to be removed. In total, 1,200m<sup>3</sup> of concrete, 500t of steel and 330t of reinforcing steel are required for this building. The new summit station was designed with a cantilever that juts out by 30m. For this purpose, a tieback structure with two compression and two tension foundations was required that were tied back into the rock up to 16m deep using anchors.

To stabilize the foundation in the mountain terminal, 38 uncoated and double corrosion protected, 32-63.5mm Ø, 6-11 m long GEWI® Soil Nails were used. In an additional

step, 34 permanent, 12 strand, Type SUSPA Systems Strand Anchors were installed. These systems serve to anchor the foundation for the 30m cantilever of the mountain station and were installed vertically into the foundation. This way, the cantilevering building is tied back and stabilized.

DSI also supplied 8 permanent 40 WR, 8-14m long DYWIDAG Anchors and 55 permanent, 40mm Ø, 8-14m long GEWI® Anchors. The DSI scope also included 700m of 28, 32 and 40mm Ø, 2.5-6m long GEWI® Bars and 300m of fabric tubes for anchor encasement.





**Owner**  
Bayerische Zugspitzbahn Bergbahn AG, Germany

**Lead Design**  
Joint Venture BauCon-Hasenauer-AIS, consisting of BauCon ZT GmbH, HASENAUER.ARCHITEKTEN ZTGmbH and AIS- Bau- und Projektmanagement GmbH, all of them Austria

**General Contractor**  
GEO-ALPINBAU GmbH, Austria

**Contractor**  
GEOS Spezialbau GmbH, Austria

**DSI Unit**  
DYWIDAG-Systems International GmbH, Austria

**DSI Scope**

Production, supply, tensioning

**DYWIDAG Products**

38, 6-11 m long, 32-63.5mm Ø GEWI® Soil Nails, 34 permanent, 12 strand, 21.5m long Type SUSPA Systems Strand Anchors, 8 permanent 40 WR, 8-14m long DYWIDAG Anchors, 55 permanent, 40mm Ø, 8-14m long GEWI® Anchors, 700m of 28, 32 and 40mm Ø, 2.5-6m long GEWI® Bars, 300m of fabric tubes for anchor encasement











## Immediate Measure Ehrenhausen: DYWI® Drill System permits fast and flexible Slope Stabilization

In Ehrenhausen in southeastern Austria, south of Graz, an embankment was recently destabilized by heavy rainfalls. A landslide occurred near the train station along the railway tracks of the Suedbahn, affecting an approximately 200m long section of the embankment.



Parts of the failed embankment buried the tracks so that approximately 5,900m<sup>3</sup> of the slope had to be removed. Afterwards, the unstable slope was stabilized by installing soil nails up to a depth of 12m and by installing high strength steel mesh to contain the slope material.

The Suedbahn railway track that had been closed due to the landslide had to be reopened

for railway traffic as soon as possible, so the slope had to be stabilized within a very tight schedule.

In total, approximately 6,850m<sup>2</sup> of embankment had to be stabilized, and 517m long rockfall protection fences had to be built. In the soaked unstable slope, stabilization using DYWI® Drill Soil Nails could only be carried out manually and using a walking crane.

The DYWI® Drill Soil Nails ensured an efficient use both for mechanized installation using the walking crane and for manual installation.

Thanks to the flexible coupler system and the comprehensive range of drill bits, the soil nails could be directly adapted to the prevailing geological conditions.





The stabilization of the embankment required 1,170 R32-320kN DYWI® Drill Soil Nails with a total length of 7,400m, 50 R38-550kN DYWI® Drill Soil Nails with a total length of 370m and 130 R51-660kN DYWI® Drill Soil Nails with a total length of 900m.

For the foundation of the rockfall protection structures, 185, 43.5mm Ø GEWI® Plus Bar Anchors with a total length of 400m were used

according to the system description provided by the manufacturer. All of the systems were supplied complete with accessories.

**Owner**  
ÖBB Infrastruktur AG, Austria  
**General Contractor**  
Swietelsky Bauges.m.b.H., Austria  
**Consulting Engineers**  
IBK Ingenieurbüro Kronawetter ZT  
Gesellschaft mbH, BGG Consult  
Dr. Peter Waibel ZT GmbH and PULSE  
Engineering GmbH, all of them Austria

**DSI Unit**  
DYWIDAG-Systems International GmbH,  
Austria  
**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
1,170 R32-320kN DYWI® Drill Soil Nails,  
50 R38-550kN DYWI® Drill Soil Nails,  
130 R51-660kN DYWI® Drill Soil Nails,  
185, 43.5mm Ø GEWI® Plus Bar Anchors



## New Pedestrian Bridge in Liège: DYWIDAG Bar Tendons keep 430t Steel Element in Balance

The Belgian city of Liège now has a new, centrally located pedestrian and bicycle bridge that connects the district of Guillemins and the city's new train station with Park Boverie. The elegant steel suspension bridge with its diagonal hangers is 294m long and crosses the Meuse River with a main span of 163m and a height of approximately 8m. The bridge deck has a wooden cover and is 7m wide.



The two prefabricated main elements of the steel bridge were positioned in only a few days using three floating cranes. For this purpose, the largest element was positioned first and then anchored to the previously prepared foundation blocks using DYWIDAG Bar Post-Tensioning Systems with posterior bond.

The largest, approximately 140m long, 430t main element cantilevered over the river during construction before the gap was closed from the park side by the approximately 60m long, 100t smaller element. To permit a free cantilevering of the main element without

any intermediate support, the element was actively stressed against the foundation block using a total of 10, St 835/1,035, 75mm Ø, 4.61m long DYWIDAG-Bar Post-Tensioning Tendons. Afterwards, the DYWIDAG Bar Post-Tensioning System was grouted to achieve posterior corrosion protection.

In all of the other, smaller foundation blocks, St 950/1,050, 18mm - 47mm Ø DYWIDAG Bar Post-Tensioning Systems were successfully installed and stressed. In total, the following DYWIDAG Bar Tendons with a total tonnage of 4.6t were used:

- 12 75 WR, St 835/1,035N/mm<sup>2</sup>, 4.61m long DYWIDAG Bar Tendons,
- 16 47 WR, St 950/1,050N/mm<sup>2</sup>, 1.475 - 3.26m long DYWIDAG Bar Tendons,
- 7 40 WR, St 950/1,050N/mm<sup>2</sup>, 1.32 - 1.58m long DYWIDAG Bar Tendons,
- 16 32 WR, St 950/1,050N/mm<sup>2</sup>, 1.005 - 1.46m long DYWIDAG Bar Tendons,
- 2 26 WR, St 950/1,050N/mm<sup>2</sup>, 0.95m long DYWIDAG Bar Tendons,
- 4 18 WR, St 950/1,050N/mm<sup>2</sup>, 0.95m long DYWIDAG Bar Tendons,
- 4 20mm Ø, S650/800N/mm<sup>2</sup> INOX Bar Tendons





Thanks to the close cooperation between the Engineer, the General Contractor and DYWIDAG-Systems International, an anchoring solution was found that combined the advantages of high anchoring forces, little required space, low anchor slip and easy installation despite the difficult conditions on site.

The DYWIDAG-Systems International team was available for the General Contractor during installation and assembly of the steel elements in order to be able to react immediately to the respective technical requirements on site.

The complete stressing and corrosion protection work was accompanied by trained stressing engineers. This way, DYWIDAG-Systems International efficiently provided its long-term experience and product know-how to the customer.

**Owner**  
Service public de Wallonie, Belgium  
**General Contractor**  
Eraerts Dragages et Entreprises SA – Jan De Nul Group, Belgium  
**Engineering**  
Bureau Greisch, Belgium

**DSI Unit**  
DYWIDAG-Systems International N.V., Belgium  
**DSI Scope**  
Production, supply, installation, engineering services, technical support  
**DYWIDAG Products**  
4.6t of 75 WR, 47 WR, 40 WR, 32 WR, 26.5 WR, 18 WR and INOX 20mm Ø DYWIDAG Post-Tensioning Tendons



## Construction of a new Quarter with DYWIDAG Strand Anchors: The Frederiks Plads in Aarhus

Aarhus is Denmark's second largest city and is located on the east coast of the Jutland Peninsula, 187km northwest of Copenhagen. This is where Frederiks Plads is currently under construction – a major project in which a new district is being built on an area of 48,500m<sup>2</sup>. In the buildings surrounding the new square, 35,000m<sup>2</sup> will be available for commercial use and office space, 12,000m<sup>2</sup> for apartments and 1,500m<sup>2</sup> for shops.



The new quarter with two 15 and 19 level high rise buildings and several other buildings is being developed on the premises of the former maintenance facility of the Danish State Railway, and the result will create a better connection between the new area and the city center in the future.

The retaining walls of the Frederiks Plads excavation had to be stabilized by permanent anchors. Additionally, some of the existing

construction and surrounding property had to be integrated into the excavation and be tied back as well. Due to its reliability and durability, the DYWIDAG Strand Anchor System was used for this purpose.

DSI supplied approximately 800 permanent Type 3-0.62" and 4-0.62" DYWIDAG Strand Anchors with a total length of approximately 20,000m for this project.

**Owner**  
Bricks A/S, Denmark  
**General Contractor**  
NCC Property Development,  
Denmark  
**Subcontractor**  
Intergrund AB, Sweden  
**Architect**  
C.F. Møller Danmark A/S, Denmark  
**Engineering**  
Rambøll Danmark A/S, Denmark

**DSI Unit**  
DYWIDAG-Systems International  
GmbH, BU Geotechnics, Germany  
**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
800 permanent Type 3-0.62" and 4-0.62"  
DYWIDAG Strand Anchors



# The REDI Complex: DYWIDAG Systems stabilize the Foundation of Finland's largest Construction Project

In April 2015, construction of Finland's largest urban project started: The REDI Complex in Kalasatama, Helsinki's eastern inner city area. This project consists of 6 new high-rise buildings with 1,200 apartments, an office and a hotel tower as well as a 60,000m<sup>2</sup> shopping center.



At a height of 132m and with 35 floors, Majakka Tower, the first building, will be Finland's tallest apartment building after its completion, which is scheduled for 2018. The complete project is scheduled for completion between 2022 and 2024.

In the first step, the excavation pit for the towers and the shopping center including the planned parking decks was excavated and the needed foundations were built. In total, the large construction site required approximately 200 temporary, 7-12 strand, 25m long DYWIDAG Strand Anchors. Furthermore, approximately 100 permanent, 7-15 strand, 20m long DYWIDAG Rock Anchors were installed to stabilize the excavation.

The TH concrete walls needed for the different buildings were anchored in the soil and rock using permanent WR single bar anchors. The TH walls were then individually post-tensioned in sections using DYWIDAG Post-Tensioning Bars, and the individual tendons were extended to the required lengths using couplers. Approximately 500 32, 36, 40, and 47mm Ø DYWIDAG Bar Anchors with double corrosion protection in lengths of 12-15m were used for this purpose.

The installation, stressing and tendon grouting was carried out by DSI Construction's licensee Tensicon. The DYWIDAG Bar Anchors were stressed using a Portable Hollow-Piston CFRP Cylinder.

**Owner**  
SRV Group Plc, Finland  
**Subcontractor**  
Tensicon Oy, Finland

**DSI Units**  
DYWIDAG-Systems International GmbH, BU Geotechnics, Germany, Tensicon Oy, Finland

**DSI and Tensicon Scope**  
Design, development, production, supply, installation, technical support, test installation

**DYWIDAG Products**  
200 7-12 strand DYWIDAG Strand Anchors, 100 7-15 strand DYWIDAG Strand Anchors, 500 32, 36, 40 and 47mm Ø DYWIDAG Bar Anchors



## High Quality Products and Technical Support: Construction of a new Children's Home with Technique Béton

Recently, a new children's home was built in a residential area in the town of Savigny sur Orge south of Paris, France. A large new building was constructed facing the street. The precast concrete elements that were needed for the construction project were produced on the jobsite.



Technique Béton provided technical support and supplied the site with high quality products and accessories for concrete.

In this project, the new mould release agent Biodem® SI3 conforms to the new Classification Synad (the French professional admixtures association) for such requirements as biodegradability, for example. This product has also been developed in order to comply with the CLP Regulation (Classification, Labelling and Packaging). The special product Biodem® SI3 releases all the precast beams from the mould easily and simultaneously creates a high quality concrete surface.

Laroche® Plastic Cones were used as spacers for setting the precast formwork. Following the

production of the precast elements, the voids left by the spacers were filled using Laroche® Concrete Cones.

Thanks to the exceptional bond strength and to its high mechanical strength, Ravalchoc® Flexible Etanche was used to create a waterproof bond between the concrete cone and the precast element.

Finally, for the precast elements produced on the jobsite, Mastar® has been used as an anchoring system.

The global offer and Technical Support of Technique Béton made the difference...once again.

**Owner**  
Municipality of Savigny sur Orge,  
France  
**General Contractor**  
VINCI S.A., France  
**Contractor**  
DUMEZ ILE-DE-FRANCE, France

**DSI Unit**  
Technique Béton, France  
**Technique Béton Scope**  
Production, supply, technical support  
**Technique Béton Products**  
Biodem® SI3 Mould Release Agent,  
Laroche® Cones, Ravalchoc® Flexible  
Etanche Self-Levelling Mortar,  
Mastar® Anchoring Mortar



# High Quality Concrete Accessories for modern Complex of Buildings: The “Côté Jardin” in Guyancourt

In Guyancourt southwest of Paris, a 20,000m<sup>2</sup> complex of buildings is being built that is named “Côté Jardin”.



After its completion, this complex will accommodate 130 apartments and offer 2,000m<sup>2</sup> of retail space. In addition, 3,000m<sup>2</sup> will be available for offices, and the “Côté Jardin” will include 100 hotel rooms as well as a medical center.

The General Contractor selected Technique Béton to produce and supply the required concrete admixtures for the mobile concrete plant on this jobsite. Technical Support recommended the use of the Super-Plasticizer/High Water Reducing Agent Addifor® 2001 in accordance with

the raw material specifications and the requirement for high quality concrete.

In addition, the DSI company supplied Biodem® S12 as a mould release agent with vegetable base, Laroche® Formwork Spacers and Concrete Cones.

The customer was extremely satisfied by Technique Béton’s technical solutions and the final result obtained for this jobsite.

**Owner**  
Sofilogis, France  
**General Contractor**  
Demathieu Bard, France  
**Architect**  
HGA - Hubert Godet Architectes -  
Architecte D.P.L.G., France

**DSI Unit**  
Technique Béton, France  
**Technique Béton Scope**  
Production, supply, technical support  
**Technique Béton Products**  
Super-Plasticizer/High Water Reducing  
Agent Addifor® 2001, Mould release agent  
Biodem® S12, Laroche® Formwork Spacers  
and Concrete Cones



# The Carré Haussmann: Technique Béton supplies Chemical Products and Spacers for modern Office Block

Due to its proximity to Charles de Gaulle Airport and due to the good traffic connections to the French capital, Marne-la-Vallée, which is located east of Paris, is a popular business location.



At this location, several new buildings are being constructed near Disneyland Paris: The Carré Haussmann. The construction project consists of 4 buildings that will offer modern offices on an area of 32,000m<sup>2</sup>.

For formwork setting, Technique Béton supplied magnetized and non-magnetized Laroche® Spacers and Concrete Cones in

sizes of 20, 25 and 30cm and SUFA Laroche® Concrete Spacers in sizes 40/50 and 30mm.

Furthermore, to ensure that the high quality concrete facades of the new buildings were achieved, Biodem® SI1 was used as a mould release agent. The vegetable based Biodem® SI1 was used together with the finishing coat mortar Finimur®.

**Owner**  
Carré Haussmann Promotion,  
France  
**General Contractor**  
Harribey Constructions, France  
**Architect**  
Agence 4A (Atelier Aquitain  
d'Architectes Associés), France

**DSI Unit**  
Technique Béton, France  
**Technique Béton Scope**  
Production, supply  
**Technique Béton Products**  
Finishing coat mortar Finimur®,  
mould release agent Biodem® SI1,  
Laroche® concrete Spacers and Cones



# Chemical Solutions and Accessories for a new Pedestrian Bridge

The town of Boulogne-Billancourt that borders on the 16<sup>th</sup> district southwest of Paris is located close to the Seine River. Until recently, there was no direct connection between Seguin Island and the town of Sèvres on the left side of the river.



Consequently, a new, 97m long and 5.7m wide pedestrian bridge was built over the Seine River. The steel structure weighs 360t and was completely pre-assembled in Lauterbourg. Afterwards, it was transported to the installation site on a barge.

On the left river bank, the bridge abutment is being erected between a railroad track and the Seine River. Due to the limited available space, the crane that was needed for construction work was mounted onto a barge and anchored at the river bank.

The two reinforced concrete bridge bearings at the river bank rest on approximately 23m long bored piles. For the abutment on the left

river bank, Technique Béton supplied several high quality products in order to ensure a long service life of the bridge bearings.

Technique Béton supplied SUFA 40/50 and DOG 36 Laroche® Concrete Spacers for the correct positioning of the reinforcing mesh.

The vegetable mould release agent Biodem® SI3 was used for the formwork. This product has been developed in response to the CLP Regulation (Classification, Labelling and Packaging).

In addition, the special wax Cirtec® was applied with high precision on the architectural formwork.

#### Owner

SAEM Val de Seine Aménagement, France

#### General Contractor

Eiffage Travaux Maritimes et Fluviaux SASU and Eiffage Construction Métallique, both France

#### Architect

Ateliers Jean Nouvel SAS, France

#### DSI Unit

Technique Béton, France

#### Technique Béton Scope

Production, supply

#### Technique Béton Products

Mould release agent Biodem® SI3 and wax Cirtec®, Laroche® concrete Spacers SUFA and DOG



## Protection against Floods: Chemical Solutions and Accessories for Water Retention Tanks

In the community of Serris east of Paris, large areas had to be sealed for a major shopping center with an extensive parking lot and other industrial buildings. In order to eliminate the risk of flooding during heavy rainfall, several large water retention tanks were subsequently built in the immediate vicinity of the shopping center. So doing will conserve water for use in the green areas of the city.



Technique Béton supplied several high quality products for the tanks. The formwork was sprayed with the mould release agent Biodem® PV before pouring the concrete in order to ensure an easy release of the formwork. This vegetable based Biodem® PV is recognized for its high level of biodegradability.

Furthermore, Bataimant Magnetic Blocks were used to allow a perfect positioning of different varieties of frames in the vertical formwork.

The company also supplied 2,000 hydroexpansive rings and twice as many associated

hydroexpansive plugs that were used to guarantee a perfect seal through or around the PVC spacer.

For the concrete floors, Technique Béton supplied Laroche® Concrete Spacers for the correct positioning of the reinforcing mesh and the VOC free curing product ProtecsoI® GE 08.

This curing product was used to ensure a high quality concrete surface by preventing rapid water evaporation and the formation of cracks. ProtecsoI® GE 08 as a water based product ensures sustainable concrete which will avoid future additional costs.

**General Contractor**  
VINCI S.A., France  
**Contractor**  
Chantiers Modernes  
Construction, France

**DSI Unit**  
Technique Béton, France  
**Technique Béton Scope**  
Production, supply  
**Technique Béton Products**  
Biodem® PV Mould Release Agent,  
ProtecsoI® GE 08 Curing product,  
hydroexpansive rings and plugs,  
Bataimant Magnetic Blocks,  
Laroche® Concrete Spacers



# Technique Béton supplies Special Products for Europe's largest Wastewater Treatment Plant

With an operating capacity of 2.1 million m<sup>3</sup> of wastewater per day, the Achères treatment plant in northwestern Paris collects approximately 80% of the wastewater of Paris. This makes the plant the largest sewage processing plant in Europe and the second largest worldwide after Chicago.



Within the scope of a modernization and enlargement project, the wastewater treatment plant is being upgraded to comply with the new European Water Framework Directive and to serve the growing population in western Paris.

Construction work includes two new parallel facilities for the biological treatment of sludge. A total of 27,000m<sup>3</sup> of concrete was needed for the new wastewater treatment plant.

Technique Béton supplied a large range of products that ensure a high-quality execution on the jobsite. This included the synthetic mould release agent Décosyntec® 2005. In addition, the following special products were used:

- Ravalchoc® PMES, a mortar with a high sulfate resistance that is suitable for aggressive environments

- The mortar Ravalchoc® Flexible Etanche used to create a waterproof bond between the concrete cone Laroche® Concrete Cone and the wall.
- Finisol® Self-Levelling Mortar for levelling the floors in the jobsite area
- The finishing coat mortar Finimur® and the finishing coat paste Revet Cryl®

Thanks to the company's know-how, different mortars with the right color have been delivered to the jobsite. Thus, the light grey repair mortar, Ravalchoc® GC, has been used to respond to a special color request.

Technique Béton is proud to have contributed to the modernization of the largest sewage works in France by supplying its high quality products.

#### Owner

SIAAP (Syndicat Interdépartemental d'Assainissement pour l'Agglomération Parisienne), France

#### General Contractor

GTM TP IDF, Sogea IDF Génier Civil and Dodin Campenon Bernard, all of them France

#### Subcontractor

Eiffage SA, FAYAT Entreprise TP, NGE SAS, all of them France

#### DSI Unit

Technique Béton, France

#### Technique Béton Scope

Production, supply

#### Technique Béton Products

Décosyntec® 2005 Mold Release Agent, special mortars Ravalchoc® PMES, Ravalchoc® GC and Ravalchoc® Flexible Etanche, Finisol® Self-Levelling Mortar, Finimur® Finishing Coat Mortar and Revet Cryl® Finishing Coat Paste, Laroche® Concrete Cones



## DSI supplies Post-Tensioning Systems for trend-setting Design: Construction of Audi's new DesignCenter

In October 2014, construction work for a new DesignCenter began on Audi AG's factory premises in Ingolstadt, Germany. After completion of construction within approx. 300 working days, the German car manufacturer will use this facility for the development of new concepts and models.



The modern reinforced concrete structure was built in two sections. In order to ensure the high quality of the exposed concrete surfaces, a new formwork system with a formwork sequence that was developed by the general contractor MAUSS was used for the construction of the DesignCenter.

Modellwerkstatt\_1 is located in the basement of the building. As a factory model workshop,

it was designed with a headroom of 7m. The Desing\_2 area is located above the workshop. Praesentationsebene\_3, the presentation area on the fourth floor, completes the building. The generous areas of the new DesignCenter with only a small number of supporting columns required that several floor slabs be designed and constructed using post-tensioned prestressed concrete. For tensioning the floor slabs

above the 1<sup>st</sup> basement floor, DSI supplied oval, Type 6-5, SUSPA Systems Tendons without additional reinforcement complete with Type E Stressing Anchorages and Type EP Fixed Anchorages. The prefabricated tendons that are protected by oval ducts were installed longitudinally and transversally into the slab formwork and tensioned in accordance with the predetermined order by experienced DSI installation technicians.





For the slabs above the first upper floor and the 1<sup>st</sup>, 3<sup>rd</sup> and 4<sup>th</sup> floor, DSI supplied both oval, Type 6-5, SUSPA Systems Tendons and Type 6-9, SUSPA Systems Post-Tensioning Systems in round ducts.

Both post-tensioning systems were placed horizontally and vertically on the formwork without additional reinforcement. They were supplied complete with Type E Stressing

Anchorage and Type EP Fixed Anchorages and were also tensioned by DSI technicians. A total of 671 prefabricated, Type 6-5, 8 - 76m long tendons with a total weight of 146t as well as 364 Type 6-9, 26 - 51m long tendons with a total weight of 125t were installed in the 5 aforementioned slabs of the new DesignCenter. In addition to the stressing and fixed anchorages, Types E and EP, 40 Type 6-9 coupling anchors were installed.

**Owner**

Audi AG, Germany

**General Contractor**

MAUSS BAU GmbH & Co. KG,  
Germany

**Architect**

gmp Generalplanungsgesellschaft  
mbH, Germany

**Engineering**

**(Support Structure Planning)**  
ULM-Ingenieurgesellschaft mbH & Co.  
KG, Germany

**DSI Unit**

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

**DSI Scope**

Production, supply, technical support,  
tensioning work

**DYWIDAG Products**

671 Type 6-5, 8 - 76m long tendons;  
364 Type 6-9, 26 - 51m long tendons



## The Karlsruhe City Railway: DYWIDAG Strand Anchors ensure Stability against hydrostatic Ground Water Pressure

Within the scope of what is called the Kombiloesung (combined solution), Karlsruhe's center is being converted to a pedestrian zone without any railway tracks. For this purpose, a 2.4km long, single-tube city tunnel is being built underneath Kaiser Road with a 1km long southern branch leading towards the Congress Center. The major project also includes the construction of a new road tunnel between Karlstor and Mendelssohn Square.



Photo reprinted courtesy of Stump Spezialtiefbau GmbH, Germany

Since most of the subterranean stations are located in the Upper Rhine Rift in layers that are unstable or not watertight, impermeable excavation enclosures consisting of diaphragm or bored pile walls had to be built in several sections due to the high ground water levels. To tie back the different retaining walls, DSI had previously supplied approximately 100t of DYWIDAG Strand Anchors. Recently, DSI received a follow-up order from the subcontractor Stump Spezialtiefbau GmbH.

At the Ettlinger Gate, DYWIDAG Strand Anchors were also used to tie back the walls.

In total, 457 semi-permanent, 8 strand DYWIDAG Strand Anchors with a total length of 11,422m were installed to stabilize the walls against ground water pressure. DSI also supplied 572 temporary, 5-6 strand DYWIDAG Strand Anchors that were installed at a total length of 12,511m. Furthermore, DSI supplied 150 load cells to monitor the forces acting on the anchors.

In this area, the high ground water levels and several obstructions in the ground such as steel sheet piles posed a special challenge.

### Owner

KASIG - Karlsruhe Schieneninfrastruktur-Gesellschaft mbH, Germany

### Contractor

Joint Venture Stadtbahntunnel, consisting of BeMo Tunnelling GmbH, Austria and FCC, S.A., Spain

### Subcontractor

Stump Spezialtiefbau GmbH, Germany

### Consulting Engineers

Planungsgemeinschaft Stadtbahntunnel Karlsruhe, Germany

### DSI Unit

DYWIDAG-Systems International GmbH, BU Geotechnics, Germany

### DSI Scope

Production, supply

### DYWIDAG Products

457 semi-permanent, 8 strand DYWIDAG Strand Anchors, 572 temporary, 5-6 strand DYWIDAG Strand Anchors, 150 load cells



## GEWI® Soil Nails ensure long-term Security: Widening of the B14 Federal Road southwest of Stuttgart

On behalf of the regional board in Karlsruhe, Germany, the B14 Federal Road between Horb-Neckarhausen and Sulz-Fischingen southwest of Stuttgart was widened. The expansion measures were carried out in two phases.



