TBM and Tunnel Expert
Dr.-Ing. ULRICH REHM



Studies

1985 - 1991
Civil-engineering at the Karlsruher Intitute of Technology (KIT) Karlsruhe/Germany;
Specialised in rock- and soil mechanics.

1992 – 1998
Ph.D. on silo- and soil mechanics at the Institute for Construction Management at Karlsruher Intitute of Technology (KIT) Karlsruhe/Germany; Research and development as scientific assistant on cohesive soils. Programming of expert systems.
Supervision and lecturing of graduands.

Career

since 2008	**Dr. Ulrich Rehm Tunnelling Consultant GmbH** Chief Executive Officer
2005	**Tunnelling expert adviser of Herrenknecht AG / Germany , worldwide consultancy**
2004	**Lecturer for mechanised tunnelling (TBM and conventional method) at University of applied science Stuttgart/Germany**
2001	**Director of research & development of TBM manufacturer Herrenknecht AG /Germany**
1998	**Director of the geotechnical department of TBM manufacturer Herrenknecht AG / Germany**

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Professional Experiences

Geotechnical analyses for structural design of soft- and hardrock tunnel boring machines (TBM) (examples: St. Gotthard/Switzerland, Gripper TBM ⦸9m; Guadarrama/Spain, double-shield TBM ⦸9,5m; Madrid M30 EPBM⦸15,20m, Seattle/USA; EPBM ⦸m17,48m Sydney/Australia Mixshield ⦸10,7m ;Hallandsas/Sweden Mixshield ⦸10,5m; Zuerich-Thalwil/Switzerland; single-shield TBM; ⦸12,2m; Limmern/Switzerland; double-Gripper-TBM ⦸8m; Uma Oya/Sri Lanka; double-shield TBM ⦸4,2m).

Feasibility studies and risk analysis for world-wide TBM projects in soft- and hardrock (Mexico City, Teheran, Sydney, Rio de Janeiro, Cairo, Italy, Copenhagen, Italy, Stuttgart, Sri Lanka) – including segmental lining and pipe-jacking projects.

- Technical TBM checker for various TBM types (Final acceptance test (FAT); onsite assembly.

Lecturer for workshops for job-site personnel of segmental lining, pipe-jack and classical rock support projects.

Application of classical rock mechanics models (CSM, NTNU, BÜCHI, EWENDT, SANIO) for prediction of performance rates and tool consumption for hardrock TBM (shielded and open gripper TBM)

- Design of TBM components (cutterhead, CH-main-drive, hardrock tools, cutter-tool distribution, muck flow, wear protection, back-up systems)

Development of own numerical cutting-tool models for TBM-design (cutterhead drive torque, cutterhead design, cutter-tool optimization

Design of logistical mucking solutions

Spoil conditioning concepts for EPBM

Annulus grouting development (single-, double components)

Ground treatment works (jet-grouting, freezing)

Bentonite-slurry application concepts, separation plant design

Environmental studies for muck disposal

Segmental lining design

Planning of world-wide job-site logistics; concepts for assembly and disassembly of TBM

Trouble-shooting on-site for difficult tunnel projects (Sydney, New Delhi, Rotterdam, Hamburg, Berlin, Freiburg, Teheran, Loetschberg, St. Gotthard, Mexico City, Turkey, Sri Lanka).

Feasibility studies on several TBM tunnel projects (Germany, Spain, Australia, Georgia, Switzerland)

Design of separation plant and slurry circuit

Concept for TBM tunnelling within squeezing rock condtions

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Development of tender documents (BoQ of headrace tunnel)

Member of important tunnel associations (DAUB, ITA, ÖIAV); attendance on international working groups for TBM standards

Development of numerical models for TBM design (face-pressure, cutter head drive-torque, thrust forces, slurry circuit, etc.).

