





Good service must be provided on a daily basis. It is our paramount aim to provide excellent services that bridge the gap between people and technology. Our goal is to fulfill your expectations day by day.



Dear clients, business partners and employees,



Patrik Nolåker, Group CEO

It is a pleasure for us to be able to present to you the 20th edition of DSI Info. The projects in the current edition once again impressively illustrate the global fields of application of our high quality products and systems.

In 2012, the DSI Group continued its profitable growth. We further secured our competitiveness and our leading market position through targeted investments in the growth regions of South America and Russia. Our growth strategy is based on two strong pillars.

On the one hand, we continue to grow strongly and organically in our core markets thanks to innovative products and systems and concentrate on our strength to always be locally present and near our clients. On the other hand, we generate growth through targeted acquisitions of technologies and patents as well as through the selective acquisition of companies and their successful integration into the DSI Group. It is our clear strategic goal to generate profitable growth based on those two pillars – both today and tomorrow.

We are proactively and continuously adapting to changing conditions in world markets, and our structure is concentrated on our two core markets, Construction and Underground, in order to guarantee you as our clients and business partners the best service possible combined with rapid response times.

It is our stated goal to always explore new methods, develop new ideas and think across barriers. All of our employees continue to have the same ambitions as during the first years of DYWIDAG following its foundation in 1865.

The DSI Group is characterized by client proximity and the high global availability of our products and systems as well as by our ability to react quickly to individual customer requirements. It is our aim to achieve globally leading positions in Construction and Underground with all of our products, systems and services through well-balanced growth. DSI's performance results from the work of our highly skilled and dedicated employees.

Good and successful service to our clients and partners is based on rapid and reliable delivery. It is our goal to fulfill our clients' expectations day after day. With our services, we bridge the gap between people and technology. Today more than ever, DSI is a successful company with a clear and dedicated structure.

It is our highest aim to always demonstrate to you, our clients and business partners, our creativity, reliability, innovative capacity, efficiency and excellent quality. In order to guarantee our proximity to you in the long term and to continue to develop our close co-operation, we are counting on reliability, trust and continuous communication. In everything we do, you as our customers are at the core of our actions.

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

Sincerely yours,

A handwritten signature in black ink, appearing to read 'Patrik Nolåker'. The signature is fluid and cursive, written on a light-colored background.

Patrik Nolåker
Group CEO

Region	Business Segment	Project
3	Editorial	
4	Content	

→ UNDERGROUND

APAC (ASIA/PACIFIC)

6	Global	Special	Significant Strategic Developments and Growth Impulses in 2012/2013
8	Global	Special	Co-Operation for Progress: DSI as an Active Member in International Organizations
10	Australia	Mining	Underground Australia: DSI Rises to New Challenges
12	Australia	Mining	DSI Australia: Newly developed Mesh Express Plate prevents Sparking in Mines
14	Australia	Mining	Long-term Use of DSI TenCate Recovery Mat System at the Springvale Underground Mine
16	Australia	Mining	DSI Australia: New Production Facilities and Realignment of R&D
17	Australia	Mining	Newly developed UPX Rock Bolt as Efficient Solution in Highly Corrosive Environments
18	China	Tunneling	AT – Pipe Umbrella System Prevents Settlement: The MTR West Island Line
19	Thailand	Tunneling	ITA-AITES World Tunnel Congress, Bangkok, Thailand

EMEA (EUROPE, MIDDLE EAST, AFRICA)

20	Austria	Special	The AT – Pipe Umbrella System
24	Austria	Special	DSI Austria obtains Certificate of Conformity for 3 Bar PANTEX Lattice Girders
25	Austria	Special	DYWI® Seal Waterproofing System protects Torrent Embankment following a Landslide
26	Austria	Tunneling	DSI supplies Tunneling Systems for the Construction of Goetschka and Freistadt Tunnels
28	Austria	Tunneling	The Pummersdorf Tunnel: Closing a Gap in one of Austria's most Important Railway Lines
29	Austria	Tunneling	The Brenner Base Tunnel: ALWAG Systems for the World's Second Longest Railway Tunnel
30	Austria	Tunneling	Energy from the Mountains – the Reisseck II Pumped Storage Power Station in Carinthia
34	Bosnia-Herzegovina	Tunneling	Use of the DYWI® Drill Hollow Bar System for the Stabilization of Vijenac Tunnel
35	Croatia	Tunneling	Stable Power Supply in Croatia: DSI delivers Special Systems for Service Tunnel
36	Germany	Tunneling	Efficient Stabilization using the AT – Pipe Umbrella System: The New Kaiser Wilhelm Tunnel
38	Great Britain	Mining	DSI DRILL TEK – DSI's Specialists for Injection Resins and Roof Bolting in Coal Mines
39	Great Britain	Tunneling	Fast Emergency Response: DSI DRILL TEK injects Wastewater System Shaft
40	Norway	Mining	DSI DRILL TEK Ltd. Supplies Specialty Systems for the World's northernmost Mine
42	Slovenia	Mining	High Quality Marble from Slovenia: Safe Advance in Underground Mining with DSI
44	Turkey	Mining	DSI Supplies Special Products for Stabilizing a Gold Mine in Turkey
46	Spain	Mining	First Use of Friction Bolts in Spanish Mines
47	South Africa	Tunneling	Large Scale Energy Generation with DSI Systems: Ingula Pumped Storage Complex
48	South Africa	Mining	A Technical Challenge: Extraction of Palladium and Platinum

NORTH AMERICA

50	USA	Mining	New Production Site for DSI Underground North America
52	USA	Exhibitions	MINExpo INTERNATIONAL 2012, Las Vegas

SOUTH AMERICA

53	Uruguay	Mining	DSI Chile contributes to the successful Development of a new Gold Mine
----	---------	--------	--

→ CONSTRUCTION

APAC (ASIA/PACIFIC)

54	Global	Special	Maximum Flexibility for Cable Stayed Bridges: The DYNA® Link Anchor Box System
56	China	Slope Stabilization	Extension of Hong Kong's Subway System using customized DYWIDAG Bar Anchors
57	Indonesia	Bridges	Balanced Cantilever Segmental Box Girder Construction: Elevated Highways for Jakarta
58	Japan	Bridges	The New Tomei Expressway – DYWIDAG Systems stabilize 31 New Bridge Structures
60	Japan	Bridges	DYWIDAG Strand Post-Tensioning Systems in Confined Areas: The Nakano Viaduct
61	Japan	Bridges	DYWIDAG Strand Tendons stabilize Sanagawa Bridge in Japan
64	Korea	Commercial Buildings	Permanent GEWI® Anchors stabilize modern Power Plant in Incheon City
65	Myanmar	Bridges	Improving Infrastructure in Myanmar: Hledan Junction Viaduct, Yangon
66	Singapore	Commercial Buildings	Spectacular Views at Gardens by the Bay, Singapore
67	Sri Lanka	Bridges	DYWIDAG Post-Tensioning System ensures Modern Infrastructure in Sri Lanka

Region	Business Segment	Project
EMEA (EUROPE, MIDDLE EAST, AFRICA)		
68	Austria	<i>Slope Stabilization</i> Safe Journey with DSI: Construction of a Rock Fall Gallery on the Reschen Federal Road
69	Austria	<i>Slope Stabilization</i> Reinforcement of an existing Retaining Wall at Lake Brennersee
70	Finland	<i>Commercial Buildings</i> Tensioning for High Tension: DYNA Grip® Stay Cables stabilize Wind Power Station
71	France	<i>Structural</i> Seismic Stability with DYWIDAG Bars: The Haspelbaechel Viaduct in Lorraine
		<i>Repair Solutions</i>
72	France	<i>Commercial Buildings</i> Technique Béton supplies Quality Products for modern LNG Terminal in Dunkirk
73	Germany	<i>Commercial Buildings</i> Berlin: Fast Construction Progress and Watertight Structures with contec® and recostal®
74	Germany	<i>Bridges</i> DYNA Grip® Stay Cable System for new Landmark: The Elbe Bridge Schoenebeck
76	Germany	<i>Tanks</i> Mastering Challenges: Construction of three Tanks at Moorburg Power Plant
77	Germany	<i>Commercial Buildings</i> The Schlosshoefe Oldenburg: Post-Tensioning of Flat Slabs using Monostrand Tendons
78	Germany	<i>Structural</i> Repair of the Kriebstein Hydro Dam using 50m long DYWIDAG Strand Anchors
		<i>Repair Solutions</i>
79	Germany	<i>Excavation</i> DYWIDAG Strand Anchors stabilize New City District: The Milaneo in Stuttgart
80	Germany	<i>Bridges</i> DSI supplies DYNA Grip® Stay Cables for new Waschmuehltal Bridge
82	Germany	<i>Excavation</i> Environmental restoration using DYWI® Drill Hollow Bars: Schondelle Creek
83	Germany	<i>Structural</i> Cost-Efficiency and Fast Construction Progress: Ring Tendons Strengthen Silos near Ulm
		<i>Repair Solutions</i>
84	Germany	<i>Excavation</i> The Rethe Bridge: DYWIDAG Geotechnical Systems for Europe's largest Bascule Bridge
85	Italy	<i>Slope Stabilization</i> Summer Holidays without Traffic Jams: DYWIDAG Systems stabilize Autostrada Adriatica
86	Italy	<i>Hydro- & Marine Structures</i> Comfort and Design: The Marina d'Arechi
87	Netherlands	<i>Excavation</i> Efficient Uplift Control using GEWI® Piles at the Sluiskil Tunnel
88	Netherlands	<i>Bridges</i> DYWIDAG Post-Tensioning Systems and DYNA Grip® Stay Cables for Ewijk Bridge
92	Poland	<i>Bridges</i> First Contract for Launching an Incremental Bridge in Poland
94	Romania	<i>Excavation</i> First Use of DYWIDAG Strand Anchors in Bukarest
95	Slovenia	<i>Slope Stabilization</i> Chasing the World Record: New Ski Jump in Planica
96	Spain	<i>Bridges</i> DYWIDAG Strand Tendons stabilize New High Speed Rail Line in Spain
97	Spain	<i>Commercial Buildings</i> Reaching high with external Prefabricated Tendons: Wind Farms in Spain
98	Jordan	<i>Commercial Buildings</i> DYWIDAG Tendons ensure Efficient Construction Progress at Al Ahwar Complex
99	Jordan	<i>Commercial Buildings</i> DYWIDAG Tendons ensure Fast Construction Cycles: The Al Atoom Center in Jordan
100	Kuwait	<i>Tanks</i> DYWIDAG Ring Tendons stabilize Kuwait's new Landmark
NORTH AMERICA		
102	Canada	<i>Commercial Buildings</i> DYWIDAG Bar Tendons Stabilize New Testing Laboratory in Canada
103	Canada	<i>Slope Stabilization</i> DSI supplies DYWI® Drill Hollow Bars for new Transportation Corridor in Western Canada
104	USA	<i>Bridges</i> New Lake Champlain Arch Bridge ensures efficient Transport Connection
106	USA	<i>Bridges</i> DYWIDAG Post-Tensioning Systems ensure Durability: The Veterans Memorial Bridge
107	USA	<i>Structural</i> Efficient and Quick Repair with DSI: The Sam Jones Bridge in Indiana
		<i>Repair Solutions</i>
108	USA	<i>Bridges</i> DYWIDAG Post-Tensioning Systems stabilize Visitors Center Bridge in Ocean City
110	USA	<i>Commercial Buildings</i> Higher Loads Thanks to External Tendons: Reinforcement of an Office Building in Alabama
111	USA	<i>Hydro- & Marine Structures</i> Modernization of Newport International Terminal using DYWIDAG Systems
112	USA	<i>Structural</i> Modern Methods allow Structural Repair of Dams
		<i>Repair Solutions</i>
114	USA	<i>Commercial Buildings</i> Stable Special Solutions using DYWIDAG Form Ties: Miami Marlins Ballpark
115	USA	<i>Commercial Buildings</i> Low-Vibration Installation of DYWIDAG Ductile Iron Piles for Operation of a Power Plant
116		<i>Special</i> Structural Repair and Reinforcement of Post-Tensioned Beams using DYWIDAG Tendons
117		<i>Special</i> ADSC Exhibition and Conference, San Antonio, TX, USA
SOUTH AMERICA		
118	Brazil	<i>Slope Stabilization</i> Faster Connections with DYWIDAG Systems: Metro Line 4 in Rio de Janeiro
119	Brazil	<i>Commercial Buildings</i> GEWI® Post-Tensioning Bars stabilize Monument of Soccer History: Maracanã Stadium
122	Brazil	<i>Commercial Buildings</i> GEWI® Post-Tensioning Bars stabilize new Soccer Stadium in São Paulo
123	Brazil	<i>Slope Stabilization</i> Retaining Walls of Transbrasiliana Highway stabilized using DYWIDAG Bar Anchors
124	Peru	<i>Slope Stabilization</i> DYWI® Drill Anchors Stabilize Spectacular Tunneling Project in Lima: Vía Parque Rimac
126	Venezuela	<i>Hydro- & Marine Structures</i> New Dam ensures Energy supply in Venezuela: The Tocoma Dam

Significant Strategic Developments and Growth Impulses in 2012/2013

Global

Special

D SI is continuously adapting its strategy to rapidly changing market conditions. The central Business

Development department is always looking for new growth areas that can be developed, and the resulting strategic changes are implemented on the markets quickly, effectively and successfully. The following two pages will provide you with an insight into the principal new developments during the last two years.

January 2012

+++ Rouyn-Noranda, Canada +++

Underground:

DSI Underground Rouyn-Noranda optimizes its production capabilities and relocates to a larger and brighter building

June 2012

+++ West Jordan, UT, USA +++

Underground: The DSI product range incorporates JFP95, a new dust suppression system for reducing dust in underground mines

February 2012

+++ West Jordan, UT, USA +++

Mining: Full relocation of DSI Underground Systems Inc. to a new plant and Corporate Headquarters from Salt Lake City to West Jordan, UT, USA

May 2013

+++ Evansville, IN, USA +++

Mining: DSI acquires the patents and opens a new manufacturing center for Mine + Safe Rock Draw Shields in the US

March 2012

+++ Recife, Brazil +++

Construction: DSI opens a new central warehouse for products and systems for the construction industry in Recife, Brazil

September 2012

+++ Medellín, Colombia +++

Construction: New central warehouse starts full operation

March 2012

+++ Bogota, Colombia +++

Construction: DSI opens a new sales office in Bogota, Colombia

April 2013

+++ Lima, Peru +++

Construction: Full relocation to a new, bigger office in Lima, Peru

February 2012

+++ Santiago de Chile, Chile +++

Underground: Full relocation of DSI Chile's plant and office into a new production and office building

September 2012

+++ Belo Horizonte, Brazil +++

Construction: DSI opens a new sales office in Belo Horizonte, Brazil



February 2012

+++ Chesterfield, United Kingdom +++
Mining: DSI acquires majority stake in specialist mining contractor Drill Tek Injection Systems Ltd.

October 2012

+++ Luedinghausen, Germany +++
Underground: Opening of a new sales office for the tunneling and mining industry in Germany

July 2013

+++ Czech Republic +++
Construction: DSI takes over license for OVM Post-Tensioning Systems and European Technical Approval in Europe

April 2013

+++ Kemerovo, Russia +++
Mining: DSI enters the Russian Mining market and establishes the company "DSI Techno"

May 2013

+++ Shanghai, China +++
DSI establishes DSI Consulting (Shanghai) Co. Ltd. for co-ordinating international purchasing activities

July 2013

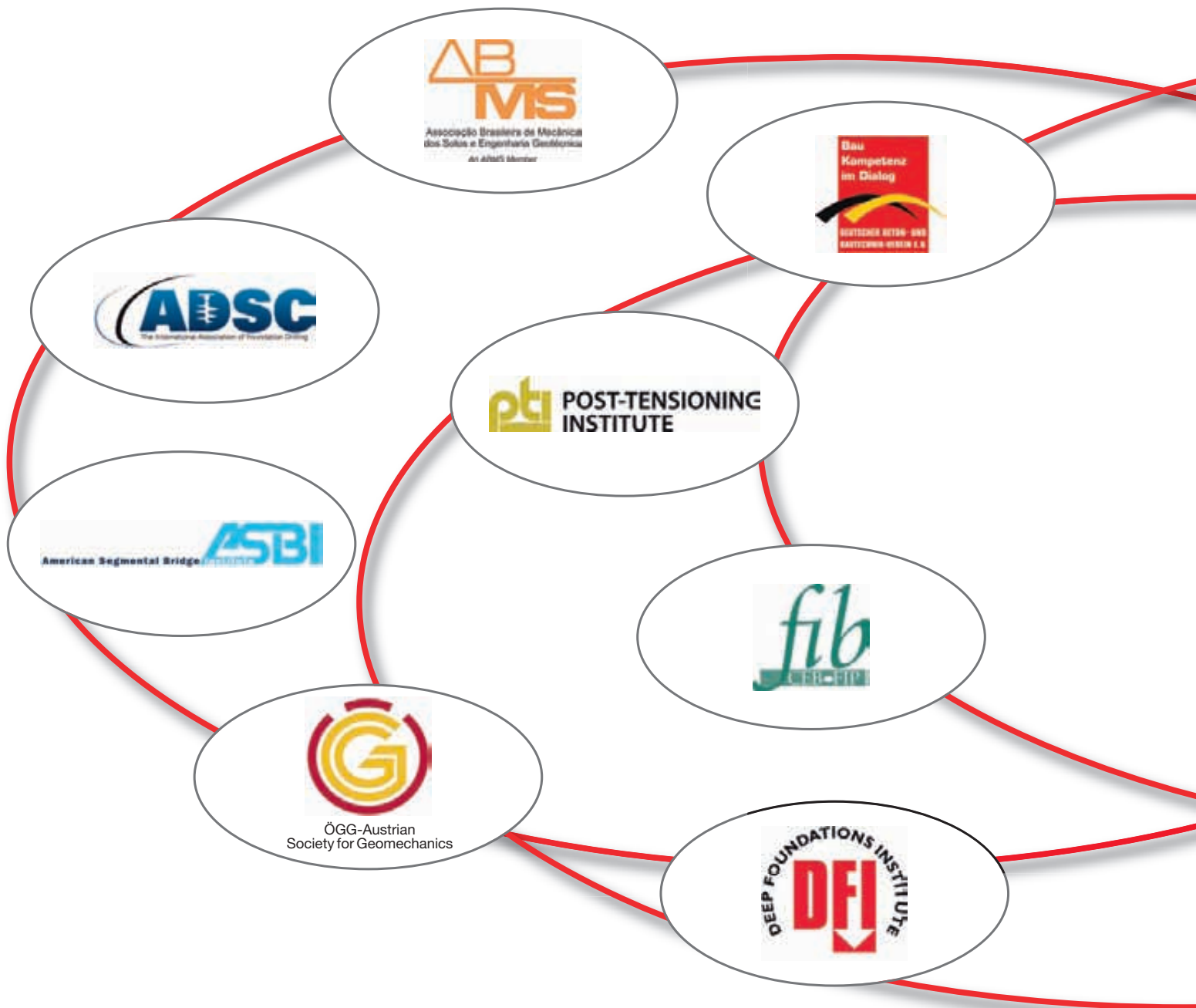
+++ Hong Kong, China +++
Construction: DSI opens new central warehouse



Co-Operation for Progress: DSI as an Active Member in International Organizations

International organizations, trade associations and standards committees are becoming more important in times in which products and services seem more and more interchangeable. Organizations and trade associations are cross-linked on a global basis and promote the exchange of technology and know-how across borders.

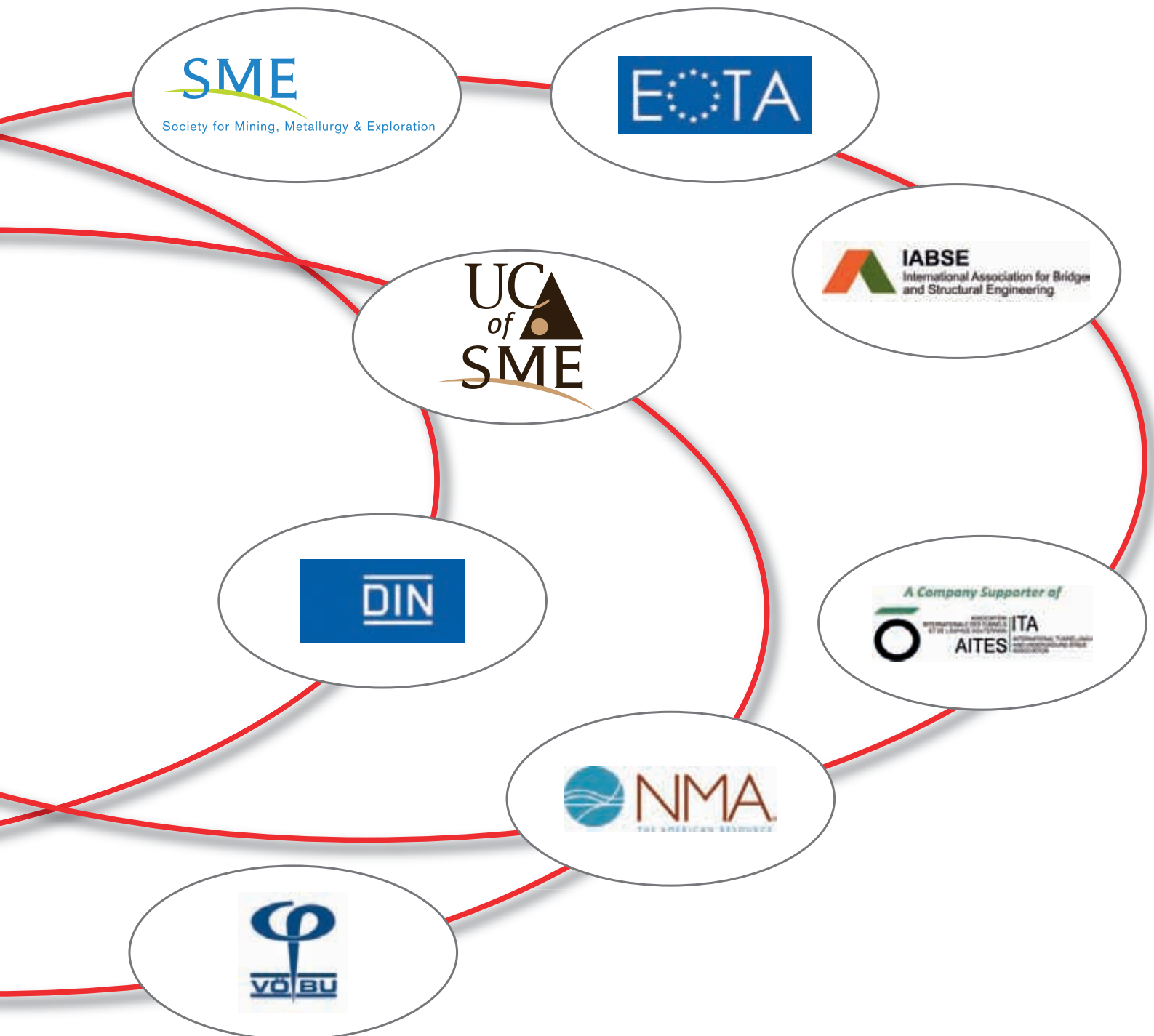
Frequently, they have decisive influence on the definition of high, compulsory quality standards for the industry. In addition, organizations and trade associations participate in national committees for norms and regulations.



Very often, international organizations also act as drivers of technological development. Widespread participation of all stakeholders in this process ensures the acceptance and practicality of these developments in the industry.

DSI is an active member in a large number of international organizations in order to focus on local markets, implement recent technologies and fully understand our clients' requirements.

The following overview is a selection of important organizations that representatives of DSI are actively involved in.



Underground Australia: DSI Rises to New Challenges

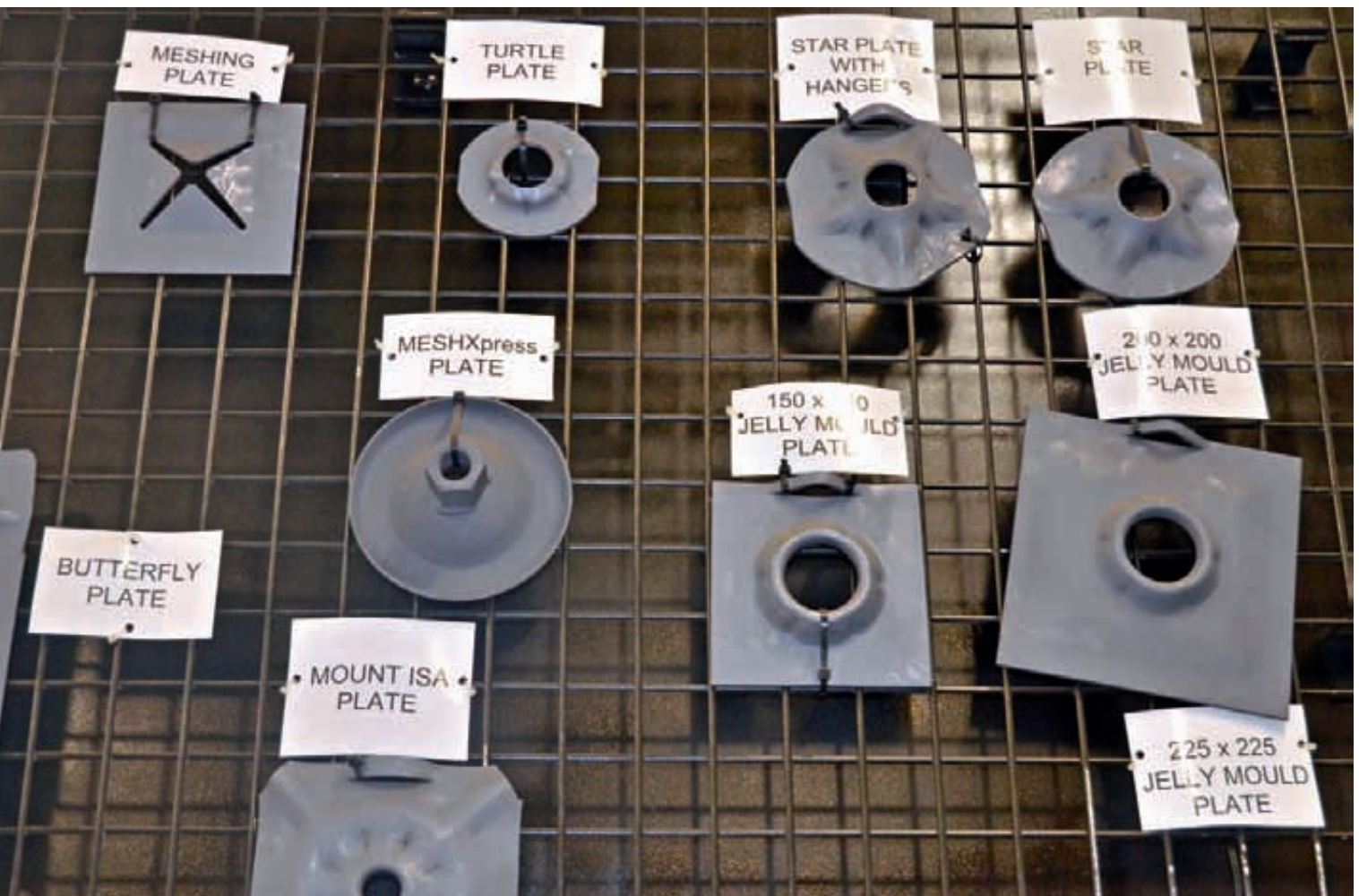
Underground mining is carried out in increasingly deeper deposits. Offering bolting products which can cope with increased stress loading, squeezing ground and dynamic loading capability is therefore becoming more and more important. At the same time, the high cost of labor and the higher safety requirements are fuelling innovations in bolting automation.

According to Steve Mackaway, Marketing Manager at DSI Australia, Australian mining in particular is a safety conscious industry: Change only takes place in incremental steps built on proven methods. There is a move to more remotely operated mining equipment with fewer personnel present at the face. This means that manual handling, respiratory hazards, crush hazards and eye and hearing protection remain key priorities in new product development.

Regulatory frameworks around the globe also require more robust testing and specifications for ground support products than ever before, posing a challenge for product development.

When a support system is selected, not only must the load capacity be considered, but also product-specific characteristics such as steel type, ductility, energy absorbency, and resistance to different environments.

