RODIO

References

KARLSRUHE CITY METRO | KARL FRIEDRICH TUNNEL | TAM-Grouting

GRUPO TERRATEST

RODIO REFERENCES

Intro

RODIO was founded in Italy in 1921 by the Eng. Giovanni Rodio. RODIO Geotechnik AG with head office in Urdorf near to Zürich (Switzerland) and RODIO Gmbh Spezialtiefbau with head office in Neusäss near to Augsburg (Germany) come from the old RODIO Group and have inherited its specialists and know-how.

We are subsoil specialists	**and we provide full range of technologies in the field of geotechnik**
We are problems solvers	**however complicate the solution could be**
We are global players	**and we look forward to overcome new frontiers**
We insure quality	**and we remember it every day**

Tunnel Trositorrents Switzerland Forepoling

Forth Crossing bridge Scotland offshore Jet Grouting columns

Slovacki tunnel Danzig Poland Ground Freezing

Metro Warsaw Poland C13 station Ground Freezing

Activities

Ground Freezing

Tunnelling

Jet Grouting

Rock Grouting

Compensation Groutung

Soil Grouting

Anchors

Micropiles

Underpinning

RODIO within the TERRATEST Group

RODIO Geotechnik AG SWITZERLAND and RODIO GmbH GERMANY are part of the network of the TERRATEST Group.

TERRATEST has a strong international presence and is involved in many major projects around the world.

Jet Grouting slab Pariser Platz Berlin Germany

Ground Freezing

Consolidation and water tightening of soils

Slovaki Tunnel Danzig

Hubertus Tunnel (Netherlands)

Liefkenshoek Tunnel (Belgium)

Ground freezing

Ground freezing as a method of ground consolidation and waterproofing of soils below the water table is a technique in the field of geotechnical engineering in which **RODIO** has developed a wide know-how since several decades. Ground freezing can be achieved by the direct method (liquid nitrogen) or indirect method (brine). In the direct method, nitrogen (close to the atmospheric pressure is liquid at a temperature of about -196 ° C) circulates in closed metal pipes causing a thermal shock in the groundwater surrounding the pipe itself. The freezing process takes approx 5-6 day to be completed. In the so-called indirect method, brine (a solution of calcium chloride in water) is cooled by means of one electric refrigeration unit (chiller) at temperatures of -35° -40° C and flows through the freezing pipes in a closed-circuit. This method requires approximately 3-4 weeks to complete a frozen structure.

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Tunnel Roveredo (Switzerland)

Tunneling Works

Pre-support ahead of tunnel face by means of horizontal jet grouting, forepoling pipes and fibreglass bars

Tunnel Neckargem (Germany)

Taborstrasse U2 Vienna (Austria)

Tunnel U3 Olympiapark Munich (Germany)

Islisberg (Switzerland)

Sodermalm Tunnel (Sweden)

Vigana Portal (Switzerland)

Tunneling Works

RODIO has been the pioneer worldwide in the tunnelling pre-support techniques. By installing jet grouting columns, steel pipes or VTR bars / pipes it is possible to create reinforcing structures ahead of the tunnel front, thus increasing the stability of the tunnel during the excavation. The same techniques, in combination with other pre-support methods, can be used to stabilize the nucleus at the tunnel face thus preventing convergence during excavation. This system finds its ideal application in heterogeneous loose soils, including in the presence of boulders (typical of glacial and colluvial deposits). The installation of these reinforcing elements is done by means of special drill rigs, equipped with long mast and capable of accurate drilling and high production output. The installation of the reinforcing elements can be achieved by different drilling method, depending on the ground conditions. Drilling Lengths reach of up to 30 meters, but the optimum value lies between 14 and 18 meters (in particular for horizontal jet çgrouting columns). The distance between the elements depends on static factors and ground conditions and is generally between 30 to 60 cm.

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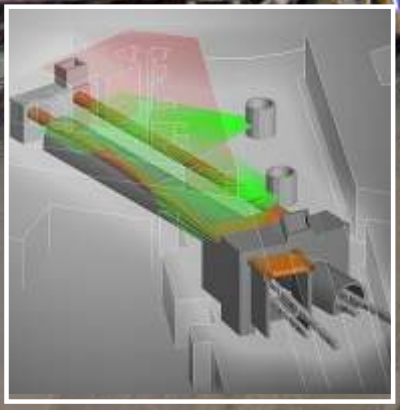
Compensation Grouting

Compensation of Settlements induced by Tunnel Excavation

Tunnel Schumann Josaphat (Belgium)

Elbetunnel (Germany)



Compensation Grouting

RODIO has been active in the field of Compensation grouting for over 15 years. Compensation grouting is a very specific application of the TAM grouting technique, aimed at compensating settlements induced by tunnel excavation. Settlements and rotation occur when tunnelling under buildings or near sensitive structures at shallow overburden: these phenomena may result in damages and collapses of the structures itself when not compensated. Compensation grouting takes place in multiple phases and through steel sleeved pipes installed in sub-horizontal holes, typically made from a shaft. A network of grouting points is thus created between the structures - or their foundations - and the tunnel. Grouting at each point can be precisely controlled in order to compensate predicted and actual settlements with the injection of cementitious grouts. Building movements are continuously monitored by means of a network of measuring points (electro levels). A specially conceived software permits to link in real time grouted volumes with settlements and heaves within each single zone and allows a precise control of the complex grouting and heave process.

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GRUPO TERRATEST

Jet Grouting

Soil improvement and tunneling reinforcement by means of jet-grouting

Turtmann (Switzerland)

Pariser Platz Berlin (Germany)

Forth Crossing (Scotland)

Victoria Center Bucharest (Romania)

Jet Grouting

Jet grouting is a method of hydraulic cutting and mixing in situ soil materials with a fluid grout injected at high pressure and velocity to create a stable admixture of soil and cement.
The **RODINJET** method, patented by RODIO, allows creating columns or panels of soil cement and can be used to solve a variety of ground engineering problems: support of excavation, tunnel pre-support, underpinning, vertical water cut-offs, subgrade bottom slabs.

There are three main jet grouting combinations, which can be used in different ground and water table conditions:

- **Rodinjet 1** system: high pressure cement grout jet
- **Rodinjet 2** system: high pressure cement grout jet surrounded by a crown of compressed air
- **Rodinjet 3** system: high pressure water jet surrounded by a crown of compressed air, cementitious grout is injected at lower pressure through a separate nozzle.

In the field of Tunnelling conical arches of overlapping sub-horizontal jet grouting columns can be created ahead of tunnel's front to sustain the ground in front of excavation.

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Rock Grouting
Sealing of Fissures and Voids into Rocks

Hongrin Léman Montreux (Switzerland)

Cleuson Dixence (Switzerland)

Tsankov Kamak Dam (Bulgaria)

Rock Grouting

Rock grouting is generally used to seal rock masses, for the construction of dams and other underground structures like tunnels and caverns, or for the filling of large cavities, such as karst features. The injection of liquid suspension into rock occurs directly from the unsupported borehole by using mechanical or hydraulic packers. For rock grouting usually stable cement suspensions based on normal or ultra-fine cements are used. In recent times, the so-called GIN method has proved to be a very efficient system for rock grouting. Control of the results of the injection is based on core drilling and water pressure tests (Lugeon tests).

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Soil Grouting

Filling of the pores in granular soils for the purpose of consolidation and/or waterproofing

Soil Grouting

The injection of natural or artificial products through small diameter holes, equipped with special valved pipes, (manchettes pipes or TAM) allows the improvement of the mechanical (resistance, deformability) and hydraulic (permeability) characteristics of the soil. The use of cement based injection products can be effective only in soils of high permeability such as gravel and coarse sands. The presence of less permeable soils, such as silts and fine sands, makes necessary the use of finer suspensions (based on ultrafine cements) or chemical aqueous solutions (gels, resins). In the case of soils below the water table, the pore water is replaced by injection products. Depending on the type of injection performed and parameters applied various effects as consolidation, waterproofing or compaction, can be achieved.

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GRUPO TERRATEST

Anchored wall made of frozen ground
Leipzig Central Station Germany

PROJECT

CITY METRO TUNNEL KARLSRUHE
MANCHETTE PIPE GROUTING

PROJECT NAME
Karl-Friedrich-Strasse Tunnel
Grouting with tubes à Manchettes (TAM)

CLIENT
KASIG GmbH

ENGINEER
Smoltczyk & Partner GmbH

MAIN CONTRACTOR
BEMO Tunnelling GmbH

SPECIALIST CONTRACTOR
RODIO GmbH Spezialtiefbau

CONTRACT VALUE
EURO 5.5 Mio. CHF 6.8 Mio.

BEGINNING OF WORKS
OCTOBER 2014

END OF WORKS
SEPTEMBER 2015 (foreseen)

JOB DESCRIPTION

The 210 m long Karl-Friedrich Tunnel is part of the new underground metro project of Karlsruhe. The low pressure permeation grouting treatment by means of tubes à manchettes, has been envisaged in order to reduce losses in the quaternary gravel and sands, during the full face excavation of the tunnel under compressed air. The soil grouting occurs as low-pressure injection with cement and soft gel based grouts. The manchette pipes (TAM) are installed into holes drilled vertically and inclined from the Kaiser Friedrich Street. The PVC TAM pipes have one valve every 33 cm. The soil to be treated by grouting is a very inhomogeneous quaternary alluvium with alternate layers of silty fine sand to coarse gravels. The aim of the injection is the reduction of the permeability to values of less than 10-7 m / sec. The injection is performed in each single valve of the TAM, by means of double inflatable packers. In the first grouting stage, a cement based stable suspension is injected over the whole volume formed by the tunnel and a 2 m thick border around it. In the second grouting stage, soft gel grout is injected over the 2 m thick border only.