Cost estimation and quantification for TBM projects (bill of quantities)

Claim Management (Dublin/Ireland, Freiburg/Germany, Singapore, Vienna, Vancouver, Santiago de Chile, Seattle)

Official court-surveyor (Canada, Austria); mediator for tunnel issues

R&D activities:

- Soil and rock treatment (application of foam and polymers); design of foam generators, ground treatment concepts
- Rock support measures for Gripper-TBM.
- Optimisation of segmental lining (gaskets etc.)
- Optimisation of chipping process for hardrock TBM.

Presentation at world-wide TBM-conferences, lecturer for TBM master courses on hardrock and softrock tunnelling (Germany, Switzerland, Italy, Malaysia)

Official Coach for project management system iTWO of the German Railway Company (Deutsche Bahn AG).

Official Coach for tunnel design of the German Railway Company (Deutsche Bahn AG).

Expert Witness and Expert Advisor on numerous worldwide projects

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Worldwide Projects involved



(1) Stuttgart/Germany – Stuttgart21: Railway tunnel

- Heavily swelling heterogeneous mixed ground conditions; settlement sensitive inner-city tunnelling, preparation of tender documents, risk analysis, cost estimation (⦸11,0m Hardrock/EPB)

(2) Copenhagen/Denmark – Newhaven: Road tunnel

- Big diameter inner-city tunnel in glacial ground conditions; feasibility study and cost estimate for TBM tunnel (⦸14,45m Mixshield)

(3) Copenhagen/Denmark – Cityringen: Metro tunnel

- Long inner-city tunnel in glacial ground conditions under historic buildings; risk analyses and TBM expertise (Mixshield and EPBM approx.⦸7m)

(4) Copenhagen/Denmark – Fehmarnbelt link: Railway&road tunnels

- Feasibility study for 3 long and very big tunnels (⦸18m) between Denmark and Germany in glacial ground conditions, risk analysis and cost estimate; method statements for tunnelling

(5) Salzburg/Austria – Seekirchen: Railway tunnel

- Environmental study for a big tunnel profile in mixed ground conditions (Mixshield).

(6) Waldkirch/Germany – Hugenwaldtunnel: Road tunnel

- Rock tunnel to be refurbished with innovative concept to avoid traffic interruption

(7) London/England – Crossrail: Railway tunnels

- Biggest infrastructure project in the world (2009) with 17 bil.€; new east-west connection under London within heterogeneous ground and inner-city challenges; preparation of tender docs; support of design team as TBM expert for EPB and slurry-TBM (⦸7,1m)

(8) Mexico City/Mexico - Emissor Oriente: Sewer tunnel

- Longest sewer system in the world with approx. 60 km of length and very deep coverage. Feasibility study for hard- and softrock sections due to changed ground conditions; performance optimization on-site (⦸8,1m)

(9) Mexico City/Mexico – Rio dela Compania: Sewer tunnel

- TBM tunnelling concept for very soft ground conditions for EPBM; optimization of tunnelling works on-site (⦸6,3m)

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(10) Beijing and Hangzhou/China – Metro line 1,9, 10: Metro tunnel

- TBM analysis on-site; development of spoil conditioning concept for improved performance of the EPBM in grainy ground (⦸6,2m)

(11) Melbourne/Australia - Kew North/North Yarra: Sewer tunnel

- Tender docs review and expertise on pipe jack in heterogeneous ground (mixed face conditions), risk analysis (⦸1,9m)

(12) Teheran/Iran – Metro Line 6: Metro tunnel

- Segment design and all related TBM constructions; segment plant design; tunnelling concept (spoil conditioning, face pressure calcs; soil mechanical FEM calcs) (⦸9,15m)

(13) Cochem/Germany - Kaiser Wilhelm Tunnel: Railway tunnel

- Tunnelling concept for big EPBM/HardrockTBM with very low coverage under houses; ground treatment concept, tunnelling optimization on-site spoil conditioning concept (⦸10,17m)

(14) Sparvo/Italy – Galeria di Sparvo: Railway tunnel

- Tunnelling concept and risk analyses for the biggest EPBM in the world (2011) ⦸15,55m EPBM within heavily methane gas containing claystone; development of spoil conditioning concept for improved performance