The systems that DSI Australia develops are inclusive of the entire mining cycle – from ground preparation, mining method, expected support life and geotechnical factors to surface support considerations. The product range includes solid bolts, cable bolts and dynamic anchor systems in several different materials and grades. According to Steve, surface support properly matched to the chosen ground support is a factor sometimes overlooked by multi-supplier,

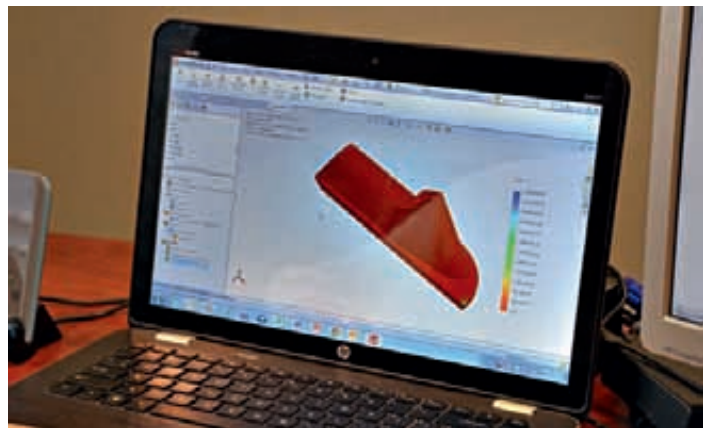


mix and match approaches. DSI attaches great importance to supplying matched systems and encourages the use of high quality systems. The main feature of DSI systems are the carefully chosen material grades which are selected for their properties relating to specific applications and the anticipated geological conditions in each mine.

For example, DSI recently launched the new Obduro® coating system. The coating was originally designed at the request of a leading North American gold producer to protect OMEGA-BOLT® Anchors supplied by DSI in very corrosive conditions and 'hot ground'. DSI tested the coated bolts against standard rebar bolts; after 30 days, the standard bolts could be pulled out by hand while the coated bolts stayed firm.

Other product advances have been focused on load indication in both developed load and mechanically-induced loading situations. "Mechanical tensioning of cable tendons in coal mining is gaining acceptance over hydraulic systems due to the risk of fluid injection injuries from high pressure hydraulic oil," explains Steve. "The difficulty has been identifying the level of tension attained from the spanner. That is why our EziTen cable bolts are now incorporating load indicators to overcome this challenge."

DSI offers products for Hard Rock as well as Soft Rock Mining. DSI counts international mine operators such as Newmont, Vale, Peabody, Rhino, BHP Billiton, Barrick, Yamana, Codelco, Volcan and Pan American Silver among its clients. DSI's product range for Mining is globally supplied to North and South America, EMEA (Europe, Middle East, Africa), and the Asia/Pacific region. In Asia, DSI recently established a new base in Indonesia and founded the new company DSI-Techno in the coal district of the Kuznetsk Basin in Russia.



Steve Mackaway,
Marketing Manager
DSI Australia

DSI Australia: Newly developed Mesh Express Plate prevents Sparking in Mines

The problem
During a DSI visit to an underground mine site in Australia, a rare event of sparking was observed during mesh installation operations as a steel mesh plate was installed on a rock bolt at a high degree of rotation velocity and spun up against non-galvanized mesh.

As ignition sources such as sparks in an underground mine can have catastrophic consequences (such as coal dust explosions), DSI quickly began a series of subjective tests in collaboration with Solid Energy to determine the root causes and prevent sparking from happening again.

Background

The Mesh Express plate is used to secure and retain mining mesh against the roof and ribs of a roadway on preinstalled rockbolts instead of installing an additional bolt.

The design of the circular plate provides a soft continuous edge to prevent breaking the steel mesh as it contacts and drives up against the mesh during installation.

Method

A test setup to simulate the rotation speed of the plate and possible contact velocities as well as durations of contact was done in a safe environment. A thermal diffusion galvanizing process called Armorgalv was used as a surface coating because of its ability to coat without binding up the thread paths. This galvanized coating and a combination of Armorgalv and powder coated paint was tested on the Mesh Express Plates in order to determine their influence on spark formation.

The testing conducted gave a clear indication of how much each coating reduced sparking under medium load with high speed contact.



Test Mock-Up



Sparking at high Rotation

Sparking was virtually eliminated when at least one surface of the anchor plate had a galvanized coating. The powder coated paint further reduced the amount of sparking generated, but did lead to the paint smoking from the friction heat.

Outcome

Solid Energy introduced the Armorgalv coated Mesh Express Plates within a week of the lab testing with no further incidents of sparking noted by production personnel. The old uncoated plates were eliminated from the work site as a further precaution during the changeover.

The DSI engineering department is glad to have been able to support its client with a safe and efficient solution thanks to the excellent co-operation with Solid Energy's geotechnical team.

Long-term Use of DSI TenCate Recovery Mat System at the Springvale Underground Mine



Centennial Coal is one of the principal fuel suppliers to the energy industry in the Australian federal state of New South Wales. Since 2005, the company has been successfully using DSI's TenCate mat system for safe longwall recovery in their Springvale Underground Mine located west of Sydney.

Longwall mining is a method for exploiting underground coal seams. Relocation of the longwall mining equipment is made easier by a polyester geo grid developed by DSI Australia. The grid is placed over the longwall shields to facilitate their safe removal. The system provides a barrier between the loose material in the goaf and the drive in which the miners remove the equipment.

The TenCate geo grid system has been developed with input from Australian and international underground coal miners to withstand the extreme load conditions experienced in underground mines. It has been tested by the state of New South Wales' Department of Mineral Resources for electrical and fire resistance and is certified Flame Resistant and Anti-Static (FRAS).

TenCate geo grids are available with different tensile strengths for flexible use. At the Springvale Mine, a geo grid with a tensile strength of 600/400kN is used behind the caving shields, and the 300/200kN variant is extended over the canopies and down the face. Centennial Coal have also used a DSI-supplied 80/80kN mat for the face section in their Springvale mine.

According to Paul Rutzou, Technical Services Manager at the Springvale underground mine, it is the mat's proven safety and operational efficiency characteristics combined with DSI Australia's willingness to get involved with the job that resulted in the decision to use the TenCate System on a long-term basis: "It's a good product, it works very well and it's well supported by the company. Both the high quality mat and the excellent customer service help us get the shield recovery program completed on time and on budget."

According to Paul Rutzou, the fact that the TenCate System is available in different tensile strengths is a considerable advantage: Rather than being restricted to the standard 600/400kN mat, 200/300kN tensile mats can be used in certain sections, which significantly reduces the mat's size and weight and improves handling.

DSI Australia's support package also includes site inspection and an examination of geological conditions. The results determine the geo grid size and the suitable method used for the overall installation process. DSI employees also offer on-site advice on the most appropriate installation technique to maximize the overall efficiency of the program. The service package is completed by crew training as well as pre- and post-installation reports.

The mat is supplied to Springvale Mine on 17m wide and 315m long rolls on an extended skid – an outcome of DSI's continuous post-installation improvement program made possible by customer support after installation. Additionally, as a result of Centennial Coal's requirements, the main gate end has been adapted to facilitate manual handling underground.



i

Owner Centennial Coal Company Ltd., Australia

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

DSI Scope Supply of the TenCate geo grid system, 600/400kN, 200/300kN and 80/80kN; technical assistance on site, realization of geological examination and training

DSI Australia: New Production Facilities and Realignment of R&D

Expansion at a time when many companies are reducing their demand is not a contradiction for DSI Australia. The company is implementing a growth program that will expand its in-house production. Even in the current market situation, planning and investment is worthwhile thanks to high quality products that are appreciated by the clients just as much as the services that DSI provides.

New design and manufacturing technology and purpose-built hydraulic presses that have been installed in the Newcastle factory are an important part of the company's growth plan. The new machines facilitate a flexible reaction to changing product requirements in mining and reduce cycle times as well. Now, DSI can more easily satisfy new requirements in coal mining in which stress corrosion issues are becoming increasingly important along with long tendon support products. With the new equipment, DSI can offer its clients optimum dynamic support products for mining.

Of course, Research & Development, which is at the heart of production, is just as important as modern and efficient manufacturing equipment. Based on detailed national and international research and customer consultation, DSI Australia has decided to completely reorganize this division. The strategy includes a realignment through which the technical planning office will be able to concentrate on its core competence: The development of new products to meet the changing needs of its customers.

When developing new products, DSI Australia pays special attention to satisfying the increasing need for underground safety and to developing safer products for manual installation underground. Within this context, the precise adaptation of support products to the specific geological conditions in each mine is crucial.



Derek Hird, RCEO Undergroud Asia-Pacific



DSI Australia's new R&D Department has already achieved a number of significant successful developments. This includes the Obduro® coating, an acid-resistant coating that consists of up to four layers and can resist pH values of 0.8 to 13.2. The new load indicators for EziTen Cable Bolts are another improvement. This product makes it possible to quickly and efficiently measure the load in the cable during mechanical tensioning.

Research in the field of dynamic ground conditions has also been successful: In co-operation with the Western Australian School of Mines, DSI Australia has developed energy absorbing surface containment such as the HEA (High Energy Absorption) Mesh.

The realignment of the R&D Department will optimize the cost-benefit relationship of DSI products for clients. The focus on the new R&D Team is especially important because one of DSI's stated goals is to support its clients in achieving more efficiency through new developments – from the production to the installation of the product.

Thanks to DSI Australia's local presence, near the customer, the company can quickly react to changing requirements as they occur. DSI Australia's motivated and experienced team develops and produces high quality products with a long working life. The constant high quality of the products is rewarded by the customers: some of them have been faithful business partners of DSI for over 30 years.

Newly developed UPX Rock Bolt provides Efficient Solution in Highly Corrosive Environments



From left to right: DSI employees Michael Pouwhare, Darren Bruce, and Brian White

A tight deadline and acidic mine water of pH2 or less in a mine located in the remote west of Tasmania were the ground rules to test DSI Australia's motto "delivering the support you need".

During a mine visit near Queenstown in Tasmania, DSI Australia's client requested a trial of corrosion resistant bolts to provide a ground support solution for their highly corrosive mining environment. DSI Australia was given a short three week window of opportunity to supply and install their system for trial at the mine.

At the time, DSI Australia was developing a corrosion protected rock bolt system that was still in the prototype phase. Within a few days, the system development was completed, and shortly afterwards, the 80 fully HDPE encapsulated and factory grouted rock bolts requested by the mine were manufactured, shipped to the site and successfully installed.

In order to perfect the corrosion protection, the anchor rods were coated with DSI Obduro® prior to encapsulation and grouting.

DSI Obduro® is a flexible thermoplastic coating serving as additional corrosion protection.

The trials were successfully accomplished before the 3 week window closed, and the customer awarded a contract to DSI for the supply of additional rock bolts. Following this order, full scale production of the new triple corrosion protected rock bolt began under the brand name of Obduro® UPX. "Obduro" is derived from Latin and stands for durability. UPX is the acronym for "Ultimate Protection". In the meantime, the customer has moved to a complete system of Obduro® coated plates and cable bolts.



DSI Unit DYWIDAG-Systems International Pty. Ltd., Australia
DSI Scope Development and supply of Obduro® UPX Rock Bolts

AT – Pipe Umbrella System Prevents Settlement: The MTR West Island Line

The MTR West Island Line (WIL) is a new, approximately 3km long subway line that will connect the Western District and northern Hong Kong Island. The new underground line will service Sai Ying Pun, Hong Kong University and Kennedy Town stations. Since the subsoil is principally rock, advancement is primarily accomplished using the drilling and blasting method and a tunnel boring machine (TBM).

DSI Austria produced and supplied 500m of Type AT-76 GRP Pipe Umbrellas that were installed piece by piece using hydraulic, rotary-percussive drilling. The installation was carried out with conventional drill booms using the overburden drilling method. In addition, DSI supplied 4,000m of Type AT-114 Pipe Umbrellas which were installed in maximum lengths of 12m to increase the stability in the working area by transferring loads in the longitudinal direction. Simultaneously, the pipe umbrellas efficiently decreased excavation induced deformations.



In contract section 703, a section with two 760m long, single-track tunnels between Sheung Wang and Sai Ying Pun stations on north-western Hong Kong Island, an unexpectedly low rock overburden was encountered during construction. A detailed investigation revealed a zone extremely prone to settlements with decomposed granite and a 35m groundwater head above.

The general contractor decided to carry on advancement by ground treatment and subsequent mechanical excavation with partial blasting. In areas with low rock cover, pipe umbrellas were installed as reinforcement ahead of the tunnel face.

In areas with a mixed ground profile, a single layer of pipe umbrellas that were installed with a spacing of 300mm was sufficient. A double layer of pipe umbrellas that were spaced at 200mm was installed near the tunnel crown, where strongly decomposed granite was encountered. Afterwards, a drainage system was installed above the tunnel roof in order to reduce water pressure within the grouted zone.

The pipe umbrellas, which can be accurately installed, are characterized by their simple and robust system components and allow for a fast, self-drilling installation.



Owner MTR Corporation Limited, China
General Contractor Joint Venture, consisting of Dragages Hong Kong Limited, Maeda Corporation and Bachy Soletanche Group Limited, all of them China

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production and supply of 500m of Type AT-76 GRP Pipe Umbrellas, 4,000m of Type AT-114 Pipe Umbrellas and 3,000 OMEGA-BOLT® Expandable Friction Bolts

The increased stability prevents settlements or subsidence of the buildings close to the jobsite.

DSI Austria also supplied a total of 3,000 OMEGA-BOLT® Expandable Friction Bolts in individual lengths of 3.60m and with a characteristic

ultimate load of 240kN for ground support. Construction work on this technically challenging section was successfully completed in April 2012.

ITA-AITES World Tunnel Congress, Bangkok, Thailand

May 18 - 23, 2012

From May 18th to 23rd 2012, the annual World Tunnel Congress and 38th General Assembly of International Tunneling and Underground Space Association (ITA-AITES) took place in Bangkok, Thailand. It was organized by Thailand Underground and Tunneling Group (TUTG) and ITA-AITES.

WTC 2012 Bangkok highlighted the fact that underground space utilization is important not only for particular nations or groups or businesses, but also for the entire global society.

For DSI, WTC was an excellent occasion to present its newest developments in tunneling products and technology to interested professionals. DSI specialists from the USA, Australia and Europe were actively represented at the DSI booth.



As an important part of the WTC in 2012, Guenther Volkmann held a lecture on the topic: "Pipe Umbrella Support Systems - Scope and Limitations" on May 23rd. DSI was very pleased with the outcome of the event and the excellent contacts it provided to clients from around the world.

The AT – Pipe Umbrella System

EMEA

Austria

Special

The growing population in metropolitan areas requires a continuous upgrade of underground infrastructure. In these areas, ground is typically composed of fluvial deposits or highly weathered rock where tunneling induces subsidence. New tunnel construction projects are often ruled by restrictions regarding allowable settlement values. Therefore, extensive and expensive temporary tunnel support measures such as ground freezing, horizontal jet grouting or pipe jacking must be applied to complete these projects.



An economic alternative to these measures is the AT – Pipe Umbrella System, which is also termed the “canopy tube method”, or “long fore-poling” in the international arena. It perfectly fills the gap between cheap normal spiling (forepoling) techniques and the above mentioned expensive support measures, which is why its use in tunnel construction is continuously increasing. Due to technical developments in drilling techniques, the AT – Pipe Umbrella System can be installed by state-of-the-art drilling machines and standard tunnel personnel. The mode of action for this support method was extensively studied by scientific site investigation, laboratory tests and numerical calculations.

Definitions and Types

The AT – Pipe Umbrella System is classified in the group of pre-support measures. The pipes are installed at the actual face position to the front parallel to the geometry that is to be excavated later (“fore-poling”). This results in a supporting “umbrella” or “canopy” acting above the working area.

The outer diameter of the steel umbrella pipes is typically between 60mm and 200mm with a wall thickness ranging from 4mm to 10mm. Today, the length of one pipe umbrella is 12m, 15m, or 18m with an overlap in the longitudinal direction of 3m to 6m to ensure load transfer into the ground ahead of the face. The installation requires additional space; consequently, a saw-tooth shaped profile is generated which is typical for pipe umbrella supported tunnel sections.

Currently, the pipes can be installed by either special machines or conventional drill jumbos. Basically, there are two installation methods; Pre-Drilling and Cased-Drilling. When using the Pre-Drilling method, the first step is to drill a hole, followed by the insertion of the pipe in a second step. The pipes are installed in segments parallel to the drilling process when using the Cased Drilling method. This method results in an immediate support of the bore hole walls, so settlements as well as stress relaxations are minimized in weak ground during installation.

System Behaviour and Support Effects

In contrast to the surrounding ground, the canopy tube pipes are unstressed after installation. The activation of its supporting effects results from stress redistribution and deformation respectively, which are induced by the following construction steps. The redistribution process results in pipe bending in the radial direction and pipe contraction in the longitudinal direction. Both are a result of ground relaxation deformations into the direction of the stress relieved working area. Due to the imposed deformations, each pipe transfers loads in the longitudinal direction from the overloaded sections at the working area to less loaded sections in the ground ahead of the face as well as the already installed support behind the face. The exact loading conditions are mainly determined by the stiffness contrasts between surrounding ground and primary lining.

Hence, a pipe umbrella has three main supporting effects:

- **Local supporting effect:** The open span in the „unsupported” working area is divided by the pipes in the longitudinal direction. This allows for the creation of arching effects between the pipes, similar to those that can be observed when using spiles (forepoling) as pre-support. This results in a support of the exposed ground against local instability. Such instability is mainly dependent on the axial distance of the pipes and the outer diameter of the pipes because these parameters determine the remaining free space between the support elements.

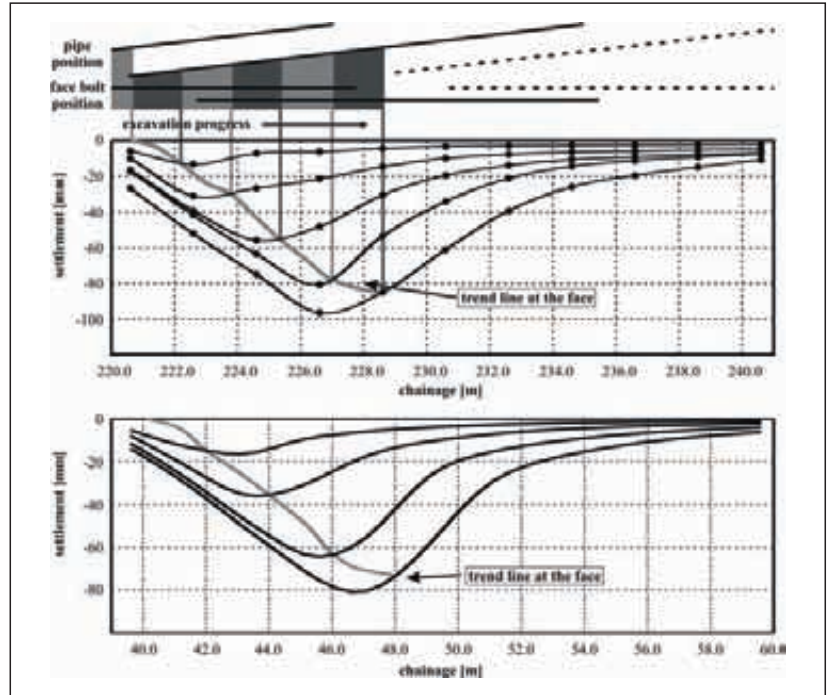


■ **Radial support effect:** The loads that are created by the local support effect and overloaded face regions are transferred in the longitudinal direction to less loaded sections by the stiffness of the pipes. The foundations are the ground ahead of the face and the previously installed support in the excavated tunnel sections. The length of this supporting effect is dependent on the excavation step length, the length of the necessary working area between support and face and the effective height of the face as well as the degree of strength utilization of the surrounding ground. The activation of this supporting effect is controlled by the section modulus. Hence, pipes with a larger outer diameter are activated faster.

■ **Longitudinal supporting effect:** During excavation, stress redistribution causes a movement in the ground ahead of the face in the direction of the stress released face. The stiffness of the ground is much lower than that the stiffness of the steel pipes so that relative movements develop between the ground and the pipe. These are decreased by friction and cohesion, so the three dimensional stress condition is positively influenced ahead of the face. This supporting effect is determined by the area of the umbrella pipes that is available to transfer forces between ground and pipe.

AT – Pipe Umbrella Pipes

Five standard pipe sizes are available which have outer diameters ranging from 76mm to 168mm. The AT – 76 Pipe Umbrella System has the smallest outer diameter and the AT – 168 Pipe Umbrella



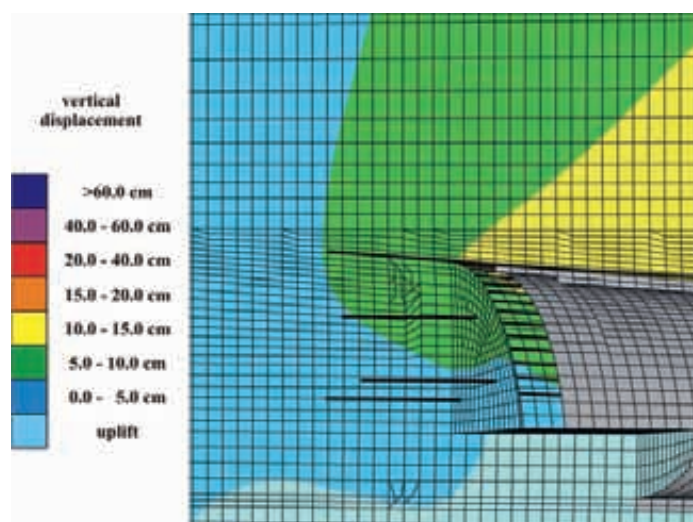
System the largest. The wall thickness depends on the pipe size and ranges from 6.3mm to 10.0mm. Generally, the steel grade is S355 (EN 10025) because unrealistic deformations would be necessary to completely activate the pipes when using higher steel grades. The standard length of the pipes is limited to 3m because this length perfectly fits on the net drill arm length of conventional drilling machines. The pipe length is only reduced up to 1m in cases of limited space or very large pipe sizes.

The steel pipes are usually equipped with injection holes with rubber valves. These injection holes are necessary to fill the remaining gap between the ground and the pipe to improve load transfer. Hence, the distance between adjacent holes is normally 1m.





The AT – Pipe Umbrella System is installed segment by segment because of the limited length of the drill jumbo's drill arm, and for this reason, the pipes must be connected to each other during installation. The type and quality of the coupler is the most important factor in achieving the maximum bearing capacity of the support system. Therefore, three different coupler types are available for the AT – Pipe Umbrella System; the standard threaded connection, the squeezed connection and the treaded nipple connection. These connection types are mainly distinguished from each other by their stiffness- and strength properties in relation to the pipes' full section. The standard threaded connection is ideally suited for installing measurement instrumentation or ground improvement because the inner diameter stays constant. On the other hand, a typical application area for the threaded nipple coupler would be a project where the pipe umbrella is used for its static supporting effect as well as for its deformation decreasing effect. This ensures a technically ideal solution for every type of application.



References

- Volkmann, G.M. & Schubert, W. 2006. "Optimization of Excavation and Support in Pipe Roof Supported Tunnel Sections." In Proc. of the 32nd ITA-AITES World Tunneling Congress, Seoul, Republic of Korea, 2006, 404 ff.
- Volkmann, G.M. & W. Schubert 2007. "Geotechnical Model for Pipe Roof Supports in Tunneling." In Proc. of the 33rd ITA-AITES World Tunneling Congress, Underground Space - the 4th Dimension of Metropolises, Volume 1. Prague, Czech Republic, Taylor & Francis Group, ISBN: 978-0-415-40802. app. 755-760.
- Volkmann G.M. & Schubert W. 2008. "Tender Document Specifications for Pipe Umbrella installation methods." Proceedings of the 34th ITA-AITES World Tunneling Congress, Agra, India, 22-24 September 2008, pp. 285-293.
- Volkmann, G.M. & Schubert, W. 2010 "A load and load transfer model for pipe umbrella support." In Proc. of EUROCK 2010. Lausanne, Switzerland, 2010.
- Volkmann G. M., M- Reith & T. Berner, 2012. "The AT - Casing System" "Das AT – Hüllrohrsystem" Geomechanics and Tunneling 5 (2012), No. 1 Ernst & Sohn Verlag für Architektur und technische Wissenschaften GmbH & Co. KG, Berlin DOI: 10.1002/geot.201200006.

DSI Austria obtains Certificate of Conformity for 3 Bar PANTEX Lattice Girders



Documented evidence of conformity has become increasingly more important for underground construction products. Consequently, in 2010, DSI Austria decided to obtain a product certification for PANTEX Lattice Girders. The company has been producing PANTEX Lattice Girders for more than 25 years and possesses extensive experience and know-how regarding the design and dimensioning, production and control of lattice girders.

Lattice girders, which are used as passive ground support in the underground industry, are not regulated by European or national norms – that is why evidence of conformity for this product can only be provided by an independent and recognized authority on a case by case basis.

A test program for such a certificate of conformity was established in co-operation with the material testing laboratory North Rhine-Westfalia (MPA NRW). In addition to the factory standard for lattice girder production, both the primary material and the welding method were subjected to detailed review. The load bearing capacity of the 3 bar girders was also proved by calculative analysis. Finally, a comprehensive series of lattice girder bending tests was carried out in the laboratory for rock mechanics and tunneling of Graz Technical University (FMT TU Graz Laboratory).

During an audit, a representative of MPA NRW visited both DSI Austria's factory in Pasching and the FMT TU Graz Laboratory in October 2011.

After producing the complete documentation package within the framework of the testing program, and after concluding a contract for external quality control, the certificate of conformity was issued for the construction product 3 Bar PANTEX Lattice Girders on the 24th of May 2012.

The certificate of conformity confirms the sustainable high quality production of ground support products for underground applications at DSI's site in Pasching according to the ISO 9001 QS System. DSI Austria has strengthened its position as a supplier of high quality products and systems for Tunneling. PANTEX Lattice Girders stand for high quality and reliability and are globally marketed under the brand name of ALWAG Systems.



DYWI® Seal Waterproofing System protects Torrent Embankment following a Landslide

Photos reprinted courtesy of Hoch-Tief-Bau-Imst Ges.m.b.H., Austria



In June 18th 2011, a landslide on a section of railroad track near Innsbruck, Austria was caused by heavy rain. The landslide penetrated a protection gallery on a side track underneath the Martinswand, a mountain face north-west of Innsbruck. The train that was passing at the time had to be stopped because of the debris penetration.

As an emergency measure, the channel embankment of the torrent above the gallery had to be repaired. A continuous shotcrete channel was built above the protection gallery and the cavity above the gallery was filled with lean concrete.

The ensuing repair measures included the construction of a new connection to a forest road, a paved channel on the talus area and a guiding channel at the protection gallery. Additionally, some temporary construction needed to be carried out for collecting and draining off the water in case of new rain showers. A total of 1,200m³ of rock and debris had to be moved for the construction work.

In order to ensure the stability of the channel, new abutments were built through the shotcrete channel. These abutments were embedded 1.5m deep in the talus and anchored to the bedrock underneath using 8m long Type R38-500kN DYWI® Drill Hollow Bar Bolts.

Considering the prevailing soil conditions and the remoteness of the construction site, the self-drilling and piecewise installation of the hollow bar anchors proved to be a great advantage.

Afterwards, the DYWI® Seal Waterproofing System was applied to the shotcrete layer of the channel to prevent the penetration of water into the subjacent talus. In order to achieve a force-fit connection between the base layer and the pavement of the channel, reinforcing bars were drilled through the waterproofing layer.

The self-healing effect of the DYWI® Seal Waterproofing System was the crucial reason for using the system because the drilling of reinforcing bars through the DYWI® Seal waterproofing layer did not cause any leakage. Due to the steep surroundings, the light weight of only 0.5kg/m² was another advantage both considerably facilitating transportation and handling on site. Furthermore, the ease of installation without the need for any additional welding equipment was much appreciated by the parties involved.

Blocks of stone and lean concrete were then placed directly above the waterproofing layer in order to stabilize the channel and protect it from abrasion.



Owner ÖBB-Infrastruktur AG, Austria
General Contractor Hoch-Tief-Bau-Imst Ges.m.b.H., Austria
Engineers Dipl.-Ing. Thomas Sigl, Ingenieurkonsulent für Bauingenieurwesen, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Supply of the DYWI® Seal Waterproofing System and of Type R38-500 DYWI® Drill Hollow Bar Bolts



DSI supplies Tunneling Systems for the Construction of Goetschka and Freistadt Tunnels

In 2009, construction began on the S10 Muehlviertel Highway in Upper Austria. The new S10 highway connects to the existing Muehlkreis A7 Motorway north of Linz near Unterweikersdorf and extends to the former border crossing near Wulowitz, Czech Republic, over a total length of 38km.

The S10 is considered to be a crucial road connection for the Muehlviertel region.

The eastern tube in the direction of Prague is being built with three lanes due to the ascending slope of up to 3.6%: two regular lanes and one slow lane. The western tube in the direction of Linz will include two lanes. The two tunnel tubes with a total length of 8.8km will be equipped with modern safety features. The axis-center distance of the two tunnel tubes measures between 17 and 45m. Both tubes will be connected via a total of 17 crosscuts, four of which will also be accessible by emergency vehicles.