WORK QUANTITIES

2.120 grouting pipes, total drill length 36.000 m, 33.000 m3 of grouted soil
~ 5.000 m3 of cement based grout with ready product (cement / limestone)
~ 5.000 m3 of soft gel grout (sodium silica + reactive)

MAIN EQUIPMENT

1 Comacchio MC22 long mast drill rig
1 Comacchio MC1200 long mast drill rig
1 Metax JM30 full automatic mixing plant
1 Grouting container with 10 pumps type **RODIO** CIRO10
Recording of drilling parameters by means of LUTZ LT3 System
Recording of all grouting parameters SOFIA

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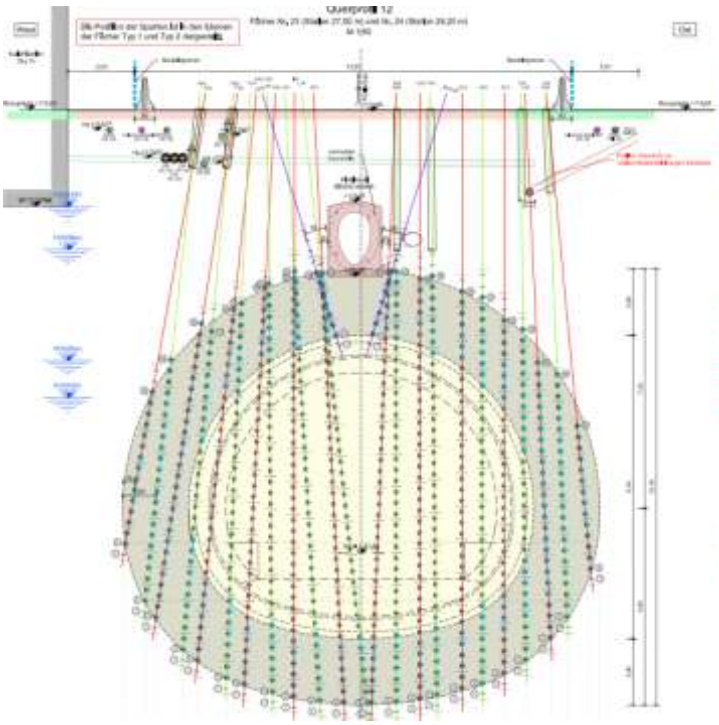
PROJECT

CITY METRO TUNNEL KARLSRUHE
MANCHETTE PIPE GROUTING

Drilling and grouting works in the Karl-Friedrich-Street



Cross section with grouting pipes and valves

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RODIO SINCE 1921

Ground Freezing

PROJECT

METRO WARSAW GROUND FREEZING

PROJECT NAME
Second Warsaw metro Line. Mixed method ground freezing at station C13 Powisle underneath the Wislostrada Tunnel

CLIENT
Capital City of Warsaw

ENGINEER
Studio Balossi Milan

GENERAL CONTRACTOR
Joint Venture AGP: ASTALDI GÜLERMAK PBDIM

SUBCONTRACTOR
RODIO GmbH Spezialtiefbau

CONTRACT VALUE
EURO 8,0 Mio CHF 9,8 Mio

BEGINNING OF WORKS
OCTOBER 2013

END OF WORKS
MARCH 2014

JOB DESCRIPTION

The freezing of soil with the mix method (combination of liquid nitrogen and brine freezing) has been carried out to create a temporary support structure for four tunnels excavated at the new underground station C13 in Warsaw. The tunnels lay in fine silty sands overlying a clay layer and are located 20 m below the ground water level. The two semi-tunnels from the West shaft are partially embedded in very plastic clays, whereas the two from the East shaft are embedded in a sandy clay layer only in the invert zone. The holes for the installation of pipes freezing and thermometers were drilled against water pressure using special Preventers (BOP) to avoid uncontrolled water and soil losses. The first stage of freezing was made using Liquid Nitrogen (LN) in order to reach quickly the required frozen wall thickness whereas the maintenance stage was performed using brine. For both phases the same freezing pipes, with high resilience steel, with the use of an additional copper pipe, have been used.

WORK QUANTITIES

670 drilled holes, drill depth: 5 to 20 m. Total drilled length: 10.500 m
Total Volume of frozen ground: 3.000 m3
610 freezing pipes, 60 Thermometer Strings with a total quantity of 380 measuring points.

MAIN EQUIPMENT

5 Drill rigs: EGT 710 SM14 MC1200 DB100 EGT FM315
1 Mixing and Grouting plant
2 Brine Freezing plants with a power of 370 KW each at -35 °C
5 LN Tanks plants with a total capacity of 260m³
Drilling Parameter Recording by means of LUTZ LT3 system
Online monitoring and control of temperatures and plants

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Ground Freezing

PROJECT

METRO WARSAW GROUND FREEZING

Liquid nitrogen installations - West Shaft

Frozen body seen from the tunnel

Liquid Nitrogen Tanks

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Ground Freezing

PROJECT

SLOVACKI TUNNEL DANZIG POLAND

PROJECT NAME
Road Tunnel 1,1 km long and 11 m internal diameter crossing under the so called Dead Vistula river in the vicinity of Danzig (Poland)

CLIENT
Gdanskie Inwestycje Komunalne (GIK)

ENGINEER
PSP Consulting Engineers GmbH

GENERAL CONTRACTOR
Obrascon Huarte Lain SA (OHL)

SPECIALIST CONTRACTOR
RODIO GmbH Spezialtiefbau

CONTRACT VALUE
EURO 4,7 Mio. CHF 7,3 Mio.

BEGINNING OF WORKS
APRIL 2014

END OF WORKS
MARCH 2015

JOB DESCRIPTION

The Slovaki road tunnel links the new airport of Gdansk, the stadium and many of the road connections to west Poland, with he old portual city on the eastern side of the Vistula river. The freezing of the soil with the so-called indirect method (brine freezing) was chose to permit the construction of the 7 cross passages located into lose ground and below the water table. The main tunnels were excavated using a Herrenknecht Hydroshild type TBM. The TBM has a cutting diameter of about 12,5 m. The cross passages are located in very heterogeneous alluvial deposits with peat to roll gravel layers and some with large boulders. The water head above the sole of the cross passages ranges between 15 and 25 m. The planned frozen wall thickness of 1.80 m was achieved using only one row of freezing pipes. The initial freezing phase required 60 to 70 days. The holes for the installation of the pipes freezing and thermometer were drilled from the south tube against water pressure, using special preventers (BOP). The freezing, thermometer and drainage pipes were installed as lost drill pipes by rotary drilling. A drill mast type EGT VD 400 mounted on a hydraulic lifting platform was used. Due to the huge dimensions of the main tunnels, the construction and implementation of an intermediate working platform was required for the achievement of the upper drilling positions.

WORK QUANTITIES

340 Drillings, average drill length 12 to 19 m. total length 4.500 m
Total volume of frozen soil: approx. 5.600 m3
300 freezing pipes, 30 Thermometer pipes, 450 temp. measuring points.

MAIN EQUIPMENT

1 drill mast EGT VD 400 installed on an hydraulic lifting paltform
1 mixing and grouting plant
1 Freezing plant with a cooling capacity of 380 KW at -35 °C
4 Freezing plants with a cooling capacity of 130 kW each at -35 °C
Recording of drilling parameters by means of LUTZ LT3 System

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PROJECT

SLOVACKI TUNNEL DANZIG POLAND

One cross passage in freezing stage

Two freezing units inside the main tunnel

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Vertical Jet Grouting

PROJECT

GOTTHARD ALPTRANSIT CENERI TUNNEL
LOT 761 CAMORINO JET GROUTING SLAB

PROJECT NAME
Alptransit Project Ceneri Tunnel, underpass of the cantonal road under the new Gotthard railway line

CLIENT
Alp Transit San Gottardo SA

ENGINEER
Consortium of Engineers of the Magadino Plan

GENERAL CONTRACTOR
Mancini & Marti SA

SPECIALIST CONTRACTOR
RODIO Geotechnik AG

CONTRACT VALUE
EURO 3,13 Mio CHF 4,70 Mio

BEGINNING OF WORKS
December 2009

END OF WORKS
December 2011 (expected)

JOB DESCRIPTION

Scope of the work is the realisation of a bottom slab by means of vertical secant jet grouting columns with the scope of watertightening and strutting of an excavation pit for the undercrossing of the new Gotthard railway line just before the north portal of the Ceneri Tunnel. The site is located in Camorino in the south Swiss canton of Tessin. The soil consists mainly of fine silty sands alternate to fine sandy gravels. The maximum drill depth is approx. 12 meters while the average thickness of the slab is 1,0 to 3,6 meters. The vertical confinement of the excavation pit is made of strutted sheet piles walls. In order to obtain the planned diameter of jet grouting columns of 1,80 m the double jet grouting system Rodinjet-2® System was chosen. This system consists in cutting and mixing the soil by means of a high pressure cement grout jet, surrounded by a crown of compressed air.

WORK QUANTITIES

In total 7.120 m of vertically oriented overlapping columns (4.800 pieces) each having a diameter of 180 cm have been executed.

MAIN EQUIPMENT

1 vertical drill rig Casagrande C8 Super with long mast
1 full automatic mixing plant Metax JM-30
1 Jet Grouting triple pumps Tecniwell TW400
Automatic recording of drilling and jet grouting parameters by means of LUTZ CL88 and LT3 systems

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Vertical Jet Grouting

PROJECT

GOTTHARD ALPTRANSIT CENERI TUNNEL
LOT 761 CAMORINO JET GROUTING SLAB

Casagrande C8 super drill rig on Lot 761

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RODIO SINCE 1921

Rock Grouting

PROJECT **WATER POWER PLANT CLEUXON DIXENCE**

PROJECT NAME
Injection work for the renewal of a Pressure pipeline between Tracouet and Beudron.

CLIENT
GRANDE DIXENCE SA

ENGINEER
EDF CIH, Stucky, Bonnard & Gardel

GENERAL CONTRACTOR
CLEUSON DIXENCE CONSTRUCTION SA

SPECIALIST CONTRACTOR
JV **RODIO** Geotechnik AG
SDEM Entreprises SA

CONTRACT VALUE
EURO 4,8 Mio. CHF 7,8 Mio.