(15) Kuala Lumpur/Malaysia – Klang Valley Mass Rail: Metro tunnel

- Risk analyses for a variable-density TBM (VD TBM) with highly innovative ground treatment concept (⦸6,8m)

(16) Karlsruhe/Germany – Kombi-solution: Metro tunnel

- Tunnelling concept and risk analyses for very low coverage under sensitive buildings (Mixshield); concept for jet-grouted tunnel (NATM) (⦸9,32m)

(17) Shenzen/China – GSG Yitianlu Tunnel: Railway tunnel

- Improvement of slurry technology on the job-site; big Mixshield ⦸13,17m under sensitive buildings; improvement of TBM tunneling concept

18) Singapore – Thomson Line (T208) Tunnel: MRT tunnel

- TBM cutting tool wear consumption estimation for ⦸6,60m EPBM

19) Singapore – DTSS (T-01, T-05, T-06): Sewer tunnels

- TBM tunnelling concepts (spoil conditioning, TBM data analyses, TBM specifications face pressure calculations), cutting tool wear estimations; ⦸4,90m, ⦸6,6m, ⦸7,20m, EPBM

(20) Eskisehir/Turkey – high-speed train connection: Railway tunnel

- tunnelling concept for EPBM ⦸13,72m in highly squeezing rock conditions; spoil conditioning concept; practical support on the job-site

(21) Qatar – Metro Doha: Metro tunnel

- Feasibility study for the use of a variable density TBM (VD TBM)

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(22) Auckland/NewZealand – Waterview: Road tunnel.

- TBM bids review of all bidders (Japan, China, France, Germany) and assessment for a very big EPBM ⦸14,41m in mixed ground conditions

(23) Sydney/Australia – Airport Link Tunnel: Subway tunnel

- Trouble shooting on-site due to heavy clogging and wear (clay and sandstone); innovative cutting tool development and improved slurry concept; concept for ground treatment woks against inner-city settlements. Mixshield ⦸10,17m

(24) Istanbul/Türkei – Bosporus tunnel: Road tunnel

- Consultancy on the feasibility of TBM tunnelling in heterogeneous mixed face conditions with high water-pressure; checking of technical tender docs (⦸14,4m)

(25) Limmern/Switzerland – hydro-power plant: 24°-inclined tunnel

- TBM expert for double-gripper hardrockTBM; checking TBM-design

(26) Vienna/Austria – commercial court expert: Metro tunnel

- Authorized court-expert for TBM tunnelling in litigation for line U2/5 (Mixshield ⦸6,8m)

(27) Sri Lanka, Uma Oya Multipurpose project: Headrace tunnel

- TBM expert for 2 double-shield hardrockTBM (⦸4,3m); tunnelling logistics and Job-site installation; TBM design and tunnelling concept; final workshop acceptance

(28) Oberhausen/Germany – Emscher: Sewer section BA 40

- Feasibility (segmental lining and pipe-jack), tunnelling concept, cost estimate for 2x10 km segmental lining (DN2600; ⦸3,35m)

(29) Tibilisi/Georgia - Liakhvi River Crossing: Pipe-line

- Feasibility study and risk analyses for river crossing (segmental lining and pipe-jack)

(30) Tibilisi/Georgia – Kura East: Pipe-line

- Feasibility study and risk analyses for river crossing (pipe-jack) (DN 1600; ⦸2,0m)

(31) Medellin/Kolumbien – Interceptor Norte: pipe-jack

- Workshop to contractors and client on pipe-jacking technology; consultancy on reinforcement optimization for concrete pipes (DN 2600; ⦸3,1m)

(32) Vancouver/Canada – Capilano Filtration Project: Water tunnel

- Hardrock-TBM expert for the client in pre-litigation phase to defend claim from the contractor (main beam gripper TBM ⦸5,2m)