Photos reprinted courtesy of PST Spezialtiefbau Süd GmbH, Germany

The first phase included the construction of an approximately 670m long and up to 4.65m high shotcrete wall designed to stabilize a slope located next to a curve in the road. In the second phase, the construction of this retaining wall provided for the complete widening of the B14 in the curved section. Thanks to the 800m long widening project, safety in this section of the road will be considerably improved.

In the first construction phase, the B14 Federal Road was completely rebuilt and shifted into the slope by approximately 2m. In total, this section required the excavation of roughly 10,000m<sup>3</sup> of soil. The slope in this area was permanently stabilized by the new shotcrete wall.

In order to stabilize the embankment for the long term, approximately 1,000 GEWI® Soil Nails were anchored into the load-bearing strata of the slope in up to 3 levels up to a height of 5m. In total, DSI Germany supplied about 6,500m of 25mm Ø GEWI® Soil Nails with standard corrosion protection in individual lengths of 6.5m.

Afterwards, a 30cm thick layer of shotcrete was applied to the retaining wall over a surface area of roughly 1,800m<sup>2</sup>. Subsequently, a 5cm thick facing was applied in a faux masonry pattern.

**Owner**  
Regional board Karlsruhe,  
Germany

**Contractor**  
PST Spezialtiefbau Süd GmbH,  
Germany

**Engineering**  
Rainer Verst Dipl.-Ing. Geotechnik &  
Spezialtiefbau GmbH, Germany

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

**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
Approximately 1,000 25mm Ø, 6.5m long  
GEWI® Soil Nails



## The 2<sup>nd</sup> Moselle Lock Chamber: DYWIDAG Strand Anchors help secure the Future of one of Germany's most important Waterways

From Koblenz in Germany to Neuves-Maisons in France, the navigable part of the Moselle River has a total length of over 390km and is the most heavily travelled inland waterway in Germany. Annually, more than 10,000 cargo ships navigate the Moselle; in the summer months, the river is also used by approximately 5,000 passenger ships.



*Photos reprinted courtesy of GBS Grundbau Bohrtechnik Spezialtiefbau GmbH & Co. KG, Germany*

With a current transport volume of 15 to 16 million tons per year, the locks have exceeded their capacity, which leads to long wait times. Furthermore, the repair work that has to be carried out on the more than 50 year old locks keep getting more extensive, resulting in full closures of 8 days per year.

To make the waterway sustainable and allow year-round navigation, 10 new locks are being built parallel to the existing lock systems from Koblenz to Trier. The new locks have a

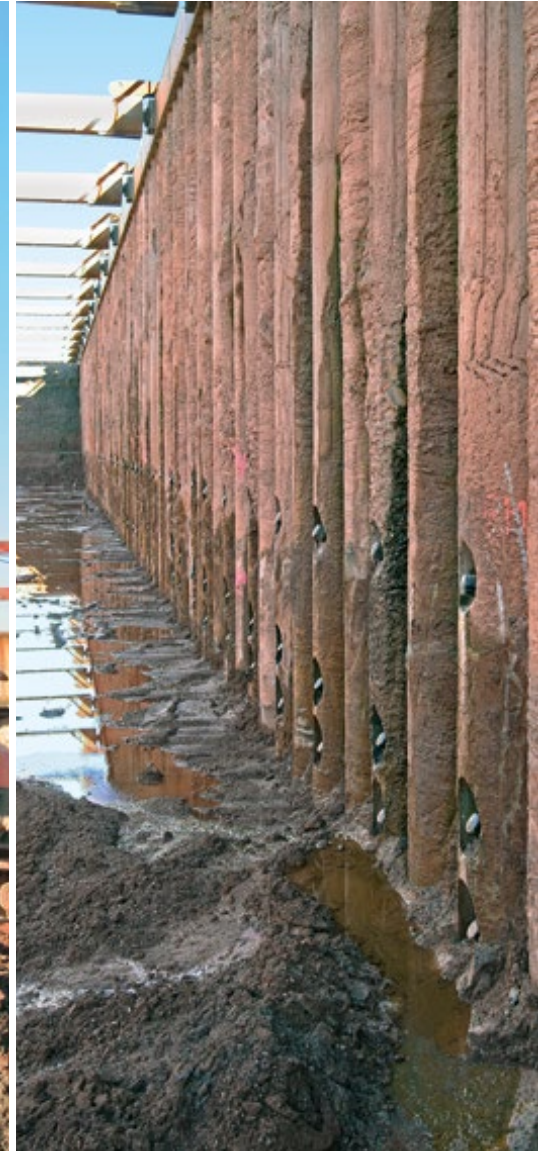
navigable length of 210m and a width of 12.5m and can therefore be used by larger ships.

The lock complex in Trier is the third system to be enlarged. The new lock chamber is being erected onshore next to the existing chamber as a monolithic reinforced concrete structure with a 3m thick base. The excavation needed for the new locks is being constructed directly next to the old locks. Therefore, a reinforced bored pile wall with double tie backs was necessary to stabilize the existing chamber.

The complete excavation for the locks is partly built as an overlap bored pile wall and partly as a sheet pile wall.

At the upper offshore terminal, the separating breakwater between the old and the new chamber was built as a bored pile wall supported by 4 layers of tie backs. The excavation sheet pile wall is also supported by 4 layers of tie backs, with the first layer employing horizontal tie rods and the other 3 layers using grouted anchors.





At the lower offshore terminal, the separating breakwater consists of an overlap bored pile wall tied back in 4 layers. The front sides of the excavation are confined by sheet pile cofferdams. In these areas, tension anchors were used at the top of the wall in addition to the tie back anchors.

The prevailing soil mainly consists of 5 layers, with back fills, alluvium, gravel and sand in the upper layers. The drilling work for the bored pile wall and the anchors were carried out in

conglomerates of highly abrasive consolidated gravel and in weakly abrasive, partly scaly claystone and siltstone.

To tie back the retaining structures around the excavation, DSI produced and supplied 223 permanent DYWIDAG Strand Anchors with 2, 4, 5, 6 and 7 strands and a total length of 5,313m as well as 393 temporary DYWIDAG Strand Anchors with 4, 6, 7, 8, 9 and 10 strands and a total length of 6,230m.

**Owner**

Wasser und  
Schiffahrtsverwaltung des Bundes  
(WSV), Germany

**Contractor**

HOCHTIEF AG, Germany

**Subcontractor**

GBS Grundbau Bohrtechnik  
Spezialtiefbau GmbH & Co. KG,  
Germany

**DSI Unit**

DYWIDAG-Systems International GmbH,  
BU Geotechnics, Germany

**DSI Scope**

Production, supply, technical support

**DYWIDAG Products**

223 permanent DYWIDAG Strand Anchors  
with 2, 4, 5, 6 and 7 strands,  
393 temporary DYWIDAG Strand Anchors  
with 4, 6, 7, 8, 9 and 10 strands



## The Augsburg Transportation Hub: DSI supplies DYWIDAG Strand Anchors for the West Tunnel

The Augsburg City project is the largest urban development to have been undertaken within the last decades in Augsburg, Germany. The redevelopment of local public transport is part of this project and is being carried out under the name of “Mobilitätsdrehscheibe Augsburg – MDA” (Augsburg transportation hub).



Photos reprinted courtesy of Stump Spezialtiefbau GmbH, Germany

The goal is a better connection between the city's different means of transport and the expansion of the tram network. For this purpose, the central interchange square for busses and trams is being converted, the tracks are being relocated and two new tram lines are being introduced.

The central section of the MDA is the multi-level underground structure for the entire

main station that also includes the construction of a 405m long, double track tram tunnel and a new station.

In the up to 14m deep and approximately 70m long excavation for the West Tunnel, the contractor Stump Spezialtiefbau GmbH installed soldier piles for the soldier pile structure that was tied back in several locations. To ensure the continuation of train

traffic during construction work, transverse steel girders or longitudinal structures were installed as sheeting wall systems in some areas. Temporary DYWIDAG Strand Anchors were especially used near the tram terminal loop. Here, 182 4-strand DYWIDAG Anchors with a total length of 2,964m, 140 5-strand DYWIDAG Anchors with a total length of 2,292m and 40 6-strand DYWIDAG Anchors with a total length of 724m were used.





The tiebacks were installed using superposition drilling. In some areas, there were up to 3 levels of anchors crossing each other, which required drilling tolerances of a maximum of 1°. The tunnel structure will be concreted as a trough structure in sections with floor slabs, walls and corners until the end of 2016. Afterwards, the excavation will be backfilled, and the tracks on the surface will resume operation.

**Owner**

Stadtwerke Augsburg Verkehrs-GmbH, Germany

**Contractor**

Stump Spezialtiefbau GmbH (as a Joint Venture), Germany

**Engineering**

Engineering association MDA Hbf, consisting of K+S Ingenieur-Consult GmbH & Co. KG and SSF Ingenieure AG, both Germany

**DSI Unit**

DYWIDAG-Systems International GmbH, BU Geotechnics, Germany

**DSI Scope**

Production, supply

**DYWIDAG Products**

182 4-strand DYWIDAG Anchors, 140 5-strand DYWIDAG Anchors and 40 6-strand DYWIDAG Anchors



## Ice Load Rehabilitation in Bielefeld: Stable Foundation Reinforcement of Electrical Towers using *GEWI*<sup>®</sup> Micropiles

For more than 20 years, bent or overturned electrical towers have repeatedly caused power blackouts in Germany. In 2005 in Munsterland, for example, 82 electrical towers bent over because they had been exposed to extraordinary ice and snow loads due to extreme weather conditions.



A few years ago, a new standard was implemented for power supply line construction that is designed to significantly improve the stability of electrical towers in Germany. With the help of ice load rehabilitation, the load-bearing capacity of the towers is improved so that they can accommodate higher loads when exposed to wet snow conditions and ice accumulation in winter.

One of the measures for ice load rehabilitation is the foundation reinforcement of existing towers such as the measures that were recently carried out in some areas in Bielefeld. During the rehabilitation of 5 overhead line towers, the existing shallow foundations of the masts were sustainably strengthened using *GEWI*<sup>®</sup> Micropiles.

The significant challenge encountered during this rehabilitation project was the fact that the micropiles had to be drilled inside the electrical towers with borehole diameters of 300mm. During this procedure, the system's real value was demonstrated by its excellent force/borehole diameter ratio.

Furthermore, the *GEWI*<sup>®</sup> Micropile system can absorb tensile, compression, and alternating loads. Another important main feature of *GEWI*<sup>®</sup> small-diameter bored piles is the flexible length adjustment that can be carried out on site. Furthermore, the proven coarse *GEWI*<sup>®</sup> Thread ensures the threadability of the system even in extreme conditions.

The rehabilitation required shorter section lengths for the *GEWI*<sup>®</sup> Steel Tendons. The fact that only the borehole is grouted so that there is no spillover is an additional advantage of the *GEWI*<sup>®</sup> System. For ice load rehabilitation in Bielefeld, DSI supplied 50 and 63.5mm  $\varnothing$  *GEWI*<sup>®</sup> Micropiles that were partly double corrosion protected as small-diameter bored piles. The complete installation was carried out using light-weight and compact drilling equipment that was small enough to fit inside the electrical towers.

The ice load rehabilitation at the 5 towers was successfully completed, and soon, the foundations of additional electrical towers will be reinforced using *GEWI*<sup>®</sup> Micropiles.

**Owner**  
Cteam Consulting &  
Anlagenbau GmbH,  
Germany  
**Subcontractor**  
GEO-BOHRTECHNIK GmbH,  
Germany

**DSI Unit**  
DYWIDAG-Systems International  
GmbH, BU Geotechnics,  
Germany  
**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
50 and 63.5mm  $\varnothing$  *GEWI*<sup>®</sup> Micropiles



# DYWIDAG Strand Anchors stabilize Excavations for Project Approval

## Section 1.5, Lot 4 North, Stuttgart 21

Project Approval Section 1.5 is part of a Stuttgart 21 sub-project – the railway project Stuttgart-Ulm – and refers to the triangle between the train station in Feuerbach, the train station in Bad Cannstatt and the access to Stuttgart Main Station. This section includes the planned, approximately 9km long underground long-distance rail and suburban train tracks to Feuerbach, Stuttgart-Nord and Bad Cannstatt.



Photos reprinted courtesy of Max Bögl Stiftung & Co.KG, Germany

In Lot 4 of this section, the new district that is being created by eliminating the existing above ground tracks in the north of the main station is being connected to public transport. For this purpose, a new station is being built for all suburban trains in the new district Rosensteinquartier at Mitternacht Street.

1.5km of the new section are being built using the open cut method, and the new suburban train station is also located in a trough. The different excavations in Lot 4 North were stabilized using DYWIDAG Strand Anchors.

At the area UL 7 at the Mitternacht Street Station, the excavation was stabilized using approximately 13,000m of temporary, grouted 3 to 5 strand DYWIDAG Strand Anchors.

At the branch-off construction in area UL 8, approximately 9,000m of temporary and permanent 3 to 5 strand anchors were installed.

For area UL 10, DSI Construction Germany also supplied approximately 18,000m of temporary and permanent, 3 to 5 strand grouted DYWIDAG Strand Anchors.

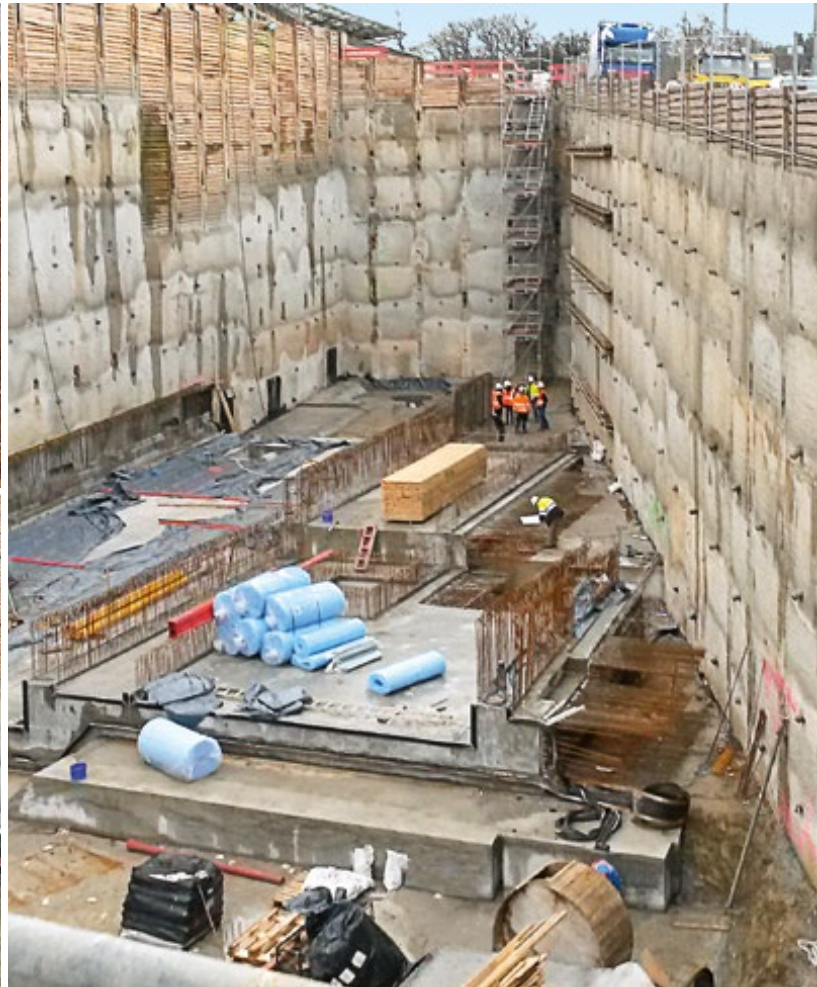
**Owner**  
Deutsche Bahn AG, Germany  
**Contractor**  
Max Bögl Stiftung & Co. KG,  
Germany

**DSI Unit**  
DYWIDAG-Systems International  
GmbH, BU Geotechnics, Germany  
**DSI Scope**  
Production, supply, technical support  
**DYWIDAG Products**  
40,000m of 3 to 5 strand DYWIDAG  
Strand Anchors



## Closing a Gap with DYWIDAG Strand Anchors and GEW® Bar Anchors: The B10 Rosenstein Tunnel in Stuttgart

The B10 Rosenstein Tunnel in Stuttgart, Germany is part of a road construction project that will close a gap in the development of the B10 Federal Road between the town of Zuffenhausen and Stuttgart East. Thanks to the construction of the tunnel, Prague Street can be reduced from 4 to 2 lanes, which will significantly reduce traffic congestion in the affected districts and will allow the creation of new green space.



Photos reprinted courtesy of Kurt Motz e.K., Germany

With a total length of approximately 1,300m, the new road tunnel passes below Rosenstein Park and parts of the Wilhelma Zoological and Botanical Gardens. After tunnel completion, which is scheduled for 2020, traffic will be run through both tunnel tubes on two lanes in each direction.

At its deepest point, the tunnel is located 20m beneath Rosenstein Park. 750m of the two tunnel tubes are advanced from the Neckar River in the direction of Prague Street using the underground method. The tunnel is accessed via an approximately 40m long approach adit. Thanks to the underground method, interferences with Rosenstein Park and Wilhelma Zoo can be avoided.

The open cut method is only used for the areas that will connect the tunnel to Prague and Neckartal Streets. The excavation at Prague Street accommodates both tunnel tubes as well as the new operational building and was therefore excavated to a depth of up to 18m.

To stabilize this excavation, DSI supplied 532 temporary Type 3-0.6" and 4-0.6" DYWIDAG Strand Anchors with a total length of 9,110m. The DYWIDAG Strand Anchors were installed in the excavation walls in lengths of 10 to 22m. Furthermore, 566 16 to 40mm Ø GEW® Bar Anchors with a total length of 4,367m were used. The GEW® Bar Anchors were installed in individual lengths from 2 to 14m.

**Owner**  
Regional Capital Stuttgart, Germany  
**Contractor**  
Wolff & Müller Spezialbau GmbH & Co. KG,  
Germany  
**Subcontractor**  
Kurt Motz e.K., Germany  
**Engineering**  
WBI Prof. Dr.-Ing. W. Wittke Beratende  
Ingenieure für Grundbau und Felsbau GmbH,  
Boll und Partner, Beratende Ingenieure VBI and  
Hyder Consulting GmbH, all of them Germany  
**Architects**  
wulf architekten GmbH and Kaag und Schwarz  
Architekten, both Germany

**DSI Unit**  
DYWIDAG-Systems International GmbH,  
BU Geotechnics, Germany  
**DSI Scope**  
Development, production, supply  
**DYWIDAG Products**  
532 temporary, 10 - 22m long Type 3-0.6" and 4-0.6"  
DYWIDAG Strand Anchors, 566 16 to 40mm Ø, 2 - 14m  
long GEW® Bar Anchors



# The Skyline Project in Stuttgart: DYWIDAG Strand Anchors stabilize large-scale Excavation

The Skyline Project in the theater district in northern Stuttgart is a new building complex that will provide space for both offices and apartments.



Photos reprinted courtesy of Kurt Motz e.K., Germany

Initially, a z shaped low-rise 5 level building with one recessed stepped story and a gross floor area of approximately 10,000m<sup>2</sup> is being built on a property of roughly 6,000m<sup>2</sup>. Daimler Financial Services AG is going to rent this office building for up to 600 employees.

In a second step, this building, which is known as Skyline Office, will be complemented by the 75m high, 22 story Skyline Living apartment tower that will accommodate approximately 140 apartments.

The project also includes a four level underground car park that will provide 345 parking spaces. 62,000m<sup>3</sup> of soil had to be removed for the large-scale excavation of the project.

DSI supplied 282 Type 3-0.6" and 4-0.6", 9 - 21m long, temporary DYWIDAG Strand Anchors for tying the excavation walls back safely. Approximately 4,020m of strand anchors were supplied in total.

#### Owner

Objektgesellschaft Skyline Stuttgart mbH, Germany

#### Contractor

Max Bögl Bauunternehmung GmbH & Co. KG, Germany

#### Subcontractor

Kurt Motz e.K., Germany

#### Architects

StructureLab GmbH and Bülow AG, Germany

#### DSI Unit

DYWIDAG-Systems International GmbH, BU Geotechnics, Germany

#### DSI Scope

Development, production, supply

#### DYWIDAG Products

282 Type 3-0.6" and 4-0.6", 9 - 21m long, temporary DYWIDAG Strand Anchors



## The Bad Cannstatt Tunnel: DYWIDAG Strand Anchors stabilize Smoke Removal Structure in Heilbronner Street

Within the scope of the major project Stuttgart 21, approval section 1.5, Lot 3, the Bad Cannstatt Tunnel is being advanced. The approximately 3.8km long railroad tunnel will connect Stuttgart Main Station with the new Neckar Bridge.



Photos reprinted courtesy of GBS Grundbau Bohrtechnik Spezialtiefbau GmbH & Co. KG, Germany

In order to provide mechanical ventilation of the tunnel and the station in the event of a fire, several smoke removal structures must be built. This project also includes the smoke removal structure near the intersection of Heilbronner and Moenchhalden Streets. It incorporates a ventilation shaft that will be connected to the tunnel tubes via ventilation galleries. The structure consists of a mainly subterranean operation and ventilation building, two 5m high vent stacks above ground and a staircase.

The excavation was built using a Berlin-type support system and tied back using strand anchors. Construction work is scheduled to take more than 2 years. Therefore, semi-permanent anchors were used instead

of temporary anchors because they are suitable for a service period of up to 7 years. An internal company approval from the Client – the Deutsche Bahn AG – was necessary before the semi-permanent DYWIDAG Strand Anchors could be used. As the DYWIDAG Strand Anchors comply with a general technical approval, they were approved by the test association Dr.-Ing. A. Städing, and DSI's customer GBS Grundbau received the DB AG's permission for installing them.

419 semi-permanent Type 4-0.6" DYWIDAG Strand Anchors including anchor heads were installed in the walls of the Berlin-type support system. The strand anchors had a total length of 8,750m and a total weight of 40t.

**Owner**  
Joint Venture Tunnel  
Cannstatt S21, Germany  
**Contractor**  
GBS Grundbau Bohrtechnik  
Spezialtiefbau GmbH & Co. KG,  
Germany  
**Engineering**  
Wayss & Freytag Ingenieurbau AG,  
Germany  
**Operator**  
DB Station & Service AG, Germany

**DSI Unit**  
DYWIDAG-Systems International GmbH,  
BU Geotechnics, Germany  
**DSI Scope**  
Production, supply, technical support  
**DYWIDAG Products**  
419 semi-permanent Type 4-0.6" DYWIDAG  
Strand Anchors including anchor heads



# GEWI® Soil Nails stabilize Embankments along the Dual Track Expansion between Weimar and Gera

The railway line between Weimar and Gera is part of the 517km long connection between Paderborn and Chemnitz, which is also known as Mitte-Deutschland-Verbindung (connection through the middle of Germany).



The 66km section between Weimar and Gera is being expanded in order to improve the connection of eastern Thuringia to the future Intercity Express train hub in Erfurt. The newly electrified section will allow trains to travel at a maximum speed of 160km/h. Work includes the construction of 30km of track, 6 switch systems, 11 overpasses and the rehabilitation of several stations.

In some places, the existing track bed had to be relocated in order to make room for the second track. Several retaining walls had to be strengthened and embankments had to be stabilized within the scope of this project. To stabilize the embankments and existing

bridge abutments along the train route, double corrosion protected GEWI® Soil Nails were installed. 6,800m of 25mm Ø GEWI® Soil Nails, 400m of 32mm Ø GEWI® Soil Nails and 2,400m of 40mm Ø GEWI® Soil Nails were used for this purpose.

Installation was made difficult by the partly restricted workspace due to fact that the existing track remained in operation during construction work. Consequently, dust formation during drilling had to be avoided to the greatest possible extent. The contractor was very satisfied with the soil nail system with proven quality provided by DSI Germany.