BEGINNING OF WORKS
DECEMBER 2005

END OF WORKS
DECEMBER 2006

JOB DESCRIPTION

Rodio performed the drilling and grouting works for the rehabilitation and renovation of the 4.2 km-long water discharge pipe of the water power plant Cleuson Dixence, Canton Valais. The purpose of the injection was the backfilling of cavities inside the rock outside the existing pressure line. A big difficulty has been performing the work from a narrow space inside the tunnel with a 3.0 to 3.4 inner diameter and also the extraordinary inclination of the tunnel by up to 68%. The work had been carried out in the upper 1.5 km long tunnel with 3 specifically designed drill rigs fitted with drilling and grouting equipment and mounted on movable work platforms. Grouting, drilling and personnel platform were moved by a complex but safe system of winds along the extremely steep pressure tunnel.

WORK QUANTITIES

5.900 m radial holes Ø 32 to 72 mm performed from water discharge pipe
Average drill depth 1,1 m. Maximal drill depth 7,2 m
1.500 m³ Cement grout injected volume
40.000 Injection hours.

MAIN EQUIPMENT

3 drill rigs model VD 400 installed on special inclined platforms
2 Full automatic mixing plants type CIMA JM30
2 Grouting plants with 4 pumps each
Automatic recording of grouting parameters by means of LUTZ VOPI system

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Rock Grouting

PROJECT **WATER POWER PLANT CLEUXON DIXENCE**

Drill rig inside the water discharge pipe

Mixing and Grouting Plant inside the cavern

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Ground Freezing

PROJECT

CITY TUNNEL LEIPZIG

PROJECT NAME
Twin Metro tunnel crossing under the main building of the Central Station of Leipzig in Germany.

CLIENT
German Railway Company DB represented by DEGES GmbH

ENGINEER
Ingenieurgemeinschaft VEPRO-FANGER Berlin

GENERAL CONTRACTOR
Consortium City-Tunnel Los C Wayss&Freytag AG, STRABAG AG

SPECIALIST CONTRACTOR
Consortium Freezing CTL
RODIO GmbH Spezialtiefbau
ZÜBLIN SPT GmbH
INSOND Ges.mbH

CONTRACT VALUE
EURO 9.0 Mio CHF 13.5 Mio

BEGINNING OF WORKS
APRIL 2007

END OF WORKS
DICEMBER 2009

JOB DESCRIPTION

Two 80 m long, up to 3,0 m thick and 20 m deep frozen walls are growing below the main building of the central station of Leipzig by using soil freezing technique. Due to the dimensions of the structures and the much extended maintenance time (more than 9 months) the so called indirect method (brine freezing) has been chosen. The thermometer and freezing pipes have been installed from two small pilot tunnels with an inside diameter of 2,40 m. The tunnels are located 4 to 5 meters below water level. All drillings have been performed by using blow-out preventer (BOP) to avoid uncontrolled spooling of soil under water pressure. The soil consists mainly of sand and gravel of the quaternary period. The frozen structure partially enters the lower impervious tertiary layer.

WORK QUANTITIES

1.200 drill holes 2 to 15 m long. Total drilled length: 9.350 m
Total volume of frozen ground: 16.400 m³
1.100 freezing pipes,
114 thermometer chains with a total of 840 measuring points

MAIN EQUIPMENT

2 Drill rigs BERETTA T43 installed on movable star shaped beams
1 Mixing and grouting plant
3 Freezing Plants ARCTOS, freezing power of 380 kW each at -35 °C
Recording of drilling parameters by means of LUTZ LT3 system.

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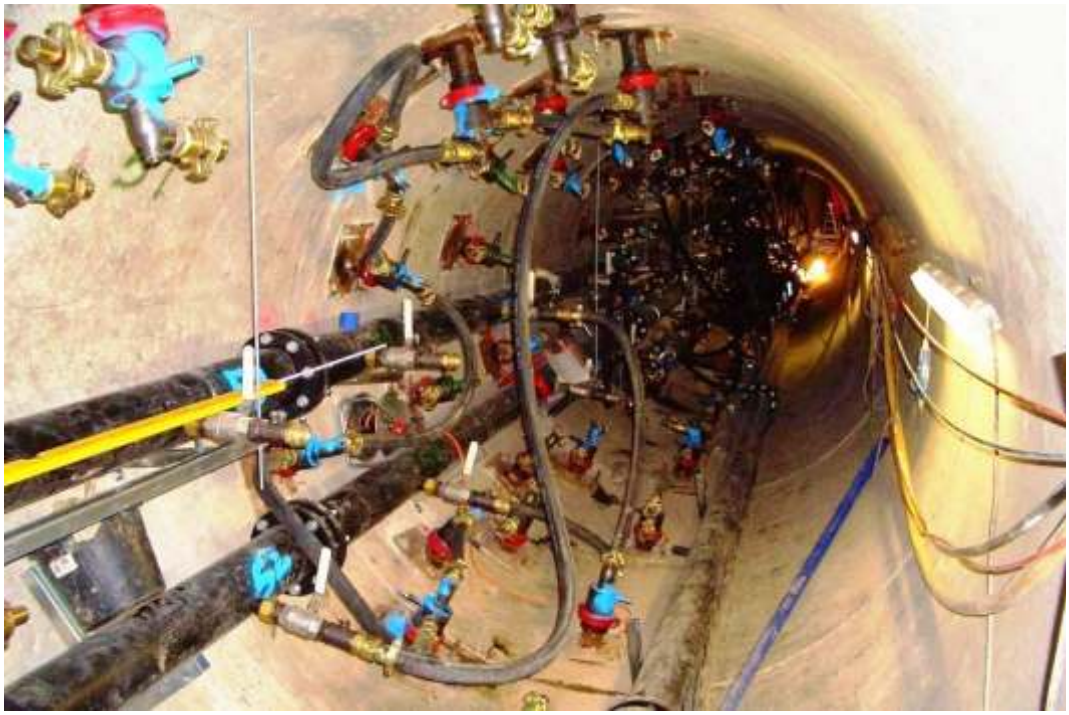
RODIO SINCE 1921

Ground Freezing

PROJECT

CITY TUNNEL LEIPZIG

Drill rig inside
the pilot tunnel



Brine distribution circuit
inside the pilot tunnel

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Vertical Jet Grouting

PROJECT

FORTH CROSSING BRIDGE
OFF SHORE JET GROUTING CURTAIN

PROJECT NAME
Forth Replacement Crossing

CLIENT
TRANSPORT of SCOTLAND

ENGINEER
HOCHTIEF Solutions

GENERAL CONTRACTOR
Forth Crossing Bridge JV
Hochtief Dragados
American Bridge Morrison

SPECIALIST CONTRACTOR
RODIO GmbH Spezialtiefbau

CONTRACT VALUE
EURO 1.25 Mio. CHF 1.53 Mio.

BEGINNING OF WORKS
October 2012

END OF WORKS
April 2013

JOB DESCRIPTION

The Forth replacement Crossing is a cable-stayed motorway 2,7 km long bridge, which crosses the famous Firth of Forth northwest from Edinburgh. The design involves the construction of four sinked caisson foundations. For three of these it has been foreseen to realize a curtain of jet grouting around the caisson and down to the bedrock in order to avoid any inlet of soil and instability during the underwater excavation inside the caisson. The drill rig is installed on a platform placed on top of the caisson. A temporary steel casing is placed from the working platform 2-3 meters inside the seabed. The main soil layers are sandy gravelly deposits and compact clay tills. To achieve the required column diameter of 1.85 m, here the DUPLEX Jet Grouting method (RODINJET 2 ®) was chosen. Following this method, the high-pressure cement grout jet that cuts the soil, is coated by an air jet to increase its action radius. Every hole is surveyed with inclinometer. The max. drill depth achieves 48 m.

WORK QUANTITIES

Total of 3.200 Meter of vertical jet grouting columns Ø 1.85m

MAIN EQUIPMENT

1 Drill rig Casagrande C7
1 fully automatic mixing plant type METAX JM30
1 high pressure pump type METAX MP7-E-CO
1 Air compressor Atlas Copco XAHS 375
Full automatic recording of drilling and jet grouting parameters by means of LT3 LUTZ System.

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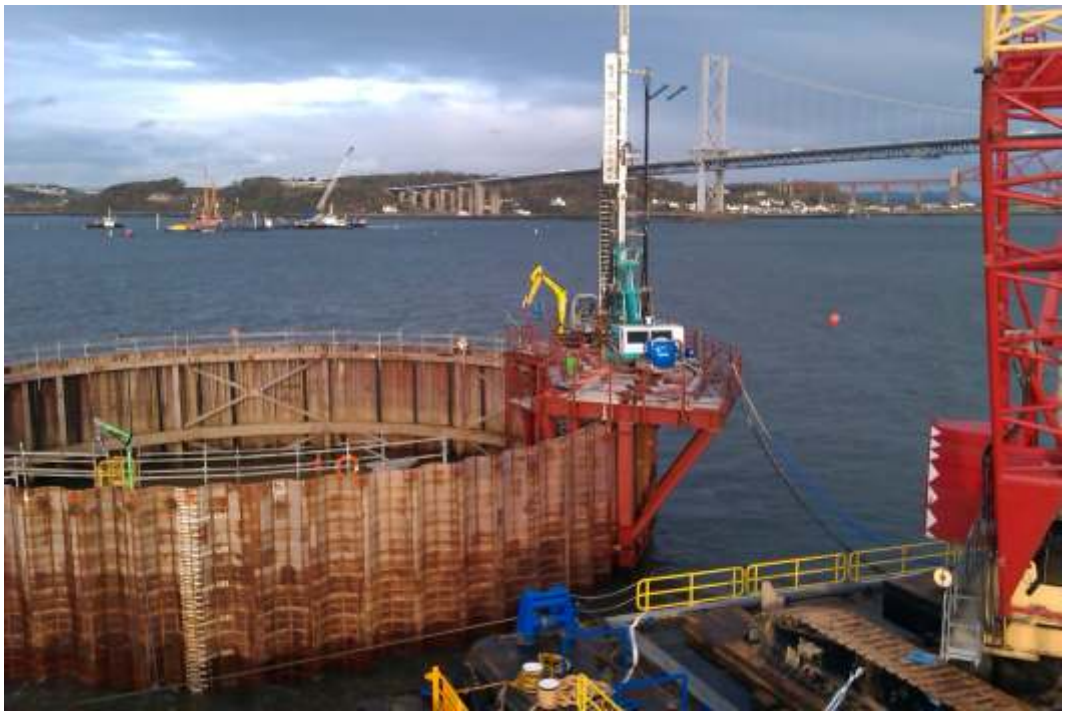
RODIO SINCE 1921

Vertical Jet Grouting

PROJECT

FORTH CROSSING BRIDGE
OFF SHORE JET GROUTING CURTAIN

Drill rig on north tower with service barge



Drill rig working on the south tower

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RODIO SINCE 1921

Rock Grouting

PROJECT **2ND WATER POWER PLANT OF HONGRIN LÉMAN**

PROJECT NAME
FMHL + New Water Power Plant
Water tightening by means of rock grouting

CLIENT
Forces Motrices Hongrin Léman SA

ENGINEER
Stucky EDF Emch&Berger (GIHLEM)

GENERAL CONTRACTOR
JV LEDI

SPECIALIST CONTRACTOR
RODIO Geotechnik AG

CONTRACT VALUE
EURO 9,0 Mio. CHF 11,0 Mio.