It will considerably enhance traffic safety in this area, create strong economic stimulus for the town of Freistadt and the Muehlviertel region and create a better traffic-related and economy-related network between the region of Freistadt and the greater Linz area.

The 22km long southern section of the S10 will be fully developed as a highway and will include four lanes with an additional hard shoulder. More than 40% of the complete route runs through four tunnels and subsurface routes. During the planning phase, when the environmental impact of the project was reviewed, many measures were developed to either avoid or compensate for adverse effects along the track.

The Goetschka Tunnel is the largest single building contract in the history of Austria's ASFINAG highway authority. The double tube tunnel is being built on a length of approx. 4.4km between the communities of Unterweikersdorf and Matzelsdorf north-east of Linz.

Following are some key technical details for the Goetschka Tunnel:

- Eastern tube: 3 lanes with a width of 11m; length: 4,432.5m; approx. 115 m² of excavation section
- Western tube: 2 lanes with a width of 7.50m; length: 4,454m; approx. 86.5m² of excavation section

The maximum overburden in the tunnel area is 110m. The total excavation material that is expected for both tunnel tubes is approx. 1.1 million m³, 300,000m³ of which will be re-used in the tunnel.

The Goetschka Tunnel leads through some demanding geological conditions, making excavation for the miners challenging. Excavation is carried out in accordance with the New Austrian Tunneling Method (NATM).

DSI supplied PANTEX Lattice Girders, SN Anchors with ALWAGRIP special rib geometry, steel spiles, tube spiles, DYWI® Drill Hollow Bar Anchors including accessories, OMEGA-BOLT® Anchors



and permanent DYWIDAG Strand Anchors in lengths of 21 and 26m. The products were used both for stabilizing the precuts and the excavation work for both the Goetschka and Freistadt Tunnels.

The installation of 200 permanent 5-0.62" DYWIDAG Strand Anchors in lengths of 21m at the breakdown bays in the 3-lane eastern tube posed a special challenge at Goetschka Tunnel.

The DYWIDAG Strand Anchors had to arrive at the tunnel site complete with a special foot plate that prevented the sliding out of the strands and sealed the borehole. The strand anchors for the breakdown bays were installed vertically using coils and a special mounting designed by Porr and then tensioned by DSI experts.

The completion of the project with its total length of 38km is scheduled for autumn 2015.



Owner ASFINAG Bau Management GmbH, Austria
Contractor Porr Bau GmbH - Tunnelbau, Austria
Engineering IL - Ingenieurbüro Laabmayr & Partner ZT GesmbH., Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Services Supply of PANTEX Lattice Girders, SN Anchors with ALWAGRIP special rib geometry, steel spiles, tube spiles, DYWI® Drill Hollow Bar Anchors including accessories, OMEGA-BOLT® Anchors and permanent DYWIDAG Strand Anchors

The Pummersdorf Tunnel: Closing a Gap in one of Austria's most Important Railway Lines



Photos reprinted courtesy of Alpine BeMo Tunneling GmbH, Austria

Within the scope of the Westbahn extension, one of the most important railway lines in Austria, a 24.7km long gap is being closed between the towns of St. Poelten and Loosdorf. The new, double tracked line runs around St. Poelten, which is located approx. 70km west of Vienna, in order to relieve the town's train station from both transit and freight traffic. In addition to 23 bridges, three railway tunnels are being built for this project.

One of the tunnels is the approx. 3.5km long Pummersdorf Tunnel, which is being built as a single tube double track structure. Six shafts are planned as emergency escapes from the tunnel. The shafts are to be driven to an average depth of 24m and will be connected to the main tube via a 15m long cross cut.

The average overburden of the tunnel is about 20m, i.e. the tunnel is a shallow tunnel in unconsolidated ground. The geology in the area of the construction site mainly consists of medium hard to hard silt with a high degree of fine sand as well as marly clay sandstone. The main driving area for the Pummersdorf Tunnel is located in highly weathered schlier.

As the tunnel is located in a very shallow area, a comprehensive precut had to be carried out at both portals in order to be able to start tunnel driving. Driving was first carried out using excavators and then continued using both excavators and blasting. DSI Austria supplied 3-bar PANTEX Lattice Girders; OMEGA-BOLT® Expandable Friction Bolts, SN Anchors and anchor spiles in individual lengths of 400cm each as well as the complete range of accessories for this project.

The main advantages of the OMEGA-BOLT® Expandable Friction Bolts during this project were the following:

- Immediate full load bearing capacity over the entire installed bolt length
- Low sensitivity to vibrations caused by blasting
- Ability to maintain load-bearing capacity even when undergoing deformations
- Safe, fast and easy installation
- No additional building materials required for installation
- Ability to accommodate differing or varying borehole diameters

Construction work at the Pummersdorf Tunnel began in January 2012 and is scheduled for completion in August 2014.



Owner ÖBB-Infrastruktur AG, Austria
Contractor Alpine BeMo Tunneling GmbH, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Production and supply of 3-bar PANTEX Lattice Girders; OMEGA-BOLT® Expandable Friction Bolts; SN Anchors and anchor spiles

The Brenner Base Tunnel: ALWAG Systems for the World's Second Longest Railway Tunnel

The Brenner Base Tunnel (BBT) is a joint project built by Italy and Austria along the Munich-Verona axis. The planned 55km long tunnel will be the world's second longest railway tunnel after the Gotthard Base Tunnel.

The current Brenner railway has a small curve radius and a gradient of up to 31 per mill, limiting maximum train speed to 180km/h. In order to relieve congestion on the Brenner highway by shifting freight traffic from the road to the railway, the BBT is designed as a shallow tunnel with a maximum gradient of six per mill. In the future, trains will be able to go through the tunnel at a maximum speed of up to 250km/h. In addition, the capacity of freight transportation over the Brenner will be tripled.

The BBT will have two 8.1m wide single track tubes that are located at a distance of 70m from each other. The Innsbruck-Ahrental exploratory tunnel is currently under construction between the two tunnel tubes. It will supply important findings concerning the geological and hydrogeological conditions on site. During construction of the BBT tunnel tubes, the exploratory tunnel will also be used for removing excavated material. After completion of the BBT, the exploratory tunnel will be used for drainage.



Advancement at the Sill Gorge

The exploratory tunnel has a diameter of 5 to 6m, a cross section of 26m² and runs 12m below the two planned main tubes. The tunnel is being excavated using blasting advance with four to five detonations per day. Up to now, DSI Austria has supplied approx. 30,000m of PANTEX Lattice Girders, approx. 150,000m of OMEGA-BOLT® Expandable Friction Bolts, DYWI® Drill Hollow Bar Anchors and SN Anchors. In addition, approx. 45,000m of self-drilling spiles in lengths of 3, 4 and 8m have been used.

The construction project also included several access galleries that will divide the BBT into four sections and will provide access from outside for maintenance and emergency evacuation. For the first of these access galleries, the Ampass approach adit, DSI Austria has supplied approx. 9,800m of PANTEX Lattice Girders, approx. 30,000m of DYWI® Drill Hollow Bar Anchors and SN Anchors as well as approx. 45,000m of self-drilling spiles in lengths of 3, 4 and 8m up to now.



Sill Gorge



Ahrental Advancement



Owner Galleria di Base del Brennero – Brenner Basistunnel BBT SE, Italy

Contractor Joint Venture STRABAG-PORR (EBN + AFA), Austria

Engineers ILF Beratende Ingenieure ZT GmbH, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production and supply of PANTEX Lattice Girders, OMEGA-BOLT® Expandable Friction Bolts, DYWI® Drill Hollow Bar Anchors, SN Anchors and self-drilling spiles

Energy from the Mountains – the Reisseck II Pumped Storage Power Station in Carinthia

The increased use of wind energy in Europe is requiring power stations that can adjust to output fluctuations of wind power stations and that can store excess energy and distribute this energy on short notice when needed. The construction of the Reisseck II pumped storage power station is a good example for a future-oriented adaptation of the electrical power supply to the increased requirements of the market.

The Reisseck II power station will connect the Reisseck/Kreuzeck and Malta power stations in upper Carinthia via an underground waterway that is more than 5km long. It allows a more efficient use of the existing plants thanks to two modern sets of turbine pumps. The turbine pumps are located in a completely subterranean power station inside a cavern and can be used both for storing and producing energy. This way, the plant contributes significantly to the region's security of supply.

The power plant, which has been under construction since 2010, is scheduled to be operational in 2014 and will have a peak generating capacity of 430MW. The power station will be built in a cavern inside the Reisseck/Kreuzeck Mountain Range in the Muehldorf Rift at a height of 1,600m. The Reisseck II Power Station will be operated fully automated, remote-controlled and telemonitored.

Construction work mainly includes the following measures:

- A 4,993m long upstream waterway with several adits, an inlet and an outlet structure as well as a pressure shaft
- The Burgstall Power Station inside a cavern
- An approx. 0.3km long, downstream waterway with a downstream gallery as well as a connection to the waterway of Malta Power Station

The main part of the project is located in the central gneiss area of the Glockner Mountain, which is characterized by predominantly high rock solidity and high abrasiveness. The excavation of the upstream pressure shaft is carried out using a hard rock tunnel boring machine with a nominal milling diameter of 7.03m. The complete excavation work in the caverns and access galleries is carried out using conventional blasting.

DSI Austria, the leading system supplier of reinforcement and ground support systems for Tunneling, produced and supplied a large range of rock support products for this important project that were used for the different caverns and excavations as well as for stabilizing the tunnel portals.

Among other products, DSI Austria supplied PANTEX Lattice Girders, OMEGA-BOLT® Expandable Friction Bolts, DYWI® Drill Hollow Bar Anchors, SN Anchors, DYWIDAG Strand Anchors, GEWI® Anchors and Self-Drilling Spiles.





i

Client Verbund-Austria Hydro Power AG, Austria
Contractor Joint Venture PSKW Reisseck II, consisting of G. Hinteregger & Söhne, ÖSTU-Stettin, Porr Bau GmbH and SWIETELSKY Baugesellschaft m.b.H., all of them Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Production and supply of PANTEX Lattice Girders, OMEGA-BOLT® Expandable Friction Bolts, DYWI® Drill Hollow Bar Anchors, SN Anchors, DYWIDAG Strand Anchors, GEWI® Anchors and Self-Drilling Spiles





Use of the DYWI® Drill Hollow Bar System for the Stabilization of Vijenac Tunnel



A new motorway is currently under construction that is designed to improve the infrastructure between Bosnia and Herzegovina as well as Croatia. The project forms part of the 5c Pan-European Transport Corridor and is an important prerequisite for ensuring the positive economic development of the whole region.

Construction work on the motorway also included the new 2.9km long Vijenac Tunnel in Bosnia. Work on the double tube highway tunnel began in July 2011, and completion is scheduled for the beginning of 2014. Tunnel advance was carried out in accordance with the New Austrian Tunneling Method.

DSI Austria supplied the complete range of important ground control products for tunnel driving. This also included Type R32 and R38 DYWI® Drill Hollow Bar Rock Bolts including accessories as well as grout pumps. The DYWI® Drill Hollow Bar System proved itself by fulfilling the following technical characteristics in this project:

- Simultaneous drilling and grouting ensures an optimum bond between the hollow bar tendon and the unconsolidated rock or ground
- The construction soil is improved by the infiltration of the grout into the surrounding unconsolidated soil
- Uniform distribution of the grout along the complete installation length

The advantages of the DYWI® Drill Hollow Bar System had already convinced the client in comparable projects. Principal advantages include the fast and safe self-drilling installation process as well as the possibility to drill, install and grout in a single operation using standard drilling equipment.

Once again, the client was very satisfied with the products that were supplied for this project as well as with the comprehensive services offered by DSI Austria and the technical support provided by experienced DSI employees on site.



Client Javno Popuzece Autoceste FBiH D.O.O., Bosnia and Herzegovina
General Contractor Joint Venture, consisting of: Euro Asfalt d.o.o., ŽGP d.d., Hidrogradnja d.o.o. and Entea d.o.o., Butmir d.o.o., all of them Bosnia and Herzegovina
Architect Divel d.o.o., Bosnia and Herzegovina
Supervisor IGH d.o.o., Croatia

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Supply of the Type R32 and R38 DYWI® Drill Hollow Bar System, DYWI® Drill accessories, grouting pumps; technical service on site

Stable Power Supply in Croatia: DSI delivers Special Systems for Service Tunnel

The city of Dubrovnik in the far south of Croatia is primarily supplied by electricity from the 126 megavolt amperes (MVA) TS Komolac transformer station in the city's North West. From there, electricity is relayed to a transformer station located near the town of Plat via two 35kV lines.

In order to expand the region's power supply system, the owner HEP is currently adding new lines to the only existing power supply, which currently has a limited capacity. For this purpose, two new transformer stations are being built: the 110kV TS Srd station, the 220/110/20kV TS Plat station and a newly planned 220kV high-voltage line.

The project also includes the construction of a 374m long service tunnel. This new tunnel will connect the two transformer stations and the existing tunnel system. All of these measures will considerably improve the entire power supply system.

The tunnel portal is located on the connecting road between Dubrovnik and Cavtat and leads to the old connection tunnel at an inclination of 18 degrees. The tunnel is stabilized conventionally using roof support products and shotcrete, and the advance is carried out using the drilling and blasting method.

DSI produced and supplied Type P95-20-30 3 bar PANTEX Lattice Girders as passive roof support for stabilizing the excavated cross section of the service tunnel. PANTEX Lattice Girders are used as a true-to-form template for shotcrete application and ensure an easy and quick assembly as well as simple handling of the supporting structure. Additionally, lattice girders offer optimum bond and interconnection with the shotcrete lining while simultaneously minimizing shotcrete spray shadows. The system also ensures simple adjustment and shaping to the excavation geometry.

Additionally, DSI Austria also supplied Type R32-280 DYWI® Drill Hollow Bar Rock Bolts and system accessories.

DYWI® Drill Hollow Bars can be used without difficulty even in unstable boreholes, thus offering a convenient alternative to systems that have to be installed using time-consuming cased or conventional drilling methods. Minor space requirements for installation and the easy adjustment of the single-use drill bits to varying ground conditions are additional decisive advantages of this system. All of the roof support products were produced by DSI on time and supplied to the jobsite just in time for installation.



i

Owner HEP (Hrvatska Elektroprivreda), Croatia
Engineers Projektini Biro Split d.o.o., Croatia
Contractor Hidroelektra d.d., Croatia

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production and supply of Type P95-20-30 PANTEX Lattice Girders and of the Type R32-280 DYWI® Drill Hollow Bar System with accessories

Stabilization using the AT – Pipe Umbrella System: The New Kaiser Wilhelm Tunnel

The Kaiser Wilhelm Tunnel is a railway tunnel that was built from 1875 to 1878 between Cochem and Eller near Koblenz. As the tunnel no longer complies with modern safety requirements, a second tube is being built that will permit access to the existing tunnel via eight connecting structures. With a maximum overburden of 255m and a clear opening cross section of approx. 50m², the tunnel passes through a spur that is known as the Cochemer Krampen.

The new tunnel tube runs parallel and to the east of the existing tunnel with an axis spacing of about 26m. The tunnel length of the new tube measures 4,242m. Along a length of 4,183.6m, the New Kaiser Wilhelm Tunnel is being driven underground using a tunnel boring machine (TBM) with an internal segment diameter of 9m, an external

segment diameter of 9.8m and an excavation diameter of 10.12m.

The surrounding ground is part of the Rhenisches Schiefergebirge, which mostly consists of slate and fine sandstone. The tectonically highly affected stratification is cut through by numerous faults parallel to the strata or the cleavage, which are flat to steeply inclined.

During the tunnel drive, there were repeated rockfalls and failures of the face due to the intersection with small to extensive fault zones. The Ø 76mm AT – Casing System was used in order to strengthen the ground locally in the crown and to improve load-bearing capacity.

The system supplied by DSI Austria was a combined pipe umbrella consisting of GRP and steel pipes. The GRP pipes were installed near the TBM shield to prevent jamming of the machine.



This was done by drilling 17m long pipes through twelve drilling channels in the crown of the TBM with an average spacing of 10° and an inclination of 10° into the surrounding ground. The holes were drilled from the drill carriage that had been mounted on the erector of the TBM.

Each hole contained a starter pipe with an integrated drill bit, three 3m long steel extension pipes, a special transition sleeve in the steel pipe for connecting the GRP pipes and three 2m long GRP pipes. The GRP pipes were primarily installed in the shield area, as it was not possible to ensure the successful dismantling of the pipes above the shield skin in the drilling channel of the TBM.

The GRP pipes were provided at the end of each pipe length, and the hole was drilled deep enough to ensure that all steel parts of the pipe umbrella would be outside the shield skin. That way, the TBM could be operated without interruption after the installation

of the pipe umbrella. After the pipe umbrella had been completely drilled, the pipes were fitted with manchette packers at the individual valves and grouted with very fine cement grout.

The fast and uncomplicated installation of the AT – Pipe Umbrella System and its versatile use once again proved itself as an efficient solution to the problems encountered in this project.

i

Owner DB Netz AG, Germany

Contractor Joint Venture Neuer Kaiser-Wilhelm-Tunnel, Alpine Untertagebau GmbH – Alpine Bau Deutschland GmbH, Germany

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Supply of the Ø 76 mm AT – Casing System



DSI DRILL TEK – DSI’s Specialists for Injection Resins and Roof Bolting in Coal Mines

In February 2012, DSI acquired the UK mining services contractor DRILL TEK Injection Systems Ltd., which now operates as DSI DRILL TEK.

DSI DRILL TEK offers both specialist contracting services such as roof bolt installation, resin injection and products for roof support and reinforcement in underground mines.

DSI DRILL TEK employs approximately 50 highly specialized employees. One of the company’s strengths is its flexibility in providing fast and highly professional ground stabilization services both in emergency situations and on a regular basis.

Based in Chesterfield, DSI DRILL TEK supplies

the full range of injection resins used to fill cavities and stop potential water inflows in underground coal mining and principally used in stabilizing belt entries, intersections of faults or roofs and mine faces.

Furthermore, DSI DRILL TEK’s products and expertise have also helped customers in cases of water sealing and water inflows in shafts, tunneling and other concrete structures.

DSI’s global mining and tunneling organization will benefit from DRILL TEK’s experience in product application and injection chemicals. On the other hand, DSI DRILL TEK will have access to DSI’s portfolio of mining products, which will be further promoted into the UK and beyond.



Fast Emergency Response: DSI DRILL TEK injects Wastewater System Shaft

At the beginning of 2012, a new series of sewage tunnels and shafts were built and the existing wastewater system was significantly expanded in Wakefield, England.

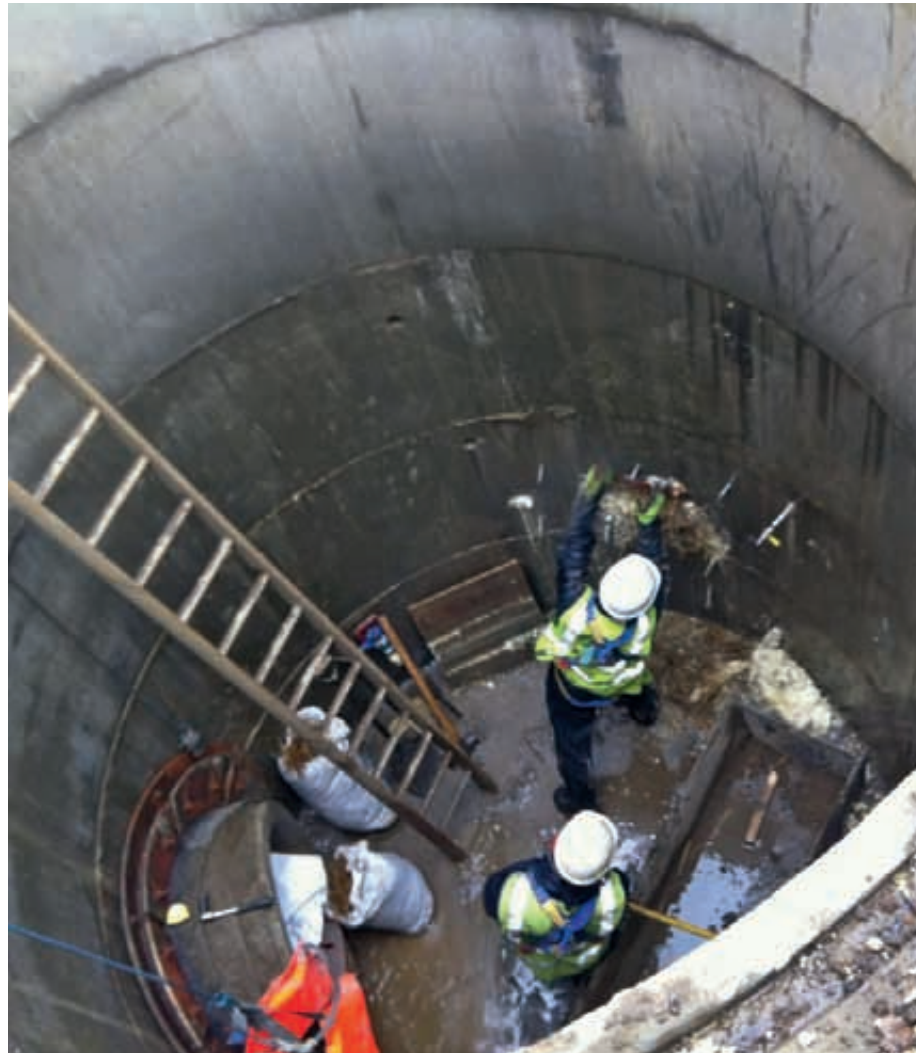
The owner, Yorkshire Water, awarded the general construction contract to Barhale Construction for the work. The new shafts were partly driven using a Micro TBM (tunnel boring machine).

When a full face TBM with a shield diameter of 1.5m was approaching the end shaft, it became apparent that the entry shaft could not be broken out as planned to allow the TBM to enter the end shaft. A ground sample confirmed that the surrounding ground consisted of very wet running sands, making it impossible to break out the shaft wall.

Due to their comprehensive experience and the fact that they have been successful many times with this type of work, DSI DRILL TEK was asked for help.

DSI DRILL TEK's specialists reacted at once and recommended the complete injection of the running sands with silicate injection foam resin in order to consolidate the noncohesive ground. After the injection work using the strongly expanding silicate injection foam resin had been carried out, the surrounding ground was sufficiently consolidated to allow the shaft wall to be removed and the TBM to enter the shaft.

In order to be able to react quickly and flexibly to emergencies at all times, DSI DRILL TEK maintains an inventory of all necessary products for this type of application. A day after first being contacted, the injection work was carried out successfully. The very same day, the shaft was broken out and the TBM entered the end shaft.



i

Owner Yorkshire Water, Great Britain
General Contractor Barhale Construction plc, Great Britain

DSI Unit DSI DRILL TEK Ltd., Great Britain
DSI DRILL TEK Scope Supply and injection of silicate injection foam resin

DSI DRILL TEK Ltd. Supplies Specialty Systems for the World's northernmost Mine

The world's northernmost mine is located on the Norwegian island of Spitsbergen, 1,300km from the North Pole. At this location, the company Store Norske Spitsbergen Grubekompani AS, which is part of the Store Norske Spitsbergen Kulkompani AS Group, extracts coal from the Svea Nord and Gruve 7 underground mines year-round.

In 2012, Store Norske awarded a contract to Veidekke Entreprenør AS for the construction of the needed infrastructure for a new mine – the Lunckefjell mine. This mine is located north-east of the Svea Nord Mine and includes coal reserves equalling approx. 8.5 million tons. The relatively thin coal seam will be mined using a longwall system. The extracted coal will then be transported by truck to the existing conveyor belt system of the Svea Nord Mine.



The Gruve 7 Mine is a small mine near the town of Longyearbyen. Since 1975, approx. 80,000t of coal are mined per year in this room and pillar mine. On average, the coal seam at Gruve 7 Mine is 1.5m thick. The coal is mined using the room-and-pillar method, extracted using a continuous miner, milled using a breaker and then transported out of the mine.



There are no roads connecting the Svea Nord mine to the town of Longyearbyen. Consequently, the mine has its own infrastructure with accommodations, an airport, a power plant and a harbor. 360 employees mine approx. 1.7-2 million tons of coal per year at the Svea Mine. This coal is processed at the mine's own coal preparation plant to produce coal with an ash percentage of 7 or 10 in accordance with the respective field of application. The processed coal is then shipped to European harbors. Approximately two thirds of the extracted coal is supplied to coal-fired power plants in Europe.

The Svea Nord Mine can be accessed via a 6km long main adit that runs through hard rock. The largest conveyor is located in a 5km long tunnel that is separated from the main adit. The coal seam in the Svea Nord Mine has an average thickness of between 3.5m and 5.0m. Coal is mined using the longwall method with longwall panels that are 250m wide and 4m high on average and that can be up to 3.5km long. The relocation of the 6.500t of longwall equipment is usually carried out within a mere 7 weeks.

The drifts at the Svea Mine are systematically stabilized using geo mesh that is assembled on the support arches and steel mesh and fixed using rock bolts. In the cross cuts, an average of six cable bolts are installed per meter on the steel mesh, while 1.9m long rock bolts are used for the main roadways.

Store Norske entered into a 4-year contract with the mining specialist DSI DRILL TEK Ltd. for the exclusive supply of roof support products at the three mines, Svea Nord, Gruve 7 and Lunckefjell.

DSI not only supplies the rock bolts and the steel mesh necessary for stabilizing the drifts, but also light fiberglass (GRP) bolts and geo mesh. In addition, DSI also supplies resin cartridges, injection resins and consumables such as washer plates, drill steels and drill bits.



i

Client Store Norske Spitsbergen Grubekompani AS, Norway

DSI Unit DSI DRILL TEK Ltd., Great Britain

DSI Scope Supply of rock bolts (steel and GRP), steel mesh, geo mesh, resin cartridges, injection resins and consumables such as washer plates, drill steels and drill bits

High Quality Marble from Slovenia: Safe Advance in Underground Mining with DSI

Since 1933, Fiorito and Unito marble have been mined in the Lipica 1 quarry in Slovenia. The high quality marble is primarily used for facades and for the construction of aesthetically pleasing buildings.

In 1987, open pit mining of marble was started in the Lipica 2 quarry. Both quarries were then extended to underground mining in 2002 and 2005 respectively.

In the meantime, Lipica 1 has become the largest underground mine and Lipica 2 the largest open pit mine in Slovenia. In order to ensure future development, open pit mining was begun in the Doline quarry, which was then also extended to underground mining in 2009.

To expand the three open pit mines to underground mining, galleries with a height of 26 to 28m had to be excavated.



During underground excavation, rock pillars are left in place at a regular spacing. These natural rock pillars support the large cavities resulting from the excavation.

In order to prevent rock falls at the pillars and to permit a safe advance of the three underground mines, DSI supplied high quality OMEGA-BOLT® Expandable Friction Bolts including accessories. The friction bolts that were supplied are insensitive to vibrations caused by blasting and maintain their load-bearing capacities even when undergoing deformations in the surrounding rock mass.



Owner Marmor, Sežana d.d., Slovenia

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production and supply of OMEGA-BOLT® Expandable Friction Bolts including accessories



DSI Supplies Special Products for Stabilizing a Gold Mine in Turkey

In 2010, a new gold mine was developed near Izmir – the new Efemçukuru Mine. The mine has been successfully exploited by TUPRAG Metal, a subsidiary of Eldorado Gold Corporation, since December 2011. The operator is expecting an average annual gold production of 112,400 ounces. The mine has an expected service life of 9.4 years and currently has more than 200 employees. The ore is processed and classified on site in a milling and flotation concentrate circuit.

The site subsurface consists of an approx. 1m thick layer of scree underlain by a 2-3m layer of weathered bedrock. The layer underneath consists of hornfels or phyllite bedrock. Up to now, mine openings with a total length of approx. 4,000m have been driven for mining the gold ore.

DSI is an important system supplier for the Efemçukuru Gold Mine and supports the operator with several specialty products for roof support. For stabilizing the heading in hard rock, DSI supplied Ø 39mm Friction Stabilizers. Friction Stabilizers are a well-proven support element and feature immediate load-bearing capability after installation.

In addition, DSI also supplied flexible GFR (glass fiber reinforced) Flat Bar Anchors in lengths of 9, 12 and 20m including accessories. The GFR Flat Bars are supplied underground on coils and cut to the required lengths on site for subsequent installation into the roof. In contrast to conventional steel bar anchors, the special GFR construction material does not obstruct the mill when processing the mined material. Therefore, the GFR anchors can simply be mined together with the ore during blasting, excavation and crushing.