**Owner**  
DB Netz AG, Germany

**Contractor**  
Jähmig GmbH Felssicherung & Zaunbau, Germany

**Engineering**  
GS-Ingenieure Germer & Schmahfeldt Ingenieurpartnerschaft für das Bauwesen, Germany

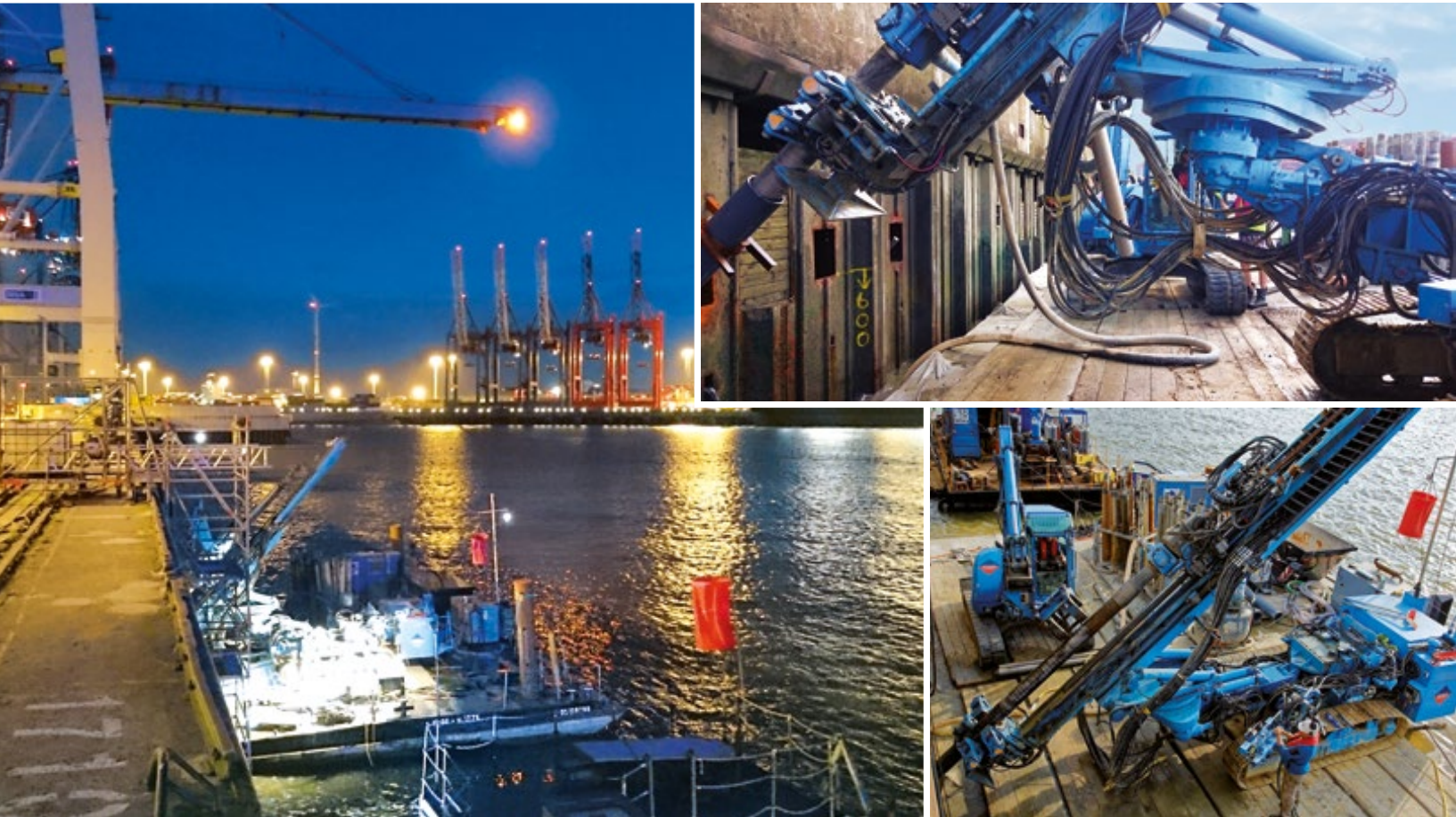
**DSI Unit**  
DYWIDAG-Systems International GmbH, BU Geotechnics, Germany

**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
6,800m of 25mm Ø GEWI® Soil Nails,  
400m of 32mm Ø GEWI® Soil Nails and  
2,400m of 40mm Ø GEWI® Soil Nails



## The Burchardkai in Hamburg: *GEWI® Plus* Anchors ensure an efficient Rehabilitation of Berth No. 7

The Burchardkai container terminal is Hamburg's largest and oldest container handling facility. Today, one in three containers passing through Hamburg Harbor is handled at this terminal, which was built in 1968. Since an increasing number of ships unload their cargo in Hamburg harbor from year to year, the Burchardkai has been expanded and modernized several times during its recent history.



One of the measures for modernizing the pier was a pilot project at berth No. 7. The project's goal was to facilitate future tiebacks for rehabilitating damaged parts at the sheet pile walls in the quay walls.

16 permanent, 28m long *GEWI® Plus* Anchors with double corrosion protection were used to tie back the sheet pile walls. Due to their high load bearing capacity and rigidity, the permanent *GEWI® Plus* Anchors are particularly well suited for this purpose.

In advance, DSI supplied 4 test piles that were used to determine the final pile and bond lengths. The drilling work for installing the *GEWI® Plus* Anchors was carried out from a floating pontoon. Since the starting point of drilling was located approximately 2m below medium high tide, work was only possible in limited time slots during low tide.

Consequently, the complete work process had to be synchronized with the water levels dependent on the tide.

The countersinking of the tendons had to be carried out using the back-step method. The piles that were left out could only be installed after tensioning and positioning the neighboring piles.

The extremely limited space within a previously welded steel box neither allowed the usual tensioning procedure nor the connection of the tendons with the structure. Therefore, a special and specifically produced socket wrench fitting the anchor nut was used to connect the bars to the structure.

**Owner**  
Hamburg Port Authority AöR  
(HPA), Germany  
**General Contractor**  
AUG. PRIEN Bauunternehmung  
(GmbH & Co. KG), Germany  
**Subcontractor**  
Neidhardt Grundbau GmbH,  
Germany

**DSI Unit**  
DYWIDAG-Systems International  
GmbH, BU Geotechnics, Germany  
**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
16 permanent, 28m long *GEWI® Plus*  
Anchors



# DYWIDAG Tendons for Germany's largest Bascule Bridge: The new Hunte Bridge near Berne

Between the municipality of Berne and the town of Elsfleth in the Wesermarsch administrative district northwest of Bremen, a new bascule bridge was recently built over the Hunte River. The bascule bridge replaces a 1951 lift bridge located at a distance of approximately 20m from the new structure that no longer fulfilled today's technical requirements.



Photo reprinted courtesy of Bauunternehmen Echterhoff GmbH & CO. KG, Germany

The new bridge is part of the new construction of Federal Road No. 212 in Lower Saxony. Thanks to its clearance that is 1.90m higher than that of the old lift bridge, and thanks to its efficient lifting and lowering mechanism, it will significantly reduce wait times for traffic.

The new bascule bridge has a total length of 84m, making it the largest single-leaf bascule bridge in Germany. The western approach bridge has a length of approximately 60m, while the eastern approach is approximately 90m long. The superstructure of the bascule bridge consists of steel over a substructure of reinforced concrete. The bridge was designed with a shallow foundation and is supported by an abutment.

The open spans of the bridge measure 66.3m, and the structure has a design width of 14.65m. When the bridge is fully opened, the leaf reaches a height of 70m. The rear part of the bridge deck lowers itself into the foundation of the bridge pier during opening, serving as a counterweight. The 700t leaf of the bridge was positioned from the shore.

The 115t pivot bearing was assembled on site using a heavy-duty crane.

To post-tension the two approach bridges, DSI supplied 48t of Type SUSPA Systems, 19-0.62" Strand Tendons conforming to Z-13.1-129 approval.

Inside the mechanism, where the hydraulic power unit with pulling cylinders is located, 108 unbonded, 26mm, 32mm and 40mm Ø, WR, grade 950/1050 DYWIDAG Bar Tendons conforming to Z-13.72-50123 approval were installed to stabilize the bascule system with the bottom counterweight and the accessible rear assembly.

A unique feature of this project was the tensioning of the anchorages of the DYWIDAG Bar Tendons for the bascule bridge. The stressing of the 44, St 32 WR DYWIDAG Bar Tendons was carried out at a height of approximately 8m from below using a 110 MP Jack.

#### Owner

Lower Saxonian Federal State Authority for Road Construction and Traffic, Germany

#### Architect

LINDSCHULTE Ingenieurgesellschaft mbH, Germany

#### DSI Unit

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

#### DSI Scope

Production, supply, installation

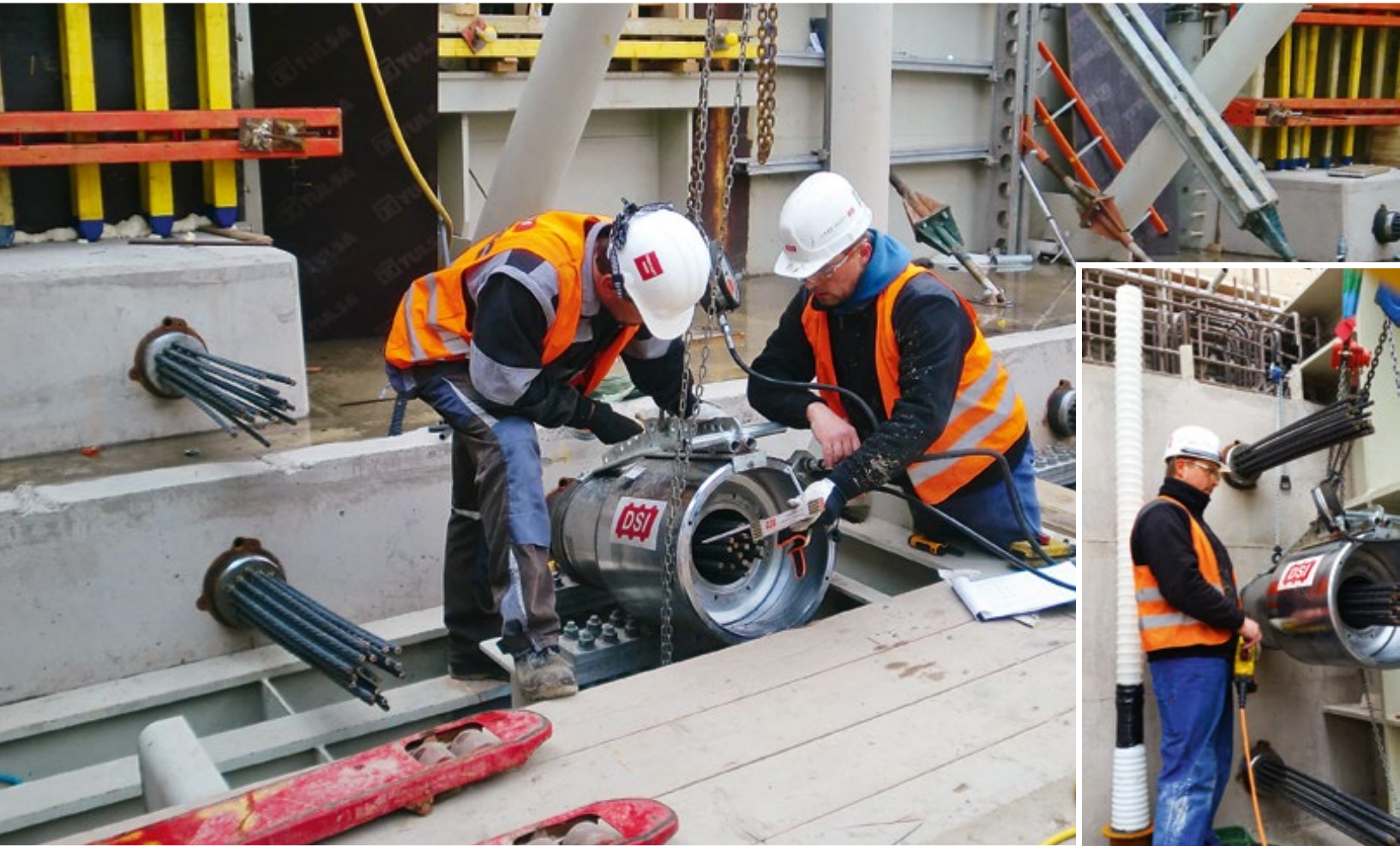
#### DYWIDAG Products

48t of Type SUSPA Systems, 19-0.62" Strand Tendons, 12t of 26mm, 32mm and 40mm Ø DYWIDAG Bar Tendons



## The Queensferry Crossing Bridge in Scotland: DSI's Strand Post-Tensioning Systems ensure Long-Term Connection

The existing Forth Road Bridge built in 1964 near Edinburgh in Scotland is an important road connection across the Firth of Forth – the Forth River Estuary into the North Sea. The 2.5km long suspension bridge was originally planned for 11 Million vehicles per year; however, it is now being used by approximately 24 Million vehicles per year.



Photos reprinted courtesy of Transport Scotland, Great Britain

That is why the new Queensferry Crossing Bridge is being built parallel to the Forth Road Bridge and to the railway bridge that was opened in 1890. Once completed, the 2.7km long bridge will accommodate the M90 Motorway on 4 lanes and will be the world's longest stay cable bridge with 3 pylons. Each of the 3 pylons is 207m high.

The individual spans of the 2,055.50m long stay cable bridge measure 104m, 223m, 650m, 650m, 223m, 104m and 101.5m. The 180,000t composite bridge deck is made

up of 110 single box precast segments, each 16.2m long. The cast in-situ North Approach Viaduct consists of 12 single box segments with a total length of 145.80m and approx. 60m long pier tables on each of the pylons. In total, 150,000t of concrete and 30,000t of steel are used for the bridge.

To prestress the bridge deck and the central tower, DSI supplied internal Type SUSPA Systems bonded Post-Tensioning Systems. The main part of the work was carried out in prefabrication sheds on site, where the

prefabricated tendons were installed as transverse prestressing into the precast concrete segments. The prestressed segments were then lifted using a cable system.

The designer also used the DSI Post-Tensioning System to provide the proper connection between the individual segments of the central pylon. This was achieved by inserting transverse and longitudinal tendons through the pylon and anchoring them inside the box girder.





An important feature of the system is its air-tightness which was implemented according to National Scottish specifications. In total, 3,000 Type 6-5 SUSPA Systems strand tendons with flat plastic ducts, 20 Type 6-9 strand tendons, 60 Type 6-12 tendons and 58 Type 6-19 strand tendons were used.

Together with the main contractor, DSI supplied a system the high performance of which was confirmed by numerous tests during construction work.

DSI also supported the contractor with engineering services as well as a full installation package including tensioning and grouting.

The experienced DSI employees successfully complied with the tight execution schedule.

**Owner**  
Transport Scotland, Great Britain  
**General Contractor**  
Joint Venture Forth Crossing Bridge Constructors (FCBC), consisting of HOCHTIEF Aktiengesellschaft, Germany, American Bridge Company, USA, DRAGADOS, Spain and Morrison Construction, Great Britain  
**Design**  
Joint Venture consisting of Ramboll Group A/S, Denmark, Grontmij N.V., Netherlands and Leonhardt, Andrä und Partner Beratende Ingenieure VBI AG, Germany  
**Design Check**  
AECOM, USA

**DSI Unit**  
DYWIDAG-Systems International GmbH, BU Special Projects, Germany  
**DSI Scope**  
Production, supply, installation, engineering services, supervision, test installation  
**DYWIDAG Products**  
3,000 Type 6-5 SUSPA Systems strand tendons, 20 Type 6-9 strand tendons, 60 Type 6-12 strand tendons and 58 Type 6-19 strand tendons



## High Capacity DYWIDAG Bar Anchors for Liverpool FC's New Main Stand

Liverpool Football Club are in the middle of expanding their main stand on Anfield Road to increase the seat capacity to 54,000, with work continuing all through the football season.



The new main stand features considerably increased depth and height and will be sheltered by a large cantilevered roof. The huge overhang of the roof is supported by backstays that had to be anchored down in the ground by 12 No. high capacity DYWIDAG Bar Anchors.

The ground anchors consist of 75mm Ø DYWIDAG Prestressing Steel Threadbars that were pregrouted at the DSI factory in Southam to ensure compliance with BS8081:2015 for permanent anchors. With an ultimate strength of 4,500kN, the tendons are the highest capacity threadbars manufactured. The boreholes for the 14m long DYWIDAG Bar Anchors were drilled into the sandstone bedrock using a down the hole hammer (DTH)

with air mist flush. This new flush mechanism features flushing jets within the stabilizer collar of the hammer that are arranged with different orientations to create a vortex effect. As a result, dust is fully suppressed, and drilling performance is increased by 10-15%.

Prior to the installation of the production anchors, three trial anchors were installed that were equipped with bond isolators consisting of foam collars. The foam collars were placed at the interface between the active and passive wedge zones to ensure the bond developed in the grout body of the passive zone cannot strut against the upper grout body within the active zone, to develop a disproportionately high load, which could be mistaken as the bond performance within the fixed length.

Following the successful load testing of all trial anchors, the DYWIDAG Anchors were approved for installation.

Due to the weight of the anchor segments, 40kg/m, each section had to be lifted using a DYWIDAG captive bar lifting shackle, and placed within the borehole. A tremie pipe was attached to the lead section, to ensure that the anchors were grouted from the base up, once fully installed. The installation method involves installing the first section with a coupler fork to hold it in position, then lifting the second section into position, rotating it fully to ensure correct engagement of the coupler, followed by a short lift to take the load and remove the coupler fork. This process is repeated for each additional section.





Following installation to depth, the anchors were grouted via the tremie pipe to the surface. Afterwards, grout levels were checked to ensure that there had been no undue settlement. Then, the top meter of each anchor was washed back with water using a lance, to ensure that there was sufficient void space at the top of the annulus to accommodate the bearing plate/stub tube assembly as well as to avoid any potential for strutting during stressing. Once the grout had set, the washback water was blown out by air.

Each anchor was then stressed by DSI stressing technicians and locked-off in accordance with the specification, enabling the full restraint to be mobilized for the cantilevered roof.

This project is the second in which DSI UK has worked with Liverpool FC (the Reds). Previously, DSI UK supplied permanent DYWIDAG Strand Anchors for the refurbishment of the stadium's famous Kop stand.

**Owner**  
Liverpool Football Club, Great Britain  
**General Contractor**  
Carillion Plc, Great Britain  
**Drilling Contractor**  
CAN, Great Britain  
**Engineering**  
Jacobs Engineering, Great Britain

**DSI Unit**  
DYWIDAG-Systems International Ltd., Great Britain  
**DSI Scope**  
Production, supply, tensioning work, test installation  
**DYWIDAG Products**  
12.75mm Ø, 14m long DYWIDAG Bar Anchors



## Quality for long-term Use: GEWI® Hangers support Victorian Sewer Pipe System in London

Even today, the sewage system in London still largely consists of the canal system that was conceived by the engineer Bazalgette in the 1860s in order to free the city from what was known as “the great stink”. Simultaneously, the new sewage system eliminated the cholera epidemic raging at the time.



As Bazalgette had chosen to build the sewer pipes more than twice as large as necessary, the Victorian System continues to transport the wastewater of a population of 8 million that is now more than three times as large as it was at the time the system was built.

The historic sewer network consisted of 1,800km of street sewers that flowed into 132km long main sewers. The main sewers, which are still intact today, have diameters

of up to 3.2m and run parallel, with up to 7 canals running side by side.

In the east of London, the sewer pipes cross the inland waterways River Lee and Channel Sea in what is known as the Northern Outfall Sewer. Here, the sewer pipes are integrated into Victorian steel and cast iron bridges spanning the tributaries. The canal pipes are suspended from the bridge girders by tie rods that were

badly corroded and had to be replaced. In conjunction with the design engineer, DSI Construction Great Britain developed a solution to replace the existing tie rods by hangers consisting of GEWI® Steel.

The 150 28mm Ø GEWI® Hangers were supplied in two sections; one of the sections had a crank, a coupler and a load bearing hex nut installed in order to anchor the bar at the girder flange at the top.





Additional supporting anchorage points were arranged at mid flange, and at the lower end, termination points served to stabilize the underside cradle.

In addition to the fully threaded coarse thread, the advantage of the *GEWI*® System was that the threadbars could be bent in the lower bar section. While the old ties were being replaced by the new *GEWI*® Tie Rods, DSI stabilized the sewer pipes using temporary tendons.

These tendons were equipped with load cells to monitor the load in the sewer barrels.

DSI also developed a precise loading sequence to ensure progressive load transfer between the old and the new tie rods. The temporary tie rods resting on the top girder had different vertical inclinations. Consequently, special rocker plates were required to place the load cells in line on each tendon.

**Owner**

Thames Water Utilities Limited,  
Great Britain

**General Contractor**

Optimise Joint Venture,  
consisting of J. Murphy & Sons Ltd.,  
Barhale Construction plc,  
The Clancy Group plc and  
MWH Global, Inc.,  
all of them Great Britain

**Subcontractor (Installation)**

PC Richardson & Co Ltd., Great Britain

**Engineering**

AECOM, Great Britain

**DSI Unit**

DYWIDAG-Systems International Ltd.,  
Great Britain

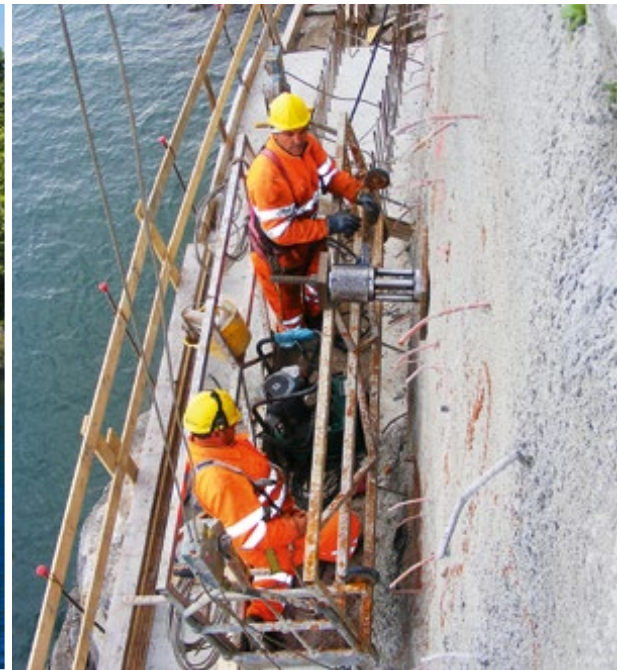
**DSI Scope**

Production, supply, technical support  
**DYWIDAG Products**  
150 28mm Ø *GEWI*® Hangers, load cells



## Structural Repair of Strada Statale 34: *GEWI® Plus* Anchors stabilize a retaining wall at Lake Maggiore

The Strada Statale 34 del Lago Maggiore is a 39km long road in northwestern Italy that runs along the shore of Lake Maggiore near the Swiss border.



Photos reprinted courtesy of Impresa Luigi Notari S.P.A., Italy

Within the scope of the structural repair and stabilization of SS 34 between kilometers 29+000 and 39+000, in addition to several repair and strengthening measures, the road was leveled and the shoulder was stabilized.

This project also included the construction of a reinforced concrete retaining wall that was built in front of an old stone wall near the town of Cannobio. In this area, the road runs immediately adjacent to Lake Maggiore, and the stone wall drops down towards the lake nearly vertically.

The new retaining wall was planned with a variable overhang of up to 3.5m. Passive rock bolts were installed in up to 3 levels to tie back

the wall. DYWIDAG supplied 3,700m of double corrosion protected, St 670/800, 25, 28 and 35mm Ø *GEWI® Plus* Anchors for this purpose.

Once the tied-back anchor wall had been finished, a faux masonry facing consisting of prefabricated slabs was installed on the lake side. The rock bolts and prefabricated slabs were installed using cantilevered scaffolds.

In sections in which the road had to be widened towards the lake beyond the retaining wall, an additional reinforcement of the wall was required within the scope of construction work. In these areas, the new retaining wall also serves as an abutment for the roadway slab that cantilevers towards the lake.

**Owner**  
Anas S.P.A., Italy  
**General Contractor**  
Impresa Luigi Notari S.P.A., Italy  
**Engineering**  
Anastasi&Partners SA, Switzerland  
**Consulting**  
Impresa Luigi Notari S.P.A., Italy

**DSI Unit**  
DYWIDAG S.P.A., Italy  
**DYWIDAG Scope**  
Production, supply, technical support  
**DYWIDAG Products**  
3,700m of double corrosion protected,  
25, 28 and 35mm Ø *GEWI® Plus* Anchors



## DYWIDAG Bar Tendons preserve a Piece of History: Reinforcement of the Basilica of Maxentius on Rome's Forum Romanum

The Basilica of Maxentius is located on the border of Rome's Forum Romanum. The structure was built on an area that originally measured 100 x 70m from approximately 307 to 313 AD and was thus one of the largest buildings in the Forum. Today, only the northern aisle of the Basilica still exists.



*Photos reprinted courtesy of Lande S.P.A., Italy*

Recently, it became necessary to stabilize the Basilica of Maxentius. For this purpose, the vertical masonry was braced using 165 St 1050, 40mm Ø DYWIDAG Post-Tensioning Bars. The individual DYWIDAG Bar Tendons are 6m long and were joined using couplers. Specially designed AISI 316 steel anchor plates were used for this project.

The DYWIDAG Bar Tendons were installed to a height of more than 30m and tensioned in stages, with the movements of the masonry

being simultaneously and continuously measured. The tensioning bars were hot dip galvanized and are permanently protected from corrosion by heat shrink sleeves.

The DYWIDAG Bar Tendons that were used had a total length of approximately 1,000m. DYWIT Italy not only supplied the necessary bar tendons including accessories, but also provided the equipment needed for the stressing work and on-site technical assistance.

**Owner**  
Roma Capitale, Italy  
**General Contractor**  
Metro C scpa, Italy  
**Subcontractor**  
Lande S.P.A., Italy

**DSI Unit**  
DYWIT S.P.A., Italy  
**DYWIT Scope**  
Production, supply, technical support, test installation  
**DYWIDAG Products**  
165, 40mm Ø DYWIDAG Bar Tendons including accessories, equipment



## No Compromises: DYWIDAG Monostrand Tendons facilitate innovative Execution of Green Hall 2 in Vilnius

Centrally located between the city center and the business quarter of the Lithuanian capital of Vilnius, a new office building is being built that will complement the existing Green Hall building: Green Hall 2.



The building, which is located next to Neris River, will accommodate offices on a total area of 10,000m<sup>2</sup>. Green Hall 2 is one of the most energy efficient buildings to be constructed in the last few years and uses natural ventilation as well as solar energy.

During construction, no compromises were tolerated that would have interfered with the original innovative concept of the architects. The design and the stipulated extraordinary form of the building also required unusual structural solutions using

cast in place concrete. This also included the suggestion of prestressing the building's floor slabs using unbonded post-tensioning tendons.

DSI's Lithuanian partner company Delta Nova coordinated closely with the project's structural engineers and carried out the post-tensioning work for this project as a subcontractor. The slabs were post-tensioned using approximately 1,300 Type SK 6-1, ME 6-3 and ME 6-4 DYWIDAG Monostrand Tendons with a total weight of 40t.

**Owner**  
Upės Projektai, UAB, Lithuania  
**Project Management**  
Contestus Projektai UAB,  
Lithuania  
**General Contractor**  
Veikmės Statyba, UAB, Lithuania  
**Subcontractor**  
Delta Nova UAB, Lithuania  
**Architects**  
Arrow Denmark ApS, Denmark and  
Archinova UAB, Lithuania  
**Consulting Engineers**  
Ribinis būvis UAB, Lithuania

**DSI Licensee**  
Delta Nova UAB, Lithuania  
**Delta Nova Scope**  
Supply, installation, technical support  
**DYWIDAG Products**  
1,300 Type SK 6-1, ME 6-3 and ME 6-4  
DYWIDAG Monostrand Tendons







## Slim Duct DYNA Grip® Stay Cables: The Mersch Stay Cable Bridge

In the community of Mersch in Luxembourg, a new, 260m long, 4 span stay cable bridge with span lengths of 2 x 43.3m and 2 x 86.7m and two 30m high pylons was recently built. The Pont Haubané Mersch is the world's first stay cable bridge to feature stainless steel slim ducts. Beginning with the preliminary planning stage, DSI provided advice for the project and took on architectural and technical responsibilities once the project had been awarded.



For the special stainless steel stay cable ducts (stainless steel grades 1.4307 and 1.4404), DSI searched for a suitable partner for the welding work, special components and surface processing. Furthermore, an assembly concept had to be developed for the stainless steel ducts that are considerably more susceptible to damage and less elastic than common ducts. Finally, a new strand lifting concept was used that was a European first. The existing welding machine also had to be remodeled completely in order to meet the changed requirements.