(33) Oberhausen/Germany – Emscher: Sewer section BA 30

- Comprehensive consultancy to the client (41 km of pipe-jacking; DN1600 – DN 2800) regarding technical tunneling concept and cost control

(34) Rastatt/Germany: High-speed-train tunnel

- Pricing of bill of quantities for tunnelling works, technical tunnelling concept for the client (Mixshield ⦸10,9m); optimization of underground works

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(35) Esfahan/Iran: Cable tunnel

- Trouble shooting for a small segmental lining slurryTBM (AVN, ⦸3,15m); improvement of slurry-tunnelling concept

(36) Andana/Turkey: Headrace tunnel

- Trouble shooting for a single- and double-shield hardrockTBM (⦸3,8m) regarding TBM specification, operational aspects and tunnel lining concept

(37) Seoul/Korea: Hardrock tunnel

- Workshop on TBM design for hardrock tunneling (with Prof. Jamal Rostami/USA)

(38) Seoul/Korea: Metro-tunnel

- Risk analyses and TBM feasibility study for multi-mode TBM type (EPBM/Mix)

(39) Makkah/Sausi Arabien: Metro-Tunnel

- Prüfung Ausschreibungsunterlagen Tunnelbau; Empfehlung technische Spezifikation für TBM

(40) Doha/Quatar: U-Bahn-Tunnel

- Machbarkeitsstudie und Risikoanalyse für den Tunnelvortrieb; Einführung eines Bewertungssystems für verschiedene Tunnelantriebskonzepte

(41) Riyadh/Saudi-Arabia: Metro tunnel

- Checking tunneling tender documents; recommendation of TBM specifications

(42) Guadalajara/Mexico: Metro tunnel

- Development of TBM bidding documents for a contractor (who finally won the tender)

(43) Scarborough/UK: Potash Mine Hardrock tunnel

- Feasibility study and support on tender document preparation for access-tunnel to potash fields (gripper-TBM ⦸6,5m)

(44) Hamburg/Germany – Elbe Düker: Pipe jacking for a gas pipeline

- TBM and tunneling expert for a 1.5 km long pipe jacking project (AVN 2400) beneath the Elbe River, through typical North German glacial soil; development of the jacking concept; technical acceptance of the TBM at the manufacturer's facility; construction supervision; optimization of the jacking process

(45) Seattle/USA – SR99: Road tunnel

- Practical support for the biggest TBM in the world (2014) ⦸17,48m on spoil conditioning; trouble shooting after severe disruption of tunnelling; TBM expert support in the litigation over the tunnel disruptions

(46) Perth/Australia - Forrestfield Airport Link: Metro-tunnel

- TBM Expert consulting the owner (PA) from bidding to construction phase; evaluating variable-density (VD) TBM ⦸7,05m proposals, assessing VD TBM tunnelling concepts; checking VD TBM manufacturing and responsible for the final acdeptance test (FAT) of the TBM; supervising tunnelling activities

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(47) German Railway Company (DB AG) - certified Coach for project management system iTWO:

- Trainer for new project management system iTWO of the German Railway Company (DB AG); topics: cost planning, billing and purchase, controlling (of complex construction projects).

(48) Minsk/Belarus: Deep Shaft

- Geotechnical study and performance assessment for Shaft Boring Roadheader SBR ⦸9m, shaft depth: 700 m through mixed ground condtions for potash salt mining.

(49) Santiago d. Chile/Chile: Alto Maipo Hydroelectric tunnel project

- TBM expert for assessment of feasibility and safety issues for a small single gripper TBM ⦸4,5m in critical hard-rock conditions (squeezing) of the Andes.

TBM expert in litigation on mining disruption

(50) Chennai/India: Metro tunnel

- EPB TBM (⦸6,6m) expert for performance optimisation on the job-site and preparation of claim report for unforeseen geology in mixed face conditions.