BEGINNING OF WORKS
Februar 2012

END OF WORKS
July 2013

JOB DESCRIPTION

The Swiss company Hongrin-Léman SA, has decided to double the capacity of existing hydroelectric plant, by the construction of a new pumped storage power plant into cavern called "Veytaux 2" with a total capacity of 240 MW. The new plant includes one new access tunnel, a cavern, two hydraulic circuit and different chambers.
RODIO performs all drilling and grouting works to seal the rocks mass below water level which lies around the cavern and tunnels. The bedrock consists of hard limestone and marl, with benches of calcareous and argillaceous slate of the so called "Bajocien." The fracturing of the massif is quite broad developed and relatively uniform., The full face rock holes 95 mm are performed by RODIO using a down-the-hole hammer type Wassara whereas the cored boreholes are made with a double core barrel equipped with a diamond crown bit 101 mm. Rock grouting is performed by means of GIN method using computer controlled hydraulic pumps.

WORK QUANTITIES

100.000 m full face drillings Ø 95 mm 600 m cored drillings Ø 101 mm.
Average depth ca. 30 m. Max. depth up to 49 m
Injection: 4.500 m3 of cement grout 4.000 Ton of cement 52.5
Ca. 8.000 Pump hours.

MAIN EQUIPMENT

up to 4 drill rigs type: Comacchio 1200, EGT 710, IPC1200, SM14
1 fully automatic mixing plant type JM30
8 hydraulic controlled grouting pumps type Scheltzke IP63
Fully automatic control of the GIN process and recording of all grouting parameters by means of LUTZ DIALOG system.

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RODIO SINCE 1921

Rock Grouting

PROJECT **2ND WATER POWER PLANT OF HONGRIN LÉMAN**

Grouting Plant with DIALOG GIN graphics on screen

Drill rigs in work in the main cavern

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RODIO SINCE 1921

Ground Freezing

PROJECT

HUBERTUS TUNNEL

PROJECT NAME
Road tunnel along the national road L386 between Wassenaar and The Hague (Holland)

CLIENT
Municipality of The Hague (Holland)

ENGINEER
Underground Works Department of The Hague

GENERAL CONTRACTOR
Joint Venture HUBERTUS TUNNEL
Wayss&Freytag AG, BAM Civiel bv,
Van Hattum en Blankevoort bv

SPECIALIST CONTRACTOR
Joint Venture RODIO HUBERTUS TUNNEL
RODIO Geotechnik AG
RODIO GmbH Spezialtiefbau

CONTRACT VALUE
EURO 1,8 Mio CHF 3,0 Mio

BEGINNING OF WORKS
APRIL 2007

END OF WORKS
NOVEMBER 2007

JOB DESCRIPTION

Ground freezing by means of the so called indirect method (Brine Freezing) for the excavation of 5 cross passages between the two main tunnels, spaced 250 m from each other. The cross passages are situated 10 to 15 m below water table. The ground is very fine and soft and is made by fine sands with silt bands. The holes for the installation of the thermometer and freezing pipes have been performed starting from the south tunnel using special preventer (BOP) to avoid uncontrolled discharge of soil and water inside the main tunnel. The freezing pipes were introduced directly into the ground as lost drill pipes made of special steel for low temperatures.
The drill rig was mounted on a hydraulic scissor platform.

WORK QUANTITIES

110 drill holes, drill depth: 5 to 9 m. Total drilled length: 800 m
The total Volume of frozen ground is 1.200 m³
100 freezing pipes, 10 Thermometer Chains with a total quantity of 80 measuring points.

MAIN EQUIPMENT

1 Drill rig EGT VD 500 mounted on an hydraulic scissor Platform
1 Mixing and Grouting plant
2 Freezing plants VLTC 350 with a power of 105 KW each at -35 ° C
2 Freezing plants WCC 200 with a cooling capacity of 200 kW each fort the pre-cooling of water at +6 ° C
Drilling Parameter Recording by means of LUTZ LT3 system

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RODIO SINCE 1921

Ground Freezing

PROJECT

HUBERTUS TUNNEL

Platform mounted drill rig on a cross passage

Excavated Cross Passage with exposed frozen walls

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RODIO SINCE 1921

Steel Pipe Umbrellas
Jet Grouting

PROJECT

METRO M2 LAUSANNE

PROJECT NAME
New M2 Lausanne Metro Line between
Ouchy and Croisettes-Epalinges

CLIENT
Metro Lausanne Ouchy SA

ENGINEER
CEPT SA, Emch&Berger SA
GVH Tramelan SA, Piguet & Ass.

GENERAL CONTRACTOR
Lot 1200 Dénériaz/Zschokke L./Walo/Grisoni Z.
Lot 1300 Prader Losinger/ Dénériaz
Lot 1400 Prader L./Murer/ Dénériaz /Frutiger
Lot 1500 JPF/Induni/Evequoz-Getra
Lot 1700 Marti TB, Marti TS, Batigroup

SPECIALIST CONTRACTOR
RODIO Geotechnik AG

CONTRACT VALUE
EURO 4.8 Mio CHF 7.7 Mio

BEGINNING OF WORKS
June 2004

END OF WORKS
August 2006

JOB DESCRIPTION

The new Lausanne Metro line M2 has been con-structed in a period comprised between June 2004 and August 2006. The new line from Ouchy to Croisettes-Epalinges, with slope inclinations of up to 12% (one of the world's steepest metro line) has a total length of 2.9 km. The nine lots saw both open cut and closed tunnels. Rodio was present in four of the nine lots and realized over 40,000 m of drill holes for soil improvement in form of steel pipes, jet grouting umbrellas and fiberglass anchors ahead of excavation's face. The difficult and very heteroge-neous ground, consisting of loose layers of silty fine sand, moraine and rock-like molasses, presented together with the very thin coverage with presence of old buildings and crowded roads had been one of the major challenges of this project.

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RODIO SINCE 1921

Steel Pipe Umbrellas
Jet Grouting

PROJECT

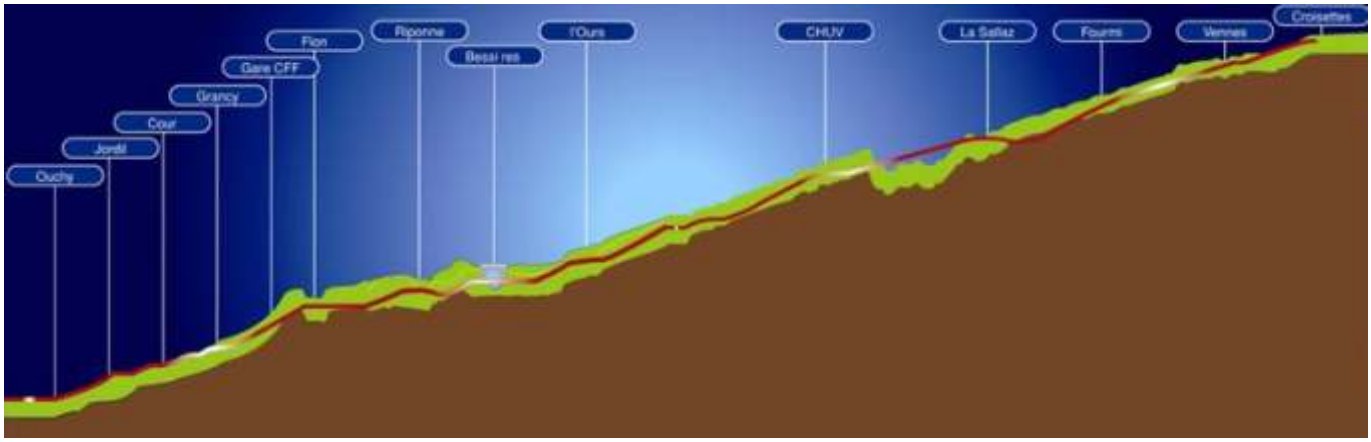
METRO M2 LAUSANNE

WORK QUANTITIES

19'000 m of steel pipe umbrellas
18'600 m jet grouting umbrellas
2.000 m Fiberglass Anchors

MAIN EQUIPMENT

Up to 3 **RODIO** SR510 Tunnel drill rigs
3 computerized full automatic MAT 13/15 mixing plants
1 ELENA grouting plant with 4 injection pumps
2 Metax MP7 high pressure triplex pumps
Recording of drilling and jet by means of LUTZ CL88 and LT3 systems



The steep route of the M2 metro line

RODIO SR510 drill rig inside the Lot 1300 tunnels

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RODIO SINCE 1921

Ground Freezing

PROJECT

TUNNEL LIEFKENSHOEK BELGIUM

PROJECT NAME
6 Km long double tube railway tunnel as new east-west connection for freight trains within the port of Antwerp in Belgium.