The Hintzen Edelstahlverarbeitung Company produced the technically and architecturally vital special components – vandalism protection pipes, transition ducts, sleeves

and flange ducts – and carried out the welding work on the continuous ducts. The Börsting Company, a specialist for stainless steel surface processing, presented several different polished sections to the customer in advance and achieved the chosen surface appearance professionally on all stainless steel parts.

20-80m long Types DG-P37 and DG-P31 DYNA Grip® Stay Cables were used for this project; the Type DG-P31 stay cables were filled with 27 strands. In total, DSI supplied 42t of grade 1860N/mm<sup>2</sup>, 150mm<sup>2</sup> strand for the stay cables. For the slim duct that had been chosen by the engineer (Slim-Duct, 156.0 x 3.0mm), DSI had to provide procedural concept studies for the supporting strands due to the limited space available.

### Owner

Administration des ponts et chaussées, Luxembourg

### General Contractor

Association Momentanée Tralux/VBSC, consisting of Tralux Construction Sarl, Luxembourg and Victor Buyck Steel Construction NV, Belgium

### Contractor

Tralux Construction Sarl, Luxembourg

### Subcontractor

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

### Architect

Schroeder & Associés Ingénieurs-Conseils, Luxembourg

### Consulting Engineers

Schroeder & Associés Ingénieurs-Conseils, Luxembourg

### Supervision

SECO LUX, Luxembourg

### Engineering

Schroeder & Associés Ingénieurs-Conseils, Luxembourg





Finally, the decision was made to push the strands in from the bridge deck towards the pylon using different compaction clamps. Thanks to the equipment that had been especially adapted by DSI, the up to 80m long stay cable strands could be pushed in completely. Afterwards, the stay cables were stressed in two steps using the Con-Ten Method developed by DSI.

After a construction time of approximately 3 months from site setup to technical approval, the complete work was handed over to the customer without any complaints. In particular the fact that there were no visible welding seams on the stainless steel components including the continuous ducts illustrates the high quality of the products and processes that were used. The quality was decisively

influenced by the ATIS post-treatment robot supplied by the Alpin Technik Company. The robot was developed during construction work and used once stay cable assembly had been completed. The robot applied the final polishing to the continuous stainless steel ducts using special rotation brushes shortly before the bridge was opened to traffic.

This new development by DSI and Alpin Technik will be used for the regular main assessments of stay cable bridges with stainless steel ducts to permanently maintain the stainless steel appearance and surface structure.

#### **DSI Unit**

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

#### **DSI Scope**

Design, development, production, supply, installation, engineering services, technical support

#### **DYWIDAG Products**

Types DG-P37 and DG-P31  
20-80m long DYNA Grip®-Stay Cables



## The ARK Bridge: DYWIDAG Strand Tendons contribute to Amsterdam's largest Infrastructure Project

A huge infrastructural project is currently under construction in the metropolitan area of Amsterdam. The SAA Project (Schiphol-Amsterdam-Almere Project) will improve the motorway network between Amsterdam, Schiphol Airport and the city of Almere, which is located east of Amsterdam. The total length of the project is 63km, and in addition to new lanes and motorway sections, the project includes a tunnel, an aqueduct and approximately 100 bridge structures. Construction work started in 2012 and is scheduled for completion in 2026.



One of the major structures in this project is the ARK Bridge that accommodates the new motorway section crossing the Amsterdam – Rhine Channel. The Joint Venture SAA one submitted proposals for several structures that are being built within the scope of this major project. The Joint Venture was awarded the contract for the ARK Bridge because it made the most attractive DBFMF-proposal (Design, Build, Finance, and Maintain) for this bridge. The design had to provide sufficient clearance for container and cargo ships which frequently travel on this important channel connecting Amsterdam with various German cities along the River Rhine.

The ARK Bridge consists of 3 parallel concrete hollow box girder bridges with a total length

of 284m. The structures have main spans of 142m and side spans of 71m each. The northern and the southern bridges are double cell box girders with 20.9m respectively 17.6m wide bridge decks. The middle bridge is a single cell box girder with an 11.25m wide bridge deck.

The bridges were built using the balanced free cantilever construction method. The first 7 segments on both sides of the hammer heads are 4m long, and the following segments are 5m long. The depth of the bridge varies between 6.25m at the pylons to 2.75m in the middle of the main span.

In order to limit the construction time of the bridge superstructure, 3 sets of form travellers

were used for an almost simultaneous erection of the segments at the 3 pylons. On average, the bridge segments were erected in a weekly cycle. First of all, the reinforcement and post-tensioning tendons were installed. After pouring the C70/85 concrete, the transverse and longitudinal Post-Tensioning tendons were stressed. Subsequently, the form travellers were moved to the next position, and the formwork was prepared for the next cycle. The DYWIDAG Tendons were stressed a day after the concrete was cast.

DSI Netherlands assisted SAAone in the final planning phase for post-tensioning and supplied, installed, tensioned and grouted the DYWIDAG Post-Tensioning Tendons in all bridges.





In the 3 new structures, the following DYWIDAG Strand Tendons, 1,860N/mm<sup>2</sup>, with a strand tonnage of 1,060t were used:

- 1,530 Type 4-0.62" DYWIDAG Strand Tendons with Type SD 6804 Anchorages as transversal tendons in the bridge deck
- 504 Type 15-0.62" DYWIDAG Strand Tendons with Type MA 6815 Anchorages as longitudinal tendons in the top concrete slab
- 178 Type 19-0.62" DYWIDAG Strand Tendons with Type MA 6819 Anchorages as longitudinal tendons in the bottom concrete slab

Thanks to the secure planning and the excellent collaboration between all parties

involved, the superstructures were completed according to plan. DSI is proud to have contributed to the realization of this bridge with expertise in Post-Tensioning and the matching DYWIDAG products. DSI Netherlands is involved in other sub-projects of the SAA Connection and delivers a valuable contribution to this important infrastructural project with know-how and high-quality products.

#### Owner

Rijkswaterstaat (Department of the Dutch Ministry of Infrastructure and Environment), Netherlands

#### General Contractor

Joint Venture SAAone, consisting of Koninklijke Volker Wessels Stevin N.V. (VolkerWessels), Royal Boskalis Westminster N.V. (Boskalis), HOCHTIEF PPP Solutions Netherlands B.V. and Dutch Infrastructure Fund B.V. (DIF), all of them Netherlands

#### Subcontractor Post-Tensioning

DYWIDAG-Systems International B.V., Netherlands

#### DSI Scope

Production, supply, installation, technical support

#### DYWIDAG Products

1,530 Type 4-0.62" DYWIDAG Strand Tendons, 504 Type 15-0.62" DYWIDAG Strand Tendons, 178 Type 19-0.62" DYWIDAG Strand Tendons



## DYWIDAG Bar Tendons enhance Load-Bearing Capacity of the A44 Approach Bridges near Leiden

The bridge accommodating the A44 Motorway near the city of Leiden northeast of The Hague is more than 50 years old. Here, two parallel steel bascule bridges with reinforced concrete approach bridges crosses the Old Rhine River. Due to a significant increase in traffic volume on this section within the last decades, the Rijkswaterstaat decided to replace the entire asphalt wearing surface, to replace the steel bascule bridges and to strengthen some sections of the approach bridges.

The superstructure of the approach bridges consists of 1.1m high, T-shaped precast post-tensioned concrete girders. The total deck width is approximately 20.2m. On the north side, there are 5 approximately 22m long spans with 2 x 8 girders per span. On the south side, there are 4 approximately 20m long spans with 2 x 6 girders per span.

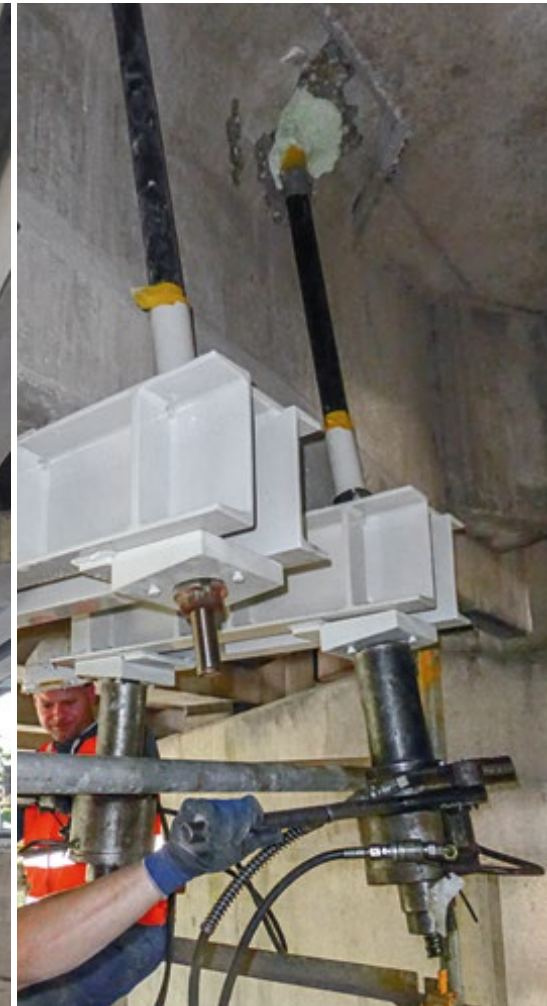
A 20cm thick top slab was cast in place partly between the 15cm thick upper flanges of the girders and partly above them. Furthermore, four transverse beams were cast in place to provide sufficient structural integration of the girders.

In various precast concrete girders, diagonal cracking and local corrosion of the post-tensioning anchorages was detected. Furthermore, some girders had been exposed to a fire in the past. After comprehensive investigations into the structure and calculations which were carried out with reduced pre-stressing forces, it was determined that the shear capacity of several girders was insufficient to meet current requirements.

Therefore, a strengthening solution using so-called “post-tensioning stirrups” was proposed by the consulting engineers. DSI Construction Netherlands produced, supplied, installed and tensioned a total of 439 of those special post-tensioning stirrups that were used near the supports of the 21 girders with reduced bearing capacity.

Each post-tensioning stirrup consisted of 2 vertical DYWIDAG Bar Tendons that were installed vertically along the girders. A total of 878 Type 32 WS, Y 1050 H DYWIDAG Bar Tendons were used. At the upper side of the girders, a massive anchor plate with two welded couplers was used as a dead-end anchor. At the lower side, a steel beam was used as support for two separate stressing anchors.

At each post-tensioning stirrup, two DYWIDAG Bar Tendons were stressed simultaneously with a force of 365kN per tendon.



After stressing, the PE sheathing of the tendons was grouted and protection caps were applied in order to obtain adequate corrosion protection for the DYWIDAG Tendons.

Work on this complex and challenging project was carried out within a very tight schedule in order to limit traffic obstructions to a minimum. DSI is proud to have contributed to the successful completion of this project.

**Owner**  
Rijkswaterstaat  
(Department of the Dutch  
Ministry of Infrastructure and  
Environment), Netherlands  
**General Contractor**  
Joint Venture, consisting of  
BSB Staalbouw B.V. and Mourik  
Infra, both Netherlands  
**Consulting Engineers**  
Movares Nederland B.V.,  
Netherlands

**Subcontractor Post-Tensioning**  
DYWIDAG-Systems International B.V.,  
Netherlands  
**DSI Scope**  
Production, supply, installation,  
post-tensioning  
**DYWIDAG Products**  
878 Type 32 WS DYWIDAG Bar Tendons



# The Nyhamna Gas Processing Plant: Permanent DYWIDAG Strand Anchors contribute to better Energy Supply

The Nyhamna Peninsula, which is part of Gossa Island on Norway's southwestern coast, accommodates one of the country's largest gas processing plants. Here, Shell processes natural gas that is extracted from the Ormen Lange Field located on the ocean bed approximately 120km northwest of Kristiansund.



*Photos reprinted courtesy of Kvaerner ASA, Norway*

From Nyhamna, the processed gas is transported through the 1,200km long Langede Pipeline to a gas terminal in Easington, England. The plant on Nyhamna currently satisfies approximately 20% of the British demand for gas.

Within the scope of the most recent expansion project, the processing capacity of the Nyhamna plant has been increased from 70 million to 84 million standard m<sup>3</sup> per day. Thanks to the new, 480km long Polarled Pipeline, the plant will also be connected to several gas fields in the Norwegian Sea. The Nyhamna Plant will now be able to supply the daily requirements of up to 22 million households in Europe with gas.

In addition to the construction of a new processing unit, a hydrogen sulfide removal unit, several storage tanks and some buildings for the associated infrastructure, the expansion of the Nyhamna plant also includes the installation of compressors that

will allow the extraction of large amounts of gas from the Ormen Lange Field. Two of the new compressors will increase pressure in the gas field and another compressor will increase the output of the Langede Pipeline.

Stable foundations had to be erected for the new compressors. For this purpose, 164 permanent DYWIDAG Strand Anchors with 19 strands in lengths from 13 to 19m and 72 permanent DYWIDAG Strand Anchors with 17 strands were installed in the foundations.

The DSI licensee DYWIDAG Norge AS supplied all anchor systems and also carried out part of the tensioning work. Work was made difficult by the dangerous environment. For instance, it was not allowed to cut the strands using standard angle cutters due to the risk of explosion. To rule out potential flying sparks, the assembly team had to use special water cooled diamond wire cutters.

#### Owner

Norske Shell AS, Norway

#### General Contractor

Kvaerner ASA, Norway

#### Contractor

AF Gruppen Norge AS, Norway

#### Subcontractor

Nordisk Fundamentering AS,

Norway

#### Consulting Engineers

Multiconsult AS, Norway

#### DSI Licensee

DYWIDAG Norge AS, Norway

#### DYWIDAG Norge Scope

Production, supply, installation, technical support

#### DYWIDAG Products

164 permanent DYWIDAG Strand Anchors with 19 strands and 72 permanent DYWIDAG Strand Anchors with 17 strands



## The Kozenice Plant: DYWDAG Strand Post-Tensioning Systems for Poland's second largest Coal-Fired Power Plant

With a total generating capacity of approximately 2,900MW, the Kozenice Power Plant southeast of Warsaw is Poland's second largest coal-fired power plant and consists of 10 generators. In 2014, construction of an 11<sup>th</sup> generator started that will provide an additional 1,075MW of energy after its completion in mid-2017.



A part of this huge construction project is a retention facility for fly ash produced in the coal burning process. The fly ash is stored in 3 identical tanks, each of them providing 20,000m<sup>3</sup> of storage capacity. These slender concrete structures have inner diameters of 25.8m, 48.3m high chambers and a wall thickness of only 300mm.

The tank walls were post-tensioned using 7 strand “hoop” tendons that were installed

in the perimeter and anchored in pilasters. Each “hoop” consists of 2 half-circle tendons.

DSI Construction Poland was awarded the post-tensioning work. The scope included the technical support of the subcontractor during post-tensioning and the supply of approximately 8,400m of Type 6-7 SUSPA Systems Strand Tendons with 1,152 MA Stressing Anchorages. The 576 bonded tendons in accordance

with ETA-06/0025 consist of Type 0.62", Y1860S7 strand. Furthermore, DSI installed, stressed and grouted the strand tendons and provided different documentation in addition to the stressing records.

In addition to the tight schedule, the very large height of the 65m tall tanks represented a challenge: The highest tendons were installed at a height of 62.25m above ground.





Furthermore, due to the fact that the chamber walls were erected using sliding formwork technology, and due to the small amount of storage space, all of the post-tensioning systems had to be supplied to the jobsite just-in-time.

Thanks to the minimal space requirements of the strand tendons that were supplied by DSI on coils, the pilasters were realized very efficiently. Also, the robust post-tensioning

system provided by DSI ensured an easy installation of the MA Anchorages and trumpets. The accessories supplied by DSI – especially the reliable threaded connections between the PE grout caps and the anchor plates – ensured that grouting work proceeded smoothly.

**Owner**

Enea Wytwarzanie Sp. z o.o.,  
Poland

**General Contractor**

Joint Venture, consisting of  
Mitsubishi Hitachi Power Systems  
Europe GmbH, Germany and  
Polimex-Mostostal S.A., Poland  
**Contractor**  
Instal Warszawa S.A., Poland

**DSI Unit**

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

**DSI Scope**

Production, supply, installation,  
technical support, supervision

**DYWIDAG Products**

576 Type 6-7 SUSPA Systems Strand Tendons  
with 1,152 MA Stressing Anchorages



## DYWIDAG Strand Anchors stabilize Slopes along the new Estreito Câmara de Lobos Expressway on Madeira

The Via Rápida Estreito Câmara de Lobos/Câmara de Lobos is a new expressway west of Funchal, Madeira's capital located on the southeastern coast of the island. The expressway is designed to improve the accessibility of several local towns as well as traffic conditions on the island as a whole.



The new route will link the village of Estreito de Câmara de Lobos with the existing VR1 expressway and will create a new road connection to the villages of Câmara de Lobos and Jardim da Serra. Work on the jobsite was halted in 2011 due to economic difficulties and is now being continued with funds from the European Union.

The approximately 2.5km long expressway includes the construction of a double tunnel, several viaducts, interchanges and road relocations. All of the new structures required the construction of 30 new geotechnical containment structures in total.

AFA – AFAVIAS, the subcontractor for the geotechnical work in this project, invited DSI Portugal to design, manufacture and

supply permanent strand anchors that were needed for a slope stabilization. In total, DSI Construction Spain produced 178 permanent DYWIDAG Strand Anchors in its production plant in Madrid and delivered them to Lisbon, from where they were shipped to Madeira. The DYWIDAG Strand Anchors that were installed in the new retaining wall had 5 strands each and were supplied complete with anchor heads that accommodated angle compensation between 0° and 30°.

DSI fulfilled all technical requirements of the client and the subcontractor, and the anchors were supplied to the jobsite as planned, ensuring a smooth and punctual completion of construction work. DSI is proud to have co-operated with such a renowned company as AFA – AFAVIAS.

**Owner**  
RAMEDM - Estradas da Madeira, S.A., Portugal  
**General Contractor**  
Joint Venture, consisting of Mota-Engil Engenharia e Construção S.A. and Somague Engenharia S.A., both Portugal  
**Subcontractor**  
AFA - AFAVIAS Engenharia e Construições, S.A., Portugal  
**Engineering**  
NRV I Norvia - Consultores de Engenharia, S.A., Portugal

**DSI Unit**  
DYWIDAG Sistemas Constructivos S.A., Portugal  
**DSC Scope**  
Production, supply, technical support  
**DYWIDAG Products**  
178 permanent DYWIDAG Strand Anchors with 5 strands and anchor heads for angle compensation between 0° and 30°



## DYWIDAG Strand Anchors permit the Stabilization of a Coastal Road on Madeira

In 2010, severe storms caused landslides on a connecting road on the southwest coast of the island of Madeira. The road therefore had to be comprehensively stabilized over a 90m long section between the towns of Moledos and Calheta.



The technical solution to this problem was a comprehensive slope stabilization using a curtain of 1m diameter concrete piles. The retaining wall was anchored using 1-3 levels of DYWIDAG Anchors. At the eastern end of the pile wall, an additional reinforced concrete retaining wall with a maximum height of 12m was built.

The Contractor asked DSI to produce and supply 75 permanent DYWIDAG Strand Anchors. The permanent anchors have 5 strands each and were supplied complete with anchor heads, 4 load cells and one hand-held measuring device in order to permit the monitoring of the forces acting on the anchors.

The anchors were produced in DSC's factory in Madrid and shipped to Madeira. DSI fulfilled all technical requirements in close cooperation with the Owner. The ground underneath the road was regraded, which significantly decreased the deposits on top of the unstable ground. The roadway improvements were successfully completed in January 2016.

**Owner**  
Governo Regional da Região Autónoma da Madeira, Portugal  
**General Contractor**  
Joint Venture, consisting of AFA - AFÁVIAS Engenharia e Construções, S.A., and ANDRADE GUTIERREZ – Europa, África, Ásia, S.A., both Portugal  
**Engineering**  
CENORGEIO – Engenharia Geotécnica Lda., Portugal

**DSI Unit**  
DYWIDAG Sistemas Constructivos S.A., Portugal  
**DSC Scope**  
Production, supply, technical support  
**DYWIDAG Products**  
75 permanent DYWIDAG Strand Anchors with 5 strands each, 4 load cells, 1 hand-held measuring device



## DYWIDAG Bar Post-Tensioning Tendons preserve Cultural Heritage in Lisbon: The historic Hotel Cais de Santarém

In the historical district of Alfama in Lisbon, a new five-star hotel belonging to the Hotusa Hotels Group is being built. The new 91 room Eurostars Hotel is being developed near the future cruise terminal on a total area of approximately 8,400m<sup>2</sup>.

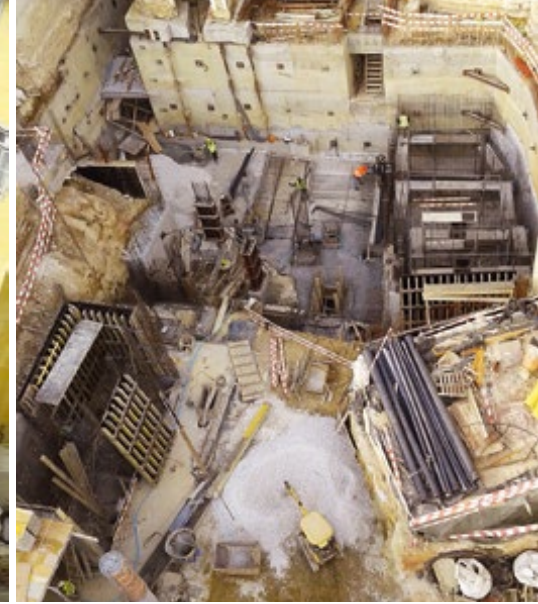


In this special construction project, the former palace of the Marquis of Fronteira and the Count of Linhares is being restored. The palace was severely damaged by an earthquake in 1755 and was temporarily used as a storage facility for iron in the 19<sup>th</sup> century. Due to the fact that important archeological findings from the Roman times and other periods have been discovered on the jobsite, the hotel will also be a museum.

The General Contractor, Constructora SANJOSE, was awarded the contract for demolition work, digging the excavations and building the necessary containment structures. Due to the palace's advanced state of decomposition, the General Contractor had to be very careful and precise. Combining the technical demands of a five-star hotel with the preservation of an important cultural heritage site was another major challenge.

First, all elements that were either contemporary or of low archeological value were demolished. Afterwards, a foundation consisting of micropiles was built for which bore holes with a total length of 9.5km were necessary. Subsequently, reinforced concrete blocks were positioned on the base level of the existing walls on top of the steel piles.





Photos reprinted courtesy of Constructora SANJOSE, S.A. Representação em Portugal, Portugal

Afterwards, the General Contractor asked DSI Construction Portugal to supply DYWIDAG Bar Tendons and couplers that were needed for tightening the concrete blocks and holding them in place.

In total, DSI supplied 192 12 m long, 26.5mm Ø DYWIDAG Bar Tendons. Furthermore, 384 26.5mm Ø couplers were used for a force-fit connection of the post-tensioning bars.

This allowed further excavation and terrain containment in order to reach the necessary excavation pit depth of 12m.

By cooperating closely with the General Contractor, DSI Portugal was able to supply all necessary products and systems to the jobsite on time. DSI is proud to have contributed to a rehabilitation project in one of Europe's oldest cities.

**Operator**

Hotusa Hotels S.A., Spain

**Owner**

IMOCAIS - Fundo Especial de Investimento Imobiliário Fechado, Portugal

**General Contractor**

Constructora SANJOSE, S.A. Representação em Portugal, Portugal

**Subcontractor**

Constructora SANJOSE, S.A. Representação em Portugal, Portugal

**Engineering**

Engitarget - Gestão, Projecto e Fiscalização de Empreendimentos, Lda, Portugal

**DSI Unit**

DYWIDAG Sistemas Constructivos S.A., Portugal

**DSC Scope**

Production, supply

**DYWIDAG Products**

192 12 m long, 26.5mm Ø DYWIDAG Bar Post-Tensioning Tendons, 384 26.5mm Ø couplers



## The Karabel Bridge in Northern Spain: Pillarless Construction thanks to Hangers

The Karabel Bridge is a new bridge in the Basque Region in northern Spain that crosses the Urumea River in the town of Hernani in the Karabel neighborhood. It replaces an old bridge with 4 massive stone pillars that often caused flooding because they narrowed the river bed. The new bridge crosses the river without any pillars so that future high water can flow freely through the area.



The new arch bridge has a free span of approximately 51.5m and was planned as a steel concrete composite structure. The bridge frame consists of steel, and the two arches that are inclined towards the outside reach a height of 8m above the bridge deck. The bridge deck itself was built using reinforced concrete after lowering and positioning the frame girder structure.

The bridge deck is supported by 18 hangers consisting of 64mm Ø, Type DST-520 M64,

St 520/650 N/mm<sup>2</sup> bar tendons. The bar tendons were produced by Daver Steel, DSC Spain's exclusive partner, and supplied to the jobsite complete with assembled forks and pins. The tendons were equipped with turnbuckles that were used for the correct assembly and stressing of the hangers supervised by DSI specialists.

The entire steel composite structure of the bridge was preassembled on the Urumea River banks. Once completed, the 250t

bridge was moved to its final position and placed on the abutments. Afterwards, the reinforcement was installed and the bridge deck concrete was poured. As soon as the reinforced concrete deck had reached the necessary strength, a DSI specialist once again checked the tension forces on each individual hanger.

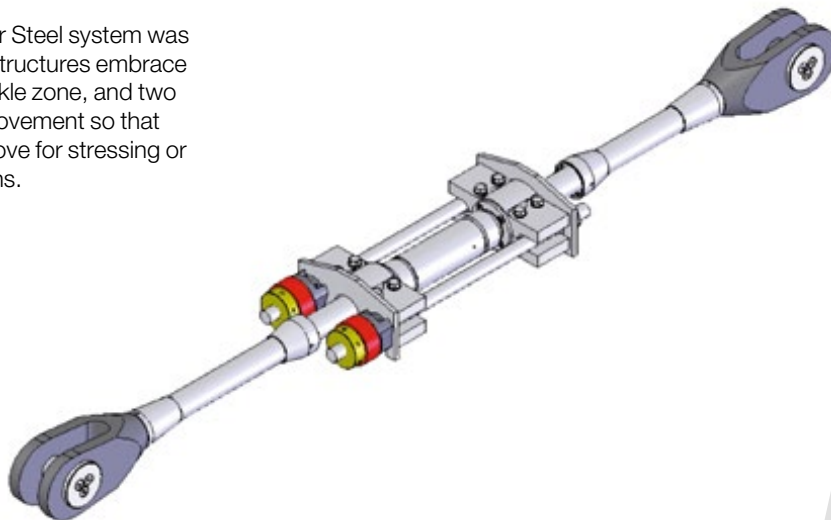
Afterwards, the designer made some adjustments during which some tendons were restressed and others destressed.