In some areas of the mine, unstable rock conditions require the use of a friction bolt with higher load capacities. DSI is supplying OMEGA-BOLT® Expandable Friction Bolts for these areas. The safe and fast installation of the anchors and their immediate load-bearing capability after installation are important advantages of the system. For tensioning and testing the rock bolts, DSI also supplied the necessary hydraulic tensioning and testing equipment.

i

Operator TUPRAG Metal Madencilik San. ve Tic. A.Ş., Turkey

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Supply of Type FS-39 Friction Stabilizers, Type MN GFR Flat Bars incl. accessories and of OMEGA-BOLT® Expandable Friction Bolts and pumps; rental of tensioning and testing equipment for the roof support products





The El Valle-Boinás/Carlés Mining Project is located in the 45km long and 4km wide Rio Narcea gold belt in northern Spain near the seaport of Avilés. As early as 2,000 years ago, the Romans extracted gold from this region, and the gold deposits have been mined repeatedly until today. At the beginning, extraction was limited to open pit mining; however, since 2004, mining is also conducted underground.

The owner of the two mines El Valle and Carlés, Kinbauri España, has been extracting gold and copper from underground mines at both sites. In order to guarantee safe advancement, the company asked DSC Spain to stabilize the mine galleries.

For this purpose, DSC supplied friction bolts produced by DSI Chile which had not been previously used in Spanish underground mines. The products supplied were 2.4m long friction bolts with wall thicknesses of 2.2mm and a diameter of 39.5mm. In addition, DSC also supplied 150 x 150 x 4mm anchor plates.

A total of 4,160 friction bolts have been delivered from Chile so far.

The DSI Friction Bolts ensure a quick and easy installation process that can be undertaken using both hand-held or fully automated equipment. The bolts reach immediate load-bearing capacity after installation and show low sensitivity to ground movements.

With a planned mine life of 15 years, the expected yearly consumption of both mines is approximately 36,000 friction bolts. Thanks to the efficient co-operation between DSC and DSI Chile, the owner can continue mining in a safe working environment.



Owner Kinbauri España, S.L.U., Spain

DSI Units DYWIDAG Sistemas Constructivos S.A., Spain; DSI Chile Industrial Ltda., Chile

DSI Scope Supply of 4,160 \varnothing 39.5mm friction bolts and of 4,160 150 x 150 x 4mm anchor plates

Large Scale Energy Generation with DSI Systems: Ingula Pumped Storage Complex

According to forecasts, South Africa's energy demand will rise to approximately 40,000MW by 2025. In anticipation of the increased demand, the Ingula pumped storage complex is being built in the Drakensberg Mountains near the border of the provinces of Free State and KwaZulu-Natal.

Two dams were built for collecting the water necessary for energy generation. The upper dam, Bedford Dam, is 810m long and 40.9m high. Braamhoek Dam, which is located 470m below at a distance of 4.5km, is 310m long and 38.6m high. With waterways leading from the two dam reservoirs of 22 million m³ capacity each, energy can be generated on short notice in the underground power station between the lakes using four 333MW turbines.

During periods of peak demand, water runs from the upper to the lower lake and is used by the turbines to generate energy. During times of low demand, the water is pumped back up to the upper lake by the turbines, which can also be used as pumps. During the pumping phase, the turbines are powered by excess energy from the country's electrical network.

More than 40 tunnels and shafts were built for this major project. In addition to the 1.25km long main access tunnel, 2.1km long double tube headrace tunnels direct the water from Bedford Dam to the power plant. A 2.3km long tailrace tunnel with an interior diameter of 9.4m directs the discharge water into Braamhoek Lake during energy generation and carries the water back to Bedford Lake in times of low demand.

Due to the predominance of relatively weak sedimentary rock with some faults and long-term creep behavior, underground work was very challenging. DSI South Africa was awarded a contract to produce and supply double corrosion protection DCP Rock Bolts for stabilizing tunnel

advancement. In total, over 150,000 bolts were supplied in diameters of 20/25/32mm and in lengths varying from 1.2 to 9m. The DCP Rock Bolts were successfully installed for crown strata stabilization.

Work on this major project is scheduled for completion in 2015 and DSI South Africa is proud to have made a significant contribution to it.



i

Owner Eskom Holdings SOC Limited, South Africa
General Contractor Joint Venture CMA, consisting of Impreglio S.p.A., Italy, and Mavundla, South Africa
Design Joint Venture Braamhoek Consultants, consisting of Arcus Gibb (Pty) Ltd, Stewart Scott International and Knight Piésold, South Africa

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

DSI Scope Production and supply of approximately 150,000 Ø 20/25/32mm double corrosion protected DCP Rock Bolts

A Technical Challenge: Extraction of Palladium and Platinum

The Bathopele Underground Mine is located east of Rustenburg in North West Province, South Africa. Anglo American Platinum Limited mines palladium and platinum at this site. The extraction of palladium and platinum is expected to continue until 2026. The mine covers a total area of more than 17km², and its narrow ore veins are located at a depth of between 40 to 300m. The ore is accessed via two central shafts: Bathopele East and Bathopele Central.

Due to the high demand for platinum, the ore has to be extracted from steadily decreasing vein thicknesses. At Bathopele Mine, the valuable ore is

often embedded in very narrow and up to 1.2m thick ore belts, which is why extraction is carried out using the bord and pillar method. The ore is usually blasted out of the rock and then transported to the surface on conveyor belts for subsequent processing.

The ore in platinum mines is approximately four times harder than coal. Consequently, the cutting tools, chisels, drills and other consumables wear out quickly. In order to ensure an economic extraction of the raw material in the future, Anglo American decided to optimize the equipment, capacity and efficiency of the mine by an enhanced planning and coordination of all activities.

DSI has been co-operating with the Bathopele Mine for many years.





The operator appreciates the reliable system solutions and the large range of mining products offered by DSI. Approximately 10,000 rock bolts and accessories are supplied to the mine per month and installed for stabilizing the advance. DSI supports the mine with experienced technicians and engineers on site and also offers special customized products and systems. All of the products and systems are centrally produced in Johannesburg and transported to the mine by trucks. DSI is looking forward to continuing this co-operation, which is characterized by trust and reliability.

Owner Anglo American Platinum Limited, South Africa

DSI Unit DYWIDAG-Systems International Inc., South Africa

DSI Scope Production and supply of 10,000 rock bolts per month as well as of plates, OSRO Strap and accessories

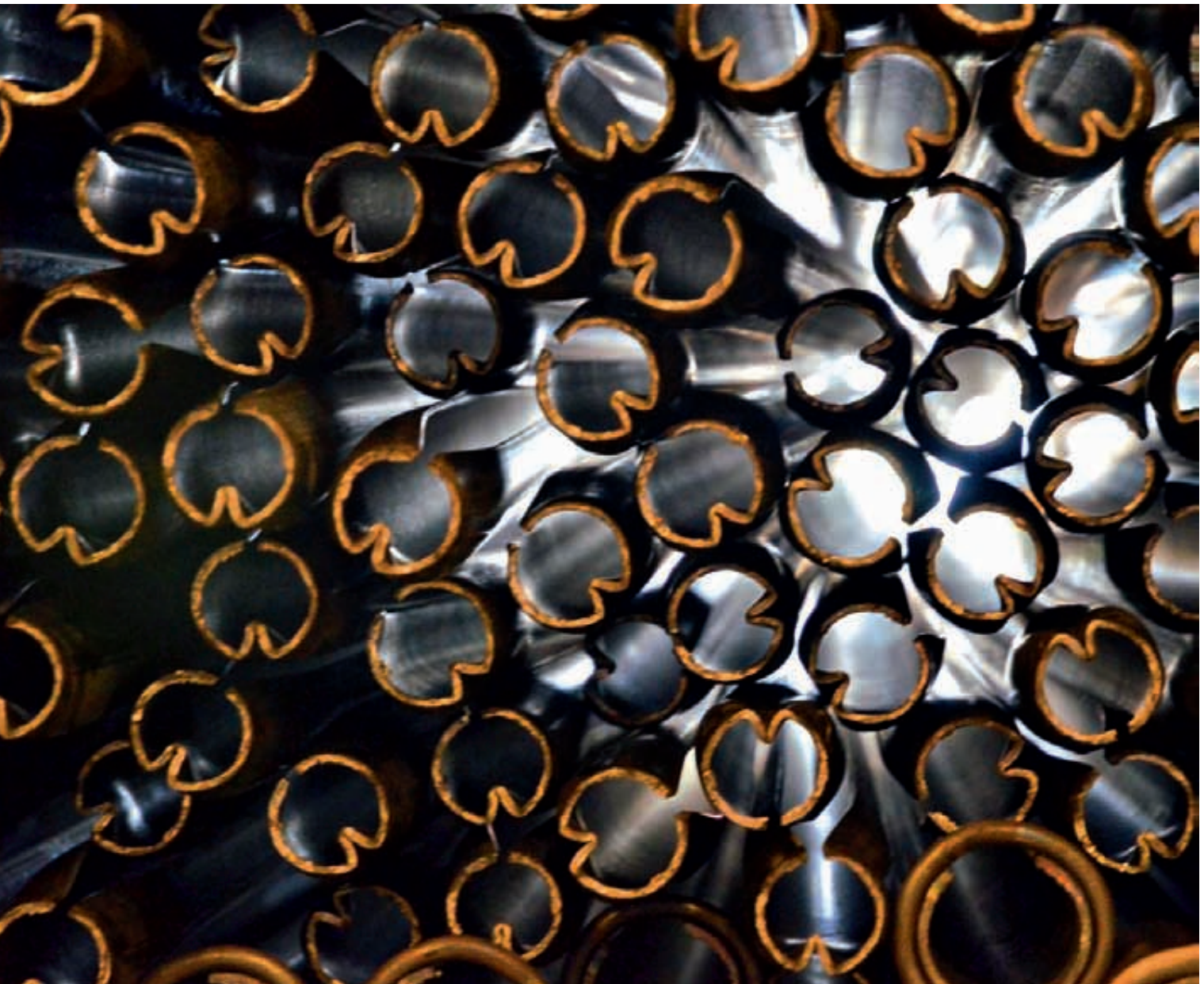


New Production Site for Improved Quality: DSI Underground North America Relocates

In January 2012, the time had come: DSI Underground Systems, Inc. received their certificate of occupancy for their new facility in West Jordan, Utah, USA. The new location includes both modern offices and production facilities. The location in West Jordan is also the principal office of DSI Underground Systems Inc.

The relocation had become necessary as a result of the organization's continued growth. The new production site can be easily and flexibly adjusted to accommodate the future growth of DSI Underground Systems, Inc.

The details of the new location were planned in advance in order to implement an exact adaptation



to DSI's needs as well as to LEAN production requirements. As requisite inventory levels were planned and built in advance of the move, the plant maintained a 93.6% on time delivery to their customers during the move. In addition, staff produced as many friction bolts on average per month as the previous year despite the relocation.

The new facility offers customers decisive benefits. Thanks to an optimized material flow and an innovative placement of equipment, both material and product flows have been considerably enhanced. This ensures an even more efficient production of high quality products and systems for Underground Mining.





MINExpo, which takes place every four years, is the largest and most important mining exhibition in North America.

From September 24th to 26th 2012, more than 1,800 companies presented their products and services for mining and tunneling in Las Vegas. In 2012, the 79,000m² exhibition area was 40% larger than when it was last held in 2008. With 58,359 attendees, the number of visitors also increased by 45% in comparison to 2008.

Visitors from 36 countries learned about new product developments in mining and tunneling during the exhibition and accompanying events.

This time, MINExpo focused on higher efficiency, better environmental sustainability and higher safety standards.



As a specialist for underground products, DSI was also represented at MINExpo. At the company booth, DSI presented various specialty products and new developments for mining to the interested expert public:

- The JFP 95 Dust Control Solutions that do not require any measuring devices and achieve underground dust reduction of up to 40%
- The DYWI® Polymer Rock Dust System, which significantly reduces respirable rock dust in the mine atmosphere
- A newly developed acid proof Polymer coating for the OMEGA-BOLT®
- The FASLOC® X-TREME resin cartridge that is inherently stable during transport and installation due to consistently high internal pressure inside the cartridge

DSI also is committed to participate in the next MINExpo in Las Vegas in 2016.

DSI Chile contributes to the successful Development of a new Gold Mine

Approx. 105km from the city of Rivera in the North of Uruguay, there is a 7km long geological fault zone in which three major gold deposits have been discovered: Arenal, San Gregorio and Santa Teresa. Up to now, more than 800,000 ounces of gold have been mined in these three deposits.

The Arenal area is currently being expanded by a new underground mine. In order to reach the deep gold deposits, a 2,000m long access gallery is being constructed. For stabilizing the underground excavation work, DSI Chile supplied a large amount of different ground support products from their plant in Santiago de Chile. DSI supplied products such as friction bolts, cable bolts and many other products needed for stabilization.

Furthermore, DSI's experienced employees participated in some of the meetings held by the mine operator, Orosur Mining, in order to impart their technical know-how to the mine personnel and to ensure optimum performance of the products used in the mine. This way, DSI contributes systematically to the success of Orosur Mining Inc.'s new project.



Photos reprinted courtesy of Orosur Mining Inc., Uruguay



Owner Orosur Mining Inc., Uruguay

DSI Unit DSI Chile Industrial Ltda., Chile

DSI Scope Supply of a large number of ground support products such as friction bolts or cable bolts

Maximum Flexibility for Cable Stayed Bridges: The DYNA[®] Link Anchor Box System

Modern cable stayed and extradosed bridges are often designed with saddles. The stay cables are deviated at the pylon and anchored to the superstructure at both sides of the pylon.

There are two types of saddles for strand bundle stays:

- Bundle saddle – the strand bundle is diverted in a curved tube and generally grouted in the deviation area using a special grout. The curved saddle pipe is guided through a curved recess pipe which is embedded into the concrete so that the strand bundle including saddle pipe can be exchanged if necessary. Differential forces in the stays at both sides of the saddle are reliably transferred via shear noses or ring nuts.
- Saddles with individual tubes; also called a cradle – the strands are placed into a multitude of individual, curved recess tubes or individual holes. The saddle or cradle itself is embedded into the concrete and cannot be replaced. However, individual strands can be replaced if necessary. Differential forces are transferred by friction.

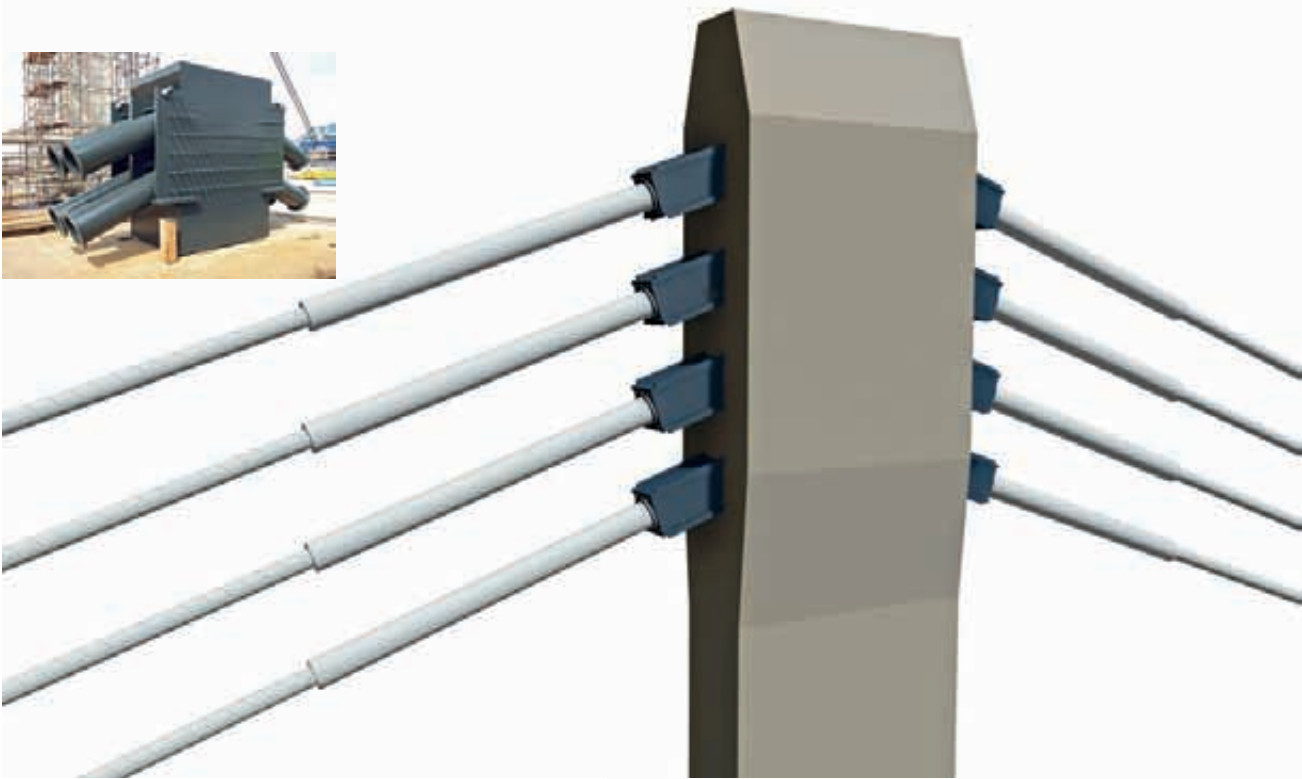
Both systems permit an economic design of the pylon because access shafts within the pylon can be eliminated, which results in a pylon with minimal

dimensions. Nevertheless, both alternatives entail a few disadvantages:

- Stay cable assembly requires simultaneous work cycles on both sides of the pylon when building the superstructure, which usually results in longer cycle times for cantilever construction.
- Strand assembly is complex because the strands have to be pulled across the saddle, and in some systems, the PE coating of the strand needs to be removed at the saddle.
- In some systems, differential forces are only transferred by friction so that the stay can slip over the saddle in cases of extreme load.
- The saddle structures have to undergo very complex and time-consuming qualification tests, and minimum radii must be taken into consideration.
- The exchange of individual strands is sometimes not possible or only feasible along the complete length of the stay cable from one superstructure anchorage to the opposite anchorage.
- Strand inspection in the critical deviation area is only possible by complex replacements.

Due to these disadvantages, deviation saddles for stay cables in road bridge construction have been explicitly excluded in current regulations in some countries such as Germany.





As an alternative to conventional deviation saddles, DSI has developed a new system that includes the advantages of saddles without the disadvantages detailed above. The new DYNA® Link System is based on conventional steel anchor boxes in which stay cables are anchored inside the pylon in a steel anchor box. As a result, the horizontal forces of the stay cables are transferred by the anchor box. What is new about the DYNA® Link Anchor Box System is that the stay cable anchorages are located outside of the pylon so that the inside of the pylon does not need to be accessible. Consequently, the pylon design can be economical and slender, and it can be accessed for inspection from the outside by industrial climbers or via hoisting platforms.

The DYNA® Link Curved Anchor Box can be assessed in terms of bearing capacity, serviceability and fatigue in accordance with conventional steel construction standards and does not require any complex tests. The anchor box can be adjusted to the respective structure, and there are no limitations in terms of deviation radii or differential forces. It is even possible to only replace a single strand bundle on one side of the pylon or to carry out the assembly of the stay cables as flexibly as in the case of common stay cables with anchorages located inside the pylon. The quantity of strand on both sides of the pylon can also differ, so that the strand bundles can be economically designed. As the strands are not deviated across a saddle in the DYNA® Link Curved Anchor Box, there are no limitations in any national regulations.

The DYNA® Link Curved Anchor Box System is being used for the first time at the Chao Praya River Crossing Bridge in Bangkok, Thailand. The 96 Type DG-P 37 and DG-P 55 strand bundle stay cables that are used for this extradosed bridge are anchored at a total of 48 DYNA® Link Anchor Boxes.



Extension of Hong Kong's Subway System using customized DYWIDAG Bar Anchors

APAC

China

Slope
Stabilization

The subway system in Hong Kong, the MTR (Mass Transit Railway), was opened in 1979 and today carries approx. 2.45 million passengers per day on a rail network of 211.6km. In 2011, work began on an extension of the 7.1km long South Island Line, which connects the southern part of the island of Hong Kong with the public transportation system.

The new section runs through a 3.5km long tunnel from Admiralty station, is then carried by a 2km long viaduct and runs through a 1.6km long second tunnel at the end of the section. The underground sections are predominantly constructed using the drill & blast method.

In areas with soft ground, some tunnels are also built in shallow excavations using the cut and cover method. MTRC904 is one of these sections. In this area, the Ap Lei Chau Tunnel is being built using the cut and cover method for Lei Tung and South Horizons stations. For the new tunnel, a pipe pile wall had to be constructed in advance of the excavation.

DSI Far East developed special temporary anchors consisting of \varnothing 36mm DYWIDAG Bars, and also supplied the accessories needed for tying back the pipe pile wall. The anchors will be removed after completion of the structure.

The bottom anchorage consists of a 36mm threaded machined cone nut with one sealed end and a 200mm long steel tube. The DYWIDAG Bar, which is covered by a duct along its complete length, is screwed into the cone nut. The duct is fixed on a sealed steel tube in order to prevent grout intrusion. The complete anchor unit is then installed into the whaling along the pipe pile wall and fully grouted.

After completion of the project, the anchors will be de-tensioned and the bars unthreaded from the bottom cone nut. Thanks to the completely removable bar anchors, the future development of the neighboring area can proceed without having to deal with any obstructions.

i

Owner MTR Corporation Limited, Hong Kong, China
General Contractor Leighton-John Holland Joint Venture
Design URS Corporation, China

DSI Unit DYWIDAG-Systems International Far East Ltd.,
 Hong Kong
DSI Scope Supply of temporary \varnothing 36mm
 DYWIDAG Bar Anchors, and accessories



Balanced Cantilever Segmental Box Girder Construction in Indonesia: Elevated Highways for Jakarta

Every day, 236 cars and 891 motorcycles are newly registered in Jakarta. In order to relieve critical traffic congestion, a decision was made to construct several toll free elevated highways in the city. The 4.8km long Pangeran Antasari-Blok M elevated highway runs from North to South, the 3.4km long Kampung Melayu-Tanah Abang section runs from West to East through Jakarta. Work on these elevated highways started in December 2010 and was completed in mid-2012.

The elevated highways were constructed using the balanced cantilever method and consist of segmental box girders that are internally post-tensioned. The many advantages of this method, such as fast and versatile construction, the avoidance of disruptions underneath the bridge and cost effectiveness have made it the preferred solution for many elevated highways, especially in Jakarta City.

DSI's licensee PT Delta Systech Indonesia participated in the development and construction of both projects. In total, 1,172t of strand were used for the 15-0.6" and 19-0.6" DYWIDAG Strand Tendons that stabilize the segmental box girders and the portal beams of the elevated highways. DYWIDAG Bars are also used for the temporary stressing and fixation of the segments during the erection work.

PT Delta Systech Indonesia cooperated with another DSI licensee, Utracon Structural System Pte Ltd, Singapore, to erect the segmental box girders. Eight sets of fully automatic lifter frames were used to erect almost 1,000 segments for the Pangeran Antasari-Blok M section.

The owner was very satisfied with the exact alignment and placement of the segmental box girders and is planning to also award a contract to both companies for the erection of the box girders in the next section.



i

Owner DPU DKI Jakarta, Indonesia

General Contractor Hutama Karya – Nindya Karya JO (Section Brawijaya / package 3); Modern – Lampiri JO (Section Prapanca / package 4); PT. Waskita Karya (Section Lapangan Mabak / package 5)

Architect PT Perentjana Djaya, Indonesia

Engineering PT DELTA SYSTECH INDONESIA, Indonesia & Utracon Structural Systems Pte Ltd., Singapore

DSI Units PT DELTA SYSTECH INDONESIA, Indonesia & Utracon Structural Systems Pte Ltd., Singapore

DSI Scope Supply and installation of 1,172t of DYWIDAG Strand Tendons, 15-0.6" and 19-0.6"; erection of the segmental box girders in balanced cantilever method using eight lifter frames

The New Tomei Expressway - DYWIDAG Systems stabilize 31 New Bridge Structures

In April 2012, approximately 162km of the New Tomei Expressway between Tokyo and Nagoya were opened.

The new expressway is located on the south-eastern coast of Honshu, Japan's main island, and runs parallel to the existing Tomei Expressway. The new expressway alleviates traffic congestion on the old Tomei Expressway and improves accessibility of Japan's three major cities.

The overall length of the bridges and viaducts on the New Tomei Expressway is 51.6km. Construction work was often difficult due to the fact that large rivers, steep hills and mountains had to be crossed.

In order to achieve cost-efficiency, environmental sustainability, construction efficiency and low maintenance, a large number of the structures were built as prestressed concrete bridges in accordance with the latest technologies of the Central Nippon Expressway Company. Among other structures, this included precast segmental box girder bridges with strutted wing slabs, prestressed concrete continuous corrugated steel web box girder bridges and prestressed concrete continuous rigid frame composite truss bridges.

Sumitomo supplied DYWIDAG Systems for a total of 31 bridge structures along the New Tomei Expressway.





A large part of the strand post-tensioning systems were used as external and internal tendons. In addition to Type 12S 15.2 MA DYWIDAG Strand Tendons with bare strands, Sumitomo also supplied Type 19S15.2 MC DYWIDAG Strand Tendons with epoxy coated and filled strand as well as Type 19S15.7 MC DYWIDAG Strand Tendons with epoxy coated and filled high strength strand.



Owner Central Nippon Expressway Co. Ltd., Japan

DSI Unit Sumitomo Electric Industries Ltd., Japan
Sumitomo Scope Supply of Type 12S 15.2 MA, 19S15.2 MC and 19S15.7 MC DYWIDAG Strand Tendons

Use of DYWIDAG Strand Post-Tensioning Systems in Confined Areas: The Nakano Viaduct

Recently, the Nakano Viaduct was built near the Ebina-Minami intersection south-west of Tokyo, Japan. As the viaduct had to be built on soft ground in a narrow piece of land sandwiched between a river and a residential area, a special beam hoisting construction method using precast U-beam segments had to be employed.

Since sufficient space for installing multiple production beds to produce the U-beams that fit between each pier was not available, the main longitudinal girders were produced in five separate segments. Once completed, the 35m long, 175t segments were lifted onto the bridge pier heads.

The girders for the underside of the bridge deck were also produced in the yard and post-tensioned using the 12S 12.7 MA DYWIDAG Strand System with bare strands. The girders were transported to the bridge on special trolleys running on rails and lifted onto the bridge piers. Consequently, the girders were connected to the main segment of the bridge pier using the external 19S 15.2 MC DYWIDAG Strand System with epoxy coated and filled strands, and the joints were concreted.

The composite slabs of the bridge deck consist of pretensioned precast panels and cast-in-place concrete. Pre-grouted 1S 21.8 prestressing strands were installed in the limited cantilever deck which is designed to accommodate the emergency parking area.



Owner Central Nippon Expressway Co. Ltd and Atsugi Construction Office, both Japan

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

Architect Sumitomo Mitsui Construction Co., Ltd., Japan

DSI Unit Sumitomo Electric Industries Ltd., Japan

Sumitomo Scope Supply of the 12S 12.7 MA DYWIDAG Strand System with bare strands and the 19S 15.2 MC DYWIDAG Strand System with epoxy coated and filled strands

DYWIDAG Strand Tendons stabilize Sanagawa Bridge in Japan



The Sanagawa Bridge is part of the New Tomei Expressway and spans the Sanagawa River in the city of Toyokawa. The design-build contract for the bridge also included the technical proposal for the construction of the superstructure and substructure, including the earthwork. Neither the span lengths nor the type of bridge structure were detailed in the bid invitation and therefore, each could be determined flexibly by the companies.

Kajima suggested a 6-span continuous rigid frame box girder made of prestressed reinforced concrete. Due to topographical conditions, the bridge piers are up to 89m high. They consist of high-strength reinforced concrete with a design strength of 50N/mm² and high-strength reinforced steel with a yield strength of 685N/mm², which ensures improved seismic resistance and durability. The bridge measures roughly 700m in length, with a maximum single span of 142m. The bridge is the fourth highest in Japan and the highest on the New Tomei Expressway.

The post-tensioning method used for the bridge is combined prestressing with unbonded external and bonded internal tendons. The Type 12S15.2MA DYWIDAG Strand Post-Tensioning System with bare strand was used for a portion of the continuous tendons and for all cantilever tendons, which were installed as bonded internal tendons. The remaining continuous tendons consist of external Type 19S15.2MC DYWIDAG Strand Tendons with epoxy coated and filled strand. The transverse post-tensioning of the deck slabs was carried out using pre-grouted Type 1S21.8 Prestressing Strand.



Owner Central Nippon Expressway Co. Ltd., Japan
General Contractor Kajima Corporation, Japan
Architect Kajima Corporation, Japan

DSI Unit Sumitomo Electric Industries Ltd., Japan
Sumitomo Scope Supply of Type 12S15.2MA and Type 19S15.2MC DYWIDAG Strand Tendons





*Bridging the Gap
between Challenge and Solution*

Permanent *GEWI*® Anchors stabilize modern Power Plant in Incheon City

The Youngheung coal fired power plant in Incheon City near Seoul, South Korea, was built to ensure energy supply in the Chungnam region. Since the beginning of construction work in 2004, four units have been completed which generate 20% of the electric energy supply in the metropolitan area. After completion of units 7 and 8 of the heating plant, it will supply 40% of the required energy in the region.