(51) Lisbon/Portugal: Drainage tunnel

- EPB TBM expert for preparation of bid proposal for contractor; mixed face conditions, inner City tunnel; cost estimation for tunnelling concept EPBM (⦸6,5m)

(52) Hull/England: Pipe line tunnel

- Mixshield TBM expert for supervision of tunnelling works and related job-site installations under the River Humber; glacial mixed face ground conditions (⦸4,5m)

(53) Virgina/USA: Chesapeake Bay Bridge Road Tunnel

- EPB TBM expert for design calculation of big EPB TBM components ⦸13,2m; wear and tear concept

(54) Baku/Azerbaijan: Baku Sewer Tunnel

- TBM and tunnel expert for technical inspection of tunnel quality for preparation of litigation ⦸3-3,5m

(55) Genova/Italy: Slurry circuit design (Bypass Genova)

- Design of a 2x9km slurry circuit with special slurryfier-box for muck conveyance and disposal from tunnel job-site to the sea along restricted public road area

(56) Lyon/France: Metro Line B

- TBM expert for bidders tender proposal support for variable density TBM ⦸9,7m, development of tunnelling concept (including sophisticated slurry/separation concept).

(57) Offenburg/Germany: railway tunnel

- Feasibility study and risk analysis for Mixshiled TBM ⦸10.7m in heterogeneous geology, sensitive environmental conditions (including drinking water protection area), inner-city buildings at risk of settlement; River underpassage with little cover, participation in public panel discussions (public event and local council) on the part of the client

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(58) Zuerich/Switzerland: Bruettenertunnel

- TBM expert for feasibility study, tunnelling concept and preparation of tender documents; railway tunnel TBM for mixed face conditions ⦸9,9m (including TBM performance estimation under consideration of clogging tendencies; wear and tear concept etc.)

(59) Paris/France: Messil-RTE sewage tunnel

- Geotechnical analyses and procedural assesment of the tunnel works (⦸3,5m); comparison between EPB and Mixshield TBM

(60) Las Placetas/Dom. Republic: Hydropower tunnel

- Geotechnical evaluation and development of a tunnelling concept including cost and performance estimation for a Double-shield-TBM(⦸5,25m)

(61) Auckland/NewZealand: Metro CRL

- Evaluation and assesemnt of techncial proposals of 3 TBM-manufacturers; (EPB ⦸7,1m)

(62) Sipplingen/Germany: fresh water supply tunnel

- Expertise for various tunnelling methods for the construction of a fresh-water supply tunnel within an environmental sensitive area (⦸3-5m) including job-site logistics, TBM performance, geotechnical analyses, construction cost estimation etc.

(63) Seoul/Süd-Korea: Metro (Daegok Sosa Subway)

- Tunnel constrution analyses and performance optimization on the job-site in Seoul for 2xEPB⦸8,0m including soil conditioning tests

(64) Leverkusen/Germany: BAB1 motorway tunnel

- Feasibility study, risk analysis and cost estimate for alternative tunnel solution, ⦸15m Rhine crossing; special environmental situation (toxic waste dump); Application of the RABT, advice for citizens' initiatives; public panel discussions on the citizens' initiative side; Examination of planning approval documents.

(65) Bruchsal/Germany: TBM data recording system VDMS

- Analyses and practical check of the TBM data recording system VDMS of VMT Bruchsal.

(66) Sacramento/USA: Delta conveyance project water tunnel

- Member of Independent Techncial Review Board for TBM tunnels and shafts; development of comprehensive tunnelling concept (TBM design, spoil handling, segment design, site logistics within environmental sensitive area etc.)