CLIENT
INFRABEL NV

ENGINEER
Ingenieurgemeinschaft VEPRO-FANGER Berlin

GENERAL CONTRACTOR
Joint Venture THV Locobouw
Wayss&Freytag AG, VINCI SaS,
CEI-De Meyer NV, MBG/CFE NV

SPECIALIST CONTRACTOR
RODIO GmbH Spezialtiefbau

CONTRACT VALUE
EURO 5,6 Mio CHF 7,3 Mio

BEGINNING OF WORKS
APRIL 2010

END OF WORKS
MARCH 2012 (foreseen)

JOB DESCRIPTION

Freezing of soil by the so-called indirect method (BRINE FREEZING) as temporary support structure for 13 cross-passages and the connection with an emergency exit shaft. The main tunnel were excavated with two Mix shield Herrenknecht TBMs. Each TBM has a diameter of about 8.4 m. The cross passages lye in fine, sandy to silty layers and are located 20 to 40 m below water level. In the four lowest locations, the main tunnels partially enter into the base clay. The holes for the installation of pipes freezing and thermometers were installed against water pressure from the southern tube using special Preventers (BOP) to avoid uncontrolled water and soil losses. Since the second half of the tunnel had to be kept free to tunnels construction traffic during all drilling and freezing activities, a special holding and movement system for the drill rig had to be studied and constructed. The drill rig could move along a vertical mast that was running on two tracks and was able to reach all the drilling positions and inclinations.

WORK QUANTITIES

740 drill holes, drill depth: 5 to 13 m. Total drilled length: 5.500 m
The total Volume of frozen ground is 3.650 m³
640 freezing pipes, 60 Thermometer Chains with a total quantity of 380 measuring points.

MAIN EQUIPMENT

1 Drill rig EGT VD 500 mounted on a vertical hydraulic mast
1 Mixing and Grouting plant
2 Freezing plants with a power of 250 KW each at -35 °C
2 Freezing plants with a power of 100 KW each at -35 °C
Drilling Parameter Recording by means of LUTZ LT3 system

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RODIO SINCE 1921

Ground Freezing

PROJECT

TUNNEL LIEFKENSHOEK BELGIUM

Drill rig mounted on a vertical hydraulic mast

Brine distribution circuit and propping structure

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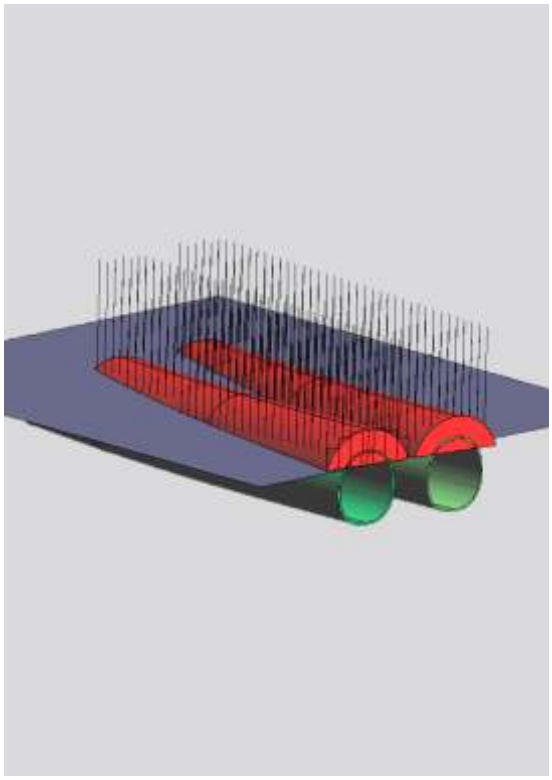
RODIO SINCE 1921

PROJECT

METRO LINE U3 MUNICH OLYMPIAPARK GROUTING UNDER COMPRESSED AIR



PROJECT NAME
Metro Linie 3 Munich Olympiapark

CLIENT
Underground Works Department of the city of Munich (Germany)

ENGINEER
Munich Undeground Works Dept.

GENERAL CONTRACTOR
Joint Venture ZÜBLIN AG,
and Max. BÖGL AG

SPECIALIST CONTRACTOR
RODIO GmbH

CONTRACT VALUE
EURO 4.0 Mio CHF 6.0 Mio

BEGINNING OF WORKS
MAY 2003

END OF WORKS
AUGUST 2004

JOB DESCRIPTION

Cement grouting of ground around the two single track tunnels was performed from inside the galleries under compressed air (0.5 to 0.9 bar) and also from the surface. Grouting was performed using pvc manchette pipes who were placed into the Munich quaternary formation who consists of very permeable gravels and sand intercalated by few thin lenses of clayey silt. Goal of grouting process was to reduce the permeability of soil to values equal or smaller 10-5 m/sec, in order to minimize the losses of compressed air around the tunnels.

WORK QUANTITIES

Grouting from ground level:
1.240 Holes, Total drill length: 13.600 m, 1.720 m³ of injected soil

Grouting from inside the two tunnels under compressed air:
370 holes, Total drill length: 7.900 m, 760 m³ of injected soil

500 m³ of cement grout with 150 ton of cement/limestone admixture

MAIN EQUIPMENT

1 Special tunnel drill rig **RODIO** SR510
1 Full automatic Mixing Plant **RODIO** IM20
1 Grouting Container **RODIO** CIRO10 equipped with 10 Pumps
Drill parameter recording by means of **RODIO** PAGURO System
Operation and monitoring of the whole grouting process for the first time by means of the complex computer software SOFIA

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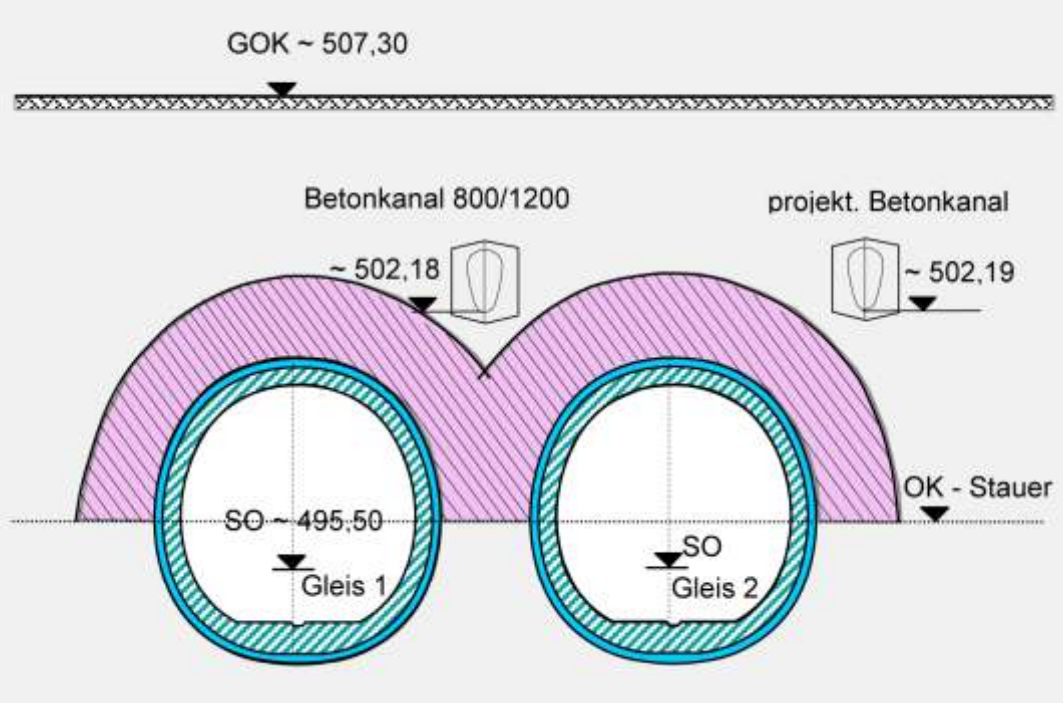
PROJECT

METRO LINE U3 MUNICH OLYMPIAPARK GROUTING UNDER COMPRESSED AIR



Grouted zone above the crown of the two tunnels

Tunnel drill rig **RODIO** SR 510 working under compressed air

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RODIO SINCE 1921

Horizontal Jet Grouting

PROJECT

METRO LINE U3 MUNICH OLYMPIAPARK HORIZONTAL JET GROUTING IN TUNNEL

PROJECT NAME
Metro Linie 3 Munich Olympiapark

CLIENT
Underground Works Department of the city of Munich (Germany)

ENGINEER
Undegr.Works Dept. Munich

GENERAL CONTRACTOR
Joint Venture ZÜBLIN AG,
and Max. BÖGL AG

SPECIALIST CONTRACTOR
RODIO GmbH

CONTRACT VALUE
EURO 2.5 Mio CHF 3.8 Mio

BEGINNING OF WORKS
MAY 2002

END OF WORKS
MAY 2003

JOB DESCRIPTION

RODIO has performed here 13 jet grouting umbrellas each with 59 sub-horizontal columns d. 70 cm (44 along the crown of the tunnel and 15 inside the core of the front). Each jet grouting column has a drill length of 15 m and a jet length of 14 m. Die excavation length under the jet grouting umbrella is of 12 m. The excavation of the double track tunnel with an area of 120 m2 occurred in full face. The jet grouting treatment was performed inside the quaternary layer of Munich Underground made of loose sandy gravels intercalated by thin silty lenses. Following this method, the high-pressure cement grout jet that cuts the soil, is coated by an air jet to increase its action radius. Every hole is surveyed with inclinometer. The max. drill depth achieves 48 m.

WORK QUANTITIES

770 sub-horizontal Jet Grouting Columns with a diameter of 70 cm
Total length of jet grouting columns: 11.200 m,
9.300 m3 injected Cement Grout, Total cem. consumption: 7.000 ton

MAIN EQUIPMENT

1 Special drill rig for tunnels SR510 with a 22 m long mast.
1 Full automatic mixing plant RODIO IM20
1 High pressure pump MP7 CIMA with a 400 HP Diesel Motor
Full automatic recording of drilling and jet grouting parameters by means of LT3 LUTZ System.