Units 5 and 6, which have been under construction since December 2010, have capacities of 870 MW each and are equipped with innovative filters that considerably reduce air pollution.

For stabilizing the foundations of units 5 and 6, DSI Korea supplied permanent *GEWI*® Anchors with double corrosion protection. The *GEWI*® Anchors that were used were planned as passive anchors able to compensate both tension and compression forces. Furthermore, the double corrosion protection is an efficient shield against seawater induced corrosion. Within the scope of the foundation works for sections 5 and 6, a total of 336 double corrosion protected permanent *GEWI*® Anchors in lengths of 8m was installed.

The client, KOSEP, was very satisfied with the installed double corrosion protected *GEWI*® Anchors. Consequently, the *GEWI*® Anchor System will also be used for other power plants as well as for units 7 and 8.



i

Owner Korea South East Power Co., Ltd. (KOSEP), Korea
General Contractor GS Engineering & Construction Co. Ltd, Korea
Subcontractor Shinwoo Construction Co., Ltd., Korea
Engineers Hyundai Engineering Co., Ltd., Korea

DSI Unit DYWIDAG-Systems Korea Co. Ltd., Korea
DSI Scope Supply of 336 permanent double corrosion protected *GEWI*® Anchors

Improving Infrastructure in Myanmar: Hledan Junction Viaduct, Yangon

Due to the rapid growth in traffic density in the city of Yangon in the South of Myanmar and in order to minimize congestion, construction work on a new overpass at Hledan Junction began in January 2012.

The overpass is 430m long and 15.4m wide. The foundation of the bridge consists of reinforced concrete bored piles. The superstructure consists of 14 spans that accommodate a total of four lanes. The pier columns and pilecaps were built as reinforced concrete elements, the pier crossheads as prestressed concrete elements. The bridge deck consists of composite steel plate girders and a reinforced concrete slab with handrails.

As a specialist subcontractor, Utracon Overseas Pte Ltd was asked to carry out the following scope of work in the project:

- supply and installation of Type 27-0.6" DYWIDAG Strand Tendons with MA Anchorages in the pier crossheads
- design and supply of the formwork systems for the pier columns and crossheads
- design and supply of the parapet and flower trough sliding formwork

The overpass is an important improvement of Yangon's infrastructure. Construction work on this project was completed in April 2013.



i

Owner Yangon City Development Committee, Myanmar

General Contractor Shwe Taung Development Co. Ltd, Myanmar

Contractor Shwe Taung Development Co. Ltd, Myanmar

Consulting Engineers T.Y.Lin International Pte Ltd, Singapore

Consulting Tokyu Construction Co. Ltd, Japan

DSI Unit Utracon Overseas Pte Ltd, Singapore

Utracon Scope Supply and installation of Type 27-0.6" DYWIDAG Strand Tendons with MA Anchorages; design and supply of formwork systems for column, crosshead, parapet and flower trough

Spectacular Views at Gardens by the Bay, Singapore



The award winning park Gardens by the Bay is located in the immediate vicinity of Marina Bay Financial District in Singapore and was designed by the world renowned architects Grant Associates and Wilkinson Eyre. Extending over 101ha, the park accommodates two giant, dome-shaped conservatories containing more than a quarter of a million rare plants that are native to Mediterranean and semi-arid subtropical climates.

In view of the large scale architectural planning and the efforts spent on energy conservation, structural design issues were only of secondary importance in this project. Notwithstanding, the construction of the giant conservatories posed some very challenging engineering problems. In order to provide a large amount of column free space and to allow maximum sunlight into the two conservatories, a decision was made not to use any vertical supports for the architectural steel-glass structures of the giant structures.

The floors of the 3-storey Flower Dome and 6-storey Cloud Forest were also designed with minimum column supports. For this purpose, the

floors were post-tensioned using DYWIDAG Strand Tendons. Utracon, DSI's licensee in Singapore, supplied \varnothing 0.6" DYWIDAG Strand Post-Tensioning Systems with 12, 15 and 19 strands for the slabs and beams.

At the Flower Dome, a 17m long cantilever platform projects out majestically. This elegant engineering structure would not have been possible without the use of a post-tensioning design.

General Contractor Woh Hup (Pte) Ltd, Singapore
Architect Wilkinson Eyre Architects, Great Britain;
 Grant Associates, Singapore
Consulting Engineers Atelier One, Great Britain;
 Meinhardt Infrastructure Pte Ltd, Singapore

DSI Unit Utracon Structural Systems Pte Ltd., Singapore
Utracon Scope Design, supply and installation of
 Type 0.6" DYWIDAG Strand Post-Tensioning Systems
 with 12, 15 and 19 strands



DYWIDAG Post-Tensioning System ensures Modern Infrastructure in Sri Lanka

The Kallady Bridge connects the cities of Batticaloa and Arrasady in Sri Lanka. The steel Bailey bridge, which was built by the British over 70 years ago, serves more than 10,000 motorists per day. Due to the narrow width of the bridge, traffic is halted in one direction at a time to give way to traffic from the opposite direction.

After the end of the civil war in 2009, the Road Development Authority of Sri Lanka decided to build a new bridge parallel to the existing bridge.

In May 2012, following a two-year delay, the government brought in the specialist companies MAGA and Utracon to take over the project and aim for an early completion of the job. The new Kallady Bridge has a dual roadway and will allow traffic in both directions. There are also pedestrian walkways on both sides of the roadway. The bridge has 6 spans, connected by 54 precast post-tensioned box girders, each with a length of 48m and a weight of 180t.

Utracon installed the strand tendons in the precast girders, carried out the post-tensioning and grouting work in the precast yards and was tasked with the logistics as well as the erection of the girders into their final position on the bridge. The Type 9-0.6" DYWIDAG Strand Post-Tensioning System with MA Anchorages and the DYWIDAG Bar Post-Tensioning System, \varnothing 47mm, 26mm and 20mm, were used in this project.



Precast yards were established at both ends of the bridge in which the precast hollow box girders were fabricated. The box segments were then lifted onto a temporary platform by lifting gantries and transported to the launching location by rail. The girders were put in place on the bridge using a self-launching erector.

Due to space constraints in the precast yards and in order to achieve optimum productivity, the production and erection of the precast concrete girders were carried out simultaneously. The positioning and lifting of the 48m long girders posed great challenges within the narrow precast yards.



Owner Road Development Authority, Ministry of Highways and Road Development, Sri Lanka

General Contractor State Development and Construction Corporation, Sri Lanka

Contractor MAGA Engineering (Pvt) Ltd, Sri Lanka

Consulting Engineers Oriental Consultants Co., Ltd, Japan; Nippon Koei Co., Ltd, Japan; Engineering Consultants Ltd, Sri Lanka

DSI Unit Utracon Overseas Pte Ltd, Singapore

Utracon Scope Supply and installation of Type 9-0.6" DYWIDAG Strand Post-Tensioning Tendons with MA Anchorages and of DYWIDAG Bar Tendons, \varnothing 47mm, 26mm and 20mm; transporting and launching of the precast concrete elements

Safe Journey with DSI: Construction of a Rock Fall Gallery on the Reschen Federal Road

EMEA

Austria

Slope
Stabilization

Due to extreme weather conditions, many streets in Austria are exposed to rock falls. In order to increase traffic safety, the Tschingels Gallery is being built in Tyrol on the Reschen Federal Road (B 180). In addition to the 116m long gallery, several rock fall fences and retaining walls as well as a 108m long bridge running along the slope will be built.

St 555/700 GEWI® Plus Anchors. In addition, each of the 10 pier foundations was reinforced with three 8m long corrosion protected \varnothing 63.5mm, St 555/700 GEWI® Plus Micropiles each that were vertically installed during stabilization work.

The superstructure of the gallery bearing structure will be additionally tied back to the rock face using GEWI® Plus Anchors in 2013. Five double corrosion protected \varnothing 50mm, St 555/700 GEWI® Plus Anchors



On the jobsite, the Reschen road runs directly underneath a 100m high rock face that overhangs the roadway in some places. To build the gallery, the overhang had to be partially removed above the road. Foundations for the retaining wall of the Tschingels Gallery were excavated at the downhill facing side of the road to a depth of approx. 10m underneath the street level.

For this purpose, each pier foundation was tied back horizontally into the rock face using 15m long, double corrosion protected \varnothing 63.5mm,

in individual lengths of 8m will be tied back horizontally to the rock face at the individual blocks.

For the construction of the Tschingels Gallery, DSI Austria produced and supplied a total of 168 GEWI® Plus Anchors and Micropiles in individual lengths of 8 and 15m.

i

Owner Federal State of Tyrol, Federal Road Administration, Austria

Contractor Joint Venture, consisting of Alpine, Hilti & Jehle, Austria

Engineers IBPA Ingenieurbüro Passegger-Autengruber ZT-GmbH, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production and supply of 168 double corrosion protected \varnothing 63.5mm GEWI® Plus Piles and of \varnothing 50mm GEWI® Plus Micropiles in lengths of 8 and 15m

Reinforcement of an existing Retaining Wall at Lake Brennersee

Near the border between Austria and Italy, the railroad line from Innsbruck to the Brenner Pass includes an embarkation area for what is known as ROLA ("Rolling Highway"). ROLA is a special transport system - also known as the Roll On Roll Off System - that is used for carrying trucks and tractor trailers by train. To stabilize the railroad line, a tied back retaining wall was built on both sides of the embarkation area in 1989 and 1990.

Due to discernible deformations and damage to the retaining wall, the retaining system had to be reinforced after more than 20 years in service. Construction work mainly included the addition of a second anchor level located approx. 0.5m below the existing anchor level.

The existing support system consists of an approx. 300m long, anchored retaining wall with walers and braces. The retaining wall has a cut width of 8m and a stabilized height of approx. 9m.

Within the scope of the reinforcement work, the support system was reinforced using grouted anchors in an additional anchor level. DSI produced and supplied 1,430m of permanent 2-0.6", double corrosion protected DYWIDAG Strand Anchors, in individual lengths of 13m each as well as 110 anchor heads. The permanent strand anchors that were subsequently installed were only tensioned to approx. 50 to 80kN after installation and grouting.

A continuous and close co-ordination with the Austrian Federal Railways (ÖBB) was necessary at all times because the reinforcement measures were carried out at the same time as other maintenance work along the complete Brenner track.



Owner ÖBB-Infrastruktur AG, Austria
Contractor Grund- Pfahl- und Sonderbau GmbH, Austria
Engineers IBPA Ingenieurbüro Passegger-Autengruber ZT-GmbH, Austria

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Production and supply of 1,430m permanent 2-0.6", double corrosion protected DYWIDAG Strand Anchors, in individual lengths of 13m each as well as 110 anchor heads

Tensioning for High Tension: DYNA Grip® Stay Cables stabilize Wind Power Station

The Finnish company Wasa Wind now produces energy using a 3.6 MW wind power generator in Vaasa.

What is special about this power station is its height: The hub is 125m high. The highest point of the rotor blade tips is 184m.

The wind generator is currently the highest wind turbine in Finland and produces energy for 600 family homes.

Due to higher wind speeds at this elevation, the wind power generator can produce more energy than conventional wind turbines. At the same time, higher vibrations are developed that have to be transferred into the foundations via the shaft.

In order to effectively protect the \varnothing 5m steel tower against wind speeds of more than 12m/s and to increase its tilting stability, DSI was commissioned to supply and install six Type DG-P 37 DYNA Grip® Stay Cables. The stay cables consist of 37 waxed and PE sheathed strands each with a total weight of 23t.

The stay cables were installed at the shaft at a height of approximately 66m and individually anchored in the soil using a steel abutment as well as two DYWIDAG Strand Anchors with 22 strands each. In three places, two DYNA Grip® Stay Cables were positioned 1m above one another at the tower. The lower stay cables have lengths of 72m, and the upper three cables are 75m long.

During the installation, the ducts for the first three stay cables were lifted with the first three strands and the strands were stressed. Afterwards, the crane stabilizing the tower could be removed.



The remaining strands were inserted using two cable winches, but not immediately stressed.

This was necessary in order to also ensure the tower's stability during the construction phase. Afterwards, the last three DYNA Grip® Stay Cables were installed in the same fashion.

All of the strands were tensioned as agreed with the owner following a sequence that had been previously determined. The patented ConTen Tensioning System with control unit ensured a uniform distribution of the forces in all strands. The installation of the stay cables was completed successfully at the end of 2011.



Owner Mervento Oy, Finland

DSI Units DYWIDAG-Systems International GmbH, Technical Services;
DYWIDAG-Systems International GmbH, Headquarter Operations, both Germany

DSI Scope Supply and installation of six Type DG-P 37 DYNA Grip® Stay Cables and 12 DYWIDAG Strand Anchors, 22 strands; technical assistance and installation surveillance on site; supply and rental of equipment

Seismic Stability with DYWIDAG Bars: The Haspelbaechel Viaduct in Lorraine

The Haspelbaechel Viaduct is located in the Vosges Mountains near the Alsatian Plain. As part of the East European High Speed Line, it links Paris with eastern France and southern Germany. Since railway lines for high speed trains may only include very small curves, the section across the Haspelbaechel valley was built as a 270m long viaduct with 40m high piers.

In order to minimize the environmental impact on the Northern Vosges Nature Park, the viaduct was built with five spans with lengths of 58m each. Recently, the hollow box girder bridge deck, which had been originally built in 2001 using the cantilever method, was transformed into a double steel beam structure as a result of new seismic design regulations.

Within the scope of the seismic rehabilitation, the bridge abutments were stabilized using 6 horizontal \varnothing 75mm DYWIDAG Post-Tensioning Bars. The post-tensioning bars had to be tensioned in accordance with a very specific predefined sequence in order not to destabilize the abutments. First, the DYWIDAG Post-Tensioning Bars were individually tensioned to 50%. Afterwards, they were tensioned to their final post-tensioning force of 300t.

Following a request of the general contractor Eiffage Construction Métallique, a test was carried out at the 50% tensioning level using a load measurement sensor in order to prove that the bars were being tensioned correctly. This test required the approval of two different engineering offices. After the successful completion of the tests, the DYWIDAG Post-Tensioning Bars were tensioned to their final loads.

The accuracy of the installation was particularly important because this was the first time such an abutment rehabilitation was being done in France. Consequently, the Post-Tensioning System only had a total load allowance of only 5%.

The DYWIDAG Post-Tensioning Bars used in this project were restressable bars in ducts that had been injected with wax. In order to test the completeness of the bars' corrosion protection and to make sure there were no leaks or permeable connections between the injection port and the vents, the impermeability of the ducts was tested using compressed air before injecting the wax.



Preparation of Wax Injection into the Ducts



Seismically stable Abutment with 6 DYWIDAG Bars



Owner RFF (Réseau Ferré de France), France
Contractor Eiffage Construction Métallique, France

DSI Unit DSI-Artéon SAS, France
DSI Scope Supply, installation, tensioning and injection of 6 horizontal \varnothing 75mm DYWIDAG Bars

Technique Béton supplies Quality Products for modern LNG Terminal in Dunkirk

EMEA

France

Commercial Buildings

A modern LNG terminal is being built in Dunkirk Harbor, the most important French harbor in the North Sea. After its completion in 2015, the 50ha terminal will have an annual regasification capacity of 10-13 billion m³, which roughly equals 20% of current natural gas demand in France.



The three post-tensioned LNG tanks, each with a diameter of 90m and wall thicknesses of 80cm, are approx. 50m high and have a capacity of 190,000m³. A concrete batch plant was built on site in order to produce the 40,000m³ of concrete needed for each tank.

In its LAROCHE® plant, Technique Béton produced two types of concrete spacers for the LNG tanks: SU spacers for wall thicknesses of 70 to 90cm as well as reinforced barrettes. These spacers are made of C50/60 concrete in order to obtain a resistance of 50MPa. The sulfate resistant cement that was used is suitable for aggressive marine environments.

In order to protect the new LNG terminal from flooding, two embankments measuring 1,715m and 2,260m were built. For this purpose, the Bouygues construction group produced X-shaped precast concrete elements with a weight of 10 and 40t respectively that were positioned at precise locations using a GPS system. For ensuring a high quality facing of the elements, the company selected Technique Béton's CIRTEC® mould release agent that consists of wax and can be precisely applied.

Technique Béton is proud to have met the requirements of this project in terms of quality and delivery quantity.



Client EDF, France

General Contractor Joint Venture, consisting of Bouygues Travaux Publics and ENTREPROSE Contracting, both France

DSI Unit Technique Béton, France

Technique Béton Scope Supply of LAROCHE® SU spacers and of reinforced LAROCHE® barrettes; supply of the mould release agent CIRTEC®

Berlin: Fast Construction Progress and Watertight Structures with contec® and recostal®

There are many canals, rivers and lakes in the city of Berlin. That is why suitable construction materials and concepts are necessary in order to safely control standing and pressurized ground water. The company Deutsche Immobilien AG built a high quality residential, hotel and office complex near the Friedrichsstrasse Train Station that was completed in the summer of 2012.

The planners in DSI's Porta Westfalica branch found a competent partner and supplier for waterproofing products and technology in contec Systems. Beginning in the planning phase, DSI's project department supported the architects by proposing a comprehensive waterproofing concept.

In order to provide an economic method of ensuring a high degree of impermeability against water pressure, a Preprufe® sealing strip for unset concrete was used to seal the exterior and closed surfaces. It also served to provide additional impermeability to the structure and results in a watertight and gas proof building in accordance with the high quality requirements of use.

Preprufe® is a multi-layer, robust HDPE sealing strip consisting of a pressure-sensitive adhesive layer, a walkable acrylic coating that is insensitive to weather conditions and a removable protective foil. The product develops an unrivalled, holohedral adhesive bond with the unset concrete, thus permanently preventing infiltration. It creates a surface seal that is completely closed, watertight and gas proof as well as extremely elastic. This product makes it possible to bridge cracks up to 5mm wide. In addition, Preprufe® displays high chemical durability and permanently protects the concrete from aggressive media. The surface seal has been issued a general approval by the building authorities of North Rhine-Westphalia's material testing establishment confirming its resistance to a water pressure of 5 bar and can be used up to a water column of 2 bar.

For the new buildings in Berlin, more than 5,000m² of sealing strip were laid. All of the planning details and special conditions encountered during construction were safely and efficiently managed by DSI Porta Westfalica's

technical support team, always taking into account an optimized handling for the installation on site. Thanks to the sealing strip, the concept of crack width of the concrete elements could be economically sized, resulting in a noticeable reduction in the amount of steel used.

For the client, this construction concept proved to be more economic on the whole. The sealing system contaflexactiv was chosen as a waterproofing for the 2,500m of expansion joints in the concrete. contaflexactiv ensures double security in the region of the expansion joints beyond its barrier effect with bentonite swelling sealing. The bentonite used is natural natrium bentonite with a high ratio of swelling and a high degree of resistance. Its permanent activation behavior in ranges between low and high water levels has been successfully proven. The sealing properties are activated immediately. The seal effect of the contaflexactiv product line has been approved by the material testing society and testing laboratory for the construction industry Leipzig (MPFA Leipzig), confirming its resistance to a water pressure of 2 bar (maximum pressure load 5 bar / 2.5 factor of safety = 2 bar).

For faster construction cycles, the recostal® lost formwork system was used in individual concreting segments during formwork removal. The elemental construction method generates the highest amount of bearing capacity with the profiled joints in the joint category "toothed" according to DIN 1045-1 – respectively EC 2. At the bottom, recostal® 2000 was used for removing the formwork. Based on a formwork plan,



Berlin, Am Zirkus 1



Preprufe® – the Sealing Strip System for unset Concrete with Approval for Sealing Surfaces.

DSI supplied the prefabricated elements just-in-time, custom-fit and ready for installation in accordance with construction progress. This ensured a fast, efficient and economic construction of the bottom or joint formwork.



Preprufe® Sealing Strip in the Wall Area with additional contaflexactiv Joint



Owner Deutsche Immobilien AG, Germany
General Contractor Ingbau; ARGE, consisting of Züblin and Aug. Prien Bauunternehmung, all of them Germany
Engineers Drei Plus Planungsgruppe, Germany
Architect Eike Becker, Germany

DSI Unit DYWIDAG-Systems International GmbH, BU Concrete Accessories, Germany
DSI Scope Supply of: Preprufe® sealing strip for unset concrete, contaflexactiv sealing system, recostal® lost formwork system; design of a waterproofing concept and a formwork plan, technical support on site

DYNA Grip® Stay Cable System for new Landmark: The Elbe Bridge Schoenebeck

With a traffic volume of approx. 13,500 vehicles per day, the town center of Schoenebeck near Magdeburg is heavily congested. Work on the B 246a ring road was begun as early as 2004. The last section of this ring road to be built was a new crossing over the Elbe River near Schoenebeck.

The 1,128.5m long and 11.6m wide bridge has one lane per direction. The bridge consists of three sections – the 309m long southern approach bridge, the 489m long bridge across the river employing the stay cables and the 330.5m long northern approach bridge.





The superstructures of the approach bridges consist of single-webbed precast concrete T-beams that were erected in eight sections using the cantilever method with falsework. An asymmetric stay cable bridge featuring one pylon at the southern shore and a span of 185m had to be built for the bridge across the river.

This bridge section has a light, bonded superstructure consisting of a hermetically welded single-webbed steel composite section and a concrete roadway slab with a thickness of 30cm. It is balanced via the stay cables and the 73m high pylon with three post-tensioned concrete side sections. Thanks to the A-shaped pylon shafts, the high loads of the cantilever bridge section across the river can be distributed on a maximized foundation area.

The alignment of the stay cables is fan-shaped in two external planes. Per plane, nine cables are tensioned in the direction of the bridge section across the river, and nine are tied back to the lateral sections.

The section of the bridge that crosses the river was erected in ten stages with factory assembled steel elements using the cantilever method. Working from the sections of the bridge that had previously been finished, the stay cable pairs were installed and tensioned in each new section. Afterwards, the deck slab of the 18.5m long segments was cast. The next section was erected as soon as the concrete of the previous segment had cured.

Approximately 340t of DYWIDAG Strand Tendons were installed as prefabricated tendons with subsequent bond for the prestressed concrete superstructures. DSI will also supply a total of 36 Type DG-P 31, DG-P 37 and DG-P 55 DYNA Grip® Stay Cables as well as approximately 205t of strand. The strand used will be waxed and PE coated St 1570/1770 N/mm² strand consisting of seven galvanized, cold finished, smooth individual wires with a circular section. For monitoring stay cable forces, elastomagnetic DYNA Force® sensors will be mounted on six of the cables.

The town of Schoenebeck's new landmark was completed in the summer of 2013.



i

Owner Federal State of Saxony-Anhalt and city of Magdeburg, Germany

General contractor Landesbetrieb Bau Sachsen-Anhalt, Germany

Contractor Joint Venture, consisting of Kirchner Holding GmbH and Donges SteelTec GmbH, both Germany

Planner/Technical Development Leonhardt, Andrä und Partner Beratende Ingenieure VBI, GmbH, Germany

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

DSI Scope Supply of approximately 340 t of DYWIDAG Strand Tendons and of 36 Type DG-P 31, DG-P 37 and DG-P 55 DYNA Grip® Stay Cables; DYNA Force® Monitoring System

Mastering Challenges: Construction of three Tanks at Moorburg Power Plant

EMEA

Germany

Tanks

Vattenfall, a German electric power company, is constructing a new coal-burning power plant in Hamburg. Three new ash filter power plant tanks were built as part of the power plant.

The first tank has a height of 55m and a circumference of 70m. The tank is post-tensioned with 8 strand tendons consisting of 15 \varnothing 150mm² strands and 100 horizontal strand tendons consisting of 9 \varnothing 150mm² strands. On the whole, 45t of strand tendons were produced, supplied and installed for the 55m high tank.



The other two silos have a height of 70m and a circumference of 100m each. 282 strand tendons consisting of 12 \varnothing 150mm² strands, 128 strand tendons consisting of 9 \varnothing 150mm² strands and 24 strand tendons consisting of 5 \varnothing 150mm² strands with a total post-tensioning steel weight of 580t were installed in these tanks. The tendons are anchored at the exterior walls of the tanks on four buttresses, with two tendons forming a full circle and the next post-tensioning group being aligned at a displacement of 90°.

The main challenge was that the individual tendons had to be subsequently installed, post-tensioned and grouted at a height of up to 70m. Assembly was carried out on two suspended platforms, with the jacks being mounted on separate lifts. Two jacks at two opposite buttresses were used to tension full circles. The grouting of the tendons was also carried out on the suspended platforms.

Despite the fact that construction work was often obstructed by storms, the installation, post-tensioning and grouting work at the two large tanks was carried out within a very short time-span. The power plant is scheduled for completion in 2014.

i

Owner Vattenfall Europe Generation AG, Germany
Contractor Wayss & Freytag Ingenieurbau AG, Germany
Engineering Vattenfall Europe Power Consult GmbH, Germany

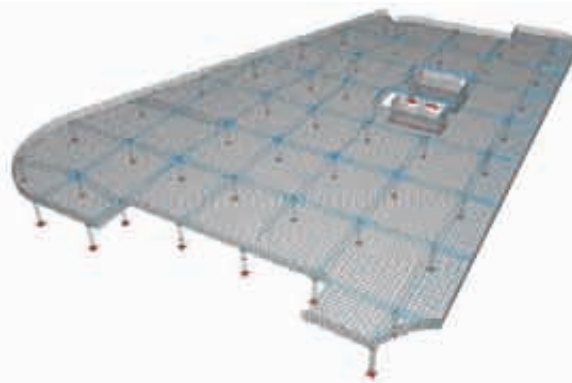
DSI Unit DYWIDAG-Systems International GmbH, BU Post-Tensioning, Germany

DSI Scope Supply, installation and injection of 15-0.6", 12-0.6", 9-0.6" and 5-0.6" strand tendons

The Schlosshoefe Oldenburg: Post-Tensioning of Flat Slabs using Monostrand Tendons



On the 16th of March 2011, a new shopping center was opened in Oldenburg's city center. The new shopping center is known as Schlosshoefe and includes 12,500m² of sales area, approx. 900m² of office space and room for cultural events.



Due to the retail center's special architecture, the individual ceilings were constructed as post-tensioned flat slabs. The building has a total of six floor slabs, all of which were post-tensioned using the unbonded Monostrand Post-Tensioning System according to ETA-03/0036 (Z-13.72-30036).

The first three slabs were poured in eight sections, the fourth and sixth slabs were poured in three sections, and the fifth slab was poured in two sections. Some of the Tendons were connected with fixed couplers and extended. The remaining Monostrand Tendons were installed as continuous tendons. In total, 146t of Monostrands, 705 stressing anchorages, 705 fixed anchorages and 252 fixed couplers were installed.



Owner KG Panta 29 Grundstücksgesellschaft m.b.H. & Co., Germany

General Contractor ECE Projektmanagement GmbH & Co. KG, Germany

Contractor Läer + Rahenbrock GmbH & Co KG, Germany

Architects Dipl.-Ing. Architekt Jost Hering, Dipl.-Des. Architektin Gisela Simon, Germany

Engineers Oltmanns & Partner GmbH, Germany

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

DSI Scope Supply and installation of 146t of DYWIDAG Monostrand Tendons with 705 stressing anchorages, 705 fixed anchorages and 252 fixed couplers



Repair of the Kriebstein Hydro Dam using 50m long DYWIDAG Strand Anchors

EMEA

Germany

Structural
Repair Solutions

The 9km long Kriebstein Dam, located approximately 60km west of Dresden, was built between 1927 and 1929 to generate electricity. The gravity dam is curved in a radius of 225m and is 235m long and 34m high at its crest.

The dam retains the Zschopau River and generates electricity using three Francis turbines in one of Saxony's largest hydropower stations. Originally, the normal pool level had a height of 214m and was regulated by four spillways on each side. This system only ensured limited flood control.



In order to comply with new regulations, the dam crest was raised by 1.25m within the scope of comprehensive repairs in the 90's. The normal pool level now measures 215.5m above sea level.

Subsequent calculations that were carried out recently determined that the dam was no longer stable. The Max Bögl construction company was awarded a contract for the second repair of the structure because of their having proposed a special solution in the area of the anchor heads.

DSI supplied permanent strand anchors for this project because the approval of the DYWIDAG Strand Anchors that were used made it possible to grout the anchor length directly on site. Additionally, DSI was able to supply the strand anchors to the site coiled on drums, which helped save space on the dam's crest.

DSI Koenigsbrunn supplied a total of 24 permanent 22 strand DYWIDAG Strand Anchors in 50m lengths for the repair of the Kriebstein Dam. In addition, DSI supplied the post-tensioning jacks needed for testing and stressing the anchors, and one of DSI's experienced technicians was on site to assist the repair team.