Photos reprinted courtesy of Construcciones Mariezcurrena, Spain

For this purpose, the Daver Steel system was used. In this system, two structures embrace the tendons in the turnbuckle zone, and two jacks produce a relative movement so that the turnbuckle is free to move for stressing or destressing the bar tendons.



**Owner**

URA (Agencia Vasca del Agua), Spain

**General Contractor**

Construcciones Mariezcurrena, Spain

**Contractor**

Construcciones Zubieder S. L., Spain

**Architect**

IKAUR Arquitectos e Ingenieros S.L. and Carlos Fernández Casado S.L., both Spain

**DSI Unit**

DYWIDAG Sistemas Constructivos S.A., Spain

**DSC Scope**

Supply, technical support, supervision

**DYWIDAG Products**

18 Type DST-520 M64, 64mm Ø hangers with forks and pins



## DSI supplies self-drilling DYWI® Drill Hollow Bar Anchors to widen National Road II in Girona

The A-2 Highway – also known as NE Highway – is a motorway that connects Spain’s capital Madrid with Barcelona. In some areas, the A-2 has not yet been expanded to a motorway, and traffic is directed via the old National Road N-II.



In the province of Girona in Catalonia, approximately 20.000 vehicles use the National Road N- II per day. Due to the high traffic density, the Public Works Ministry decided to develop the 6km long section between Sils and Caldes de Malavella near the French border into a motorway.

Work on this section was delayed for more than 7 years due to the economic difficulties experienced by one of the companies participating in the construction joint venture. In 2013, Acciona Infraestructuras resumed construction work and successfully completed the section in 2014.

The development of the old National Road II into a new motorway also required the construction of new bridges in this area. The abutments of the new bridges are founded on existing retaining walls that were originally built for the construction of the old National Road II.

The height of the retaining walls had to be partly increased. To increase their load-bearing capacity, the existing retaining walls were tied back using self-drilling 32mm Ø DYWI® Drill Hollow Bar Anchors. For this purpose, the hollow bar anchors were installed by means of a lost drill bit using rotary percussion, with the hollow bar serving for flushing with water, respectively a water cement suspension.

This method allowed mesh to be anchored vibration-free at the existing retaining walls and then shotcreted. Due to the excellent adhesion between the shotcrete and the existing retaining wall, no bonding course was required and the surface was closed monolithically. As a result, the load-bearing capacity of the retaining walls was permanently increased.

Due to the flexibility of the DYWI® Drill Hollow Bar System, the self-drilling DYWI® Drill Anchors were used both as temporary anchors and as soil nails. The soil nailing served to augment the soil’s stability by means of installing reinforcing elements. Soil nailing builds up a supporting structure, with the soil nail being primarily subject to tensile loads.

In this project, the DYWI® Drill Hollow Bar System was not only used because of its proven high quality, but also due to the fact that DYWI® Drill Hollow Bars can be installed quickly: They neither require primary drilling nor sheathing. In total, DSI supplied 6,700m of R32-320 DYWI® Drill Hollow Bars and accessories for widening this section of the road.

**Owner**  
Public Works Ministry, Spain  
**General Contractor**  
Acciona Infraestructuras, S.A.,  
Spain  
**Subcontractor**  
Perfo – Roca, S.L., Spain

**DSI Unit**  
DYWIDAG Sistemas Constructivos  
S.A., Spain  
**DSC Scope**  
Production, supply, technical support  
**DYWIDAG Products**  
6,700m of R32-320 DYWI® Drill Hollow  
Bars and accessories



## GEWI® Soil Nails stabilize Slopes in the Historic Spa Town Solán de Cabras

In 2011, the Mahou San Miguel Group, the market leader in the Spanish beer market with approximately 2,700 employees, bought Spain's prestigious Solán de Cabras mineral water brand. The bottling plant of the mineral water producer is located in the traditional spa town of Solán de Cabras, approximately 2 ½ hours' drive east of Madrid.



Photo reprinted courtesy of Keller Cimentaciones, S.L.U., Spain

As part of their growth strategy, the Mahou San Miguel Group decided to remodel the mineral water factory and bottling plant in the historic spa town Solán de Cabras.

In order to protect and preserve the very scenic natural environment around the bottling plant, private passenger traffic towards the spa was separated from the delivery traffic for the bottling plant. The company CRC was therefore awarded the contract for the construction of two separate roads on different levels. Construction work was carried out under strict environmental supervision.

In order to permit the construction of the roads on two different height levels,

several retaining walls had to be erected to protect the slopes next to the planned alignments, some of which were permanently tied back using GEWI® Soil Nails.

For the permanent slope stabilization in this area, DSI Construction Spain supplied 258 double corrosion protected (DCP) 25mm Ø GEWI® Soil Nails as well as 385 DCP 32mm Ø GEWI® Soil Nails. DSC supplied the soil nail systems including nuts and anchor plates and also provided the equipment needed for installation.

**General Contractor**  
CRC Obras y Servicios S.L.,  
Spain

**Subcontractor**  
Keller Cimentaciones, S.L.U., Spain

**DSI Unit**  
DYWIDAG Sistemas Constructivos  
S.A., Spain

**DSC Scope**  
Production, supply, technical support  
**DYWIDAG Products**  
258 25mm Ø DCP GEWI® Soil Nails and  
385 32mm Ø DCP GEWI® Soil Nails,  
rental of equipment



## Ready for the Future: DYWIDAG Strand Anchors with DYNA Force® Sensors secure Grančarevo Dam

The Grančarevo Dam is located on the Trebišnjica River in the southeast of Bosnia and Herzegovina near its border with Montenegro. With a height of 123m, this arch dam, near the town of Gornje Grančarevo in the municipality of Trebinje, is the country's highest dam. The adjacent Bileća Reservoir is the largest reservoir in Bosnia and Herzegovina in terms of active storage.



The Grančarevo Dam went into operation in 1967, and the two hydroelectric power plants, Trebinje-1 and -2, with a total output of 188MW were completed in 1968 and 1979.

Recently, the monitoring systems for the safety of the dam were rehabilitated and modernized. In order to ensure the long-term stability of the dam, permanent Type 12-0.62" DYWIDAG Double Corrosion Protected (DCP) Strand Anchors were installed in the right flank of the slope directly underneath the arch dam. The anchors used were electrically testable

EI-Iso Strand Anchors in lengths of up to 61.5m. This system has been approved for permanent use (applications with a 100+ year design life).

By electrically uncoupling the anchor head and the tendon from the anchor plate, a resistance test between the anchor and the soil can be carried out – the integrity of the corrosion protection sheathing can be tested at any point of time in the future by the use of standardized resistance tests. Furthermore, the EI-Iso System complies with SIA requirements.

In order to allow the owner to continuously monitor the prestressing forces in the strand anchors, 46 DYNA Force® Sensors were installed in the bond length of 23 anchors. The DYNA Force® Sensors also provided an additional mechanism for monitoring the forces during tensioning. Additionally, DSI supplied 4 multiplexers with a stainless steel casing for permanent outdoor use that were connected to the DYNA Force® Sensors in the anchors. Furthermore, DSI engineers installed a readout unit and a controller to automatically read the data.





The data measured by the DYNA Force® Sensors are continuously read and saved by a controller that is connected to the readout unit. The data is transferred via a glass fiber connection with the controller to a computer located in the control room and analyzed once a month. The control room serves for the centralized monitoring of the complete dam.

The strand anchors supplied by DSI were tensioned using two coupled Hollow-Piston CFRP Cylinders. For additional protection,

greased stainless steel caps were installed over the anchor heads.

Thanks to the type EI-Iso Strand Anchors that were used, the slope underneath the Grančarevo Dam will be permanently monitored to help ensure the safety and reliability of the acting forces.

**Operator**  
HET (Hidroelektrane na Trebišnjici),  
Bosnia and Herzegovina  
**General Contractor**  
Geosonda d.o.o. Zenica, Bosnia and  
Herzegovina  
**Subcontractor**  
HISTEH d.o.o., Slovenia  
**Consulting Engineers**  
IBE d.d., Slovenia

**DSI Unit**  
DYWIDAG-Systems International GmbH,  
Austria  
**DSI Scope**  
Production, supply, technical support,  
supervision  
**DYWIDAG Products**  
Permanent Type 12-0.62", up to 61.5m long  
DYWIDAG Strand Anchors with double corrosion  
protection, EI-Iso System, 46 DYNA Force®  
Sensors, 4 multiplexers, 1 readout unit, 1 controller



## Post-Tensioning Silos with DYWIDAG Strand Tendons: The Al Arish Cement Plant in Egypt

Recently, a cement plant was extensively expanded in the northeast of the Sinai Peninsula near the coastal town of Al Arish.



2 raw meal silos, 2 clinker silos and 4 cement silos with a production capacity of 11,000t of cement per day were built in the first project phase between 2009 and 2010. The Egyptian DSI licensee MISR DYWIDAG participated in the construction of 6 of those silos.

During the second expansion phase in 2015, 2 raw meal silos, 2 clinker silos and 4 cement silos were built that will increase production capacity by 11,500t of cement per day.

MISR DYWIDAG carried out the post-tensioning work on all silos. One raw meal silo, one clinker silo and the 4 cement silos were built together with the contractor Gama for Trading & Contracting S.A.E. The other raw meal silo and the second clinker silo were built in co-operation with the contractor SIAC.

The silos were built using the slipform method. Work was carried out in 2 shifts, with approximately 1m concreted per shift, which roughly equals construction progress of 2m per day.

For post-tensioning the silos, MISR DYWIDAG supplied and installed Type 7-0.60" DYWIDAG Strand Tendons with a total weight of 435t and 2,840 Type SD Plate Anchorages.

Since MISR DYWIDAG simultaneously worked on 4 silos, a total of 40 technicians and 4 supervisors was on site. The fact that the silos had to be completed with two different contractors within a very limited timeframe posed a special challenge.

**Owner**  
Ministry of Defense, Egypt  
**General Contractor**  
Chengdu Design and Research  
Institute of Building Materials  
Industry Co., Ltd., China  
**Contractor**  
SIAC, Industrial Construction &  
Engineering Company and Gama  
for Trading & Contracting S.A.E,  
both Egypt  
**Consulting**  
Reliance Heavy Industries (RHI), Egypt

**DSI Licensee**  
MISR DYWIDAG, Egypt  
**MISR DYWIDAG Scope**  
Production, supply, installation, technical  
support, supervision  
**DYWIDAG Products**  
Type 7-0.60" DYWIDAG Strand Post-  
Tensioning System with 2,840 Type SD  
Plate Anchorages



## Safe and fast: Flat Slab Post-Tensioning at the AQ 01 Gateway Tower at Abraj Quarter on The Pearl

The Pearl is a 400ha artificial island located 330m from Qatar's east coast and approximately 11km northeast of the center of Doha. The island is divided into 10 quarters and offers room for many new family homes and apartment buildings, schools, kindergartens, hotels, shops and restaurants.



One of the 10 zones on the island, the 13ha Abraj Quarter, accommodates 200 new town houses and 7 apartment towers. Two of these towers, Gateway Towers AQ 01 and AQ 02, flank the access road to the Pearl, thus forming the island's gate.

The slabs of the podiums, mezzanine floors and floors with a total area of 90,000m<sup>2</sup> were built as post-tensioned flat slabs. The joint venture consisting of DSI Middle East W.L.L. and DYWIDAG-Systems International GmbH, GBU, Germany, was awarded the contract for

the production and supply of Types 3-0.5" and 5-0.5" DYWIDAG Strand Tendons including approximately 8,000 Type FA Flat Anchorages for Tower AQ 01. Approximately 400t of strand were needed for the tendons.

As the subcontractor for post-tensioning, DSI Middle East not only supplied the post-tensioning systems, but also supervised the correct installation of the DYWIDAG Strand Tendons on site, thus ensuring that construction proceeded smoothly.

#### Owner

United Development Company  
QSC (UDC), Qatar

#### General Contractor

Redco Construction - Al Mana,  
Qatar

#### Consulting

Dar Al-Handasah (Shair and  
Partners), Qatar

#### Architect

WZMH Architects, Canada

#### Consulting Engineers

KEO International Consultants, Qatar

#### Subcontractor

##### Post-Tensioning Systems

DSI Middle East, Qatar (formerly QACS)

##### DSI Middle East Scope

Design, production, supply, supervision

##### DYWIDAG Products

Types 3-0.5" and 5-0.5" DYWIDAG Strand  
Tendons including approximately 8,000 Type  
FA Flat Anchorages



# The Education City People Mover System in Doha: DYWIDAG Post-Tensioning Systems ensure environmentally friendly Transportation

Education City in the western outskirts of Doha, Qatar is a new, 14km<sup>2</sup> district with different educational institutions. Approximately 1,300 students are enrolled at the 6 western universities of Education City. In addition to the universities, the district also accommodates several educational facilities for children and adolescents as well as research institutes.



Once all facilities have been completed, the entire campus will be car-free. The different institutes will be connected by a battery operated, 11.5km long streetcar system with 26 stations. The People Mover System will transport 3,300 passengers per hour in each direction using a total of 19 trains.

A 915m long viaduct that accommodates two parallel lanes and two stations is also part of the new route. The tracks run at a height of approximately 7.5m above ground level. The viaduct consist of a total of 10 elevated structures with 2 to 5 spans. The longest elevated structures are 125 m long and consist of five 25m spans.

DSI Middle East W.L.L. was responsible for installing, stressing and grouting the post-tensioning tendons. 90 Type 22-0.62" DYWIDAG Strand Tendons complete with Type MA-A Stressing Anchorages and Type MA-B Fixed Anchorages were used for post-tensioning the viaduct. The tendons were up to 125m long.

Furthermore, 680 unbonded, 40mm Ø, St 950/1050WR, 2.20m long bar tendons conforming to ETA 05/0123 and 680 40mm Ø, St 950/1050WR DYWIDAG Rock Anchors with double corrosion protection were used. These systems served to anchor the steel structures at the tram stops.

**Owner**  
Qatar Foundation, Qatar

**General Contractor**  
Joint Venture STC Siemens Tram Consortium, consisting of Siemens AG, Germany, Siemens WLL, Qatar and Habtoor Leighton Group, Qatar

**Contractor**  
Habtoor Leighton Group, Qatar

**Architect**  
GRIMSHAW, USA

**Consulting Engineers (Viaduct)**  
Halcrow Consulting Engineers & Architects Ltd., Qatar

**Consulting**  
WorleyParsons Ltd, Qatar

**DSI Units**  
DSI Middle East, Qatar (formerly QACS) and DYWIDAG-Systems International GmbH, GBU, Germany

**DSI Middle East Scope**  
Production, supply, installation, engineering services, technical support, supervision

**DYWIDAG Products**  
90 Type 22-0.62" DYWIDAG Strand Tendons, 680 unbonded, 40mm Ø bar tendons, 680 40mm Ø DYWIDAG Rock Anchors



# DYWIDAG Strand Tendons for new Silos: Expansion of the Qatar National Cement Company Production Facility

Founded in Qatar in 1965, Qatar National Cement Company (QNCC) is a major producer of Portland cement, sulphate resistant cement, hydrated lime, calcined lime, washed sand and clinker. QNCC has set itself the target to increase its annual cement production in order to satisfy the increasing demand for construction projects due to the Soccer World Cup that will take place in Qatar in 2022.



For this reason, QNCC awarded the FIVES company with the contract for the construction of a 5<sup>th</sup> production line in the town of Umm-Bab in western Qatar that will have a capacity of 5,000t of clinker per day once completed.

The new production facility also required the construction of 4 silos (two cement silos, one raw meal silo, one clinker silo) that were post-tensioned using loop tendons. DYWIDAG-Systems International GmbH, GBU, Germany proposed a special solution to the planners Peter and Lochner that consisted of changing the planned tendon types 7-0.6", 9-0.6" and 13-0.6" to uniform Type 7-0.62" DYWIDAG Strand Tendons with SD Plate Anchorages and Type 12-0.62" Post-Tensioning Systems with MA Anchorages. By reducing the tendon sizes, the number of required stressing jacks could also be reduced. The horizontal tendons were simultaneously stressed using two jacks.

For the two new, 72m high, 35m Ø cement silos, DSI Middle East produced and supplied 162 Type 7-0.62", 39m long DYWIDAG Strand Tendons per silo with a total strand tonnage of 102t.

In the 86m high, 32m Ø raw meal silo, 112 Type 12-0.62", approximately 38m long DYWIDAG Strand Tendons with a strand tonnage of 57t were used. In the 46m high, 51m Ø clinker silo, 52 Type 7-0.62" and 76 Type 12-0.62" DYWIDAG Strand Tendons in lengths of approximately 54m and with a strand tonnage of 81t were installed.

The installation of the anchorages for the two cement silos that were built using the slipform construction technique had to be carried out shortly after the SIAC company awarded the contract to DSI Middle East. All of the parts that had to be imbedded in the concrete were shipped from Germany via air freight. The SD Plate Anchorages according to ETA 13/0815 had a decisive advantage in comparison to MA Anchorages: For the SD Anchorages, only a lightweight plastic trumpet had to be installed before concreting because the heavy steel component of the SD anchorage is only required at the time of stressing.

Due to the low weight of the required plastic trumpets, the additional cost for air freight was low. Since the steel anchorage plates were only needed later on, they could be shipped via sea freight from DSI's central warehouse in Langenfeld to Qatar.

The installation of the DYWIDAG Strand Tendons including post-tensioning was successfully completed within 9 months' time.



**Owner**  
Qatar National Cement Company (QNCC), Qatar  
**General Contractor**  
FIVES, Société Anonyme, France  
**Contractor**  
SIAC, Industrial Construction & Engineering Company, Egypt  
**Consulting**  
Peter und Lochner Beratende Ingenieure für Bauwesen GmbH, Germany

**Subcontractor Post-Tensioning**  
DSI Middle East, Qatar (formerly QACS) and DYWIDAG-Systems International GmbH, GBU, Germany  
**DSI Scope**  
Production, supply, supervision  
**DYWIDAG Products**  
162 Type 7-0.62", 39m long DYWIDAG Strand Tendons, 112 Type 12-0.62", approximately 38m long DYWIDAG Strand Tendons, 52 Type 7-0.62" and 76 Type 12-0.62", 54m long DYWIDAG Strand Tendons



# DYWIDAG Strand Tendons stabilize multi-level Interchange in Qatar: The North Road Enhancement Project

The national road network in Qatar was mainly built with roads consisting of 1 or 2 lanes in the 1970s and 80s. Within the last few years, traffic has greatly increased, which has led to ever-increasing traffic loads. As a preparatory measure for the 2022 FIFA World Cup, the government has therefore started a large scale program for expanding its road network.



This program includes the expansion of the North Road, the main connection between Doha and the north of the country, from 2 to 4 lanes per direction. The North Road has a total length of 95.2km, connecting Doha to Madinat Al Shamal on Qatar's North Coast. A large number of new interchanges, flyovers, undergrade crossings and roads are built for the expansion.

In package P059, several large, multi-level interchanges, bridges and flyovers are being built. The post-tensioning systems for the bridge structures with a total of 3,700t of

strand tendons were supplied and installed by DSI Middle East, Qatar (formerly QACS) and DYWIDAG-Systems International GmbH, GBU, Germany. A total of 1,000 sets of Type MA 6837 Anchorages were required for the tendons. According to the specifications applicable in Qatar, the tendons were inserted in 80,000m of HD-PP plastic ducts.

DSI also supplied the equipment required for the installation, stressing and grouting of the DYWIDAG Strand Tendons, including stressing jacks with a capacity of 9,750kN (approx. 1,000t).

#### Owner

Ashghal – Public Works Authority, Qatar

#### General Contractor

Tekfen Construction and Installation Co., Inc., Turkey

#### Consulting Engineers

KBR, Inc., Great Britain

#### Consulting

KEO International Consultants, Great Britain

#### Subcontractor

DSI Middle East, Qatar (formerly QACS)

#### DSI Units

DSI Middle East, Qatar (formerly QACS) and DYWIDAG-Systems International GmbH, GBU, Germany

#### DSI Scope

Production, supply, installation, engineering services, technical support, supervision

#### DYWIDAG Products

DYWIDAG Strand Tendons with 1,000 Type MA 6837 Anchorages







## The Riyadh Metro Project: DSI develops watertight Special Solutions for Qasr Al Hokom Station

In 2012, the city of Riyadh in Saudi Arabia had a population of 5.7 million. This figure is expected to increase to 8 million by 2030. Therefore, the infrastructure needs to be adapted to the expected growth in population.



In order to reduce traffic congestion and improve the city's air quality, the decision was made to construct a new rapid transit system: The Riyadh Metro. Construction work on this major project started in April 2014, and the project is expected to be completed by 2018.

The project will have a total length of 178km and includes 6 new metro lines with 85 underground, elevated and at grade stations. The ArRiyadh New Mobility (ANM)

joint venture has been awarded the contract to build Line 3 as well as the Qasr Al Hokom and Western Stations.

Line 3 is the longest line of the metro project and will have a length of 41.58km. It runs from west to east and will have 22 stations in total. At the surface, the new Qasr Al Hokom Station has an innovative concave design resembling a bowl. Underground, the blue Line 1 runs above the orange Line 3 at this station.

A deep, completely impermeable pit that was excavated step by step in 3m deep sections was required for the new station.

The excavation walls were stabilized with water beams that were tied back into the stable soil using an untensioned, passive anchor system. Since the final building also had to be stabilized by the passive anchor system, the system had two functions.





On the one hand, it served to stabilize the excavation, and on the other hand, it served as buoyancy control for the building. For this purpose, DSI Construction Germany produced and supplied 1,183 double corrosion protected, 63.5mm Ø *GEWI® Plus* Tension Piles. In addition, to prevent uplift, 997 double corrosion protected, 75mm Ø *GEWI® Plus* Micropiles were used in the station floor slab.

Due to the fact that the station had to be completely impermeable, DSI developed watertight special solutions for both systems in cooperation with the contractor.

DSI engineers continuously supervised and checked the correct installation of the systems.



#### Owner

Arriyadh Development Authority (ADA), Saudi-Arabia

#### General Contractor

ArRiyadh New Mobility (ANM) Joint Venture, consisting of Ansaldo STS S.p.A. and Salini Impregilo S.p.A., both Italy, Larsen & Toubro Limited and Nesma and Partners Contracting Co. Ltd., both Saudi-Arabia and Bombardier Inc., Canada

#### Contractor

Nesma and Partners Contracting Co. Ltd., Saudi-Arabia

#### Subcontractor

Sonar Sondaj, Turkey

#### Engineering

One Works S.p.A., Italy

#### DSI Unit

DYWIDAG-Systems International GmbH, BU Geotechnics, Germany

#### DSI Scope

Development, production, supply, engineering services, technical support, supervision

#### DYWIDAG Products

1,183 63.5mm Ø *GEWI® Plus* Tension Piles, 997 75mm Ø *GEWI® Plus* Micropiles



## The Vancouver House Project: Impressive Architecture with DYWIDAG Systems

The Vancouver House project is one of the most spectacular projects currently under construction near the False Creek in Vancouver, Canada. It is a 150m high tower building that will include restaurants, retail facilities and 375 apartments and that will be opened in 2019.



Thanks to its unusual design that has already won several awards, the high-rise building will become a new landmark. Vancouver House is being built on a triangular ground area of only 557.4m<sup>2</sup>. The twisted tower transitions from a mostly triangular base to a rectangular top section. This way, the upper floors have a 1,208m<sup>2</sup> large floor space that is approximately twice as large as the foundation area.

The Vancouver House's 7 levels of underground parking required a 24.4m (80ft) deep excavation that was stabilized by a shotcrete anchored wall for the full depth. To tie back the retaining wall, DSI Construction Canada produced and supplied 1,200 Type 3-0.6" and 4-0.6" DYWIDAG Strand Anchors in lengths of approximately 13.7m. Due to the changing ground conditions in the excavation area, 200 R51, 13.7m long DYWI® Drill Hollow Bar Anchors were also installed.

Since the area on the south side does not form part of the owner's property, the use of anchors was not permitted so that the area of the excavation was stabilized by horizontal girders that were diagonally braced at the corners.

One of the biggest challenges on this project was the close proximity to the Granville Street Bridge approach spans. The foundation loads of this bridge are transferred to large spread footings that reach right to the edge of the Vancouver House excavation. While the excavation progressed, the bridge was monitored at many different locations for any sign of movement. Thanks to the efficient stabilization of the excavation, no movement was recorded during the entire excavation process.