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RODIO SINCE 1921

Horizontal Jet Grouting

PROJECT

METRO LINE U3 MUNICH OLYMPIAPARK HORIZONTAL JET GROUTING IN TUNNEL

Special tunnel drill rig **RODIO** SR 510 inside the start shaft

Special tunnel drill rig **RODIO** SR 510 inside the start shaft

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RODIO SINCE 1921

Horizontal Jet Grouting

PROJECT

NECKARGEMÜND CITY ROAD TUNNEL HORIZONTAL JET GROUTING IN TUNNEL

PROJECT NAME
Neckargemünd city road tunnel

CLIENT
Road Works Department of the Rhein-Neckar County (Germany)

ENGINEER
Road Dept. Rhein-Neckar

GENERAL CONTRACTOR
BARESEL GmbH

SPECIALIST CONTRACTOR
RODIO GmbH

CONTRACT VALUE
EURO 2,2 Mio CHF 3,5 Mio

BEGINNING OF WORKS
FEBRUARY 2009

END OF WORKS
JULY 2009

JOB DESCRIPTION

RODIO has executed here 7 jet grouting umbrellas with an average of 110 sub-horizontal columns d. 60 cm in each umbrella. The jet grouting umbrellas consist of a double crown of jet grouting columns. Each jet grouting column has a drill length of 15 m and a jet length of 14 m. Die excavation length under the jet grouting umbrella is of 10 m. The excavation of the double track tunnel with an area of 120 m2 was done as full face. The jet grouting treatment was performed inside silty and clayey sedimentary deposits filled with sandstone cobbles and blocks having a minimum overburden of only 4-5 meters from existing buildings.

WORK QUANTITIES

Approx. 700 sub-horizontal Jet Grouting Columns with a diameter of 60 cm. Total length of jet grouting columns: 10.200 m,
Total cement consumption: approx. 3.000 ton

MAIN EQUIPMENT

1 Tunnel drill rig EGT JM140 equipped with 22 m long twin mast,
Total weight of 70 ton and a max. drill height of 10,0 meters.
2 Full automatic mixing plants RODIO JM 30
2 High pressure pumps MP7 CIMA with 650 HP Diesel Motor
Full automatic recording of drilling and jet grouting parameters by means of LT3 LUTZ System (one unit on each mast).

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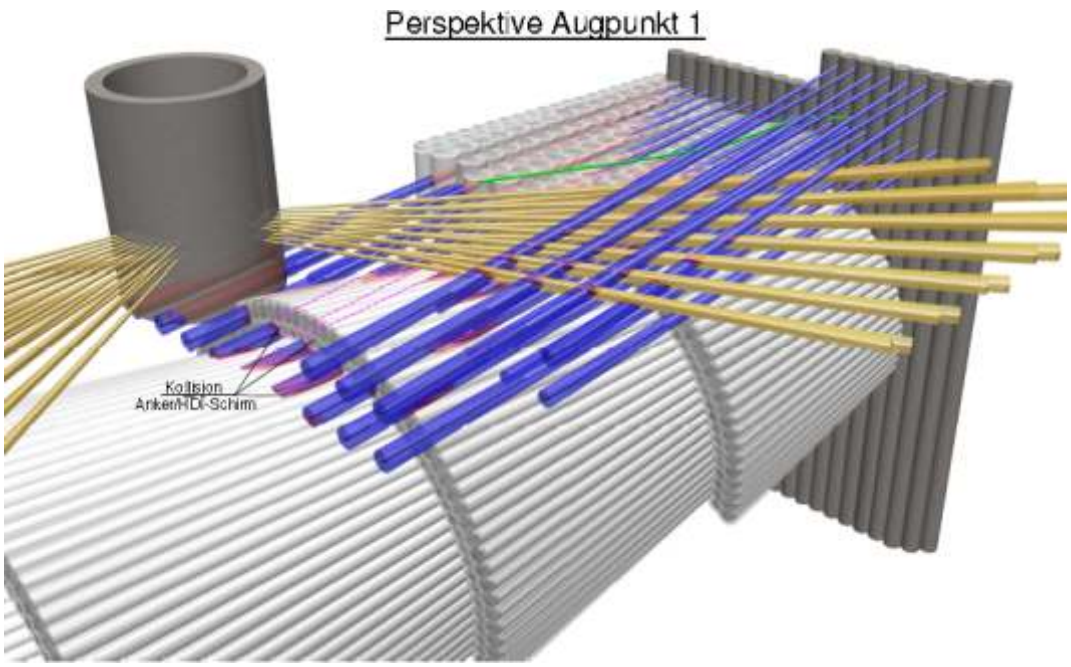
RODIO SINCE 1921

Horizontal Jet Grouting

PROJECT

NECKARGEMÜND CITY ROAD TUNNEL
HORIZONTAL JET GROUTING IN TUNNEL

Tunnel drill rig JM140 with twin boom inside the start shaft



3D view of the overlapping between jet grouting umbrellas, compensation grouting and ground anchors

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RODIO SINCE 1921

Vertical Jet Grouting

PROJECT

NORRA LÄNKEN LOT 51 SWEDEN
TUNNEL VÄRTAN JET GROUTING

PROJECT NAME
Norra Länken Stockholm
Tunnel Värtan water tightening of moraine soil against base rock by means of Jet Grouting

CLIENT
VÄGVERKET SWEDEN

ENGINEER
VÄGVERKET

GENERAL CONTRACTOR
HOT Joint Venture
Hochtief AG HODEN AB

SPECIALIST CONTRACTOR
RODIO Geotechnik AG

CONTRACT VALUE
EURO 1.20 Mio. CHF 1.92 Mio.

BEGINNING OF WORKS
June 2008

END OF WORKS
October 2008

JOB DESCRIPTION

The Värtan tunnel, as a part of the new northern road bypass of Stockholm (The Norra Länken) it's an open pit, partly crossing soft soils, between two rock tunnels. The performance of Rodio includes the execution of Jet Grouting vertical columns (1.60 m) for the water tightening of the soil (moraine) between the foot of the sheet pile wall and the sheet rock (hard granite). Before starting with Jet grouting, every second sheet pile, a steel pipe (140 mm) had been welded to the sheet pile and rammed together just before the top of rock. The soil is generally made by soft to half compact clay, the so called Lera. The last 2-3 meters above the base rock are made of high permeable sandy gravels (friction moraine). The bottom of excavations lies on some extent a few meters under the foot of the sheet piles. The purpose of the Jet Grouting is not only water tightening but also the strengthening of the loose soil up to the rock. To achieve the required column diameter of 1.60 m, here the DUPLEX Jet Grouting method (RODINJET 2 ®) was chosen. Following this method, the high-pressure cement grout jet that cuts the soil, is coated by an air jet to increase its action radius.

WORK QUANTITIES

A total of 2.000 Meter of vertical jet grouting columns Ø 1.60m

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RODIO SINCE 1921

Vertical Jet Grouting

PROJECT

NORRA LÄNKEN LOT 51 SWEDEN
TUNNEL VÄRTAN JET GROUTING

MAIN EQUIPMENT

1 Drill rig Casagrande C8 Super
1 full automatic mixing plant type MA 004
1 high pressure pump type Techniwell TW 400
1 Air compressor Atlas Copco XAHS 365
Full automatic recording of drilling and jet grouting parameters by means of LT3 LUTZ System.

Casagrande C8 Super drill rig at work

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RODIO SINCE 1921

Compensation Grouting

PROJECT

TUNNEL SCHUMANN JOSAPHAT BRUSSELS, BELGIUM

PROJECT NAME
Compensation grouting in the Ilôt des Maisons Place Plasky

CLIENT
INFRABEL

ENGINEER
BELIRIS Direction Transports

GENERAL CONTRACTOR
JV THV Plasky

cei-de meyer galère w&f Jan De Nul

SPECIALIST CONTRACTOR
RODIO GmbH Neusäß

CONTRACT VALUE
EURO 2.30 Mio. CHF 3.50 Mio.

BEGINNING OF WORKS
September 2009

END OF WORKS
March 2012

JOB DESCRIPTION

The establishment of a new connection between the railway tunnels of the line 26, built in 1911, and the new Schumann Josaphat railway requires the construction of a 105 m long branch line nearby Eugene Plasky place. This tunnel passes under a triangular isle of brick houses of three to four floors. To avoid possible damages underneath the existing buildings, due to the construction of new tunnel, it has been planned a large injection campaign to compensate possible settling of buildings. The horizontal drillings have been performed from inside two round shafts. The maximum drill depth was about 56 m. The holes were equipped with 2" 1/8 steel sleeved pipes. The injection was carried out using double-packers from a fully computer controlled grouting container with 10 pumps. In the houses was installed an electro-hydraulic leveling system with a total of 150 measuring points. Specially designed computer software controls the programming of the injection quantities and enables the permanent monitoring of all measurements with automatic alarms when defined settlement and/or rotations are exceeded.

WORK QUANTITIES

3.480 m of grouting holes equipped with steel TAM pipes
100 shifts of pre-grouting and 140 shifts of compensation grouting

MAIN EQUIPMENT

1 Soilmec PSM8 drill rig
1 fully computerized grouting container CIRO 10 with 10 pumps
1 GERTEC GERMIX CM 280 mixing plant
Recording of drilling parameters via LUTZ LT3 system

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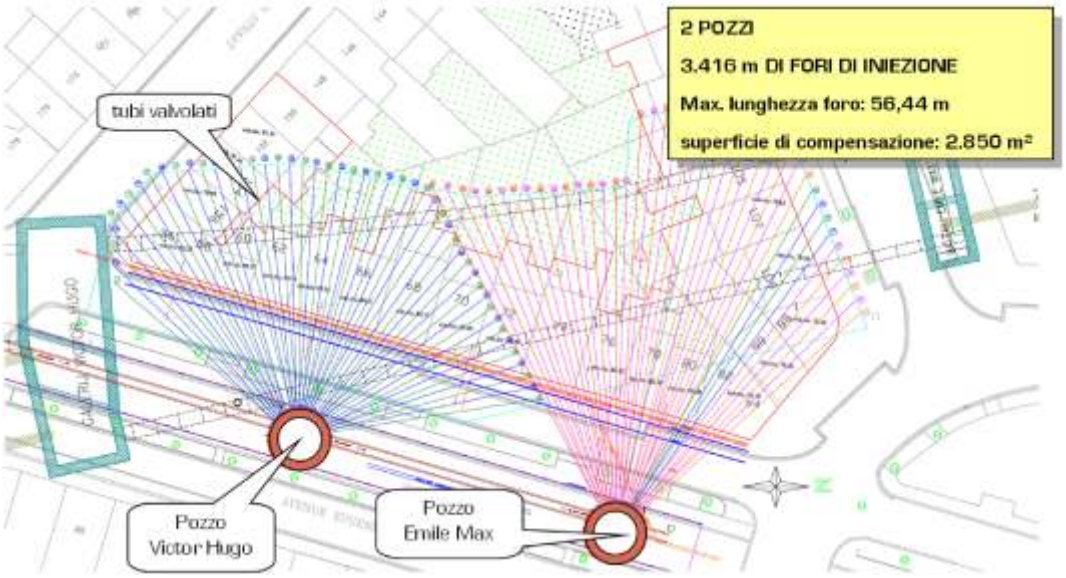
RODIO SINCE 1921