General Contractor Max Bögl Spezialtiefbau, Germany

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

DSI Scope Supply of 24 50m long permanent 22 strand
DYWIDAG Anchors, rental of post-tensioning jacks;
technical assistance

DYWIDAG Strand Anchors stabilize New City District: The Milaneo in Stuttgart

79

Construction

EMEA

Germany

Excavation

The “Milaneo”, a new, lively city district is currently being built in the heart of Stuttgart, the German federal state of Baden-Wuerttemberg’s capital. It is scheduled for completion in the summer of 2015 and will include more than 30,000m² of residential area and approx. 43,000m² of commercial space.

The three buildings that are linked by bridges are located in the “Europaviertel” district and will also include service and restaurant areas, 7,400m² of office space, 8,300m² for hotel accommodation as well as approx. 200 shops.

The Züblin construction company was asked to build a turnkey shopping center with a parking garage on the premises. The excavations in three working panels had to be stabilized by Berlin walls and bored pile walls.

The walls were tied back using temporary DYWIDAG Strand Anchors that were installed in two to three anchor levels. The anchor heads were countersunk into the Berlin walls. Angle adjustment was achieved using bearings welded to the U profiles. This way, the seated rectangular anchor plates, wedge supports and PE caps disappear inside the bearing structure and do not represent an obstacle on site. For the bored pile walls, the bearings for the round anchor heads were created by core hole drilling at the appropriate angles.

The fact that nearly 50,000m or 55t of strand had to be produced within a mere eight weeks at DSI Koenigsbrunn’s factory near Augsburg represented a challenge in this project. However, production took place simultaneously on three production lines, and the 768 Type 4-0.6” temporary DYWIDAG Strand Anchors in lengths of 12 to 25m were produced and supplied on time.



Photos reprinted courtesy of Züblin Spezialtiefbau GmbH, Germany



i

Client ECE Projektmanagement G.m.b.H. & Co. KG, STRABAG AG and Bayerische Hausbau GmbH & Co. KG, all of them Germany

General Contractor Züblin Spezialtiefbau GmbH, Germany

Architect RKW Rhode Kellermann Wawrowsky GmbH + Co., Germany

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

DSI Scope Production and supply of 768 temporary DYWIDAG Strand Anchors with 4 strands each in lengths of 12-25m

DSI supplies DYNA Grip® Stay Cables for new Waschmuehltal Bridge

In conjunction with the six-lane extension of federal highway A6 between Mannheim and Saarbruecken, the Waschmuehltal Bridge, which is a listed monument, is being repaired and widened. For this purpose, a new bridge is being built on the north side parallel to the existing historical sandstone arch bridge. The structure was planned as a continuous post-tensioned beam with spans of 45.05m, 2 x 68.10m and 45.55m and is very thin due to the masts that are placed above the piers and the slim tendons.

The superstructure is built using the composite construction method, with the main girders consisting of welded steel hollow box girders. The masts are designed as steel structures tapering down from top to bottom. The stay cables consist of parallel strand bundles with adjustable anchorages in the superstructure and non-adjustable anchorages in the masts. The galvanized, waxed and PE coated strands (St 1570/1770) are hexagonally aligned using a guide deviator on both sides and are inserted in HDPE ducts.

The alignment of the 22 to 27m long stay cables resembles the shape of a harp in two exterior planes. Three stay cables are located on each side of each mast. For six masts, a total of 36 Type DYNA Grip® DG-P 55 Stay Cables with a maximum capacity of 55 strands are used. The actual number of strands



per stay cable is 42. This makes it possible to add strands in reaction to higher loads caused by increasing traffic volumes in the future.

For stay cable installation, the strands are individually placed in the ducts using a hydraulic pushing device. The tensioning work was carried out using the patented ConTen Method with control unit in order to ensure a uniform allocation of strand forces.





The individual approval (ZiE) necessary for the DYNAGrip® Stay Cable Method was issued by the Landesbetrieb fuer Mobilitaet Rheinland-Pfalz. Prior to this, the DIBt (German Institute for Civil Engineering) had issued the necessary advisory opinion.



i

Owner Landesbetrieb Mobilitaet Kaiserslautern, Germany

Contractor Joint Venture Waschmuehlalbruecke, consisting of ALPINE Bau Deutschland AG and Plauen Stahl Technologie GmbH, both Germany

Architect Leonhardt, Andrä und Partner and AV1 Architekten GmbH, both Germany

Engineers IWS Beratende Bauingenieure, Germany

DSI Units DYWIDAG-Systems International GmbH, BU Post-Tensioning; DYWIDAG-Systems International GmbH, Headquarter Operations, both Germany

DSI Scope Supply and installation of 36 Type DYNAGrip® DG-P 55 Stay Cables; technical assistance and installation management on site; rental of equipment

Environmental restoration using DYWI® Drill Hollow Bars: Schondelle Creek in North Rhine-Westphalia

Within the scope of the environmental restoration of the Emscher River in North Rhine-Westphalia, Germany, the southern branch, the Schondelle, is being converted from what is now an underground combined wastewater canal. The Schondelle is being uncovered, and a new canal is being built exclusively for sewage disposal in the underground excavation.

The creek is being restored along a length of 1,000m and will be fed directly into the Emscher River. This measure both protects the environment and provides flood prevention in the area.

During the excavation for the new streambed, DSI supplied 3,200m Type R32-280 DYWI® Drill Hollow Bars with accessories that were used as a permanent soil nailing system for stabilizing the banks.

The DYWI® Drill Hollow Bar is a fully threaded self-drilling anchorage system which can be simultaneously drilled and grouted without the need for bore hole casing. The system is especially suitable for loose, collapsing or unstable soils. Type R32-280 Hollow Bars attain an ultimate load of 280kN and an ultimate strength of 680N/mm².



Owner Stump Spezialtiefbau GmbH, Germany
General Contractor Joint Venture, consisting of Kirchner Holding GmbH and Johann Bunte Bauunternehmung GmbH & Co. KG, both Germany

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

DSI Scope Supply of 3,200m of Type R32-280 DYWI® Drill Hollow Bars

Cost-Efficiency and Fast Construction Progress: Ring Tendons Strengthen Silos near Ulm

In 2012, ThyssenKrupp Polysius AG awarded a contract to DSI to repair silos No. 6 and 7 on the factory grounds of the Schwenk company in Allmendingen near Ulm.

In order to strengthen the silos, an additional exterior concrete wall with a height of approx. 3.5m was built around each tank. 9 unbonded ring tendons were installed horizontally in the exterior wall and post-tensioned in accordance with DIN 1045-1 and DIN Technical Report 102.

Additionally, both silos were strengthened up to a height of 25m using double extruded unbonded monostrand Ring Tendons.

At silo No. 6, a total of 200 double extruded monostrands were externally installed and post-tensioned. DSI's scope also included the production and supply of 100 horizontal beams with two tendons each, 37 ladders with a total length of 192.2m and 1,692 hooks.

Silo No. 7 was post-tensioned using 146 ring tendons. Assembly also required 73 horizontal beams, 27 ladders with a total length of 153.75m and 1,236 hooks.

The fully sheathed SUSPA Systems Monostrand Tendons were positioned in pairs in special horizontal beams that, like the ladders, were produced by DSI in Langenfeld. The ring tendons were successfully installed and anchored at both silos.



Owner ThyssenKrupp Polysius AG, Germany
Contractor Schwenk Zement KG, Germany

DSI Unit DYWIDAG-Systems International GmbH,
BU Post-Tensioning, Germany
DSI Scope Production, supply and tensioning of
346 Monostrand Tendons, Type SUSPA Systems,
as well as of 173 horizontal beams and 64 ladders

The Rethe Bridge: DYWIDAG Geotechnical Systems for Europe's largest Bascule Bridge

The Rethe Lift Bridge was built in 1934 at the southern rim of Hamburg's inner harbor area in Germany. It is currently being replaced by a new structure which rests on a single substructure and features separate superstructures for road traffic and the harbor train. The old grade level crossings are being replaced so that road traffic will no longer be held up by passing trains. Shipping will also benefit from the considerably widened waterway, which will have a width of 64m instead of 44m.



Both the road and the railroad bridge are designed as double-winged steel bascule bridges with a counterbalance at the bottom. The bridges' main span measures approx. 104.2m between the pivot bearings. The road bridge has a total width of approx. 14m, the railroad bridge has a total width of 10.2m. The main girders are designed as welded hollow box girders.

The single span foreshore bridges south of the bascule bridges are designed as separate superstructures with a distance of 40m between supports that rest on the abutment of the lifting bridge.

The railway bridge is built using the steel construction method, and the foreshore bridge of the road bridge is designed as a composite structure consisting of steel and concrete.

As they are located in the Rethe River, the construction of the two leaf pillars required a watertight excavation employing a tied-back underwater concrete slab. The existing foundation soil required a deep foundation with grouted piles. The two excavations had dimensions of 28 x 34m and 29 x 34m.

The excavations were reinforced with interior walers and sets of struts. The grouted piles were used as uplift control for the underwater concrete slab during construction and then used as deep foundation elements after completion of the structure. Consequently, the grouted piles had to be anchored in the underwater slab and in the foundation slab of the leaf pillars. The grouted piles were arranged in a grid of 1.8 x 1.8m and in lengths of 25 to 30m beneath the bottom edge of the underwater slab. In order to prevent any possible movement of the leaf pillars, the pillars were additionally tied back using grouted piles.

DSI produced and supplied DYWIDAG Micropiles made of *GEWI® Plus* steel that were installed as grouted piles into the foundations and used as tie-back anchors in the leaf pillars. In total, approx. 18.000m of double corrosion protected, Ø 63.5mm and Ø 75mm DYWIDAG Micropiles made of *GEWI® Plus* steel were installed at the jobsite. Additionally, DSI also supplied the complete range of accessories needed for the micropile systems including anchor heads and couplers. DSI also rented the equipment necessary for the pile and anchor tests as well as for tensioning the micropiles.

Thanks to the excellent co-operation between all parties involved, the DYWIDAG Micropiles were supplied just in time to the jobsite. The project is scheduled for completion at the end of 2013.

i

Owner Hamburg Port Authority, Germany
General Contractor Joint venture, consisting of HOCHTIEF Aktiengesellschaft and F+Z Baugesellschaft mbH, both Germany
Contractor Neidhardt Grundbau GmbH, Germany
Consulting Engineers Ingenieurgesellschaft Grassl/Sellhorn; Steinfeld & Partner, both Germany

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

DSI Scope Supply of Ø 63.5mm and Ø 75mm DYWIDAG Micropiles made of *GEWI® Plus* steel including accessories; rental of equipment

Summer Holidays without Traffic Jams: DYWIDAG Systems stabilize Autostrada Adriatica

85

Construction

EMEA

Italy

Slope
Stabilization



The A 14 motorway in Italy, which is also known as the Autostrada Adriatica, starts near Bologna and connects the North and the South of the country. Construction work is currently underway between northern Rimini and Pedaso in order to widen the motorway from two to three lanes in each direction along a total length of 171km.

The widening of the motorway is designed to provide relief during peak traffic that currently totals up to 107,000 vehicles per day during the summer months. In addition to the third lane, five new motorway exits and one emergency lane per direction are being constructed.

DYWIT participated in the section between the towns of Cattolica and Fano, which features several steep 45 degree slopes. In the upper slope section, safety mesh with a mesh size of 1.30 x 1.30m was used to stabilize the slopes. DYWIT supplied 6m long double corrosion protected \varnothing 26.5mm DYWIDAG Soil Nails to secure the mesh.

Additionally, the slope toes were stabilized by several sheet pile walls. In the area of the pile heads, the sheet pile walls are tied back with 26m long double corrosion protected \varnothing 36 and 40mm DYWIDAG Bar Anchors that were subsequently grouted.

The experienced colleagues of DYWIT provided technical support on site and supplied the equipment needed for installation and grouting. The DYWIDAG Soil Nails and Bar Anchors supplied for this project had a total length of approx. 90,000m.



Owner Autostrade per l'Italia Spa, Italy
Contractor Pentapoli S.c.a.r.l. – Imola, Italy
Consulting Engineers SPEA Ingegneria Europe, Italy

DSI Unit DYWIT S.P.A., Italy
DYWIT Scope Supply of double corrosion protected \varnothing 26.5mm DYWIDAG Soil Nails and of \varnothing 36 and 40mm DYWIDAG Bar Anchors; technical support, rental of equipment

Comfort and Design: The Marina d'Arechi

The Marina d'Arechi is a modern and convenient wharf for up to 1,000 boats with lengths between 10 and 100m. Located east of Salerno, the marina is one of the largest in the Mediterranean and offers moorings with water depths of up to 7m.

In order not to affect the coast in this area by construction work, extensive meteorological and marine studies were carried out during the construction of the marina. This also included state-of-the-art physical and mathematical modelling simulations under the direction of HR Wallingford, the prestigious British Institute for Research.

DYWIT supplied a total of 7,600m of double corrosion protected \varnothing 50mm DYWIDAG GEWI® steel Tie Rods to stabilize the new berths.



The production of the tie rods was carried out in accordance with EN 1537. The system offers the following main advantages:

- Easy handling due to hot rolled coarse thread over the entire length
- DYWIDAG Tie Rods can be cut to the desired length after alignment – the system does not require thread recuts
- Couplers, fixed and flexible connections as well as special parts are available
- Robust coarse thread is suitable for jobsite conditions

Each berth will be equipped with the latest and most efficient electrical supply systems as well as water supply and sanitation in order to offer maximum comfort to clients of Marina d'Arechi.

Owner Gallozzi Group, Italy
General Contractor Impresa Pietro Cidonio S.p.A., Italy
Architect (Marina Buildings) Santiago Calatrava, Spain
Engineers Ing. Migliorini, Italy

DSI Unit DYWIT S.P.A., Italy
DYWIT Scope Supply of 7,600m of double corrosion protected \varnothing 50mm DYWIDAG Tie Rods made of GEWI® steel

Efficient Uplift Control using *GEWI*[®] Piles at the Sluiskil Tunnel

The existing swing bridge near Sluiskil in Southwestern Netherlands is one of the biggest bottlenecks along the channel from Ghent to Terneuzen. The bridge has to be opened frequently to passing ship traffic, leaving it useable to road traffic for just five hours per day.

In order to allow road traffic to move freely, work on the new Sluiskil Tunnel began in October 2011. The double tube tunnel runs underneath the channel, thereby creating a bypass to the swing bridge. The 1,330m long (including access ramps) double tube tunnel is being driven using a Tunnel Boring Machine (TBM). The two approx. 1,150m long, 11m diameter tunnels will accommodate two lanes each after their completion. At their lowest point, the tubes are more than 30m below sea level.

The entry and exit ramps for the tunnels are built in excavations that are up to 15m deep. These excavations also serve as a starting and reception shaft for the TBM. A bottom seal had to be installed for the waterproof excavations. The underwater concrete slabs had to be additionally secured against uplift due to the high prevailing water pressure. For this purpose, DSI produced and supplied a total of 999 Ø 63.5mm *GEWI*[®] Piles with anchor plates in average lengths of 25.3m. The installation was executed by a subcontractor joint venture of BAM Speciale Technieken and Voorbij Funderingstechniek, both the foundation specialists of BAM Civiel and TBI Mobilis respectively.

Due to a layer of clay underneath the excavations that exhibited swelling both during and after the excavation work, the *GEWI*[®] Piles were fitted with special casings to minimize the influence of the swelling loads. The special casings were designed to prevent the clay from adhering to the *GEWI*[®] Piles so that the access and exit ramps for the Sluiskil Tunnel could be built in a way that was both economical and time efficient.

In addition, DSI also supplied 279 temporary DYWIDAG Strand Anchors in lengths of 36m and 29 removable 47 WR DYWIDAG Bar Anchors in lengths of 56m for tying back the sheet pile walls.



i

Owner Government of the Province of Zeeland, Netherlands
Owner's Representative BV KanaalkruisingSluiskil (KKS), Netherlands

General Contractor Joint Venture BAM TBI, consisting of BAM Civiel BV and Wayss & Freitag Ingenieurbau AG, Germany; Croon Elektrotechniek B.V. and TBI Mobilis, both Netherlands

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

DSI Scope Production and supply of 999 Ø 63.5mm *GEWI*[®] Piles with special casings; 279 temporary DYWIDAG Strand Anchors and 29 removable DYWIDAG Bar Anchors, 47 WR



DYWIDAG Post-Tensioning Systems and DYNA Grip® Stay Cables for Ewijk Cable Stayed Bridge

The Waal Bridge near Ewijk in the Netherlands is part of the A50 motorway, one of the country's most important north to south corridors.

The existing bridge with a main span of 270m was built between 1971 and 1976 and is one of the longest bridge structures in the Netherlands. Due to the importance of the A50, the Rijkswaterstaat, the executive arm of the Dutch Ministry of Infrastructure and the Environment, decided to widen the A50 motorway between Ewijk and Valburg in both directions from two to four lanes each over a distance of 7km.

For this purpose, a second bridge running west of the existing bridge was built over the Waal River. In addition, the motorway junctions of Ewijk and Valburg were expanded.

The entire project was carried out within the scope of a Design-Build contract. The consortium responsible for its execution and design is Waalkoppel, a consortium consisting of Mobilis, Van Gelder B.V. and DYWIDAG Bau GmbH. The architectural design of the new Waal Bridge is adapted to the appearance of the existing steel bridge so that the two bridges will form a unified architectural entity in the future. However, a post-tensioned concrete structure with additional stay cables was chosen for the new bridge.

The bridge is a typical post-tensioning bridge with a total length of 1,055m. The bridge construction is divided into the southern approach area with spans of 75.0m + 90m + 90m + 90m + 105m = 450m, a main span of 270m as well as the northern

approach area with spans of 105m + 85m + 75m + 70m = 335m. The extraordinary bridge design by the German engineers Kinkel und Partner included a maximum construction depth of 4.25m for the post-tensioned concrete superstructure, with the superstructure depth in the large span across the river being reduced to 3.35m. Two small hollow box girders were laterally connected using approx. 21.80m long precast girders, which results in a total bridge width of 32.5m. Bonded PT strand tendons are located in the hollow box girders and between the lateral girders.

The Waal Bridge was built using a combination of incremental launching and cantilever construction. Starting from the abutments, both approach bridges were simultaneously constructed using the incremental launching method. The incremental launching area extends approximately 20m into the main span area. After completion of the incremental launching section, the launching noses were removed in the southern and northern sections. DSI supplied a total of 1,200t of strand tendons for the longitudinal and transverse post-tensioning of the bridge deck. Simultaneously, the two parallel, 52m high pylons and the form travellers were built. Thanks to the combination of these construction methods, negative impact on the valuable landscape of Waal River was kept to a minimum. The concentric post-tensioning during incremental launching was carried out using prefabricated PT tendons. The Type SUSPA Systems Prefabricated Tendons were installed into the reinforcing cage of the floor and roadway slabs within a short time span.





PE sheathing using pushing equipment with driving rollers. The pushing equipment, which was set up at the tip of the pylon, pushed down a steel wire inside the PE sheathing towards the superstructure. There, the steel wire was connected to the strand, and subsequently, the pushing equipment pulled the wire with the attached strand upwards through the pylon anchorage where the strand was anchored.

Additionally, the 32 longest stay cables were fitted with external dampers to limit cable vibrations. The dampers were installed following the completion of work at the DYNA Grip® Stay Cables.



This procedure significantly reduced interference with the other subsections (in particular with concrete formwork and reinforcement).

In the final state, eccentric and parabolic DYWIDAG PT Tendons were used in the longitudinal girders of the hollow boxes to complement the concentric post-tensioning that had been installed while construction was in progress. For these tendons, the strands with a maximum length of approx. 108m were pushed into ducts that had been previously positioned.

In the transverse direction, the two hollow box girders were connected to each other using precast concrete elements. Prefabricated tendons with 8 and 9 strands respectively were also used between the U shaped precast elements. The tendons were anchored at the interior girders of the two hollow box girders using SD Plate Anchorages.

In the main span, the bridge's bearing capacity is augmented by 19 strand DYWIDAG Tendons that are located externally in the hollow box girders.

A staggered arrangement without deviation was chosen for the tendons. The external tendons were anchored at the girders using brackets.

The 270m long main span was erected using the stayed cantilever method in sections of approx. 5m. To stabilize the cantilever sections, temporary stays were installed in addition to the permanent DYNA Grip® Stay Cables. Afterwards, the temporary stays consisting of the 15 and 19-0.62" DYWIDAG Strand Post-Tensioning System with MA Anchorages were successively removed in accordance with the construction progress.

Both stay levels of the cable stayed bridge are fitted with two different types of stay cables. DSI produced and supplied 40 DYNA Grip® Stay Cables each of types DG-P 73 and DG-P 91 in lengths of 57m to 126m totaling 850t for this project. The stay cables were arranged in pairs.

DSI also provided the equipment necessary for installation and carried out the complete installation of the stay cables. The strands were installed into the



Owner Rijkswaterstaat, Netherlands

General Contractor Joint venture, consisting of Mobilis B.V., Netherlands, DYWIDAG Bau GmbH, Germany and Aannemingsmaatschappij Van Gelder B.V., Netherlands

Engineers Kinkel + Partner, Germany

Architects Paul Wintermans van Quist Wintermans Architecten, Netherlands

DSI Units DYWIDAG-Systems International GmbH, BU Post-Tensioning, Germany; DYWIDAG-Systems International B.V., Netherlands

DSI Scope Installation, tensioning and grouting of approx. 1.000t of prefabricated tendons as well as of tendons assembled on site, 8-0.62", 9-0.62", 19-0.62" and 22-0.62" with MA Anchorages and SD Plate Anchorages; engineering, production, supply and assembly of 80 Type DG-P 73 and DG-P 91 DYNA Grip® Stay Cables





First Contract for Launching an Incremental Bridge in Poland

The S3 highway is an important North-South connection located in western Poland. After its scheduled completion in 2015, the highway will run from Swinemuende on the Baltic Sea to the Czech border in southwestern Poland. The WS-09 Bridge between the Polish cities of Miedzyrzecz and Sulechów forms part of this project.

The 404m long bridge consists of two parallel structures with individual spans of 34m + 8 x 42m + 34m. The bridge features two challenging elements: a horizontal curvature and a vertical gradient of 1.6%.

Originally, both bridge decks were to be built using a movable scaffolding system (MSS).



Due to the fact that there was a rapidly approaching deadline for completion, necessitating that both lanes be built at the same time, the contractor started looking for an alternative solution to accelerate the construction cycle.

The owner asked DSI Poland to supply a special technical solution. The decision was quickly made to build the second bridge deck using the incremental launching method. DSI supported the owner during the optimization of the hollow box girder cross section and the tendon alignment. In addition,

DSI supported the construction site in the realization of the needed structural alterations such as the abutment reinforcement for the launching equipment. Furthermore, DSI supplied the complete technical equipment needed for incremental launching.

DSI employees provided the necessary know-how and supported the jobsite during the execution and supervision of the construction work. At the beginning of August 2012, DSI began to implement a solution that was both economical and optimized for the requirements. Making it possible to complete the work within the very limited time-span, this solution both took into account the bridge's complex geometry and the current state of construction.

DSI suggested the construction of the bridge superstructure using the incremental launching method as the best and most economical method. Both the design and the economic viability of this solution convinced the owner. Within a mere six months, the technical problems for incremental launching that resulted from the complex geometry were solved. Within the same time span, the new construction method was adapted to the current state of construction so that the demanding schedule for the completion of the bridge deck was met successfully. At the end of August 2012, DSI Poland already started the production of the first segments. This required previous redesign of the reinforcement in the abutment on which the launching equipment was to be assembled.

DSI supplied the following products and systems for this project:

- A launching nose with high-strength connections and steel post-tensioning strand
- DYWIDAG Bar Tendons for tying back the launching equipment, the launching bearings and the launching nose
- Bonded DYWIDAG Strand Tendons
- Eberspaecher AH-317 launching equipment with a lifting load of 2,200t, a launching force of 9,120kN and a breaking force of 4,290kN – one of the most high-capacity equipment sets currently available on the market
- 22 lifting jacks of 100t each for lifting the formwork on to the launching bearings
- 4 lifting jacks of 500t each for exchanging the sliding bearings
- 22 sliding bearings for reducing the friction forces at the supports

Most incrementally launched bridges are built on a 7-day cycle. Usually, three to four multi span supports have to be produced before reaching an optimum 7-day cycle. Thanks to the excellent preparatory work and on-site co-operation, the 7-day cycle was already achieved for the second part of the bridge superstructure.



For this purpose, the complete superstructure was divided into 10 segments (9 x 42m + 1 x 26m). The launching of a multi span support only took 7 hours, which permitted a launching speed of 6m per hour.

The construction of the individual multi span segments – specifically the hollow box girder cross sections – was carried out in sections behind the abutment in the construction yard. On Tuesdays and Wednesdays, the formwork was aligned, the reinforcement was installed and the ducts and tendons were installed in the formwork. On Thursdays, the 42m long multi span segments were concreted in the formwork, and the tendons of the previously assembled segments were grouted. Fridays and Saturdays were needed for the concrete to harden in the formwork. On Mondays, the formwork was removed, the multi span segments were lifted by a few millimeters, and the bridge section was launched together with the previously completed section above the pillars in order to be able to build the following section.

DSI's employees, who had been trained by the Eberspächer company, assembled the launching equipment on site and successfully carried out the launching work on a 7-day cycle. Due to the complex vertical curvature and the selected launching method, the individual multi span segments had to be accurately positioned in order to avoid problems during the launching of subsequent segments.

Thanks to the worldwide exchange of know-how within the DSI network, DSI Poland was able to offer a technically sophisticated and fast solution for the project. The complete construction of the bridge superstructure and the launching of the bridge segments were successfully completed within the tight schedule.

Finally, the sliding bearings necessary for launching had to be replaced by permanent bridge bearings at the pillars. During this project, DSI Poland demonstrated the high degree of competence and the global know-how of DSI as a specialized system supplier for technically demanding solutions.



i

Owner GDDKiA o. Zielona Góra, Poland
General Contractor Mota-Engil Central Europe S.A., Poland
Consulting Engineers Stähler + Knoppik Ingenieuresellschaft mbH, Germany

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

DSI Scope Production and supply of 199 t of DYWIDAG Post-Tensioning Tendons 4, 7, 19 and 22-0.62" with MA Anchorages; supply of temporary DYWIDAG WR Bar Tendons, execution and supervision of the installation and launching work



First Use of DYWIDAG Strand Anchors in Bukarest

Within the scope of the Floreasca City Center district development, the SkyTower, which is Romania's tallest building with a height of 137m and with 37 floors, is being built in the North of Bukarest in addition to the FCC Promenada Shopping Center and the Floreasca Office complex.

Once completed, the FCC Promenada Mall Shopping and Entertainment Center will offer attractive and modern shopping opportunities for thousands of people who work and live in the area.

Following the collapse of an excavation, the use of strand anchors had been prohibited for ten years in Romania. In close co-ordination with the contractor STRABAG SRL, Bukarest and the engineers, Dipl.-Ing. Kurt Ströhle ZT GmbH, Vienna, DSI Austria proposed a special solution using one layer of DYWIDAG Strand Anchors with a service load of 1,000kN for stabilizing the excavation.

In December 2011, four test anchors in lengths of 23 and 27m were supplied to the site, which included two Type 7-0.62" temporary DYWIDAG Strand Anchors. All of the anchors were successfully installed in the presence of the planning office Dipl.-Ing. Kurt Ströhle ZT GmbH, and a comprehensive test demonstrated that the technical requirements were fully met.

Afterwards, DSI Austria produced and supplied a total of 3,765m of Type 7-0.62" DYWIDAG Strand Anchors in lengths of 20 to 27m with special vents for two post grouting operations as well as 155 anchor heads with angle compensation capability of between 10 and 17 degrees. In addition, five 1,250kN capacity anchor load plates were installed for monitoring purposes. These anchors had to demonstrate that constant forces were maintained during the complete construction time in accordance with the requirements of the engineers.

Furthermore, DSI Austria produced and supplied 151m of Type 9-0.62" temporary anchors in lengths of 8.5 to 30m with 16 anchor heads for corner reinforcement using tendons. They also supplied the complete equipment needed for installation,



grouting and tensioning of all anchors. DSI is proud to have found an optimum and innovative solution for this project in close co-operation with the client STRABAG SRL and the engineers Dipl.-Ing. Kurt Ströhle ZT GmbH.



Owner Raiffeisen Evolution, Austria
Contractor STRABAG SRL, Romania
Subcontractor Drilling Work Züblin SRL, Romania
Engineers Dipl.-Ing. Kurt Ströhle ZT GmbH, Austria;
 STROEHLE ENGINEERING SRL, Romania
Executing Company Züblin Romania SRL, Romania

DSI Unit DYWIDAG-Systems International GmbH, Austria

DSI Scope Production and supply of 3,765m of replaceable DYWIDAG Strand Anchors, 7-0.62"; 151m of DYWIDAG Strand Anchors, 9-0.62", with 16 anchor heads, 5 load cells with 1,250kN; rental of the complete tensioning equipment

Chasing the World Record: New Ski Jump in Planica

Ski jumping looks back on a long tradition in what is known as the valley of ski jumps in Planica, Slovenia. The first ski jumps in this region were built before 1930.