**Owner**  
Westbank Projects Corp.,  
Canada

**Contractor**  
Southwest Contracting Ltd.,  
Canada

**Architects**  
BIG, USA, DIALOG and James  
K.M. Cheng Architects Inc.,  
both Canada

**Consulting Engineers**  
GeoPacfic Consultants Ltd.,  
Canada

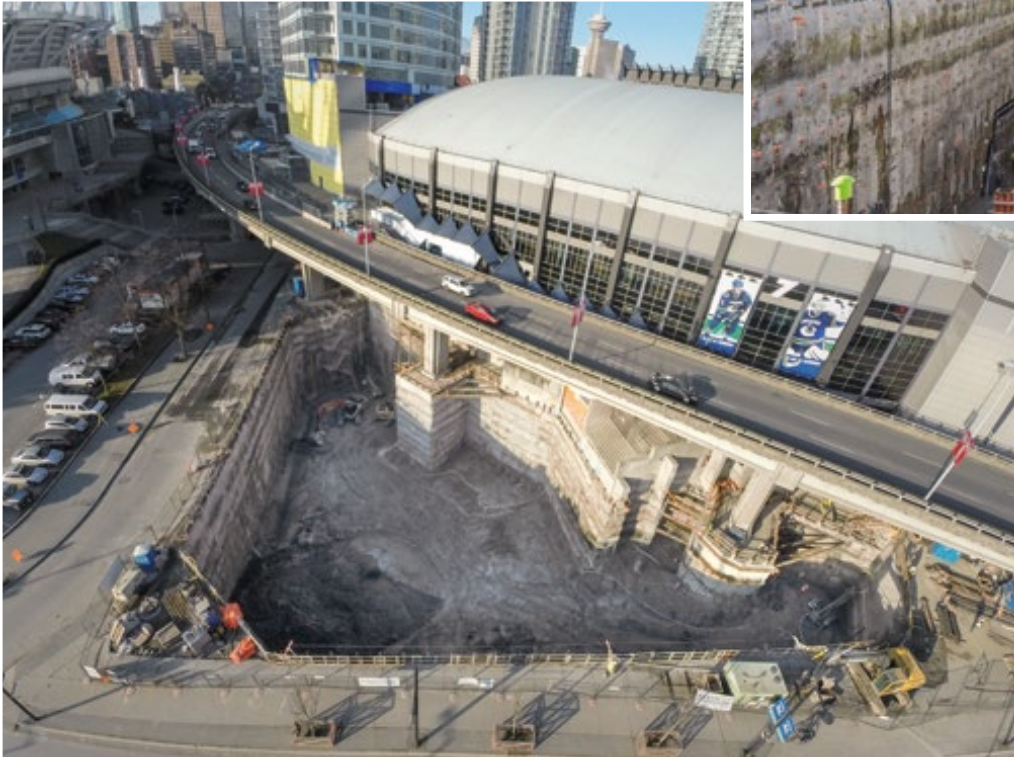
**DSI Unit**  
DSI Canada Civil Ltd., Canada

**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
1,200 Type 3-0.6" and 4-0.6" DYWIDAG  
Strand Anchors, 200 R51 DYWI® Drill  
Hollow Bar Anchors



# Stabilization of an Excavation in a Confined Space: The Rogers Arena South Tower in Vancouver

The Rogers Arena South Tower is part of the Aquilini Centre, a construction project in northern Vancouver. At this location, three new towers are being built around the Rogers Arena – the home of the Canucks hockey team – that will accommodate offices, apartments and sports and multiple use facilities.



The South Tower with 5 underground parking decks and 31 levels above ground is being built on a small, triangular area near the entrance to the Rogers Arena. The realization of the excavation between the southern wall of the stadium, the Georgia Viaduct, Pacific Avenue and Griffiths Way was a special challenge because the space is extremely confined.

The Contractor had to use special care during excavation and shoring to ensure the stability of the existing structures surrounding the excavation. Furthermore, buried debris and the underground utilities complicated construction work.

A foundation consisting of micropiles and a retaining wall were employed to stabilize the excavation. Since the Georgia Viaduct is used by approximately 2,000 vehicles per hour during peak times, the foundation had to be built with special care in this area. The three viaduct piers were stabilized by installing 12 micropiles evenly around each pier.

Each of the 36 micropiles consisted of a 66mm Ø DYWIDAG THREADBAR® with Double Corrosion Protection that was installed to a depth of approximately 25.3m (83ft). The piers were additionally monitored during the entire construction work using a variety of instrumentation, and none of the piers showed any sign of movement.

The conventional shotcrete reinforced wall was tied back using 9-11 rows of tieback anchors. The anchors were installed with vertical spacing of about 1.2m-1.8m (4-6ft) and anchored against a horizontal shotcrete water. For this purpose, DSI Construction Canada produced and supplied 25mm Ø DYWIDAG Bar Anchors and T40 DYWI® Drill Anchors with a total length of 15,240m. The anchor systems were installed at various angles from 5 to 45° and at depths of up to 24.4m (80ft). The Contractor completed all the anchoring and excavation work successfully and safely with no detrimental impact on the surrounding structures.

**Owner**  
Aquilini Development and Construction Inc., Canada  
**Contractor**  
Matcon Civil Constructors Inc., Canada  
**Architect**  
B+H Architects, Canada  
**Consulting Engineers**  
GeoPacific Consultants Ltd., Canada

**DSI Unit**  
DSI Canada Civil Ltd., Canada  
**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
36, 66mm Ø DYWIDAG Micropiles,  
15,240m of 25mm Ø DYWIDAG Bar  
Anchors and T40 DYWI® Drill Anchors



## Hydro-Canyon Saint-Joachim Project: DYWI® Drill Soil Nails permit long-term Slope Stabilization

The Hydro-Canyon Saint-Joachim project is a new hydroelectric facility under construction on the Sainte-Anne du Nord River in the community of Saint-Joachim, Quebec, in southeastern Canada.



*Photos reprinted courtesy of AXOR Group Inc., Canada*

The run-of-river facility is being built next to the 60m high Sainte-Anne Waterfalls and will have a nominal capacity of 23.2MW after its completion, which is scheduled for November 2016. The facility will produce an average of 82,400MWh of renewable energy per year, which is equivalent to the needs of 4,800 local households.

The project involved extensive slope stabilization to ensure a reliable access to the powerhouse site.

Due to challenging access constraints and the need to prevent any visual impact on

the popular tourist attraction of Sainte-Anne Falls, the decision was made to construct three permanent retaining walls.

The main retaining wall crosses the Cap Tourmente fault line, where challenging ground conditions were anticipated and effectively encountered. These included very steep natural terrain slopes, extremely dense soil in the lower sections of the wall and the presence of large boulders.

For the retaining walls, DSI Construction Canada supplied a total of 1,671 permanent DYWI® Drill Hollow Bar Anchors that were

used as soil nails. The highest sections of the soil nail walls are 20m high and had to be stabilized by up to 11 rows of up to 18m long soil nails. The DYWI® Drill Hollow Bar Systems were supplied with carbide drill bits in diameters of R32N, R32S, R38N, R51L, T40 and R51N.

All hardware was galvanized for long-term corrosion resistance. Following soil nail installation, a permanent concrete facing was applied on top of the shotcrete retaining walls to guarantee a minimum service life of 75 years.





**Owner**  
Société Hydro-Canyon Saint-Joachim Inc., Canada

**General Contractor**  
AXOR Construction Canada Inc., Canada

**Subcontractor**  
Les Entreprises Michel Beupied Inc., Béton Projeté MAH Inc., MK2 Excavation Inc. and Mamu Construction Inc., all of them Canada

**Consulting Engineers**  
AXOR Group Inc., Hydrosys Experts-Conseils Inc. and GHD Inc., all of them Canada

**DSI Unit**  
DSI Canada Civil Ltd., Canada

**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
1,671 R32N, R32S, R38N, R51L, T40 and R51N  
DYWI® Drill Hollow Bar Soil Nails with carbide drill bits



## Flexible on-site Installation: Prefabricated DYWIDAG Tendons for George V. Voinovich Bridge in Cleveland

The George V. Voinovich Bridge is part of the I-90 Interstate in Cleveland, Ohio, carrying vehicular traffic across the Cuyahoga River. The 5 lane structure replaces a truss bridge built in 1959 that had deteriorated badly and needed replacement.



The new crossing consists of two sister structures, the first of which was completed in 2013. Until the completion of the second bridge, for traffic into the eastern direction, the first structure will continue to accommodate the total traffic volume of approximately 140,000 vehicles per day.

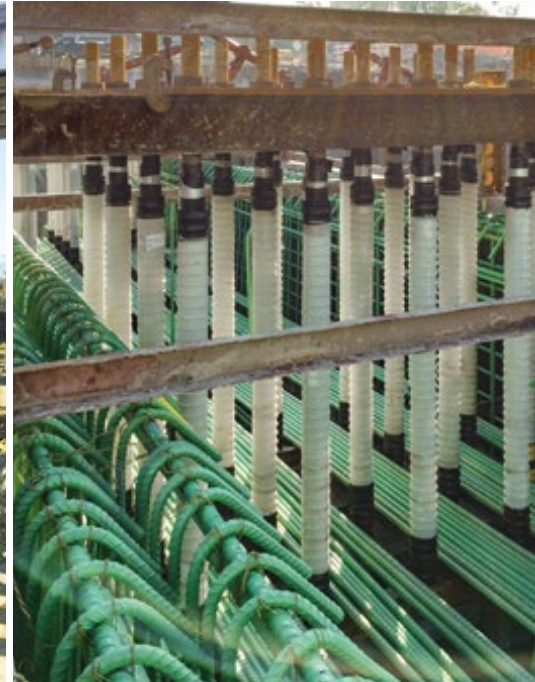
The current bridge under construction for eastbound traffic is where the DYWIDAG system is being used. The main bridge is approximately 1,194.8m (3,920ft) long and consists of two units. The first part – the approach bridge – is a 4 span conventional steel plate girder bridge. The second part is a 10-span, 5 girder line, steel plate girder bridge supported by steel delta frames.

The span lengths vary from 82.3m to 110m (270ft to 361ft). Both bridge decks have a total width of approximately 30.5m.

With a length of approximately 27.4m (90ft), the 18 x 204 HP piles are the largest ever manufactured in the USA. The steel piles were hammered up to 61m (200ft) deep into the underlying stable bedrock. The piers rest on two concrete blocks that measure 8.5 x 8.5 x 2.6m (28ft x 28ft x 8.5ft). The columns of the piers were built in 3 sections, with the last section cantilevering laterally. The columns have a hollow core in order to reduce the overall weight of the bridge structures. On top of the two columns is a solid reinforced pier cap joining them together.

There are 5 pedestals on top of each pier cap. Five groups of 20-24 GR150 DYWIDAG Post-Tensioning Bars are embedded multiple feet in to each pier cap, pass through the pedestal, and protrude several feet above, so structural steel can be positioned onto the bars and they can still be stressed. After pier cap concrete placement, the top of the DYWIDAG Bar Tendons were required to pass through an area where a grout pad would be poured after the setting of knuckles (at the bottom of the delta), prior to the completion of the delta frame erection. While placing the grout pad, it was critical that the fluid grout pad material did not enter the ducts and cause blockage or prevent proper tensioning of the tendons.





Photos reprinted courtesy of Trumbull Corporation, USA

Furthermore, the interface between the delta frame base plate and the grout pad had to be sealed against moisture intrusion. DSI developed a groutable system meeting both the owner's requirements for durability and satisfying requirements in terms of installation. The DYWIDAG Bar Tendons were required to be stressed to approximately 72% of their ultimate strength, after the setting of the knuckle (at the bottom of the delta), but before the rest of the delta frame was erected.

In a true partnering approach, the contractor and DSI worked together and finalized an anchorage system using 46 and 65mm Ø DYWIDAG Bar Tendons. In order to eliminate the complicated site assembly requirements

for tendons, DSI proposed a preassembled, pick and place tendon system that could be flexibly used, thus saving the contractor time and labor.

The DYWIDAG Bar Tendons were assembled including all accessories in DSI Construction USA's Bolingbrook facility and then sent to the jobsite. In total, 300 46mm Ø DYWIDAG Bar Tendons with a total weight of 12t and 680 66mm Ø DYWIDAG Bar Tendons with a total weight of 53t were needed. The contractor placed the DYWIDAG Tendons in a jig held by setting templates at both top and bottom that was used to fly the tendons into place.

#### Owner

Ohio Department of Transportation (ODOT), USA

#### General Contractor

Trumbull-Great Lakes-Ruhlin a Joint Venture, consisting of Trumbull Corporation, The Great Lakes Construction Company and The Ruhlin Company, all of them USA

#### Architect

Touchstone Architecture, USA

#### Consulting Engineers

URS Corporation, An AECOM Company, USA

#### DSI Unit

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

#### DSI Scope

Development, production, supply, technical support

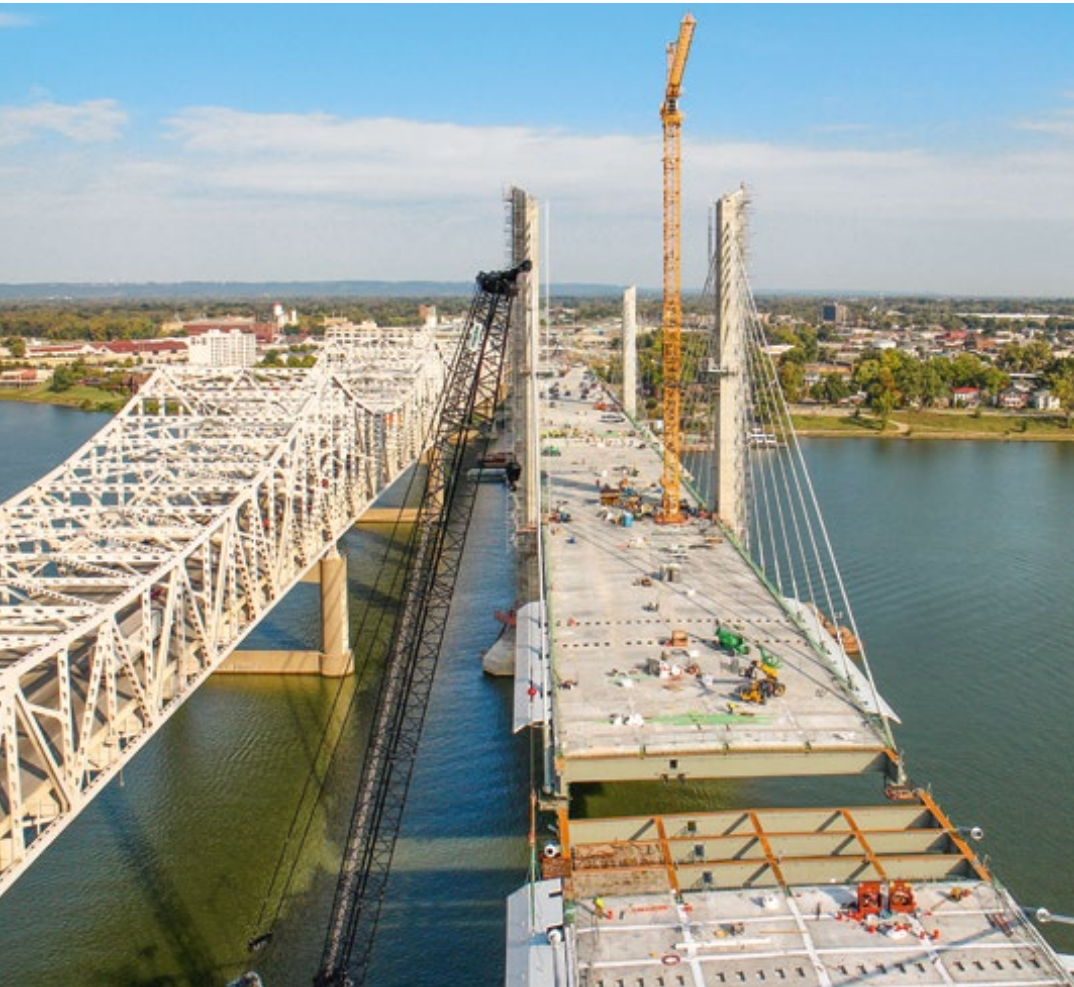
#### DYWIDAG Products

300 46mm Ø DYWIDAG Bar Tendons, 12t and 680 66mm Ø DYWIDAG Bar Tendons, 53t



## Large Scale Use of DYNA Force® Sensors and DYNA Grip® Stay Cables: The Abraham Lincoln Bridge in Louisville

The Abraham Lincoln Bridge is part of the large infrastructure project “Ohio River Bridges Downtown Crossing” in Louisville, Kentucky, USA. The bridge that was originally named Louisville Downtown Crossing accommodates northbound traffic of the Interstate I-65 and connects the center of Louisville in Kentucky with Jeffersonville in Indiana. In the meantime, the structure has been named after Abraham Lincoln, the 16<sup>th</sup> president of the USA, who was born in Kentucky in the 19<sup>th</sup> century and grew up in Indiana.



The Abraham Lincoln Bridge runs parallel to the John F. Kennedy Memorial Bridge, which was opened to traffic in 1963, and will accommodate all northbound I-65 traffic once the project has been completed. The John F. Kennedy Memorial Bridge will then carry southbound traffic.

The new bridge was built as a stay cable bridge with three pairs of pylons. The stay cables hold the six lane composite steel/concrete deck in place. The bridge has a

total length of approximately 642m (2,106ft) and consists of two 228.6m (750ft) long main spans and two 92.35m (303ft) long side spans.

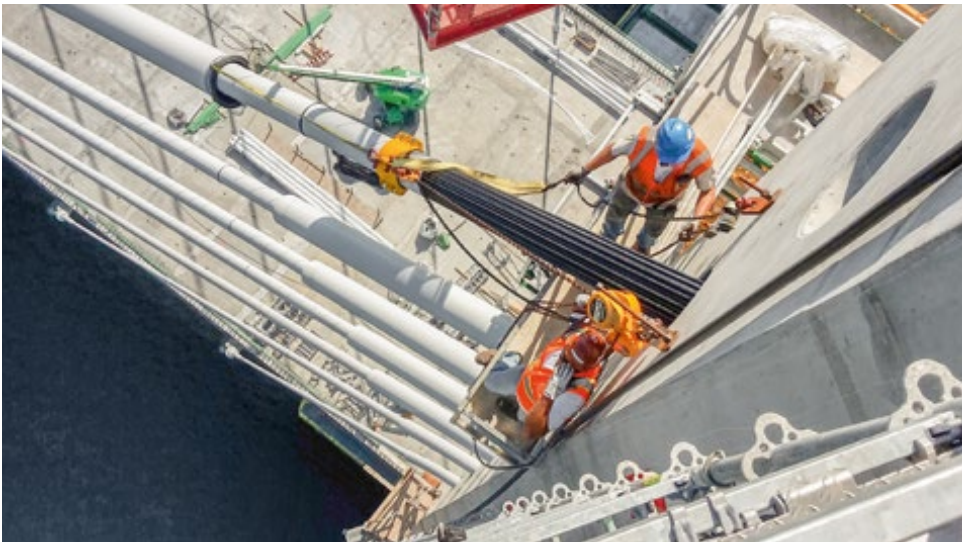
For this project, DSI produced and supplied the DYNA Grip® Stay Cable System as well as the DYNA Force® Measuring System including equipment. Furthermore, DSI provided technical assistance and on-site supervision. Before installation started, DSI performed two successful full-size tests with Type DG-P37 and DG-P109 DYNA Grip® Stay Cables.

In total, 176 DYNA Grip® Stay Cables including anchorages and 597t of strand were needed:

- 40 Type DG-P37 Stay Cables
- 56 Type DG-P48 Stay Cables
- 32 Type DG-P55 Stay Cables
- 8 Type DG-P73 Stay Cables
- 8 Type DG-P91 Stay Cables
- 32 Type DG-P109 Stay Cables

DSI also supplied 88 internal hydraulic dampers. The DYNA Grip® Stay Cables were successfully





installed by the General Contractor, assisted by DSI technicians and engineers, from November 2014 to November 2015.

DSI was awarded the contract to supply the DYNA Force® Measuring System including a remote controlled readout unit for the long-term monitoring of the forces acting on the stay cables. With a total of 264 DYNA Force® Sensors for Type 0.62" Strand and 3 readout units equipped with a remote system supplied, the Abraham Lincoln Bridge is the

largest application of DYNA Force® Sensors for DSI in Post-Tensioning so far. The first lanes were opened to traffic approximately 4 months earlier than planned at the beginning of December 2015. The complete Downtown Crossing Project including the rehabilitation of the Kennedy Bridge and the connecting roads on both sides of the Ohio River is expected to be completed by the end of 2016.

**Owner**  
Kentucky Transportation Cabinet (KYTC), USA  
**General Contractor**  
Walsh Construction Company, USA  
**Contractor**  
Milestone Contractors, L.P., USA  
**Engineering (Lead Design)**  
Jacobs Engineering Group Inc., USA  
**Engineering (Design)**  
COWI Bridge North America (formerly Buckland & Taylor Ltd.), Canada

**DSI Units**  
DYWIDAG-Systems International GmbH, BU Special Projects, Germany and DYWIDAG-Systems International USA Inc., BU Post-Tensioning, East, USA  
**DSI Scope**  
Production, supply, engineering services, technical support, supervision  
**DYWIDAG Products**  
176 Type DG-P37, DG-P48, DG-P55, DG-P73, DG-P91 and DG-P109 DYNA Grip® Stay Cables, 88 internal hydraulic dampers, 264 DYNA Force® Sensors with readout unit



## Plant Vogtle Units 3 & 4: DSI supplies DYWIDAG Form Ties for new Reactors

In February 2012, Plant Vogtle in Waynesboro, Georgia, USA, was approved for the construction of two new nuclear reactor blocks: Units 3 and 4. This is the first time new reactors have been approved in the USA since 1978. Units 3 and 4 are an addition to the original Units 1 and 2 that were built in the 1980s. Units 3 and 4 are set to be operational in 2019 and 2020 respectively. Once completed, Plant Vogtle will supply approximately 1 million households and companies with energy and create 800 new jobs.



The two new reactors will have an output of approximately 1,117MW each. The construction of the two units includes the cooling towers, nuclear islands, turbine islands, and other concrete framed buildings.

For the construction of the reinforced concrete structures, DSI Construction USA supplied DYWIDAG Form Ties and other Concrete Accessories. This included anchor bars consisting of 15, 20 and 26mm Ø DYWIDAG THREADBAR®, shebolts, steel setting cones, couplers, hex nuts, wobble anchors, welded angle brackets and many other Concrete Accessories.

A concrete volume of approximately 382,277m<sup>3</sup> (500,000yd<sup>3</sup>) is needed for the two new reactors. The 15 and 20mm Ø DYWIDAG THREADBAR® supplied by DSI alone had a total length of over 3,000m (9,842.5ft), and construction is still underway.

**Owner**  
Southern Nuclear Operating Company, USA  
**General Contractor**  
Westinghouse Electric Co. LLC, USA  
**Subcontractor**  
HSG Constructors, USA

**DSI Unit**  
DYWIDAG-Systems International USA Inc., Concrete Accessories, USA  
**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
15, 20 and 26mm Ø DYWIDAG THREADBAR®, shebolts, steel setting cones, couplers, hex nuts, wobble anchors, welded angle brackets



## The Elephant Trunk, Highway 1: Stabilization of a Steep Coastline using permanent DYWIDAG Strand Anchors

Near the northern border of San Luis Obispo County in southern California, Highway 1 is located in the immediate vicinity of a rocky bluff. Through an area known as the Elephant Trunk along this route, the Pacific coast is characterized by unstable geology. Major landslides and settlements occurred time and again in this area, which is why repair work was required on a regular basis.



Photos reprinted courtesy of John Madonna Construction Co., Inc., USA

In order to permanently stabilize this area, a soldier pile wall was constructed in this section below the route, and Highway 1 was straightened. The lanes are being widened from 3.35m to 3.65m (11 to 12ft), and an additional 1.2m (4ft) wide hard shoulder is being built.

To prevent possible rock falls from the steep coast above the road, a 0.60 to 1.2m (2-4ft) wide catchment area was built for falling debris, and the existing drainage system was optimized and repaired.

The new soldier pile wall has a total length of approximately 305m (1,000ft). On the surface, only a part of the maximum 15m (50ft) high retaining wall is visible.

The steel girders of the soldier pile wall were tied back to the stable slope strata using permanent DYWIDAG Strand Anchors. To tie back the retaining wall, DSI Construction USA supplied 259 Type 5-0.6" and 6-0.6" DYWIDAG Strand Anchors.

The DYWIDAG Strand Anchor System was especially suitable for use due to its high degree of flexibility with regards to the required anchor lengths. As construction and storage space was limited, the anchors were supplied to the jobsite on coils, thus minimizing space requirements.

#### Owner

Caltrans (California Department of Transportation), USA

#### General Contractor

John Madonna Construction Co., Inc., USA

#### Subcontractor

Drill Tech Drilling & Shoring Inc., USA

#### Engineering

Caltrans (California Department of Transportation), USA

#### DSI Unit

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

#### DSI Scope

Production, supply

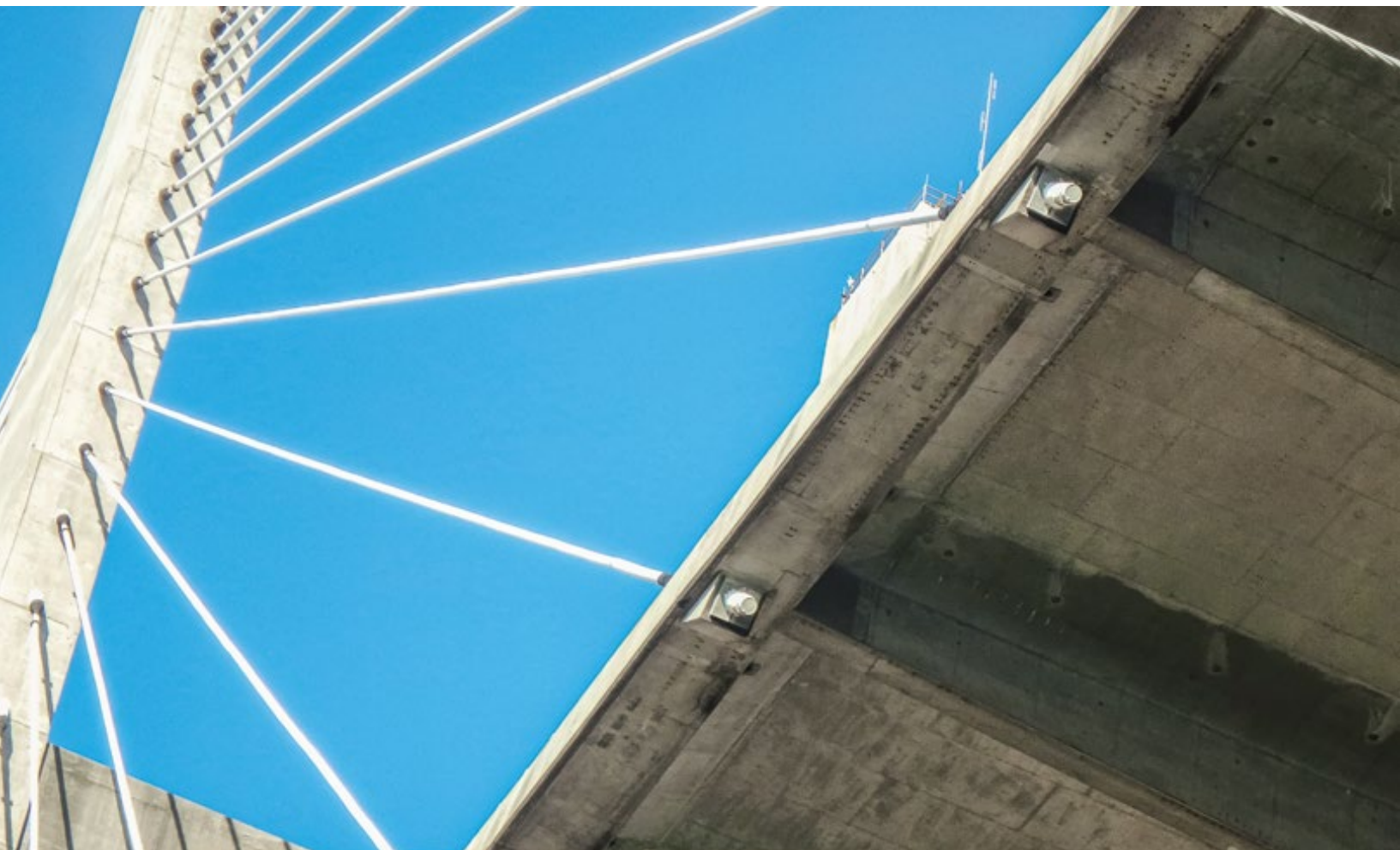
#### DYWIDAG Products

259 Type 5-0.6" and 6-0.6" permanent DYWIDAG Strand Anchors



## DSI demonstrates its technical Competence during Repair Work on the Talmadge Bridge

The Talmadge Memorial Bridge is a four lane, cable stayed bridge in the state of Georgia, USA carrying US route 17 through Downtown Savannah across the Savannah River to Hutchinson Island. There are two pairs of H-shaped pylons supporting the stay cables. The main span of the bridge that was completed in 1991 is 335m (1,100ft) long, and the overall bridge length is 3.1km (1.9mi).