Compensation Grouting

PROJECT

TUNNEL SCHUMANN JOSAPHAT
BRUSSELS, BELGIUM



Plan view of TAM pipe fans with the two drill shafts

Electro-hydraulic leveling point mounted on an external wall

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RODIO SINCE 1921

Tunnelling Works

PROJECT

HIGHWAY BYPASS KURORTNIJ SOCHI (RU)
TUNNELS 8 and 8 A FIBREGLASS ANCHORS AT FRONT

PROJECT NAME
Highway Bypass of Kurortnij Sochi (Russia)
Tunnels 8 and 8 A

CLIENT
DSD “Chernomorie” (Russia)

ENGINEER
Peterburg Dorservice

GENERAL CONTRACTOR
MOSTOTREST

SPECIALIST CONTRACTOR
RODIO Gmbh

CONTRACT VALUE
EURO 2,40 Mio CHF 3,0 Mio

BEGINNING OF WORKS
March 2012

END OF WORKS
November 2013

JOB DESCRIPTION

The Kurortnij highway bypass is a crucial infrastructure to the development and modernization of the city of Sochi in preparation for the 2014 Winter Olympics, allowing a fast crossing of the city from north to south, and an easier reach of some points of interest. The project includes nine tunnels and 13 bridges. RODIO part of the work consists in the installation of fiberglass pipes D 40/60 mm ahead of excavation face at tunnel no. 8 The double pipe tunnel has a total length of about 2.5 km. This is the first tunnel in Russia to be built by following the ADECO-RS method. The north entrance is the most problematic area of work, for which the intervention of RODIO was particularly required. The large section of the tunnel of 150 m² (3 lanes road) and the unfavorable geomorphologic conditions (poor coverage, the presence of an active landslide and of hydrological flows directed towards the tunnel, the soil itself mainly silty clayey with presence of boulders) have required the realization of heavy consolidation measures. The work consists in the installation of blind and valved FG pipes. The sub-horizontal drillings of 18 m length are performed with a DTH hammer at the bottom. The cement injections through the individual valves reach a maximum pressure of up to 15 - 18 bar.

WORK QUANTITIES

175.500 m of drillings with FG-pipes D 40/60 mm L=18 m 25 Umbrellas

MAIN EQUIPMENT

1 Double mast drill rig SOILMEC ST 120
1 Full automatic mixing plant type TECNIWELL TW20
2 Horizontal duplex pumps LORENZETTO L01 Q.max.: 200 l/min
2 Vertical duplex pumps Elena 80/200 Q.max.: 30 l/min

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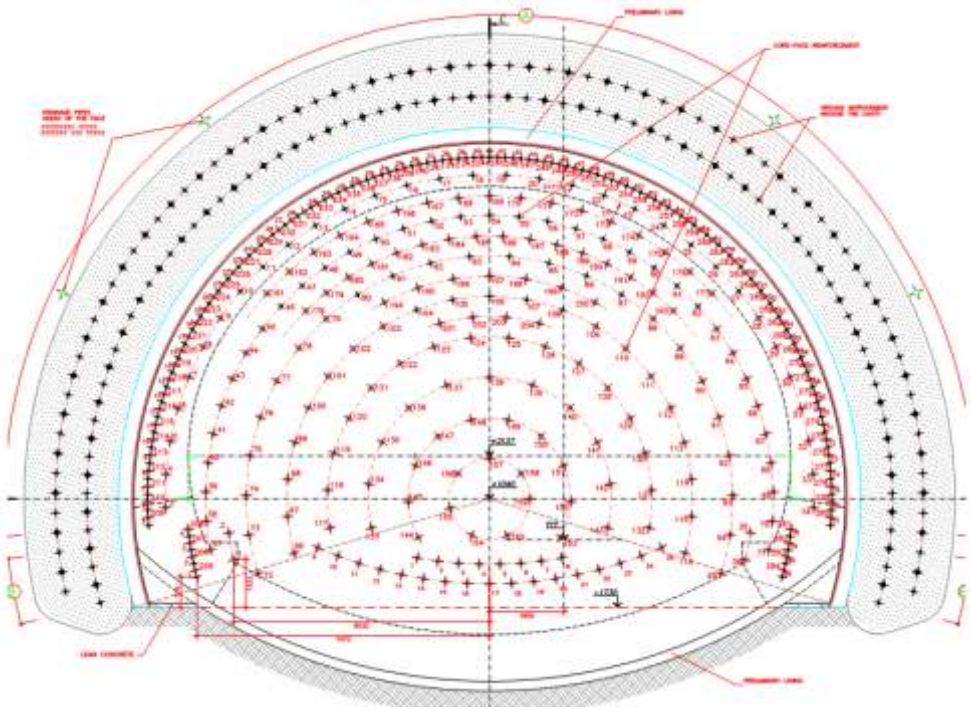
RODIO SINCE 1921

Tunnelling Works

PROJECT

HIGHWAY BYPASS KURORTNIJ SOCHI (RU)
TUNNELS 8 and 8 A FIBREGLASS ANCHORS AT FRONT



Cross section showing consolidating works at Nord entrance

Double mast horizontal drill rig Soilmec ST120 at work

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RODIO SINCE 1921

Horizontal Jet Grouting

PROJECT

METRO LINE U2 TABORSTRASSE VIENNA

PROJECT NAME
Extension of the Vienna Metro line U2 at the Taborstrasse Station

CLIENT
Wiener Linien Ges.m.b.H.

ENGINEER
Engineering JV U2/2 Taborstrasse: WBI, IGT, Verbundplan

GENERAL CONTRACTOR
Joint Venture U2/2 Taborstrasse Wien
Östu-Stettin GmbH, Wayss & Freytag Ingenieurbau AG,
G. Hinteregger & Söhne Bau Ges.m.b.H.

SPECIALIST CONTRACTOR
DSV Joint Venture U2/2
RODIO Geotechnik AG
RODIO GmbH Spezialtiefbau

CONTRACT VALUE
EURO 7.6 Mio CHF 11.7 Mio

BEGINNING OF WORKS
October 2004

END OF WORKS
October 2005

JOB DESCRIPTION

Due to the presence of water bearing layers, the soil surrounding the full face excavation of the twin tunnels had to be consolidated and waterproofed by means of sub-horizontal umbrellas of jet grouting columns and also by fan shaped cut-offs of columns installed from ground level. A particular difficulty has been the reduced overburden of only 12 m of the tunnels passing underneath high buildings with deep foundations. The treatment allowed the withstanding of local water pressures of up to 0.7 bars in the zone of excavation. In order to minimize the possible settlements, a complex volume measuring system to control the balance between injected grout and the evacuated spoil had been set up. The complex geology around the tunnel with frequent alternation of silts, fine sands and coarse gravels with boulders had been another hard trial for the good success of the project.

WORK QUANTITIES

Total of 25'900 Jetmeter. Jet grouting umbrellas with 27-35 Columns each. Column diameter: ø 0.6 m; drill length 15 m; Jet length 12.5-14 m; Length of excavation: 12 m. Up to 9 Core Columns with a drill length of 15 m and a jet length of 14 m. Execution of impervious cut-offs at the end of the umbrellas made of 52-86 Jet Grouting Columns each having a drill length of 15 m and a jet length of 3 m.

MAIN EQUIPMENT

2 Special Tunnel drill rigs RODIO SR510
1 Full automatic mixing plant Obermann MPR800
1 High pressure triplex Pump Metax MP7
Automatic recording of drilling and jetting parameters by means of LUTZ CL88 and LT3 systems.

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RODIO SINCE 1921

Horizontal Jet Grouting

PROJECT

METRO LINE U2 TABORSTRASSE VIENNA

Exposed jet grouting column

Tunnel drill rig
RODIO SR510

Placement of wooden plug

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RODIO SINCE 1921

Rock Grouting

PROJECT

TSANKOV KAMAK DAM
BULGARIA

PROJECT NAME
Tsankov Kamak Dam

CLIENT
NEK (Nat. Elektr. Comp. Bg.)

ENGINEER
Pöyry Energy GmbH

GENERAL CONTRACTOR
Alpine Bau GmbH Bulgaria

SPECIALIST CONTRACTOR
RODIO GmbH

CONTRACT VALUE
EURO 2,45 Mio. CHF 3,90 Mio.

BEGINNING OF WORKS
October 2008

END OF WORKS
November 2009

JOB DESCRIPTION

The double-curvature concrete arch dam of Tsankov Kamak is under construction in the Rhodopian Mountains (near to Greek border) with a maximum height of 130 m will allow for a reservoir volume of 111 Mio. m3. Tsankov Kamak dam is the third of four hydraulic barriers of the so called Dospat-Vacha-Cascade and with a crown height of 130 m is the highest dam of Bulgaria. The 110 mio cu.m water reservoir feeds an hydro power plant with two Francis turbines with a power of 40 MW each. The rock under dam's foundation consists mainly of metamorphic rocks of Vacha motley suite consisting of marbles, amphibole-biotite gneisses and thin intercalation of gneissic slates. The dick veins of pegmatite and quartzite are very hard to drill and extremely and abrasive. RODIO has built an 80 m deep waterproofing grout curtain under the whole foundation of the dam. In total 20.800 m full face drillings (D 90 mm) using a water powered down-the-hole hammer and 1.300 m NQ-cored boreholes (D 76 mm) by means of impregnated diamond core barrels have been executed. All drillings started from dam's foundation from inside a 2,40 m high and up to 80% inclined pilot tunnel. The well known GIN grouting method developed by Dr. Lombardi has been applied for the automated control of grouting operations and for the interpretation of grouting results.