Today, the “Letalnica bratov Gorišek“ ski jump, or for short, Letalnica, is the world’s second largest jump. Up to now, 28 world records in ski jumping have been established here.

Since July 2011, the new Planica Nordic Center is being built in this valley. Construction work includes the construction or retrofit of a total of 9 jumps, new cross-country ski runs and new tribunes in order to meet the demands of the 100,000 ski jumping enthusiasts that visit for the annual ski jumping weekend.

The retrofit of the famous Letalnica ski jump requires special attention. From 2014 onward, Letalnica will permit jumps up to 270m, which will set a new record by making this ski jump the world’s largest.

The landing zone is especially important during the construction or retrofit of ski jumps. This area is often very steep and has to be stabilized –

The bar anchors were installed by MINERVO D.D. using rotary percussive drilling equipment. Construction work was completed to the full satisfaction of the owner.



respectively anchored – extensively. The landing zone features a convex curve towards the jump-off platform and a concave curve towards the landing slope. The transition between the two curves is known as the critical point.

During the construction and retrofit of the jumps in Planica, the steep inclinations in the landing zone were tied back using horizontal concrete walers. For several jumps, DSI produced and supplied Type R32 DYWI® Drill Hollow Bar Anchors as well as the complete range of system accessories such as couplers, drill bits and adapters.



Owner Zavod za šport RS Planica, Slovenia
General Contractor Gradbeni Holding – GH D.D., Slovenia
Subcontractor MINERVO D.D., Slovenia

DSI Unit DYWIDAG-Systems International GmbH, Austria
DSI Scope Production and supply of Type R32, 250kN DYWI® Drill Hollow Bar Anchors and system accessories

DYWIDAG Strand Tendons stabilize New High Speed Rail Line in Spain

EMEA

Spain

Bridges

Due to its location, the town of Antequera in the province of Málaga in southern Spain is an important transportation hub both from North to South – from Cordoba to Málaga – and from East to West - from Granada to Seville. Due to its strategic location, an important railway hub was built here for high speed trains from Madrid or Málaga to Granada.



In each section, DSC installed at least 16 tendons and carried out the post-tensioning and grouting work afterwards.

Both 37-0.6" and 12-0.6" DYWIDAG Strand Tendons with MA Anchorages and couplers were used in the 490m long Ramal Málaga-Granada Viaduct, which was built in nine construction phases. Six 37-0.6" DYWIDAG Strand Tendons and four 12-0.6" DYWIDAG Strand Tendons were installed per section. Installation was followed by tensioning and grouting.

In sections 4, 5 and 6, DSC also installed additional 19-0.6", 22-0.6" and 27-0.6" DYWIDAG Tendons with MA Anchorages for reinforcement. The tendons that were used had a total weight of approx. 120t.

Furthermore, DSC supplied \varnothing 25mm GEWI® Bar Anchors, which were used for the catenary support foundations. Construction work on the new section for high speed trains began in January 2012 and was completed in February 2013.



DYWIDAG Sistemas Constructivos (DSC) participated in the construction of two viaducts in the Málaga-Granada section in both directions. Since the project was constructed within a very tight schedule, both viaducts had to be built at the same time. Each construction phase took two weeks. Phase construction was always time-delayed by a week so that the construction of both bridges could be carried out using the same equipment.

For the 380m long Guadalhorce Viaduct, which was built in eight sections, DSC supplied 19-0.6" DYWIDAG Strand Tendons with MA Anchorages and couplers with a total tendon weight of 150t.

i

Owner ADIF (Administrador de Infraestructuras Ferroviarias), Spain
General Contractor Joint Venture Antequera, consisting of Sogeos S.A., Peninsular de Contratas, S.A., Mipelsa, all of them Spain
Consulting Engineers ACL, Spain

DSI Unit DYWIDAG Sistemas Constructivos S.A., Spain
DSC Scope Supply, installation, tensioning and injection of 172 19-0.6" DYWIDAG Strand Tendons with MA Anchorages, 40 12-0.6" DYWIDAG Strand Tendons, 60 37-0.6" DYWIDAG Strand Tendons and 8 22-0.62" and 27-0.6" DYWIDAG Strand Tendons; supply of \varnothing 25mm GEWI® Bar Anchors

Reaching high with external Prefabricated Tendons: Wind Farms in Spain

Acciona is one of the world's largest producers of wind power turbines and operates approx. 22% of all wind parks in Spain. In 2011, DSI began a collaboration with Acciona to promote the use of prefabricated post-tensioning tendons for the construction of concrete wind towers.

Acciona 100 and 120m concrete towers are installed within their AW3000 product range equipped with 100m, 109m and 116m rotors. Acciona Technology concrete towers are made of precast concrete segments that are assembled into towers on site.

Concrete towers are post-tensioned with external strand tendons. Furthermore, short Type WR Bar Tendons are used for anchoring the tendons. The tendons used are prefabricated external DYWIDAG Tendons that are supplied to the jobsite just in time.

As soon as the coils with external prefabricated tendons arrive on site, the assembly of a complete tower starts, and the prefabricated tendons are



installed vertically. Each delivery includes the complete range of tendons necessary for assembling a full tower.

Consequently, a complete tower tensioning system can be assembled within two days' time, and while the first installation team moves to the next tower, a second team can start stressing the external prefabricated tendons.

The prefabrication of the tendons in Langenfeld, Germany, combined with a precise timing both during transportation of the coiled tendons to the jobsite and when returning the empty coils to Langenfeld, offers a fast, flexible and safe solution to the client.



Owner Acciona Windpower, Spain
Consulting Engineers Acciona Windpower, Spain

DSI Units DYWIDAG Sistemas Constructivos S.A., Spain;
DYWIDAG-Systems International GmbH,
BU Post-Tensioning, Germany

DSI Scope Supply, installation and post-tensioning of external tendons; supply of Type WR DYWIDAG Tendons



DYWIDAG Tendons ensure Efficient Construction Progress at Al Ahwar Complex

EMEA

Jordan

Commercial Buildings



Al Ahwar Street is one of the most famous shopping streets in Amman, the capital of Jordan. A seven story building is being constructed on this street on a total area of 10,000m²: The Al Ahwar Complex.

The building includes several restaurants, a supermarket, retail stores and a play area as well as parking spaces and is especially family-friendly.

Similar to most construction projects in the Middle East, the rapid completion of the shopping center was a decisive factor during the construction of the Al Ahwar Complex. Consequently, the building's flat slabs were post-tensioned using DYWIDAG Monostrand Tendons because of their easy and quick installation.

Flat 3-0.5" and 5-0.5" MA Anchorages were used for this purpose. The tendons were post-tensioned using a Type SM 240 kN Monostrand Jack supplied by DSI.



DSI provided technical assistance to the subcontractor and ensured that the installation was in accordance with DSI's high quality standards.



Owner Eng. Faraj Zghier, Jordan
Contractor Mohammad Abbas Contracting Co., Jordan
Architect George Zabaneh Engineers, Jordan
Consulting Engineers George Zabaneh Engineers, Jordan
Post-Tensioning Subcontractor Al Assas for Concrete Products Co. Ltd., Jordan
Consulting Post-Tensioning eConstruct FZ-LLC, UAE

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

DSI Scope Supply of 3-0.5" and 5-0.5" MA Anchorages; sales of a Type SM 240 kN Monostrand Jack and a hydraulic pump Type 77-193; technical support on site

DYWIDAG Tendons ensure Fast Construction Cycles: The Al Atoom Center in Jordan

The Al Atoom Center is a modern building complex on Al Gardens Street, one of the most popular shopping streets in Amman, Jordan. The ten story building includes offices, retail stores and underground garages and has a total floor area of 20,000m².

The building's flat slabs were post-tensioned using DYWIDAG Monostrand Tendons. Post-tensioning with DYWIDAG Tendons is space saving and ensures very fast construction cycles due

to the system's efficiency. DSI supplied flat 3-0.5" and 5-0.5" MA Anchorages for the Al Atoom Center. The post-tensioning and grouting work was carried out using a Type SM 240 kN Monostrand Jack and a Type 77-193 hydraulic pump, both of which were supplied by DSI.

Thanks to DSI's technical support, the project was successfully completed within a very short time frame.



i

Owner Mr. Mohammad Al Atoom, Jordan
Contractor Al Assriya Contracting Co., Jordan
Architect George Zabaneh Engineers, Jordan
Consulting Engineers George Zabaneh Engineers, Jordan
Post-Tensioning Subcontractor Al Assas for Concrete Products Co. Ltd., Jordan
Consulting Post-Tensioning eConstruct FZ-LLC, UAE

DSI Unit DYWIDAG-Systems International GmbH, Headquarter Operations, Germany
DSI Scope Supply of 3-0.5" and 5-0.5" MA Anchorages; sales of a Type SM 240 kN Monostrand Jack and a hydraulic pump, Type 77-193; technical support on site

DYWIDAG Ring Tendons stabilize Kuwait's new Landmark

Water is a valuable commodity in Kuwait – bottled water is even more expensive than petrol. Consequently, the six new water towers that were built in the Al Jahra area in Kuwait City are an investment of decisive importance for cities in that country.

The huge, mushroom-shaped water tanks have already become a new landmark of the country and can be seen from afar thanks to their blue and white stripes. The elevated tanks are 38.5m high and have diameters of 32m at the upper rim of the water tanks. This way, the tanks can store more than 2.4 million liters or 650,000 gallons of fresh water.

The towers' mushroom-shaped water tanks were post-tensioned using DYWIDAG Strand Tendons. DSI supplied 66 6-0.5" DYWIDAG Ring Tendons with anchorages and accessories to post-tension each tank.

Initially, the ducts and tendons were installed into the formwork at ground level. They were then hydraulically lifted onto the pillars of the water towers. Afterwards, concreting, post-tensioning and grouting of the tendons were carried out using the equipment that had been supplied by DSI.





Owner Government of Kuwait – Ministry of Electricity and Water, Kuwait

General Contractor Khalid Ali Al-Kharafi & Bros Co., Kuwait

Consulting Engineers Government of Kuwait – Ministry of Electricity and Water, Kuwait

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

DSI Scope Supply of 396 6-0.5" DYWIDAG Ring Tendons with anchorages; sale of equipment

DYWIDAG Bar Tendons Stabilize New Testing Laboratory in Canada

A new high-strength floor slab was installed in a testing laboratory at the University of British Columbia's Okanagan Campus (UBCO) in Kelowna, approximately four hours east of Vancouver, Canada. The new slab is needed for testing various structural elements for both public and private research and development programs.

The slab was the first phase of the project, which will eventually incorporate two massive walls to expand the capacity and flexibility of the testing



facility. The massive slab measures 20m x 6m and was reinforced with a total of 407 vertically installed, short \varnothing 36mm DYWIDAG THREADBAR® Tendons. The tendons supplied by DSI Canada have bottom anchorages, with the THREADBAR® reaching to the concrete surface, and couplers positioned just below the surface level.



Photos reprinted courtesy of Maple Reinders Constructors Ltd., Canada

DSI installed two types of tendons: 86 DYWIDAG Bar Tendons were installed in the areas of the future massive walls. These bonded tendons will be permanently tensioned and grouted in place after the walls have been constructed.

In addition, 321 unbonded DYWIDAG Tendons are located in the main floor slab. These tendons are oriented in a grid pattern with a spacing of 500mm in each direction. The narrow grid provides a maximum amount of flexibility in the layout of testing equipment and specimens on the slab. The slab tendons are replaceable, which is important should individual tendons become damaged during testing programs.

DSI worked closely with the contractor in designing the optimum Post-Tensioning System and was able to successfully complete the production, supply and installation of the DYWIDAG Tendons within a very tight schedule.



Owner University of British Columbia Okanagan Campus (UBCO), Canada

General Contractor Maple Reinders Constructors Ltd., Canada

Consulting Engineers Axis Engineering, Inc., Canada

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

DSI Scope Supply and installation of 407 \varnothing 36mm DYWIDAG Bar Tendons

DSI supplies DYWI® Drill Hollow Bars for new Transportation Corridor in Western Canada

The approx. 40km long South Fraser Perimeter Road (SFPR) is a new four lane road between the towns of Delta and Surrey in Western Canada. The new road provides an efficient transportation corridor for freight traffic while simultaneously relieving traffic congestion on municipal roads in the Greater Vancouver area. The last section of SFPR is scheduled for completion in December 2013.



The construction project also included several retaining walls for slope stabilization. The project was one of the first for which DSI Canada supplied “T” Thread DYWI® Drill Bars. Consequently, extensive testing was necessary in order to confirm the material performance of the DYWI® Drill System. All of these tests were successfully completed.

DSI supplied more than 13,000m of Type T40N/16 DYWI® Drill Hollow Bars and 10,800m of Type R38N DYWI® Drill Hollow Bars with accessories. The hollow bar system proved itself on site due to the following advantages:

- Simultaneous drill and grout installation for increased bond performance
- Self-drilling and flexible system
- Installation into loose or collapsing soils without the need for bore hole casing
- Flexible length adaptation thanks to fully threaded rod sections

The on time delivery of the DYWI® Drill System was challenging because the design was not completed until shortly before the installation of the systems was required on site.

This resulted in extremely short timelines from order placement to installation. In addition, more than one contractor was working on more than one wall at a time. Thanks to its efficient production in Surrey, DSI was able to maintain the extremely tight schedules for all of the structures.

i

Owner Government of British Columbia, Canada
General Contractor Fraser Transportation Group (FTG), Canada
Subcontractor Vancouver Shotcrete & Shoring Inc. / Belpacific Excavating & Shoring Limited Partnership, both Canada
Consulting Engineers Stantec Inc., Canada

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

DSI Scope Supply of 13,000m of Type T40N/16 DYWI® Drill Hollow Bars and 10,800m of Type R38N DYWI® Drill Hollow Bars with accessories

New Lake Champlain Arch Bridge ensures efficient Transport Connection

The new Lake Champlain Bridge was opened to traffic on November 7th 2011, replacing a bridge built in 1929 that had to be closed unexpectedly in October 2009 due to the discovery of severe structural defects. The elegant arch bridge connects the US states of Vermont and New York. The new bridge had to be completed quickly because once the old bridge had been closed, crossing Lake Champlain was very time-consuming and only possible by ferry.

Construction of the new bridge started in June 2010. The structure is an arch bridge with a concrete substructure and a steel and concrete superstructure. The bridge's substructure consists of two concrete abutments and seven concrete piers, six of which were constructed directly in the lake on

32 drilled shafts with diameters of 1.8m each. After completion of the shafts, a reinforced concrete pile cap was placed at water level, allowing steel girders to be subsequently installed on the piers.

The principal feature of Lake Champlain Bridge is its 123m (403.5ft) long network tied arch span. The arch structure was prefabricated near Port Henry in the state of New York and then floated into position on the Lake. Hydraulic lifting jacks then raised the span to its final position.

In order to minimize the weight of the arch for lifting, the center span was erected without its concrete deck, and the precast concrete panels for the deck were only installed after the arch structure had been lifted into position. Even without the bridge deck, the arch structure had a weight of 900t, posing a logistical challenge.





DSI USA supplied a total of 64 DYNA Grip® Stay Cables consisting of 7-0.6" DYWIDAG Tendons for the arch structure of Lake Champlain Bridge. Initially, the stay cables were placed in the arch structure and partially tensioned. Only after the arch had been lifted to its final position were the stay cables tensioned to their final force. In addition, DSI also supplied and installed the post-tensioning systems for the precast concrete segments of the bridge deck and carried out the tensioning and grouting work of the systems.

Due to the limited timeframe, the installation and tensioning work had to be realized within a very limited schedule. Thanks to the dedication of all the specialists involved, work could be completed efficiently and safely within the determined time line.



i

Owner New York State Department of Transportation (NYDOT); Vermont Agency of Transportation (VTrans), both USA
General Contractor Flatiron Constructors, Inc., USA
Architect HNTB Corporation, USA
Consulting Engineers HNTB Corporation, USA

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

DSI Scope Supply and installation of 64 DYNA Grip® Stay Cables 7-0.6", and post-tensioning systems for the bridge deck

DYWIDAG Post-Tensioning Systems ensure Durability: The Veterans Memorial Bridge in Maine



Located on the North-East coast of the state of Maine, USA, Veterans Memorial Bridge forms part of Route One that crosses the Fore River south of Portland. Constructed in 1954, the original bridge was found to be structurally deficient and functionally obsolete and therefore needed to be replaced.

The new bridge consists of two approximately 488m long, parallel structures and was built using the precast segmental construction method. Extensive pile foundations in the river bed were necessary to build the bridge piers. Temporary cofferdams were installed in the river bed for each pier in order to construct the pile foundations. The cofferdam sheets were removed after concreting the pier shafts.

For the superstructure of Veterans Memorial Bridge, Unistress Corporation produced a total of 361 precast reinforced concrete segments in its plant in Pittsfield, Maine. The segments are approximately 2.4-3m long and 12m-14m wide and were transported to the job site on 12m long trailers.

For post-tensioning the precast segments, DSI USA supplied a total of 318 19-0.6" DYWIDAG Strand Tendons, as well as 196 27-0.6" DYWIDAG Strand Tendons, with Type MA multiplane



anchorages. In addition, 3,000 4-0.6" DYWIDAG Strand Anchors were supplied for the transverse tendons. In total, 532t of 7 wire GR270 strand was used for the DYWIDAG Post-Tensioning Systems.

After lifting the precast segments into position using a crane, the DYWIDAG Strand Tendons were post-tensioned with jacks that had been supplied by DSI and injected with cement grout. In addition, DSI USA supplied 70t of \varnothing 36mm DYWIDAG Bar Tendons as well as ducts and the necessary accessories for the Post-Tensioning Systems.

After successfully completing the new Veterans Memorial, the old bridge was completely removed. The new bridge is designed for a service life of 100 years.

i

Owner Maine Department of Transportation, USA
General Contractor Reed & Reed Inc., USA
Consulting Engineers McNary Bergeron & Associates, LLC, USA
Engineers T.Y. Lin International, USA

DSI Unit DYWIDAG-Systems International USA Inc., BU Post-Tensioning, East, USA
DSI Scope Supply of 318 DYWIDAG Strand Tendons, 19-0.6", 196 DYWIDAG Strand Tendons, 27-0.6", with MA Anchorages, 3,000 4-0.6" DYWIDAG Strand Anchors and of 70t of \varnothing 36mm DYWIDAG Post-Tensioning Bars incl. accessories and ducts; rental of equipment

Efficient and Quick Repair with DSI: The Sam Jones Bridge in Indiana

Shortly after completion of the Sam Jones Bridge over Highway I-465 in the city of Indianapolis, Indiana, a vehicle that was too high attempted to drive under the bridge and collided with the structure. The collision caused major damage to some of the bridge deck girders, and the strands of the prestressing tendons in the outer girders were completely severed in multiple locations.

As an experienced specialty services supplier, DSI was contracted to design and implement a repair system for the pre-stressed strands to restore the structural integrity of the damaged girders. DSI developed a repair plan that utilized special post-tensioning turnbuckle anchors to reattach and splice the severed strands together and to allow for an application of stressing forces.

In order to precisely monitor the forces that were applied to the strands via the turnbuckles, DSI used the elasto magnetic DYNA Force® System.

Upon completion of the strand repair, DSI crews performed the necessary concrete repair mortar and, last of all, epoxy injected all cracks. All of this work was successfully completed at night under a very time sensitive schedule.



Owner Indiana Department of Transportation, USA
General Contractor Walsh Construction Co., USA

DSI Unit DYWIDAG-Systems International USA Inc.,
Structural Repair, USA

DSI Scope Design and implementation of repair work,
supply of post-tensioning tendons with turnbuckles and
of DYNA Force® Sensors

DYWIDAG Post-Tensioning Systems stabilize Visitors Center Bridge in Ocean City

The seaside resort of Ocean City, which is located on the coast of New Jersey on Garrets Island, approximately two hours' drive from New York, is a very popular vacation resort. Within the scope of one of largest projects ever built by the New Jersey Department of Transportation (NJDOT), the bridges and streets of Route 52 leading from the mainland to Ocean City were completely replaced by new structures.

As part of the project, the Visitors Center Bridge (VCB) was built to replace an older bridge in front of Ocean City's new Visitors Center. Since aesthetics played a significant role, the new bridge was built as a curved post-tensioned cast-in-place spline bridge in a 137m (449ft) radius and a 2% vertical grade in superelevation.

Measuring just under 122m (400ft) in length with four spans measuring 2 x 28m (92ft) and 2 x 33m (107ft), the bridge has wings extending just over 6m (20ft) from both sides. The 21m (70ft) wide superstructure accommodates a sidewalk on each side. Square precast concrete piles in the bridge foundation support the interior piers and end abutments. The abutments are stabilized by 16 strands, and the interior piers are strengthened by 36 strands each.

Both a 2-dimensional material time dependant and a 3-dimensional finite element model were used for the structural analysis and design of the bridge. The first model simulated the loads of the structure in conjunction with uniform temperature and temperature-gradient load cases and their impact on the structure's bending stiffness for its entire design life. The 1978 CEB FIB 3rd Edition code was used to model the concrete's time dependant creep and shrinkage behavior. The 3D finite element model was used to generate the forces and stresses necessary to properly predict the transverse post-tensioning requirements. In addition, the bridge structure was also subject to an intense seismic spectral analysis in accordance with the latest requirements of the American Association of State Highway and Transportation Officials (AASHTO).

The curved bridge was built above an old road, unpaved shoulder, and former marshland with different load capacities. Consequently, the positioning of the falsework necessary for constructing the superstructure was especially difficult.

In order to prevent a cracking of the bridge prior to post-tensioning and due to differential settlement of the shoring foundation, the road underneath was removed and the unstable parts of soil were leveled and stabilized using geogrids.

With the help of several bulkheads on both sides



Photos reprinted courtesy of Route 52 Constructors Joint Venture and Janssen & Spaans Engineering, Inc., USA

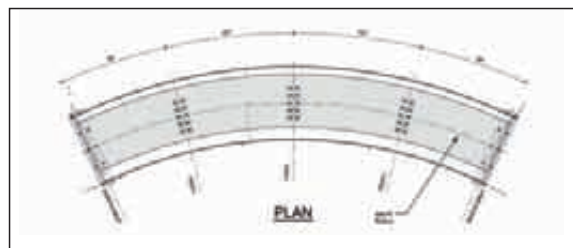
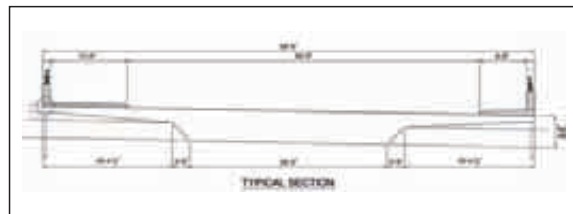
of each bridge pier and near the bridge ends, the mid spans were poured simultaneously with the cantilever wings to avoid any cold joints.

After the superstructure concrete reached strength, a total of 256 4-0.6" DYWIDAG Strand Tendons were radially spaced for transverse post-tensioning. Gradually, 30 strand tendons were installed from north to south and stressed. The tendons were grouted upon completion of the stressing operations in the



Tendons, 9-0.6", were installed in the lateral cantilever wings of the bridge. The path of the tendons is parabolic in the vertical plane and curved in the horizontal plane.

Due to the required 75 year design life, the DYWIDAG Tendons are protected by corrugated, high density polypropylene duct and permanent fiber reinforced polymer grout caps. In addition, the anchorages used are galvanized, and the tendons were pressure grouted with a special grout to ensure permanent corrosion protection. In total, approximately 85,000m (279,000lf) of 0.6" strand were installed in the new Visitors Center Bridge.



previous section. Since the falsework was not designed to accommodate additional loads, installation was carried out from a flatbed at the east side of the bridge.

Subsequently, the longitudinal post-tensioning of the bridge deck was carried out. The main stabilization of the bridge consisted of 17 longitudinal 27-0.6" DYWIDAG Strand Tendons in the deck. Afterwards, 6 longitudinal DYWIDAG Strand



Owner New Jersey Department of Transportation (NJDOT), USA
General Contractor Joint Venture Route 52 Constructors, consisting of G.A. & F.C. Wagman, Inc. and R.E. Pierson Construction Co., Inc., USA
 Engineers Michael Baker Jr., USA

DSI Unit DYWIDAG-Systems International USA Inc., BU Post-Tensioning, East, USA
DSI Scope Supply of 256 4-0.6" DYWIDAG Strand Tendons, 17 27-0.6" DYWIDAG Strand Tendons and of 6 9-0.6" DYWIDAG Strand Tendons

Higher Loads Thanks to External Tendons: Reinforcement of an Office Building in Alabama

North America

USA

Commercial
Buildings

Recently, a new twelve story office building consisting of post-tensioned concrete beams and slabs was built in Montgomery, Alabama, USA. Once the building had been completed, the owner rented some of the office space to a tenant who had a computer server room requirement. Due to its size, the chiller system that was needed for the server room had to be installed on the roof. However, this turned out to be a problem because the weight of the chillers exceeded the design capacity of the roof structure.



DSI was contracted to help develop a design-build solution for the installation of a suitable external post-tensioning system to support the loads of the chillers. Five precast concrete beams had to be strengthened to support the new loads. To start, DSI conducted a ground penetrating radar (GPR) scan of the beams to locate and identify all internal reinforcing systems. These measurements were critical for the design because the installation of the end brackets and deviators for the external



Post-Tensioning systems required that holes be cored through the beams.

For strengthening, DSI provided external 4-0.6" 1,860 N/mm² (270 KSI) DYWIDAG Strand Tendons in steel ducts. DSI installed a total of 10 tendons for the five roof beams, with two tendons used per beam. A tendon with an anchorage at each end was placed on either side of each beam. Two deviators were assembled on each of the beams in order to accommodate both beam tendons. The resulting eccentricity created the additional moment capacity that was needed to accommodate the higher load.

DSI fabricated and installed the brackets and secured them in place utilizing through bolts and anchors. The tensioning work was carried out by experienced DSI employees to make sure that the stressing sequence coincided with the new loads being applied to the roof. The DYWIDAG Post-Tensioning System was stressed in two phases: just before the chillers were placed and immediately afterwards. Upon final stressing, the ducts were grouted in order to secure the strands in place and provide a high degree of corrosion protection.

The project was implemented within a very tight schedule and required close coordination with other contractors. Thanks to the excellent co-operation of everyone involved, the strengthening of the office building's roof was completed safely and successfully.



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

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

DSI Scope Planning and installation of an external
Post-Tensioning System, supply of 10 external 4-0.6"
DYWIDAG Strand Tendons and of anchorages,
deviators and end brackets

Modernization of Newport International Terminal using DYWIDAG Systems

The port of Newport administration in Oregon on the western US coast is rebuilding its International Terminal. Two former World War II concrete cargo vessels serve as the dock foundation. The very robust vessels were manufactured from concrete due to the scarcity of steel during the war and were purposefully sunk in place in the late 1940's.

Within the scope of the modernization work, each sunken vessel was surrounded by a coffer dam made by steel sheet piles. The outer sheet piles are tied to the inner piles through the vessels by double corrosion protected (DCP) DYWIDAG Tie Rods. In addition, the inner piles are tied to a cast-in-place reinforced concrete dead-man pile cap with additional DCP DYWIDAG Tie Rods.

The dead-man wall, in turn, is tied back to stable ground by DCP DYWIDAG Strand Anchors and supported at the toe, facing the sheet piles, by uncoated DYWIDAG Micropiles.

DSI USA supplied the following products for this unique project:

- 24 6-0.6" DCP DYWIDAG Strand Anchors in lengths of 30.5m to 33.5m (100ft to 110ft)
- 19 2.5" Grade 150 and 3.0" Grade 150 DCP DYWIDAG Tie Rods in lengths of 16.76m to 22.86m (55ft to 75ft)
- 21 57mm Grade 75 DYWIDAG Micropiles in lengths of 13.72m to 19.81m (45ft to 65ft).

DBM Contractors was responsible for designing and installing the 21 micropiles which acted as vertical and lateral support for the cast in place dead man. Once the micropiles had been installed, the concrete dead man was concreted with blockouts for the tierods and tieback anchors. After the cast in place pile cap had cured, DBM installed the DCP tieback anchors. They acted as the primary lateral support for the DYWIDAG Tie Rods, which were the last elements to be installed.

The installation of the tie rods presented a challenge because they had to be installed through holes in the existing concrete ships. In addition, some DYWIDAG Tie Rods extended through the sheet pile wall to a waler system that could only be accessed during low tide. After all the elements had been installed, the tie rods were tensioned to a nominal load using a hydraulic tensioning jack and locked off. Afterwards, the tieback anchor system was stressed to ensure that the sheet pile wall did not deflect during placement of the backfill.