In the summer of 2015, DSI was contracted by the General Contractor, The Industrial Company (TIC), to perform important component repairs to the Talmadge Memorial Bridge. As with all bridges, periodic repair and maintenance is needed to keep the structure in good condition, and this was the second time DSI's expertise was called upon for the repair work. DSI had already supplied and installed

288 retrofit dampeners on the Talmadge Bridge cables between 2006 and 2008.

The scope of DSI's second contract was to replace all the stay cable boot seals at the pylons and underneath the bridge deck. Furthermore, DSI renewed the cable stay pipe tape where the existing tape had sustained damage. The contract also included the

inspection and repair of all the anchorage caps on the stay cables – both at the lower anchor locations below the bridge deck and at the upper anchor locations in the pylons. The anchor cap repairs included installing new seals, packing the caps with new corrosion inhibiting compound and replacing anchor bolts as required.





Access was the most challenging component of this repair program and required the utmost attention to detail. DSI provided a total of 4 man baskets for access to the upper boot locations. Each basket was individually controlled with a safety spotter to ensure safe movement up and down the pylon exteriors.

The repair work on the Talmadge Bridge was completed safely, on time and on budget in February 2016.

**Owner**

Georgia Department of Transportation (GDOT), USA

**General Contractor**

TIC – The Industrial Company, USA

**Subcontractor**

DYWIDAG-Systems International USA Inc., Structural Repair, USA

**Consulting Engineers**

TranSystems Corporation, USA

**DSI Unit**

DYWIDAG-Systems International USA Inc., Structural Repair, USA

**DSI Scope**

Supply, installation, technical support

**DYWIDAG Products**

Anchor cap seals, corrosion inhibiting compound, stay cable pipe tape



## The San Antonio Y Interchange: Permanent Repair with DYWIDAG Systems

The San Antonio Y Interchange in the center of San Antonio, Texas, USA, is a Y shaped interchange between US Highway 35 from the northeast and US Highway 10 from the northwest that merge together moving south. The viaducts of this elevated intersection were built in the 1980s utilizing precast concrete segmental type construction. The 755 sections were post-tensioned together using longitudinal and transversal tendons, and the bridge has a total length of approximately 23km (14.3mi).



When the interchange was built, it was not yet known how important it is to completely grout the tendons, and at the time industry standards did not place a strong emphasis on this component of the construction. As the grouting operations were not carried out thoroughly, voids often occurred that allowed moisture and oxygen to infiltrate the system, thereby causing corrosion of the post-tensioning strands. During a cursory evaluation of the Y Interchange, the Owner, TXDOT, found voids in some of the tendon ducts. Furthermore, the ducts of many tendons were damaged, and most anchors had no caps, which are important for protecting the strand

tails and act as an additional level of corrosion protection.

DSI Construction USA was selected as the subcontractor by the Owner and Contractor to perform all of the remediation work associated with this section of the elevated highways. One of the biggest challenges was determining the number of the originally installed tendons that had to be repaired because an in-depth evaluation and survey was not possible in advance.

DSI engineered all test inspection and repair protocols as part of their construction plan and

carried out the work through the use of bore scopes to identify the condition of the strands within the voided areas. In addition, when DSI identified voids, specialized vacuum grouting techniques were employed to measure the void volumes and then fill the voids with grout.

Since the original construction of the Y Interchange was done in several phases and by different contractors, the tendons had also been supplied by several different Post-Tensioning companies, resulting in many different anchorage types. DSI designed, produced and installed custom caps for each type of anchorage.





For those ducts that had incurred major damage over the years in the form of splitting and cracking, DSI designed and installed a special split duct system for permanent repair. All of the existing voids inside the post-tensioning tendons were filled by DSI using a vacuum or vacuum-assisted grouting method.

The largest challenge to overcome on the project was the access to the work areas inside of the precast segments. This was primarily done from directly underneath the bridge segments through integrated hatches that were many times located directly above heavy traffic areas of street level roadways

and parking lots. This demanded considerable traffic control with lane closures and the need to complete a significant amount of the work at night.

Despite the large project footprint and other challenges encountered, DSI completed all repair measures within the contract timeframe of just over two years. DSI's crews worked safely on these structures, logging over 75,000 man hours to complete the work.

**Owner**  
Texas Department of  
Transportation (TXDOT), USA  
**General Contractor**  
SCR Construction Co., Inc., USA

**DSI Unit**  
DYWIDAG-Systems International  
USA Inc., Structural Repair, USA  
**DSI Scope**  
Design, production, supply, installation,  
technical support, grouting  
**DYWIDAG Products**  
Anchor caps, duct system



## Safe from Floods with DYWIDAG Anchor Systems: Reinforcement of the Folsom Dam in California

Completed in 1955, Folsom Dam is located on the American River in northern California, approximately 40km northeast of the city of Sacramento. The 100m (340ft) high and 430m (1,400ft) long dam creates the Folsom Reservoir that has a maximum possible water area of 4,830ha (11,930 acres). The Folsom Power Plant has 3 Francis Turbines with a total output of 198.72MW.



In order to significantly lower the probability of floods and to double the amount of water the dam can hold in the event of flooding, the U.S. Army Corps of Engineers and the Central Valley Flood Protection Board cooperated with the state of California and the Sacramento Area Flood Control Agency to undertake the “Joint Federal Project” (JFP).

The JFP includes a new spillway with six submerged tainter gates located in a

new control structure. This structure is an additional dam that prevents water from entering the spillway when the gates are closed. The project consists of 5 phases.

In phase IV of the construction, a 335.3m (1,100ft) long approach channel is being built for the new spillway on the reservoir side. Essentially, this includes a second dam, the 922.6m (3,027ft) long spillway chute and the stilling basin on the downstream side.

The stilling basin works as an energy dissipater to slow the water as it enters the American River.

In this phase, the soil for the additional dam and part of the spillway chute is excavated, and the foundation of the control structure is built.

For this purpose, DSI Construction USA supplied a total of 316 90mm Ø DYWIDAG





Rock Anchors consisting of 168t of galvanized THREADBAR® Tendons that were installed in the approach slab of the spillway chute.

Furthermore, DSI supplied 75mm Ø, GR 150 THREADBAR® Tendons to extend the 30 rock anchors that were installed in phase III as well as the complete stressing equipment and a grease pump. The technical challenge was to develop four different customized anchor geometries to extend just 30 anchors.

The rock anchor systems supplied by DSI proved to be superior to those of the competitors. Furthermore, DSI was able to secure this project by taking advantage of its high quality products and excellent customer service.

**Owner**  
US Army Corps of Engineers, USA  
**General Contractor**  
Kiewit, USA  
**Subcontractor**  
Neil's Controlled Blasting, L.P., USA  
**Engineering**  
US Army Corps of Engineers, USA

**DSI Unit**  
DYWIDAG-Systems International USA Inc., BU Geotechnics, USA  
**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
316 90mm Ø DYWIDAG Rock Anchors, 75mm Ø THREADBAR® Tendons, stressing equipment and grease pump



## Large Scale Use of DYWIDAG Anchors: The San Gabriel Trench in California

The San Gabriel Trench Project is being built in the city of San Gabriel in Los Angeles County. A 2.25km (1.4mi) long section of the Union Pacific railway tracks is being lowered into a trench that runs through the city.



The project includes four new road and pedestrian bridges crossing the tracks that will ensure a safe transit of the railway line for the almost 90,000 vehicles using the roads every day. Consequently, the long wait times and the ensuing environmental impact will be eliminated.

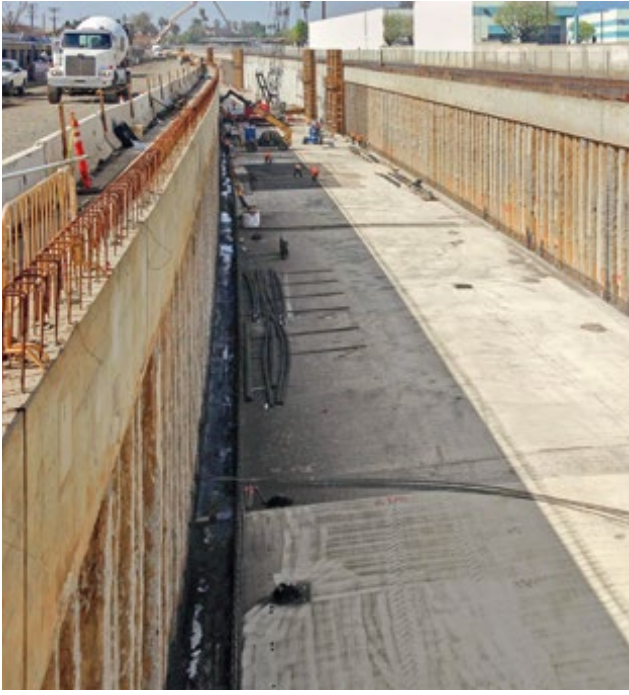
The trough structure is being built to a depth of 9.14m (30ft) and a width of 19.81m (65ft) using the open cut method. Once the excavation and stabilization measures have been finished, concrete walls will be erected in the trench, and the new railway tracks will be placed.

Different DYWIDAG Anchor Systems were required to stabilize the excavation walls. DSI Construction USA produced and supplied 202 temporary, 3-6 strand DYWIDAG Strand Anchors with a total length of approximately 13.3km (43,700ft) including accessories. Furthermore, 2,206 permanent, double corrosion protection (DCP) 4-10 strand DYWIDAG Strand Anchors were installed in the excavation. The permanent anchors utilize 0.6" strand with a total length of nearly 229km (751,000ft) as well as corresponding accessories.

DSI also produced and supplied 433 permanent, double corrosion protected (DCP) DYWIDAG Bar Anchors including accessories. More than 5km (16,700ft) of 26mm Ø, GR 150 DYWIDAG THREADBAR® was used for the bar anchors.

Furthermore, DSI supplied the equipment for testing and stressing the strand and bar anchors. The Tensa and HOZ type jacks ensured efficient and fast tensioning and a time-optimized lock off of the anchors.





**Owner**  
Alameda Corridor-East  
Construction Authority (ACE), USA  
**General Contractor**  
Walsh Construction Co., USA  
**Subcontractor**  
Malcolm Drilling Company, Inc., USA  
**Consulting Engineers**  
Moffat & Nichol, Pirooz Barar &  
Associates, Inc. (PB&A),  
BMA Construction Engineers, Inc.,  
all of them USA

**DSI Unit**  
DYWIDAG-Systems International USA  
Inc., BU Geotechnics, USA  
**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
202 temporary, 3-6 Type 0.6" strand  
DYWIDAG Strand Anchors, 2,206 permanent,  
4-10 Type 0.6" strand, DCP DYWIDAG Strand  
Anchors, 433 permanent, 26mm Ø  
DCP DYWIDAG Bar Anchors



## The California Incline: DYWIDAG Soil Nails stabilize a Bluff at an important Coastal Road in Santa Monica

The California Incline in Santa Monica near Los Angeles, originally designed as a walkway in 1896, was cut through the bluffs to provide access to the local beach. In 1930, the path was widened to create a 426.7m (1,400ft) long road for vehicle use. The road also includes a 213.4m (700ft) long reinforced concrete bridge built in 1939. Since then, the road has been the major artery connecting the Pacific Coast Highway and Ocean Avenue, which leads into the center of Santa Monica.



After 85 years of heavy traffic, the California Incline was identified as structurally deficient. Consequently, the section is now being completely rebuilt and made seismically resistant. The old bridge with transverse concrete girders will be replaced by a new bridge that is being built in the same location.

The new structure consists of a pile-supported reinforced concrete slab structure. At a width of 15.8m (51.8ft), the new bridge deck is wider than the old one and accommodates additional sidewalks and bicycle lanes.

Within the scope of this project, the eroding bluff that extends 30.5m (100ft) above the incline roadway grade had to be stabilized for the long term.

For this purpose, 1,000 double corrosion protected (DCP), 32mm Ø, 75ksi DYWIDAG Soil Nails were anchored in the stable layers of the steep coast. A total of 15,850m (50,000ft) of DYWIDAG THREADBAR® with a net weight of 110t was used for soil nail fabrication.

Most of the DYWIDAG Soil Nails that were up to 22.9m (75ft) long were installed using high reach drill rigs and a crane-suspended work platform. Even with the challenging access conditions, the subcontractor Malcolm Drilling managed to meet the target schedule by successfully installing all of the DYWIDAG Soil Nails. To minimize visual impact, each nail head was cut off behind the slope face and patched with colored grout to match the surrounding soil.

### Owner

City of Santa Monica and California Department of Transportation (Caltrans), both USA

### General Contractor

MCM Construction, Inc., USA

### Subcontractor

Malcolm Drilling Company, Inc., USA

### DSI Unit

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

### DSI Scope

Production, supply

### DYWIDAG Products

1,000 double corrosion protected (DCP), 32mm Ø DYWIDAG Soil Nails



## DSI supplies Wire EX Tendons for one of the highest Capacity Wind Parks in Mexico: Ventikas I&II

In April 2014, Acciona Energy was awarded a new wind farm project known as Ventikas I&II. The wind park is one of the highest capacity wind farms in Mexico. Acciona will operate the new park for 20 years. The project is located approximately 60km east of the town of General Bravo in the federal state of Nuevo León, roughly 80km from the US border.



Within the scope of the project, two wind parks with a capacity of 126MW each are being built. A total of 84 wind towers with 120m high prefabricated concrete towers and Type AW 116/3000 turbines are being erected. Each of the turbines has a capacity of 3MW, and the rotor diameters measure 116m.

DSI was awarded a contract to produce and supply Wire EX Tendons for the two wind parks, Ventikas I and II. The prefabricated tendons were produced in DSI Construction's facility in Langenfeld, Germany and installed and tensioned by DSI Construction Spain, Acciona's partner for wind energy projects. A total of 504 Wire EX Tendons were necessary to prestress the wind towers.

In order to perform the installation and stressing work, two of DSI Spain's specialists stayed on the jobsite for 3 months. All of the Wire EX Tendons were installed

and post-tensioned in 3 shifts in approximately 7 months. This corresponds to an average installation pace of 3 wind towers per week – which is considered to be excellent productivity.

The DSI specialists cooperated with two local installation teams. The first team was responsible for hoisting the Wire EX Tendons inside the towers from the bottom up. The second team carried out the stressing work on the tendons following installation. Thanks to the excellent cooperation and the supervision and guidance provided by DSI Spain's employees, work was successfully completed within the scheduled time frame.

DSI finished the installation of the Wire EX Tendons in November 2015 – at that time, 40% of the towers were either already producing energy or in the testing phase.

#### Operator

Acciona Energy S.A., Mexico

#### Owner

Joint Venture, consisting of Cemex S.A.B. de C.V. and Fistera Energy México as well as private investors, all of them Mexico

#### General Contractor

EMEPH STEEL SL., Mexico

#### DSI Units

DYWIDAG Sistemas Constructivos S.A., Spain and DYWIDAG-Systems International GmbH, BU Post-Tensioning, Germany

#### DSI Scope

Production, supply, installation

#### DSI Products

504 Wire EX Tendons



## Rehabilitation of the Panama Canal: DYWIDAG Bar Tendons stabilize new Lock Gates

In 2007, the comprehensive expansion of the 80km long Panama Canal that was opened in 1914 began. Thanks to the construction of a third, larger lock complex and a third waterway, the capacity of the canal that is used by 13,000 to 14,000 ships per year will be tripled. When the expansion is completed, ships with up to 12,000 containers on board will be able to use the navigation channel – currently, the canal only accommodates ships with a maximum of 4,500 containers.



For the new locks on the Atlantic and Pacific sides, a total of 4.4 million m<sup>3</sup> of concrete had to be poured. During the filling of the lock chamber for testing purposes in August 2015 and within the scope of some routine load tests, several cracks appeared at the new Cocoli Locks on the Pacific side.

The leaks appeared in the concrete sill of the inner bulkhead 3 that divides the middle

chamber from the lower chamber of the Cocoli Lock Complex. The water filtered through across the width of the chamber near the top of the sill just below the rolling gate.

The reason for the leak was the fact that not all of the acting stresses had been considered in the original design so that, in some places, the steel reinforcement was insufficient to resist the water pressure.

As a precaution, the General Contractor decided to also reinforce the three sills of the Agua Clara Lock Complex on the Atlantic side in addition to the three sills that divide the chambers in the Cocoli Lock Complex on the Pacific Side using bar tendons.

For rehabilitation, the cracks in the sill of gate No. 3 were sealed using resin.





Afterwards, bore holes were drilled into all sills into which horizontal and vertical tendons were installed for strengthening. The tendons used were 180 66mm Ø, St 150, 10.97m long DYWIDAG Bar Post-Tensioning Tendons.

DSI Construction USA supplied the bar tendons complete with 180 nuts and 180 steel anchor plates. The individual bar tendons

were vertically installed into the sills using 1,000 spacers and were stressed afterwards. DSI also provided the 4 stressing jacks needed for post-tensioning and provided on-site technical assistance.

**Owner**

ACP – Autoridad del Canal de Panamá, Panama

**General Contractor**

Joint Venture Grupo Unidos por el Canal, S.A. (GUPEC SA), consisting of Sacyr S.A., Spain, Salini Impregilo S.p.A., Italy, Jan De Nul Group, Belgium and Constructora Urbana, S.A. (CUSA), Panama

**Engineering**

Joint Venture CICIP, consisting of MWH Global, Inc., USA, Tetra Tech, Inc., USA and Iv-Groep b.v., Netherlands

**DSI Unit**

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

**DSI Scope**

Production, supply, technical support

**DYWIDAG Products**

180 66mm Ø, 10.97m long DYWIDAG Bar Tendons including accessories, 4 stressing jacks







## DYWIDAG Soil Nails stabilize a Slope in Puerto Rico's most popular National Park

El Yunque National Park in northeastern Puerto Rico is a cool, subtropical rain forest that is visited by 1.4 million tourists every year and therefore forms part of the most popular nature reserve in the Caribbean.



The annual amount of precipitation at the 1,067m high El Yunque Mountain amounts to approximately 3,400mm. Together with some hurricanes, the heavy rainfalls have caused over 100 landslides over the years.

The main access road to the national park, PR 191, has also been affected by several landslides and had to be closed for stabilization work.

DSI Construction USA was asked to contribute to one of these slope stabilization measures along PR 191. The slope was stabilized by a 12.8m (42ft) tall gabion wall that was tied back in the slope using DYWIDAG Soil Nails.

The unique feature of this project was that the drilling process had to be carried out as the gabion wall was being completed.

The DYWIDAG Soil Nails were anchored at a minimum depth of 6.1m (20ft) into the rock to reach a load-bearing capacity of 15t.

DSI USA produced and supplied 56 epoxy coated, 32mm Ø, 75ksi DYWIDAG Soil Nails with 45.7 x 45.7cm (18" x 18") bearing plates for this project.

**Owner**

US Department of Transportation  
Federal Highway Administration, USA

**General Contractor**

TAMRIO INC., Puerto Rico

**Subcontractor**

Carro & Carro Enterprise Inc., Puerto Rico

**Architect**

US Department of Transportation Federal  
Highway Administration, USA

**Engineering**

Eastern Federal Lands Highway Division,  
USA

**DSI Unit**

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

**DSI Scope**

Production, supply

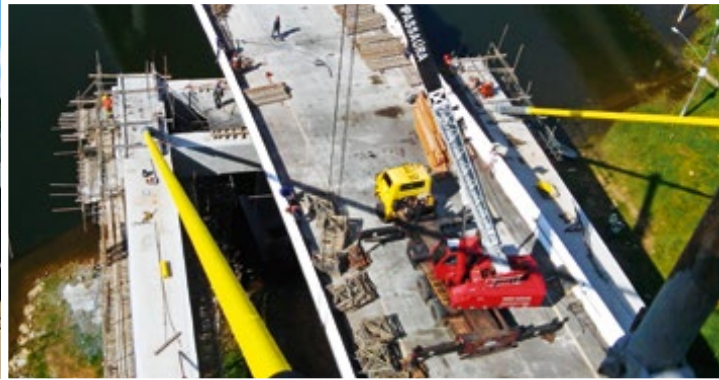
**DYWIDAG Products**

56 epoxy coated, 32mm Ø DYWIDAG Soil Nails



## A permanent Solution: DYNA Grip® 109 Strand Stay Cables stabilize Capivari Bridge, Brazil

Recently, DSI was awarded a contract to strengthen an existing steel girder bridge that crosses the Capivari Water Reservoir in southern Brazil. The bridge forms part of the BR-116 connecting road that leads from Curitiba, the capital of the federal state of Paraná, further north towards São Paulo.



The existing bridge was re-built in 2006 after it collapsed in 2005. Since the bridge was built on unstable ground, settlements occurred that caused the bridge pier to sink into the soil by approximately 40cm so that the bridge was once again in danger of collapse.

As a permanent solution, the decision was made to build a reinforced concrete frame below the existing bridge. This bracing structure consists of two longitudinal girders, two transverse girders around the caved pier, an H-shaped pylon and two concrete abutments on the opposite side of the river to anchor the back span stay cables.

The support frame is suspended from 4 approximately 55m long, Type DG-P109 DYNA Grip® Stay Cables that are anchored at the pylon. The support structure accommodates the weight of the existing bridge so that the damaged pier of the existing structure could be removed.

The tricky part of this job was to determine the exact force that had to be applied to the

stay cables. The force had to be sufficient to lift the old bridge deck without overstressing it. Furthermore, all of the strands in each of the DYNA Grip® Stay Cables needed to have the same stress level. This was achieved by dividing the stressing process into 5 steps, an accurate estimation of the existing loads that had to be lifted and the precise functioning of the ConTen stressing method developed by DSI.

In addition to the DYNA Grip® Stay Cables, the DSI companies Protendidos DYWIDAG and DSI Prepron also supplied, installed, stressed and grouted the 32 and 36mm Ø DYWIDAG Bar Post-Tensioning Systems that were used in the pylon and the strand post-tensioning systems for the transverse girders of the new structure.

This special application is a milestone and a first reference for DSI for stay cable systems in Brazil. Furthermore, DSI Prepron successfully acted as a subcontractor for stay cable systems for the first time in this project.

**Owner**  
Agência Nacional de Transportes Terrestres (ANTT), Brazil  
**Operator**  
Arteris S.A., Brazil  
**Contractor**  
Leão Engenharia Ltda., Brazil  
**Engineering**  
Enescil, Brazil

**DSI Units**  
Protendidos DYWIDAG Ltda. and DSI Prepron, both Brazil  
**Protendidos DYWIDAG & DSI Prepron Scope**  
Production, supply, installation, engineering services, technical support, supervision  
**DYWIDAG Products**  
4 Type DG-P109, 55m long DYNA Grip® Stay Cables, 32 and 36mm Ø DYWIDAG Bar Post-Tensioning Systems, strand post-tensioning systems



# The Mina de Águas Claras: GEWI® Soil Nails stabilize a huge Open Pit Mine

The Mina de Águas Claras is an open pit mine in the Brazilian federal state of Minas Gerais in which iron ore was extracted from 1971 to 2002. The mine is located in southeastern Brazil, only 10km to the northeast of Belo Horizonte.



Until the depletion of the iron ore reserves in 2002, approximately 300 million tons of iron ore were extracted from Águas Claras over an area of roughly 1,000ha. After the mine was closed, the deep pit was partly filled with water, which created a large lake over the years.

Before the mine was closed, a large landslide occurred in 1992, causing a part of the Curral Ridge to collapse. A 2008 report also detected many steep slopes that were not covered by vegetation and therefore exposed to erosion. However, the shutdown and rehabilitation of the mine area, which had been planned for the years 2003 to 2013, were repeatedly delayed.

Since the former mine is located in the immediate vicinity of a densely populated area, the uncovered, steep slopes in the open pit mine represented a major security risk. In 2013, the owner Vale decided to carry out stabilization measures in order to minimize the risk of landslides and to enable the future use of the entire area.

Within the scope of the project “Cava Oeste”, the comprehensive stabilization of the highest portion of the western pit started in August 2014. During this project, loose soil was removed and a drainage system was installed that will prevent future erosion. Afterwards, a stepwise slope stabilization is carried out from the top down. The slopes are stabilized using high-strength steel mesh and revegetated following installation.

The passive steel mesh slope stabilization system is anchored in the stable slope strata using GEWI® Soil Nails that act directly on the slope surface. 47,535m of 32mm Ø, GR 50/55 GEWI® Soil Nails with a weight of 21t were installed to safely secure the steel mesh. Protendidos DYWIDAG supplied the soil nails complete with 7,310 nuts.

**Owner**  
Vale S/A, Brazil  
General Contractor  
BVP Engenharia, Brazil  
**Subcontractor**  
Joint Venture Consorcio  
EMPA-SEEL - Cava Oeste,  
consisting of EMPA S/A and  
SEEL Serviços Especiais de  
Engenharia Ltda., both Brazil  
**Engineering**  
BVP Engenharia, Brazil

**DSI Unit**  
Protendidos DYWIDAG Ltda.,  
Brazil  
**Protendidos DYWIDAG Scope**  
Production, supply  
**DYWIDAG Products**  
47,535m of 32mm Ø GEWI® Soil  
Nails including nuts



## International Cooperation for Progress: Wire EX Tendons at the Itarema Wind Park in Brazil

The Itarema Complex in the federal state of Ceará in northeastern Brazil consists of several wind parks and is located near Jericoacoara Beach, which is especially popular with kite surfers due to the strong winds in this area.