WORK QUANTITIES

20.800 m of full face drillings D 90 mm (Injection + Drainage)
1.300 m of NQ (D 76 mm) cored boreholes

MAIN EQUIPMENT

1 type VD400 rig placed on a drill wagon
1 fully computerized grouting plant CIRO 10 with 10 pumps
1 GERTEC Mixing plant
Recording of grouting parameters by means of IDE System

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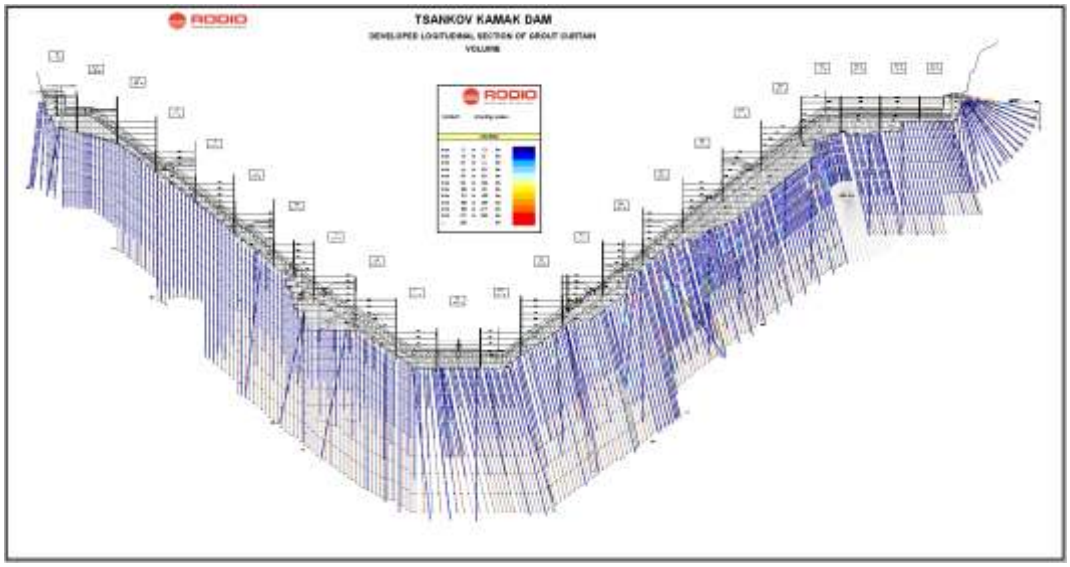
Rock Grouting

PROJECT

TSANKOV KAMAK DAM
BULGARIA

RODIO mixing and Grouting installations on dam abutment

Drill rig inside the Pilot tunnel



3D view of the overlapping between jet grouting umbrellas, compensation grouting and ground anchors

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Vertical Jet Grouting

PROJECT

A9 TURTMANN CUT AND COVER TUNNEL ANCHORED JET GROUTING SLAB

PROJECT NAME
A9 Rhone Highway Section Siders - Gampel
Lot 5523 cut and cover section of Turtmann

CLIENT
Department for Infrastructures and Environment of Canton Wallis

ENGINEER
Gruner AG, Basel

GENERAL CONTRACTOR
Consortium GEBAT Ledit + Frutiger

SPECIALIST CONTRACTOR
Consortium **RODIO** Geotechnik AG
BAUER AG Schweiz

CONTRACT VALUE
EURO 17,3 Mio CHF 22,5 Mio

BEGINNING OF WORKS
September 2007

END OF WORKS
December 2011

JOB DESCRIPTION

Scope of work is the realisation of an anchored jet grouting slab. The goal of the slab is the reduction of the possible deformations and horizontal movement that could occur at the toe of the sheet pile walls during excavation. The scope of the GEWI bar anchors Ø 63,5 mm is the reduction of the possible upheaval of the jet grouting slab during the excavation. The average thickness of the slab is 3,50 m. The slab has, for static reasons a slightly curved form. In order to avoid the problem of possible shadow zones against the sheet pile it has been decided to install one smaller (Ø1,70 m) column into each sheet-pile niche. For all other slab columns a projected diameter of 2,40 m has been chosen. The bigger slab columns have been realised using the so called duplex system RODINJET 2®. This system consists in cutting and mixing the soil by means of a high pressure cement grout jet, surrounded by a crown of compressed air. The border column the triplex system RODINJET 3 was chosen. In the central part of the slab the jet grouting columns were so disposed to leave some windows of untreated soil while in the terminal parts a narrower grid was chosen in order to obtain a closed structure.

WORK QUANTITIES

Total volume of Jet Grouting Slab approx: 39.500 m³.
1.500 Border Columns Ø 1,70 m and 7.080 Centre Columns Ø 2,40 m
1.285 pcs of Micropiles Type GEWI BSt 500, Ø 63,5 mm L = 14 m

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Vertical Jet Grouting

PROJECT

A9 TURTMANN CUT AND COVER TUNNEL ANCHORED JET GROUTING SLAB

MAIN EQUIPMENT

1 Drill Rig Type SM21
1 Drill Rig Type Bauer IB 18
2 Full automatic mixing plant SCW MAT
2 HDI-Pumps Type Metax MP7 and Soilmec 7T 800
Full automatic recording of drilling and jet grouting parameters by means of LT3 LUTZ System

Drill rigs at work for the execution of the jet grouting slab

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Horizontal Jet Grouting

PROJECT

CENERI BASE TUNNEL LOT 853 VIGANA HORIZONTAL JET GROUTING IN TUNNEL

PROJECT NAME
Ceneri base tunnel lot 853 crossing of the A2 Motorway in Vigana

CLIENT
ALPTRANSIT GOTTHARD AG

ENGINEER
JV of ITC ITECSA and Toscano

GENERAL CONTRACTOR
Joint Venture Pizzarotti, Cossi, Ferrari, LGV and RODIO

SPECIALIST CONTRACTOR
RODIO Geotechnik AG

CONTRACT VALUE
EURO 3,5 Mio CHF 5,4 Mio

BEGINNING OF WORKS
FEBRUARY 2009

END OF WORKS
JULY 2010

JOB DESCRIPTION

RODIO has performed on this site a total of 20 conical treatment ahead of tunnel front (890 jet grouting columns ø 60 cm with a total length of 9.600 meters, 350 vertical columns ø 80 cm (2.700 m of jet), 400 vertical columns ø 60 cm (3.400 m of jet) and 5.700 meters of forepoling tubes d. 140 x 10 mm. The most critical and challenging operation has been the realisation of three conical treatments by means of a double crown of partially reinforced jet grouting columns above the tunnel's crown, underneath the A2 motorway with an overburden of only 8 meters. The basis of the arch has a span of 23 meters. No significant settlement has occurred whether during the execution of jet grouting nor during excavation, The motorway remained full in service the whole working period.

WORK QUANTITIES

9.600 m of sub-horizontal jet grouting columns ø 60 cm
5.700 m of tubular forepoling ø 140 x 10 mm
8.500 m of vertical jet grouting columns ø 60 to 80 cm
6.600 m³ injected Cement Grout, Cement consumption: 5.000 ton

MAIN EQUIPMENT

2 Special tunnels drill rig SR510 HD and SR510 with a 22 m long mast
2 Full automatic mixing plant RODIO SCW 13/10
2 High pressure pumps MP7 CIMA with a 680 HP Diesel Motor
Full automatic recording of drilling and jet grouting parameters by means of LT3 LUTZ System

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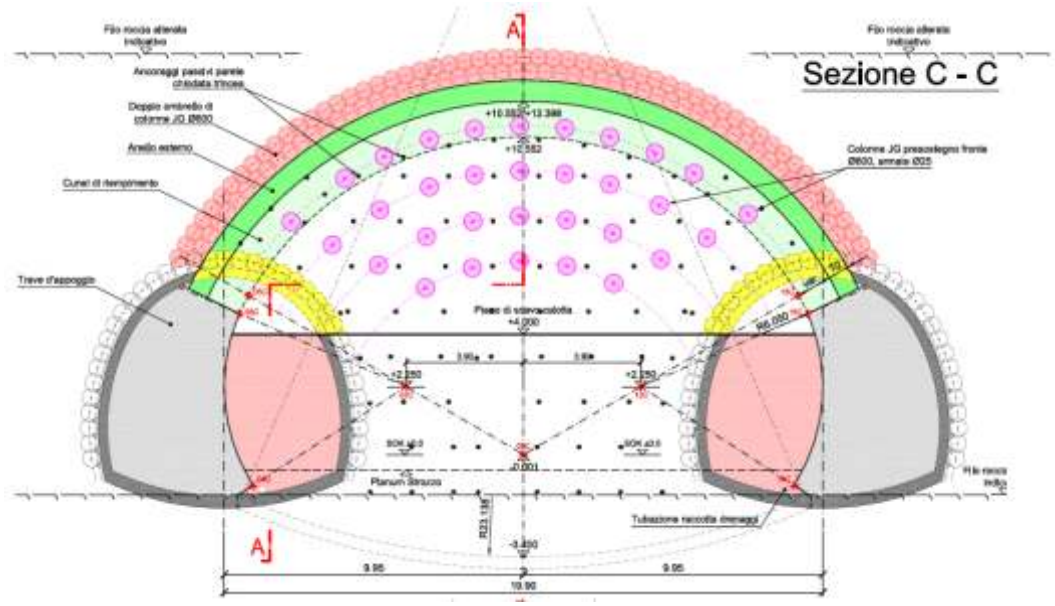
RODIO SINCE 1921

Horizontal Jet Grouting

PROJECT

CENERI BASE TUNNEL LOT 853 VIGANA HORIZONTAL JET GROUTING IN TUNNEL

Tunnel drill rig **RODIO** SR 510 working on the upper crown



Scheme of jet grouting treatment above the tunnel's arch

RODIO GMBH SPEZIALTIEFBAU

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