Thanks to the close coordination between all of the companies involved, work on this project was completed meeting all design criteria within the defined time frame.



Photos reprinted courtesy of DBM Contractors Inc., USA



Client Port of Newport, USA
General Contractor NATT McDougall Company, USA
Contractor DBM Contractors, Inc., USA
Consulting Engineers KPFF Consulting Engineers, Inc., USA

DSI Unit DYWIDAG-Systems International USA, Inc.,
 BU Geotechnics, USA
DSI Scope Supply of 24 6-0.6" DCP DYWIDAG Strand Anchors,
 19 2.5" Grade 150 and 3.0" Grade 150 DCP DYWIDAG Tie Rods and
 of 21 57 mm Grade 75 DYWIDAG Micropiles

Modern Methods allow Structural Repair of Dams

In the 1960s and 70s, the US Army Corps of Engineers regularly used high-strength, smooth, post-tension steel bar tendons for trunnion girder anchorages in many of the dams constructed in this period.

These are the structural elements that were also used for the West Point flood control dam in Georgia and the Robert F. Henry lock and dam in Alabama, both of which were built in the 1960s. The challenges associated with this design method include difficulty with repair and inspection of the trunnion rods. This early form of post-tensioning limits the ability to

current tension force of the bar tendons in the structures, but the accuracy of this method is limited.

After the recent failure of several tendons from corrosion, the need to develop and employ a new and more conclusive tendon testing method became a priority. To ensure public safety, the Army Corps initiated an evaluation and maintenance program that utilized both the wave testing method and hydraulic monitoring of the tendon forces. A full-scale test facility was constructed at FDH Engineering's office in North Carolina where a mock-up of the trunnion anchorage was built. This mock-up consisted of a large reinforced



perform in-place load tests since the bars are not threaded.

Consequently, the Army Corps had been utilizing a nondestructive testing method at the West Point and Robert F. Henry dams that initiates and records impact vibration response (U.S. Patent 8096195) in the steel tendons without disturbing them. This measured wave motion is compared to the theoretical one and then used to determine the

concrete block incorporating four full scale bar tendons. It was used to test and confirm the effectiveness of using hydraulics to evaluate and measure loads in the bars.

DSI USA was contracted to perform the lift-off tests in order to determine the actual tensioning force of the bars currently in place in the dams. To accomplish this task, DSI's engineers first conducted load tests on the specially constructed



mock-ups at FDH's test facility using a gripping device that had been specially developed by DSI. The gripping device was necessary because the bars used in the construction of these dams were smooth and without the threads which would have allowed for a coupling device.

Upon completion of the mock-up testing, DSI USA developed a suitable testing method for the tendons of both dams and then again tested them on site. DSI's experts had to find suitable places to test the tendons because they were located in areas of difficult access.

Out of a total of 376 post-tensioning tendons at West Point Dam and 476 tendons at Robert F. Henry Dam, DSI tested a total of 216 tendons and successfully determined and recorded their actual tension force. Having this information allowed the Corps of Engineers to make critical decisions on the condition and safety of both dams.



Owner US Army Corps of Engineers, Mobile District, USA
General contractor Dorsey & Dorsey Engineering, Inc., USA
Engineer of Record Thompson Engineering, Mobile, Alabama;
 Vibration Response Consultant FDH, Inc., USA

DSI Unit DYWIDAG-Systems International USA Inc.,
 Structural Repair, USA

DSI Scope Development of the load testing means and methods,
 performance of testing, asbestos abatement, and minor associated
 structural maintenance

Stable Special Solutions using DYWIDAG Form Ties: Miami Marlins Ballpark

North America

USA

Commercial
Buildings

On July 18th 2009, a long-awaited ground breaking was held for the Miami Marlin's baseball team: They were finally getting their own ballpark. In the past, the team played their home games in the multi-purpose Sun Life Stadium in Miami, Florida. This stadium was not suitable for baseball because of its unfavorable size and lighting conditions.

The larger Miami Marlin's Ballpark is 86,215m², has 37,442 seats and was opened on Opening Day of the 2012 Major League Baseball Season.

The structure's innovative retractable roof was awarded a Silver Certificate in 2012 for its environmentally friendly, resource-friendly, and sustainable design by the Leadership in Energy and Environmental Design (LEED). The retractable roof consists of nearly 8,000t of high-strength steel. The rails for the roof structure are supported by two rows of tall columns consisting of two parts. The lower part of the piers is massive and crossed at the base, while the upper part of the columns branches into three sub-piers curving outward.

As the columns have different bend angles at each level due to their curvatures, a particularly complex, single face climbing system was used for this project. Alsina Forms Co. supplied the complete formwork system that was used to build the piers.

The approx. 46m high columns were erected using an average of 9 individual segments. During pier construction, extreme weather conditions such as tropical storms and hurricanes that regularly occur in Florida had to be taken into account.

In order to absorb the high lateral forces, the formwork system was stabilized using continuous high-strength \varnothing 15mm DYWIDAG Form Ties. The DYWIDAG Form Ties were in turn joined to the climbing system using strong struts in order to counterbalance the horizontal loads of the concrete. For stabilizing the complex formwork system, DSI USA supplied more than 3,000m of DYWIDAG Form Ties.



Photos reprinted courtesy of Alsina Forms Co., Inc., USA



Owner Miami Marlins, USA
General Contractor Hunt/Moss Joint Venture, consisting of Hunt Construction Group and Moss & Associates, both USA
Contractor Mars Contractors, Inc., USA
Subcontractor Baker Concrete Construction, Inc., USA
Subcontractor Formwork Alsina Forms Co., Inc., USA
Architect Populous Holdings, Inc., USA
Structural Engineers Bliss & Nyitray, Inc., USA

DSI Unit DYWIDAG-Systems International USA Inc., Formwork Systems & Concrete Accessories, USA
DSI Scope Supply of \varnothing 15mm DYWIDAG Form Ties

Low-Vibration Installation of DYWIDAG Ductile Iron Piles for Unobstructed Operation of a Power Plant

115

Construction

North America

USA

Commercial Buildings

The municipal power provider **St. Lucia Electricity Services (LUCELEC)** expanded its power plant on the island of St. Lucia in the West Indies. Due to difficult geological conditions, the construction of the building that was needed for the new generator posed a special challenge. The building ground was situated close to sea level and founded on fill and alluvial material with boulders over highly weathered bedrock.

The pile system did not only have to be suitable for the strongly varying substrate, but also for confined space and limited access on site. As the new foundation pilings needed to be driven within a mere 400mm of a working generator, vibration and noise had to be kept to a minimum.

The \varnothing 170mm DYWIDAG Ductile Iron Piles supplied by DSI USA proved to be the perfect solution for this special case. During the piling operation, vibrations of only 2mm/s were recorded, which was well below the allowable British standard (BS5228) of up to 30mm/s for commercial buildings.

In total, 72 ductile iron piles with a minimum length of 4m and a maximum length of 23m were driven to an average depth of 16m. Two test piles were subsequently loaded to 716kN using a hydraulic tensioning jack that was supplied by DSI. Loads were simply transferred to the reaction beams using bars consisting of DYWIDAG THREADBAR® that were set into the wet mortar after driving the



Photo reprinted courtesy of Complete Marine Services Limited, St. Lucia



piles. The piles passed the tests without any difficulties.

The grouted annulus piles were very effective in overcoming the varied ground conditions. In addition, the piling rig could be moved to the different installation locations easily and quickly so that a flexible and very fast reaction to the different ground conditions that were encountered was possible.



Owner St. Lucia Electricity Services Limited, St. Lucia
General Contractor Wärtsilä Corporation, Finland
Contractor Jamecob's Quality Construction Ltd., St. Lucia
Piling Subcontractor Complete Marine Services Limited, St. Lucia
Architect Wärtsilä Corporation, Finland
Consulting Engineers Roland Theobalds, St. Lucia

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

DSI Scope Supply of DYWIDAG Ductile Iron Piles with accessories and injection equipment, supply of DYWIDAG THREADBAR®

Structural Repair and Reinforcement of Post-Tensioned Precast Beams using DYWIDAG Tendons



A paper mill in the southern United States required comprehensive repair of the roof support system of one of their manufacturing buildings. More than 10 years ago, the concrete roof beams were strengthened to account for additional loads applied to the structure. Since then, the roof was structurally altered several more times. In addition, because of the extremely hot and humid air in the manufacturing building, the concrete beams experienced severe corrosion and concrete delamination. These factors required the owner to implement a comprehensive repair and strengthening program.

The design was complex because the existing strengthening system had to be removed. To start, a temporary shoring system had to be installed for the beams. Since shoring to ground level was not possible, a temporary system utilizing horizontal post-tensioned tendons was designed by DSI. Once the temporary tendons were installed, the damaged girders were unloaded and the new permanent tendons were installed.

Double corrosion protected DYWIDAG Bar Tendons with an ultimate stress of 1,034 MPa (150 KSI) were installed and tensioned for the new system. They were positioned on either side of the beams, running from the beam end locations down to a center deviator, and stressed to create the required uplift forces. All components such as anchor plates and couplers were epoxy coated in order to ensure long-term corrosion protection.

In addition, the concrete repairs required a very detailed plan to restore the structural integrity of the beams. This was accomplished by removing all delaminated concrete in the beams and by splicing the damaged post-tensioning strands back together and re-stressing them. Finally, the damaged concrete beams were repaired with an engineered cementitious repair mortar and restored to the original beam specifications.



DSI Unit DYWIDAG-Systems International USA Inc.,
Structural Repair, USA

DSI Scope Remedial design; reinforcement of precast girders using double corrosion protected DYWIDAG Bar Tendons

ADSC Exhibition and Conference, San Antonio, TX, USA

March 14-17, 2012

117

Construction

Special

Exhibitions

Once again, the International Association of Foundation Drilling's (ADSC) Equipment Expo and Conference met with great interest in 2012. More than 2,000 participants from 40 countries attended the annual event.

Participants active in geotechnics and foundation drilling profited from the large international forum in order to network with geotechnical specialists and to hear about the latest developments in the industry. Visitors were especially interested in the technical presentations given by many industry experts in the foundation construction industry, as well as various Committee Meetings that all took place on day one of the event. Topics included recent developments in hollow bar soil nailing, anchor testing and slope stabilization using micropiles.

DSI North America was represented by several individuals from Construction and Underground. DSI participated with its own booth in the ADSC Exhibition and presented many innovative products and systems including the DYNA Force® Monitoring System. DSI has been involved in the development and testing of this system since its introduction into the market. The force monitoring system is used to reliably and accurately measure forces in various post-tensioning systems, including but not limited to ground anchors and soil nails.

The DSI employees introduced themselves to many interested geotechnical experts and were able to network with customers and long-term business partners.

Mike Kelley, who is responsible for DSI North America's Geotechnics business segment, has been representing DSI on different commissions such as the Anchored Earth Retention Committee, the Micropile Committee, and the Rebar Cage Design Task Force.



Faster Connections with DYWIDAG Systems: Metro Line 4 in Rio de Janeiro

The Metro system in Rio de Janeiro, Brazil, currently has a length of 40.9km and consists of Lines 1 and 2. Line 3 is being planned, and beginning in 2016, the new Line 4 will be operative. Line 4 will run from the city's south west to the city center, where it will connect with Line 1. Once completed, the new line will have seven stops and transport 425,000 passengers per day in order to bring relief to the city's west, where population has been steadily increasing.

The construction of a tunnel that will connect the stations of São Conrado and Jardim Oceânico is one of the biggest challenges in this project. Running under a hill with an overburden of 850m, the 8m high tunnel will be between 8 and 15m wide.

As São Conrado Station is at the foot of an unstable hill that is prone to landslides, comprehensive stabilization work had to be carried out in this area. Several retaining walls were built for



stabilizing the tunnel portals. In addition, weathered rock formations were stabilized using mesh and anchors.

The corrosion protected DYWIDAG Bar Anchors supplied by Protendidos DYWIDAG were installed 6 to 30m deep into the rock and grouted using cement suspension. The bar anchors are fitted with post grouting tubes connected to the PVC tubes of the anchors and can thus be re-grouted to increase their carrying capacity at a later stage if necessary.

In addition, Ø 32mm DYWIDAG Bars were produced and supplied for stabilizing Jardim Oceânico Station. The bar anchors were epoxy coated due to aggressive soil conditions. Up to now, 4,038m of DYWIDAG Bar Anchors in average lengths of 12m have been installed.



i

Owner Government of the Federal State of Rio de Janeiro, Brazil

General Contractor Joint Venture Consórcio Construtor Rio Barra (CCRB), consisting of: Queiroz Galvão, Odebrecht, Carioca, Cowan und Servix, all of them Brazil

Consulting Engineers MC Link, Brazil

Subcontractor Tecnogeo Engenharia e Fundações Ltda., Brazil

DSI Unit Protendidos DYWIDAG Ltda., Brazil

Protendidos DYWIDAG Scope Supply of 4,038m of corrosion protected Ø 32mm DYWIDAG Bar Anchors

GEWI® Post-Tensioning Bars stabilize a Monument of Soccer History: Maracanã Stadium, Rio de Janeiro

119

Construction

South America

Brazil

Commercial
Buildings



The Maracanã Stadium in Rio de Janeiro, Brazil, was built for the Soccer World Cup in 1950. At the time, the oval stadium, consisting of precast concrete, had the world's largest cantilever roof with a span of nearly 30m. Due to its historical significance for Brazilian soccer history, the open air stadium was not replaced by a newer stadium, but repeatedly renovated and expanded in the course of time.

In order to prepare for the World Cup in 2014 and the Olympic Summer Games in 2016, the stadium is being repaired comprehensively. The stadium's capacity is being increased from 82,238 to 85,000 spectators. In addition, the roof is being extended so that all seats of the stadium will be protected in the future.

For the new roof, the upper tier along the stadium's oval had to be anchored to the tier lying underneath. \varnothing 32mm GEWI® Post-Tensioning Bars were used for this purpose. For anchoring the upper tier, Protendidos DYWIDAG supplied a total of approx. 1,000m of GEWI® Bars in lengths of 1.85m to 3.60m as well as 240 anchor plates and nuts.



i

Owner Governo do Estado do Rio de Janeiro, Brazil
General Contractor Consórcio Maracanã Rio 2014, Brazil
Architect EMOP, Brazil
Engineers EMOP, Brazil

DSI Unit Protendidos DYWIDAG Ltda., Brazil
Protendidos DYWIDAG Scope Supply of approx. 1,000m of \varnothing 32mm GEWI® Post-Tensioning Bars as well as of 240 anchor plates and nuts





GEWI® Post-Tensioning Bars stabilize new Soccer Stadium in São Paulo



On May 30th 2011, construction began on the new Corinthians Arena in the east of São Paulo.

The stadium was originally planned for a capacity of 48,000 but will now include 65,807 seats in order to comply with FIFA regulations for hosting the opening match of the Soccer World Cup in 2014.

The stadium, which was designed by the famous Brazilian architect Anibal Coutinho, is being built on an area of approx. 200,000 m². Once completed, it will be the new home of the traditional soccer club Sport Club Corinthians Paulista.

In order to shorten the time needed for construction, precast concrete supports that were post-tensioned using GEWI® Post-Tensioning Bars were used for building the tribunes. Protendidos DYWIDAG supplied approx. 1,300m of Ø 32mm GEWI® Post-Tensioning Bars with accessories for the construction of the precast concrete supports. So far, the GEWI® System has been successfully used at approx. 4,904 anchorage points.



Owner Sport Club Corinthians Paulista, Brazil
General Contractor Construtora Norberto Odebrecht S.A., Brazil
Architect CDC Arquitetos, Brazil
Engineers Werner Sobek Engineering & Design, Brazil

DSI Unit Protendidos DYWIDAG Ltda., Brazil
Protendidos DYWIDAG Scope Supply of approx. 1,300m of Ø 32mm GEWI® Post-Tensioning bars with accessories

Retaining Walls of Transbrasiliana Highway stabilized using DYWIDAG Bar Anchors

123

Construction

South America

Brazil

Slope
Stabilization

The BR-153 Motorway, which is also known as Transbrasiliana Highway, is Brazil's fourth longest highway and connects the country's north and south over a total length of 4,355km. It is important for Brazil's infrastructure and carries a significant amount of traffic.

In order to improve traffic flow on this main route and to accommodate future increases in volume, some intersections with approach roads had to be removed. Work on the BR-153 included the construction of an approx. 100m long underground passage as well as two retaining walls and a viaduct.

At their highest point, the retaining walls are 10m high each. For tying back the retaining walls, Protendidos DYWIDAG supplied permanent, epoxy coated DYWIDAG Bar Anchors with accessories. On the whole, 37,130m of DYWIDAG Bars were supplied for this project. Protendidos DYWIDAG is proud to have contributed to this important infrastructure project in Brazil.



Owner Governo do Estado de Goiás, Brazil

General Contractor Egesa Engenharia S.A., Brazil

Subcontractor EMBRE - Empresa Brasileira de Engenharia e Fundações and SETE Engenharia, both Brazil

Engineers EMBRE - Empresa Brasileira de Engenharia e Fundações, Brazil

DSI Unit Protendidos DYWIDAG Ltda., Brazil

Protendidos DYWIDAG Scope Supply of 37,130m of permanent, epoxy coated \varnothing 32mm DYWIDAG Bar Anchors with accessories

DYWI® Drill Anchors Stabilize Spectacular Tunneling Project in Lima: Vía Parque Rímac

The Vía Parque Rímac Project is an important infrastructure project that is currently under construction in Lima, Peru. A 7km long section of this 16km long road is being completely rebuilt; 9km of new roads are part of the project, and the work also includes the construction of 11 new viaducts.

The construction of a 2km long tunnel under the Rímac River is the most important and technically challenging part of this project. Once completed, the six-lane tunnel will decrease traffic congestion in this area by up to 80%. Initially, the river had to be

deviated into a newly constructed canal that is separated by a wall from the tunnel excavation. To build the tunnel, the exterior walls of the excavation were then stabilized along a length of 200m using high-strength soil nails.

DSI Peru supplied Type R51 Self-Drilling DYWI® Drill Anchors in lengths of 9 to 15m. The hollow bar anchors were produced in lengths of 2, 3 and 4m and installed in varying lengths using force-fit couplers. Due to the soil strata that mainly consisted of gravel and boulders, the anchors were fitted with carbide button bits.



The DYWI® Drill Anchors were installed using a hammer head and injected with cement mortar that simultaneously served as drilling fluid.

In the next phase, tunnel excavation was carried out up to a depth of 15m. During this process, the walls of the excavation and the tunnel walls that were being excavated were also stabilized using Type R51 DYWI® Drill Anchors. On the whole, DSI Peru supplied 62,000m of DYWI® Drill Anchors for this project and carried out the soil nail tests. The DYWI® Drill Hollow Bar Anchors for this important project were produced in DSI Austria's new plant in Pasching near Linz and shipped to Lima in time and on schedule.

Subsequently, the tunnel walls were stabilized using reinforced concrete in order to provide a maximum of stability and earthquake resistance. After completion of the excavation work, the tunnel, which consists of precast elements, will be built. The tunnel roof will subsequently be covered with a

watertight coating and backfilled with soil. Afterwards, the river will be redirected over the tunnel, and the construction of the second tunnel will be carried out following the same procedure.



i

Owner Municipalidad Metropolitana de Lima, Peru
Client Linea Amarilla S.A.C. (LAMSAC), Peru
General Contractor Constructora OAS Ltda., Peru
Subcontractor Geotechnics Mota-Engil Perú S.A., Peru

DSI Unit DSI Peru S.A.C., Peru
DSI Scope Production and supply of 62,000m Type R51
 DYWI® Drill Anchors

New Dam ensures Energy supply in Venezuela: The Tocoma Dam

South America

Venezuela

Hydro- & Marine
Structures

The Manuel Piar hydropower station and Tocoma Dam are located approximately 85km from the town of Puerto Ordaz in the federal state of Bolívar in Venezuela. The project is the last phase of a construction project aimed at ensuring electrical energy supply in this region. After its completion, the power plant with its ten 216MW generators will have an annual capacity of 12,100GWh.



Tocoma Dam is located on the Caroní River and has an impounding capacity of 13 mio. m³. The main dam is 300m long and 82m high. The dam's spillway is 175.86m long, and the crown is 106.3m above sea level.

For retaining the girders supporting the axis of the spillway's swing gates, DSI supplied a total of 66t of Type 0.60" strand as well as 140 Type MA 6819 DYWIDAG Anchorages and 140 Type ZR 6819 DYWIDAG Bond Anchorages. The Type 19-0.6" DYWIDAG Strand Tendons were installed in metal ducts with a total length of 3,500m. In addition, a total of 216 four meter long, Ø 36mm Type 36WS DYWIDAG Bar Tendons were needed for retaining the swing gate hydraulic winches on the spillway.

For installation work, DSI supplied a HOZ 5400 Tensioning Jack, hydraulic pumps, an uncoiler and load cells for load monitoring. In addition, DSI rented another tensioning jack, a hydraulic pump and a grout machine with pump for grouting the bar tendons. Postensado V.N. Industrial de Venezuela S.A. (PIV) tested the DYWIDAG Tendons and performed the installation, tensioning and grouting work.



Owner CORPOELEC, Venezuela

General Contractor Joint Venture OIV, consisting of: Construtora Norberto Odebrecht S.A, Brazil; Impregilo S.p.A., Italy and Vincler, Venezuela

Subcontractor Postensado V.N. Industrial de Venezuela S.A. (PIV), Venezuela

Engineers Harza, USA; EDELCA and Consorcio de Ingeniería Caroní, both Venezuela

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

DSI Scope Supply of 140 MA Anchorages, 66t of strand and 216 Ø 36mm DYWIDAG Bar Tendons; supply and rental of equipment

Imprint

Published by

DSI Holding GmbH
Destouchesstrasse 68, 80796 Munich, Germany
Phone +49-89-30 90 50 200
E-mail info@dywidag-systems.com
www.dywidag-systems.com

Design and Editorial Content

DSI Holding GmbH
Marketing Department
Chief Editor
Gerhard Kahr
Assistant Editor
Christine Ritz

Revision

Ron Bonomo
Naperville, Illinois, USA

Design, Layout and Typesetting

GO2, Karsten Gorissen
Munich, Germany

Picture Editors

NUREG Neue Medien
Nuremberg, Germany

Printing

Holzer Druck und Medien
Weiler im Allgaeu, Germany

Picture Credits

DYWI® Seal Waterproofing System protects
Torrent Embankment following a Landslide (page 25)
Photos reprinted courtesy of Hoch-Tief-Bau-Imst
Ges.m.b.H., Austria

The Pummersdorf Tunnel: Closing a Gap
in one of Austria's most Important Railway Lines (page 28)
Photos reprinted courtesy of Alpine BeMo Tunnelling GmbH,
Austria

DSI DRILL TEK Ltd. Supplies Specialty Systems
for the World's northernmost Mine (pages 40-41)
Photos reprinted courtesy of the International
Mining Magazine, Great Britain

DSI Chile contributes to the successful Development
of a new Gold Mine (page 53)
Photos reprinted courtesy of Orosur Mining Inc., Uruguay

Berlin: Fast Construction Progress and Watertight Structures
with *contec*® and *recostal*® (page 73)
Photo reprinted courtesy of Deutsche Immobilien AG, Germany

The Schlosshoefe Oldenburg: Post-Tensioning of Flat Slabs
using Monostrand Tendons (page 77)
Photos reprinted courtesy of Läer + Rahenbrock
GmbH & Co KG, Germany

DYWIDAG Strand Anchors stabilize New City District:
The Milaneo in Stuttgart (page 79)
Photos reprinted courtesy of Züblin Spezialtiefbau GmbH,
Germany

Reaching high with external Prefabricated Tendons:
Wind Farms in Spain (page 97)
Photos reprinted courtesy of Acciona Windpower, Spain

DYWIDAG Bar Tendons Stabilize New Testing Laboratory
in Canada (page 102)
Photos reprinted courtesy of Maple Reinders Constructors Ltd.,
Canada

DYWIDAG Post-Tensioning Systems stabilize Visitors
Center Bridge in Ocean City (pages 108-109)
Photos reprinted courtesy of Route 52 Constructors
Joint Venture and Janssen & Spaans Engineering, Inc., USA

Modernization of Newport International Terminal
using DYWIDAG Systems (page 111)
Photos reprinted courtesy of DBM Contractors, Inc., USA

Stable Special Solutions using DYWIDAG Form Ties:
Miami Marlins Ballpark (page 114)
Photos reprinted courtesy of Alsina Forms Co., Inc., USA

Low-Vibration Installation of DYWIDAG Ductile Iron Piles for
Unobstructed Operation of a Power Plant (page 115)
Photo reprinted courtesy of Complete Marine Services Limited,
St Lucia

Text Copyright © DSI Holding GmbH, 2013

All rights reserved. The articles in this brochure are protected
by copyright. No part of DSI Info 20 may be reproduced or
transmitted in any form or by any means, electronic or
mechanical, including photocopying, recording or any
information storage or retrieval system, without the express
prior written consent of DSI Holding GmbH.

This publication is printed in English (13,000 pcs.)
and German (3,000 pcs.)

DSI Holding GmbH

Destouchesstrasse 68
 80796 Munich, Germany
 Phone +49-89-30 90 50 200
 E-mail info@dywidag-systems.com
www.dywidag-systems.com

North America

Construction
 DYWIDAG-Systems International USA Inc.
 320 Marmon Drive
 Bolingbrook, IL 60440, USA
 Phone +1-630-739 1100
 E-mail dsiamerica@dsiamerica.com
www.dsiamerica.com

North America

Underground
 DSI Underground Systems Inc.
 9786 S Prosperity Road
 West Jordan, UT 84081, USA
 Phone +1-801-973 7169
 E-mail dsiunderground@dsiunderground.com
www.dsiunderground.com

South America

Construction
 PROTENDIDOS DYWIDAG Ltda.
 Itaim Bibi
 Rua Iaiá, 150 – 10º andar - Cj.102
 04542-060-São Paulo/SP, Brazil
 Phone +55-11-21 31 37 00
 E-mail vendas@dywidag.com.br
www.dywidag.com.br

South America

Underground
 DSI Chile Industrial Ltda.
 Las Encinas #1387
 Valle Grande
 Lampa, Santiago de Chile
 Chile
 Phone +56-2-596 96 20
 E-mail informaciones@dsilatinamerica.com
www.dsi-chile.com

EMEA

Construction, Post-Tensioning Systems
 DYWIDAG-Systems International GmbH
 Max-Planck-Ring 1
 40764 Langenfeld, Germany
 Phone +49-2173-79 02 0
 E-mail suspa@dywidag-systems.com
www.dsi-posttensioning.com

EMEA

Construction, Geotechnical Systems
 DYWIDAG-Systems International GmbH
 Germanenstrasse 8
 86343 Koenigsbrunn, Germany
 Phone +49-8231-96 07 0
 E-mail geotechnik@dywidag-systems.com
www.dsi-geotechnics.com

EMEA

Construction, Concrete Accessories
 DSI-Holding France
 12-14, rue des Cressonnières
 Z.I. Nord
 95500 Gonesse, France
 Phone +33-1-34 45 90 45
www.dsi-accessories.com

EMEA

Underground & Civils
 DYWIDAG-Systems International GmbH
 Alfred-Wagner-Strasse 1
 4061 Pasching/Linz, Austria
 Phone +43-7229-61 04 90
 E-mail office@dywidag-systems.at
www.dsi-tunneling.com

APAC

Underground & Civils
 DYWIDAG-Systems International Pty. Ltd.
 25 Pacific Highway
 Bennetts Green, NSW 2290, Australia
 Phone +61-2-49 48 90 99
 E-mail dsi@dywidag.com.au
www.dsiminingproducts.com/au

ARGENTINA
 AUSTRALIA
 AUSTRIA
 BELGIUM
 BOSNIA AND HERZEGOVINA
 BRAZIL
 CANADA
 CHILE
 CHINA
 COLOMBIA
 COSTA RICA
 CROATIA
 CZECH REPUBLIC
 DENMARK
 EGYPT
 ESTONIA
 FINLAND
 FRANCE
 GERMANY
 GREECE
 GUATEMALA
 HONDURAS
 HONG KONG
 INDONESIA
 ITALY
 JAPAN
 KOREA
 LEBANON
 LUXEMBOURG
 MALAYSIA
 MEXICO
 NETHERLANDS
 NORWAY
 OMAN
 PANAMA
 PARAGUAY
 PERU
 POLAND
 PORTUGAL
 QATAR
 RUSSIA
 SAUDI ARABIA
 SINGAPORE
 SOUTH AFRICA
 SPAIN
 SWEDEN
 SWITZERLAND
 TAIWAN
 THAILAND
 TURKEY
 UNITED ARAB EMIRATES
 UNITED KINGDOM
 URUGUAY
 USA
 VENEZUELA

www.dywidag-systems.com