In total, 69 wind towers consisting of prefabricated concrete segments and rotor diameters of 125m and 116m were erected there. 26 wind towers have a hub height of 100m, and 43 towers reach a hub height of 120m. Each of the wind towers accommodates a 3MW turbine, so that the total electrical output of the Itarema Wind Park equals 207MW.

Six Wire EX Tendons were installed from the bottom up in each of the wind towers.

Type 56 Wire EX Tendons were used in the 26 100m high towers, and Type 62 Wire EX Tendons were installed in the 43 120m high towers.

In total, DSI Germany produced 414 Wire EX Tendons that were supplied to the jobsite on coils for the 69 new wind towers at the Itarema Park. In this project, the coordination with Acciona Windpower was once again managed by DYWIDAG Sistemas Constructivos (DSC), Spain.

On site, the DSI companies Protendidos DYWIDAG and DSC carried out the installation and post-tensioning of the Wire EX Tendons.

The Itarema Complex is the 5<sup>th</sup> Wind Park in which Acciona has successfully cooperated with DSI. Thanks to the excellent cooperation of all partners involved, the project was carried out successfully from production, supply and installation to jobsite supervision.





**Owner**  
Rio Energy, Brazil  
**General Contractor**  
Acciona Windpower  
**Contractor**  
Acciona Windpower

**DSI Units**  
Protendidos DYWIDAG Ltda., Brazil  
DYWIDAG Sistemas Constructivos S.A., Spain  
**DSC and Protendidos DYWIDAG Scope**  
Production, supply, installation, supervision  
**DYWIDAG Products**  
414 Types 56 and 62 Wire EX Tendons



## Renewable Energy in Brazil:

# Wire EX Tendons and DYWIDAG Bar Tendons for the new Aracati Windpark

The State of Ceará has one of the largest installed capacities of wind energy in Brazil, and its conditions are ideal for generating energy thanks to its consistently high wind velocities, which on average exceed 10m/s. To make even more use of its favorable location and conditions of the federal state, additional wind parks are being built in Ceará.



This also includes the Aracati Wind Park located at Aracati and near the touristic beach Canoa Quebrada. The project consists of 47 new wind towers, each of which is 120m high and supports a turbine with an output of 2.1MW, allowing the park to reach a total output of 98.7MW.

Each Wind Tower is post-tensioned with 6 Type 78 Wire EX Tendons installed inside the tower shaft.

Protendidos DYWIDAG faced several challenges for installing the Wire EX tendons in towers without installed elevators while having to complete the work in a short time period. Type 78 Wire EX tendons were installed and stressed in approximately 22 towers in a period of just two months. Protendidos DYWIDAG's experienced technicians were able to achieve a high level of installation safety and efficiency throughout the project's construction period.

In addition to the 282 Wire EX Tendons, Protendidos DYWIDAG also supplied and installed 1,128 36mm Ø, 2.3m long DYWIDAG Bars including accessories that were used on the last section of the tower to connect the concrete to the steel ring that supports the nacelle.





**Owners**  
Cassol Pré-Fabricados, Brazil  
**General Contractor**  
Alupar, Brazil  
**Contractor**  
WEG S.A., Brazil  
**Engineering**  
Calter, Spain

**DSI Unit**  
Protendidos DYWIDAG Ltda., Brazil  
**Protendidos DYWIDAG Scope**  
Supply, installation, engineering services, supervision

**DYWIDAG-Products**  
282 Type 78 Wire EX Tendons, 1,128 36mm  
Ø, 2.3m long DYWIDAG Bars including accessories



## The Porto Sudeste in Itaguaí: DSI Prepron provides Technical Support for the Startup of a Conveyor System

The Porto Sudeste do Brasil is a private harbor terminal in Itaguaí located approximately 80km from Rio de Janeiro. The recently opened harbor has a surface area of approximately 52ha and is currently designed for a capacity of more than 50 million tons of iron ore and other bulk goods per year. The new harbor premises were mainly built to export iron ore that is extracted from mines in the federal state of Minas Gerais into other countries.



On the premises, conveyor belts with a length of more than 4,000m and a carrying capacity of 12,000t/h were installed that can transport the iron ore at a velocity of 5m/s. A steel bridge that leads over a railway track is also part of the conveyor system.

The bridge is braced by 4 coupled bar tendons that are protected by ducts. Construction of the bridge was started by a foreign company, but never finished. For this reason, the General Contractor was looking for a domestic

company that could carry out the stressing of the bar tendons and complete the bridge structure.

Among other local companies, DSI Prepron was selected to provide a solution and asked to carry out the tensioning work. DSI Prepron's experienced employees retensioned the bar post-tensioning tendons in accordance with a precisely defined tensioning protocol, bringing the steel structure to the right position, thus ensuring the proper functioning of the bridge.

#### Owner

Impala Terminals UK Ltd,  
Great Britain, Mubadala  
Development Company PJSC.,  
United Arab Emirates and MMX  
Mineração e Metalicos SA, Brazil  
**General Contractor**  
Construtora Tecnomont, Brazil  
**Contractor**  
Construtora Tecnomont, Brazil

#### DSI Unit

DSI Prepron, Brazil  
**DSI Prepron Scope**  
Engineering services, technical support



## Strong Growth with DYWIDAG Tie Rods: Pecém Harbor in Brazil

Pecém Harbor in northeastern Brazil, located approximately 60km from the city of Fortaleza, is one of the two largest harbors in the federal state of Ceará. From 2009 to 2014, the harbor had a consistently high growth rate. From January to September 2014, a total of 6.4 million tons of goods were handled here, which corresponds to a 61% rise in comparison to the same period of the previous year.



The harbor, which was opened in 2002, is being extensively expanded in 3 phases and is being modernized in order to be able to handle 480,000 containers instead of the current 212,000 containers per year in the future.

The berths of the deep sea harbor are protected by an L-shaped breakwater. The two piers are connected to the mainland by a bridge that also connects the storage yard and the berths.

The second phase of the expansion includes the construction of a new, approximately

1.5km long access bridge to the harbor area, new drainage facilities and the lengthening, widening and rehabilitation of the existing breakwater. Another part of the second phase is the expansion of the wharf by 600m and the construction of several new piers.

DYWIDAG Tie Rods were used for reinforcing the beams of the new piers. In total, Protendidos DYWIDAG supplied 5,138m of 50mm Ø GEWI® Tie Rods including accessories. The tie rods were needed in this area to prevent damage caused by high tides at the piers.

### Owner

Cearáportos – Companhia de Integração Portuária do Ceará, Brazil

### Operator

APM Terminals, Brazil

### General Contractor

Joint Venture, consisting of Marquise Infraestrutura, Queiroz Galvão S.A. and Ivaí Engenharia de Obras S.A., all of them Brazil

### Contractor

Joint Venture, consisting of Marquise Infraestrutura, Queiroz Galvão S.A. and Ivaí Engenharia de Obras S.A., all of them Brazil

### Architect

Joint Venture, consisting of Planave S.A. and RAM Ltda., both Brazil

### DSI Unit

Protendidos DYWIDAG Ltda., Brazil

### Protendidos DYWIDAG Scope

Production, supply, installation

### DYWIDAG Products

5,138m of 50mm Ø GEWI® Tie Rods including accessories



## The São Paulo Metropolitan Ring Road, Lot 2: Production of Precast Segments for the Construction of a Motorway

The Rodoanel Norte is the fourth part of the 177km long Rodoanel Mario Covas around São Paulo and the last part to be completed. The road, which is also known as São Paulo Metropolitan Ring Road, will relieve the city from very high through traffic of approximately 300,000 vehicles per day.



The Rodoanel Norte connects São Paulo, Guarulhos and Arujá. This northern section of the ring road has between 3 and 4 lanes in each direction. The project was divided into 6 lots and includes the construction of 7 tunnels as well as 114 bridges and viaducts. The OAS Company was awarded the contract for construction of Lots 2 and 3. In Lot 2, OAS built a bridge that is connected to a tunnel. The bridge that crosses a valley consists of two separate bridge structures, the precast segments of which were produced in a field factory on site.

DSI Prepron produced and supplied the post-tensioning system that was required for stressing the precast segments. Also, DSI Prepron supplied material and provided services for the construction of successive cantilevers on the jobsite. 30 Bonded Type 15-0.6" Strand Tendons were installed into the precast concrete segments of both structures (15 per segment). DSI Prepron carried out the stressing and grouting of all tendons on site using equipment developed by the company.

Minimum tolerances were applied during tendon stressing in order to ensure the high quality of the precast beams.

Thanks to the excellent cooperation of all parties involved, the first bridge was successfully completed in only 6 months and the second bridge in only 4.5 months.





**Owner**  
Government of the Federal State of São Paulo and DERSA – Desenvolvimento Rodoviário S.A., both Brazil  
**General Contractor**  
OAS S.A., Brazil

**DSI Unit**  
DSI Prepron, Brazil  
**DSI Prepron Scope**  
Production, supply, installation, engineering services  
**DYWIDAG Products**  
30 Type 15-0.6" DYWIDAG Strand Tendons, technical equipment



## The Rodoanel Norte, Lot 6: DSI supplies Strand Tendons for one of the largest Construction Projects in Latin America

With approximately 20 million inhabitants in its metropolitan area, São Paulo is the largest city in Brazil and the country's most important economic and financial center. Currently, 93% of all goods are transported on the roads of the city, which regularly causes up to 200km long traffic jams.



To relieve the city area from traffic flowing through the city, the 177km long Rodoanel Mario Covas is currently under construction. The road that is also known as São Paulo Metropolitan Ring Road is one of the largest construction projects in Latin America and will be connected to the 10 motorways that lead into São Paulo.

The fourth section of the ring road, the Rodoanel Norte, is divided into 6 lots.

Lot 1 is carried out by the Joint Venture Mendes Júnior-Isolux Corsán, the General Contractor OAS is building Lots 2 and 3, Acciona has been awarded the contracts for Lots 4 and 6, and the Construcap-Copasa Joint Venture is carrying out Lot 5. The two lots Acciona has been awarded the contract for have a total length of 25km.

DSI Prepron supported all 6 lots with high quality products and services.

Nearly 2,000 prefabricated segments for the new bridges and viaducts were stressed using DSI Prepron's post-tensioning systems. DSI Prepron also carried out the stressing and grouting work.

For Lot 6 that is being built by Acciona, DSI Prepron also produced and supplied its strand post-tensioning system for the prefabricated segments.





The beams were produced in a factory on the job site, and 5 Type 12-0.5" DSI Prepron Strand Post-Tensioning Tendons were installed in each segment. The strand tendons that were inserted in ducts were stressed using a jack supplied by DSI Prepron.

Due to the very limited time frame, DSI Prepron and Acciona planned all the steps necessary for a faster construction progress.

Thanks to the optimized workflow, DSI Prepron successfully carried out the complete stressing and grouting work on the tendons of the 70, 40m long prefabricated beams in only 3 weeks.

Work at this major project has not yet been finished, and DSI Prepron continues to support Acciona with high-quality products and technical know-how.

**Owner**  
Government of the Federal State of São Paulo and DERSA – Desenvolvimento Rodoviário S.A., both Brazil  
**General Contractor**  
Acciona Infraestructuras S.A., Spain

**DSI Unit**  
DSI Prepron, Brazil  
**DSI Prepron Scope**  
Production, supply, installation, engineering services  
**DYWIDAG Products**  
350 Type 12-0.5" DSI Prepron Strand Post-Tensioning Tendons, technical equipment



## Efficient Earthquake Protection: DSI supplies DYWIDAG Tie Rods for Valparaíso and Coquimbo Harbors

The movements of the South American and the Nazca Tectonic Plates often result in earthquakes in Chile. As a consequence of the severe earthquakes that occurred in 2010 and 2015, reinforcement and emergency measures have been carried out in the country's most important harbors to resist future earthquakes and tsunamis. The expansion and reinforcement of Valparaíso Harbor in western Santiago de Chile forms part of these important security measures. The reinforcement of Coquimbo, located northwest of the country's capital, for protection against tsunamis is another significant part of this development plan.



During the expansion of Valparaíso Harbor, Berth No. 3 in Terminal 1 is being enlarged and Berth No. 4 and 5 are being reinforced for earthquake protection. These measures will facilitate the expansion of one of Chile's most important commercial harbors.

The length of main wharf No. 3 is being extended from 620m to 740m so that

two Post Panamax generation ships will be able to dock here in the future.

To extend the harbor, concrete floor slabs were poured in the wharf basin. The floor slabs were anchored in the ocean bed using driven piles.

Furthermore, a 120m long and 30m wide

blanket was built that was stabilized by a 1,479.87m<sup>2</sup> triangular support.

To stabilize this structure, bar tendons were vertically inserted in order to tie the blocks of the existing wall securely to each other. Furthermore, a deadman structure was built in which a sheet pile wall was tied back using tie rods. The tie rods were anchored in an additional concrete retaining wall.





For this purpose, DSI Construction Chile supplied double corrosion protected DYWIDAG Tie Rods that were protected by grease filled ducts.

The tie rods consisted of 760m of GR 150, 75mm Ø THREADBAR® including 102 nuts, anchor plates and accessories. To reinforce Coquimbo Harbor, DSI supplied 88 galvanized

GR 75, 50mm Ø GEWI® Anchors including accessories. The GEWI® Anchors were vertically installed into the harbor wall and connect the individual wall blocks.

#### Operator

Terminal Pacifico Sur Valparaíso (TPS) and Dirección de Obras Portuarias - Ministerio de Obras Públicas (MOP), Chile

#### General Contractor

Empresa constructora Belfi SA and SalfaCorp®, both Chile

#### Subcontractor

Compañía Sudamericana de Postensados y Geotecnia (CSP), Chile

#### Consulting Engineers

PRDW Consulting Port and Coastal Engineers, Chile

#### Engineering

PRDW Consulting Port and Coastal Engineers, Chile

#### DSI Unit

DSI-DYWIDAG SYSTEMS Construcción SPA, Chile

#### DSI Scope

Production, supply, technical support

#### DYWIDAG Products

760m of 75mm Ø DYWIDAG Tie Rods including accessories, 88 50mm Ø GEWI® Anchors



## Reliable Slope Stabilization with DYWIDAG Strand Anchors: The Large-Scale Project Costa Verde del Callao

The large-scale project Costa Verde del Callao is being constructed between the district of La Punta in the seaport of el Callao and the coastal district of Chorrillos southwest of Lima, Peru. A new, 5.8km long expressway is being built in this area to improve the connection with Jorge Chávez Airport and to reduce travel times from La Punta to Chorrillos to 25 minutes.



The new road includes 3 lanes per direction and is built directly along the coast on a man-made landfill. Within the scope of the project, connecting roads are being built for the Santa Rosa and Haya de La Torre roads that consist of access ramps and viaducts.

Comprehensive slope stabilization was required in order to build these viaducts. The subcontractor Mota-Engil awarded DSI Construction Peru the contract for supplying permanent, Type 4-0.6" DYWIDAG Strand Anchors for the long-term stabilization of the sidehill cuts.

A total of 60 DYWIDAG Strand Anchors were installed in 4 layers to tie back the slopes at both viaducts. 49 DYWIDAG Strand Anchors with 4 load cells were installed in the sidehill cut for the Haya de la Torre Viaduct. 11 DYWIDAG Strand Anchors and 1 load cell were required for stabilizing the Santa Rosa Viaduct. The permanent strand anchors had lengths of 14.5-19m.

**Owner**  
Callao Regional Government, Peru  
**General Contractor**  
Joint Venture Vía Costa Verde  
Callao, consisting of Constructora  
Norberto Odebrecht S.A., Sucursal  
Perú, and Odebrecht Perú Ingeniería y  
Construcción S.A.C., both Peru  
**Subcontractor**  
Mota-Engil Perú S.A., Peru

**DSI Unit**  
DSI Peru S.A.C., Peru  
**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
60 permanent Type 4-0.6" DYWIDAG Strand  
Anchors



## The Megaplaza in Jaén, Peru: DYWIDAG Soil Nails stabilize an Excavation for a new Shopping Center

In the town of Jaén, Cajamarca in northern Peru, DSI Construction Peru recently contributed to the construction of a new shopping center owned by the company Megaplaza. The project with an investment volume of more than 15 million US Dollars is the town's first shopping mall and, when completed, will include restaurants and a cinema in addition to shops on an area of 18,000m<sup>2</sup>.



Photos reprinted courtesy of FLESAN ANCLAJES S.A.C., Peru

The new shopping center was completed within 8 months' time. For the construction of the center, some side hill cuts had to be comprehensively stabilized. As a specialist company, FLESAN ANCLAJES was awarded the contract for installing the soil nails that were necessary for the slope stabilization. It is the second major project in which DSI Construction Peru worked hand in hand with FLESAN ANCLAJES.

To build the cuts near the excavation, DSI Construction Peru supplied a total of 139 pieces of 32mm Ø DYWIDAG Soil Nails. The passive and very resistant system stabilizes the side hill cuts during the digging of the excavation and the construction of the basement floors.

The soil in the area of the excavation consisted of backfill overlying layers of clay and silty sand. In addition, there were several groundwater springs near the jobsite that were located very close to the surface.

In the area with the largest difference in elevation, the DYWIDAG Soil Nails were installed in as many as 5 levels. In the area with the smallest difference in elevation, 3 layers of the passive anchor system were installed. The installed DYWIDAG Soil Nails had lengths of 11.8m each.

**Owner**  
INMOBILIARIA EBURNS S.A.C.,  
Peru  
**General Contractor**  
FLESAN ANCLAJES S.A.C., Peru  
**Contractor**  
FLESAN ANCLAJES S.A.C., Peru

**DSI Unit**  
DSI Peru S.A.C., Peru  
**DSI Scope**  
Production, supply  
**DYWIDAG Products**  
139 32mm Ø DYWIDAG Soil Nails



# bauma, Munich, Germany

April 11 - 17, 2016

Between April 11<sup>th</sup> and April 17<sup>th</sup> 2016, bauma, the world's leading and largest trade fair for construction machinery, once again took place in Munich. This year, 3,423 exhibitors from 58 countries displayed their products and systems on a record 605,000m<sup>2</sup> of exhibit space. Approximately 580,000 visitors from 200 countries attended the trade fair, which represents an increase of more than 9% in comparison to bauma 2013.



DSI Construction was represented by its Concrete Accessories and Geotechnics business segments. In Concrete Accessories, DSI's French subsidiaries showed many special solutions such as dowels, spacers and joints and the newly developed environmentally friendly mold release agents. The German subsidiaries displayed contec<sup>®</sup> Waterproofing Systems and recostal<sup>®</sup> Formwork Systems as well as the DYWIDAG Form Tie System, answering a large number of questions from interested expert visitors.

In Geotechnics, the sample of the completely removable DYWIDAG Quick Ex<sup>®</sup> Strand Anchor System met with great interest

by knowledgeable experts visiting the booth. A DYWIDAG Strand Anchor with a DYNA Force<sup>®</sup> Sensor and readout unit demonstrated the flexible use of the DYNA Force<sup>®</sup> Measuring System for the life-long monitoring of post-tensioning forces in structures.

DSI Underground exhibited a variety of products and systems for Mining and Tunneling. Innovative product developments and system solutions for the DYWI<sup>®</sup> Drill Hollow Bar System that is produced by DSI drew the interest of the expert visitors. For example, at the company booth, DSI presented four different applications of the DYWI<sup>®</sup> Drill System

with a comprehensive range of predominately new system accessories, thus proving the versatility and high quality of this system.

The recently published product catalogue featuring the complete range of ground support solutions including special resins in a clearly arranged way was also greeted with great interest by experts in Mining and Tunneling.

DSI's participation at bauma 2016 was a great success. DSI is looking forward to participating at the next bauma, which will take place in Munich from April 8<sup>th</sup> to 14<sup>th</sup>, 2019.



## DSI Construction Europe expands its Service Offer in Geotechnics

In order to better support customers in Europe in the future, DSI Construction Europe has sustainably expanded its service range in Geotechnics.



Now, DSI supports construction and special civil engineering companies with site supervision during the installation of high quality DYWIDAG products and systems. DSI has expanded its pool of experienced service technicians and specialists who are available for installation and stressing work on jobsites as required.

The scope of services mainly includes:

- Equipment and system instructions on site
- Performance tests for temporary DYWIDAG Bar and Strand Anchors
- Support during performance tests for permanent DYWIDAG Bar and Strand Anchors
- Proof testing of temporary and permanent DYWIDAG Anchors

- Tensioning protocols supplied on demand
- Anchor head assembly
- Threadbar countering
- Lengthening of strands and strand coupler assembly
- Extrusion press work
- Support during the inspection of existing buildings

One of the key advantages for construction companies is that they can rely on DSI's experience and competence during peak periods. With this strategic expansion of its full service package, DSI is offering maximum flexibility to its customers. All services are provided just-in-time for customers. Demand is high, and many clients have already profited from the extended service package.

This includes recent construction projects such as a jobsite for Porsche in Zuffenhausen, Germany, construction work for the new gondola on the Zugspitze, Germany's highest mountain, and the Augsburg Main Station project.



# First General Managers Meeting of DSI Underground Europe & CIS

Mai 9 - 11, 2016

Following the closing of the acquisition of the European Jennmar companies, the first DSI Underground Europe Managers Meeting took place in Rzeszow, Poland, from May 9<sup>th</sup> to 11<sup>th</sup> 2016.



*The picture shows all participants of the meeting together with our colleagues in Stalowa Wola*

On the first day, Martin Rier, RCEO DSI Underground Europe & CIS, started with an introduction of the new organization in Europe and provided a strategic overview of the targets for 2016. Andrik Fuellberg, RCFO Underground Mining Europe & CIS, then proceeded by providing an in-depth Finance introduction, presenting the tools and reports used by DSI.

On the second day, the participants visited DSI Underground Merol in Stalowa Wola, a modern manufacturing plant of around 2,000m<sup>2</sup> housing a variety of manufacturing equipment and machine tools. DSI Underground Merol is a producer of Cable Bolts for hard coal mines, Resin Bolts

used to bolt underground dog and longwall headings and expansion bolts to bolt underground headings in copper, zinc and lead ore mines. In addition, machinery and devices for the mining industry such as hydraulic power supplies and drilling devices are designed and manufactured in Stalowa Wola as well.

During the Managers Meeting, each unit introduced itself and its key figures. The companies that introduced themselves were DSI Schaum Chemie and DSI Underground Multitex, both Poland; DSI-Techno, Russia; DSI Underground Spain, DSI Underground Austria and DSI Drill Tek, U.K.. Additionally, there were two participants

from DSI Holding in Munich who presented the topics Legal and the "DSI Spirit" as well as Marketing. To conclude the event, there was an animated group discussion about product & business development and priorities.

The Managers Meeting in Rzeszow and Stalowa Wola was an important measure to accelerate the integration of the former Jennmar companies in Poland, the Czech Republic and Spain with the existing DSI Units. The rebranding of the former Jennmar companies are under way, and all of the units involved are working on forming a new, powerful organization in Mining and Tunneling in Europe.



## Metallic Mining Hall in Seville, Spain

November 3 - 5, 2015

Southern Spain has a long tradition in mining, and Europe's largest copper mine is located approximately 20km from Seville. In the adjoining mining area near Rio Tinto, an old copper mine was reopened a few years ago. Consequently, Seville was predestined to host the Metallic Mining Hall trade show from November 3<sup>rd</sup> to 5<sup>th</sup> 2015.

The international exhibition has experienced significant growth in recent years and provides a platform for the world's leading metal mining companies. The exhibition was accompanied by a comprehensive congress program and an extensive business agenda.

The participation was very successful for DYWIDAG Sistemas Constructivos (DSC). A large number of contacts were



established and existing contacts were strengthened during the congress. This year's MMH congress was attended by all important companies that are active on the Spanish mining market.



DSC is hoping to further strengthen business relations and to achieve follow-up orders during the review of the contacts collected during the event.

## World Tunnel Congress (WTC) 2016

April 22 - 28, 2016

From April 22<sup>nd</sup> to 28<sup>th</sup> 2016, the World Tunnel Congress (WTC) 2016 was held at the Moscone Center, the largest convention complex in San Francisco, California, USA. The WTC is one of the leading and top performing conferences for the tunneling industry.

This year's WTC was attended by more than 2,500 tunneling professionals, and 800 industry speakers spoke about recent developments in tunneling. More than 200 exhibitors displayed their latest technologies and innovations at the accompanying exhibition. As a leading ground support supplier, DSI Underground was also represented with their own company booth.

Furthermore, DSI employees also contributed with two expert presentations. The first presentation, which was given by Guenther Volkmann, DSI Underground GmbH Austria, was titled "The Hirschhagen



Highway Tunnel (BAB 44) in Germany: Pre-Support in Extremely Difficult and Inhomogeneous Ground Conditions".

The second presentation's topic was "Innovative Rehabilitation Approach for Overstressed Existing Linings Using an Adaptable Yielding Support System".

This presentation was co-authored by Wolfgang Dolsak, DSI Underground GmbH Austria.

DSI Underground will also participate in the next World Tunnel Congress, which will take place in Bergen, Norway, from June 9<sup>th</sup> to 15<sup>th</sup> 2017.



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***DSI – DELIVERING SUPPORT & INGENUITY***





**DSI – RELIABLE GROUND SUPPORT**









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BAHRAIN  
BELGIUM  
BOSNIA AND HERZEGOVINA  
BRAZIL  
CAMBODIA  
CANADA  
CHILE  
CHINA  
COLOMBIA  
COSTA RICA  
CROATIA  
CZECH REPUBLIC  
DENMARK  
EGYPT  
ESTONIA  
FINLAND  
FRANCE  
GERMANY  
GREECE  
GUATEMALA  
HONDURAS  
HONG KONG  
INDIA  
INDONESIA  
IRAN  
ITALY  
JAPAN  
KOREA  
KUWEIT  
LEBANON  
LITHUANIA  
LUXEMBOURG  
MALAYSIA  
MEXICO  
NETHERLANDS  
NIGERIA  
NORWAY  
OMAN  
PANAMA  
PARAGUAY  
PERU  
POLAND  
PORTUGAL  
QATAR  
RUSSIA  
SAUDI ARABIA  
SINGAPORE  
SLOVAKIA  
SOUTH AFRICA  
SPAIN  
SWEDEN  
SWITZERLAND  
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UNITED ARAB EMIRATES  
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