(67) Copenhagen/Denmark: Sewage tunnel Novafos (DN1200)

- Supervisor for mining activities for inner-city pipe-jack under sensitive railway bridge

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(68) Copenhagen/Denmark: Sewage tunnel BVT (DN1800-DN3200)

- Cost estimation for inn-city pipe-jack (L=3,3 km)

(69) Dublin/Ireland: Dodder River Crossing (DN1800-DN3200)

- Tunneling concept for construction of district heating pipe under river Dodder (DN2500)

(70) Niechorze/Poland: Ostessegasleitung Gas Pipe-line (DN2000)

- Checker for mechanized tunneling (pipe-jack) from Denmark (L=1.000m) und Poland (L=600m); responsible for final acceptance test of AVN 2000 in Germany

71) New Delhi/India: Dwarka Tunnel Road tunnel

- Tunnel expert for feasibility study TBM and NATM, cost and time estimation; risk assemsment and tunnelling strategy recommendation for Mixshield/EPB ⦸12, ⦸15 and ⦸18m

72) Kashmir/India: Pir Ki Gali Road tunnel

- Tunnel expert for feasibility study TBM and NATM, cost and time estimation for a hard rock tunnel; risk assemsment and tunnelling strategy recommendation

73) Paris/France: Metro Line 18.3

- TBM expert for bidders tender proposal support; comparison of EPB and VD-TBM ⦸9,1m, development of tunnelling concept; spoil condtioing concept; laboratorium concept

74) Los Angeles/USA: Metro Westside Line Section 1

- TBM expert for spoil conditioing in gassy ground (methane) on client side during hearing (EPB ⦸6,7m), preparation of technical opinion and rebuttal paper for Despute Review Board (DRB)

75) Snowy Mountains/Australia: Snowy 2.0 Hydro-Electric Scheme

- TBM expert in the legal dispute over the tunneling performance and penetration test (drag testing) of a shielded hard rock machine (⦸10,9m)

76) East London/South-Africa: East London Diversion Sewer Tunnel

- Develop and price an offer for the TBM drive (hardrock TBM (⦸3,5m) segmental lining

77) Tapovan/India: Tapovan-Vishnugad Electric Hydro Power Project

- TBM expert in the legal dispute over mining problems of a double shield TBM (⦸6,4m) in highly squeezing rock conditions

78) Offenburg/Germany: Railway Tunnel

- Risk analysis for tunnel passing under a public shopping center and wine cellar with small cover (Mixshiled TBM(⦸11m)

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79) Luoning/China: steep water tunnel

- Risk analyses for the construction of a very steep water tunnel (inclination 39°) with a double-gripper TBM (⦸7,3m)

80) Toulouse/France: Metro tunnel Line 3 Lot 2

- Evaluation of the tender documents and corresponding TBM design for the offer (EPBM ⦸9,7m)

81) Rotterdam/Netherlands: innovative wind turbine project

- Development of drilling equipment for monopile foundation (⦸9-15m)

82) Genua/Italy: Genova Bypass road tunnel

- Comparison and assesemnt of 2 technical tunnelling proposals and development of own tunnel concept (design of slurry circuit and separation plant; Mixshield ⦸14,7m)
  Assessment of squeezing rock conditions in view of TBM design
  Development of tunnelling concept within asbestos contaminated rock

83) Michigan/USA: Line 5 pipeline, Straits of Mackinac

- Evaluation and assessement of 3 technical TBM proposals (variable density TBM, Mixshield, Variable denisty-TBM ⦸7,7m. operational face pressure: 20 bar)

84) Lodz/Poland: PKP railway tunnel, axis 23

- Analyses of soil conditioning concept and development of alternative mining concept for a big EPBM (⦸13,1m)

85) Paldiski/Estonia: Paldiski hydro energy storage project (PHES)

- Comprehensive feasibility study for TBM tunnels within PHES (including technical concept; logistics, costs, performance) Mixshield TBM (⦸8,4m)

86) Singapore: CRL -Punggol ext.; Metro Tunnel contr. P103, CR202

- TBM design checker EPBM (⦸12,7m)

87) Cusco/Peru: Hydro-power tunnel Santa Teresa II

- Feasibility study and pre-planning for head race tunnel (⦸7,1m) of hydro-power plant Santa Teresa II

88) Barcelona/Spain: Metro Line 9

- Checking technical TBM design (EPB ⦸12m) for planned tunnel section (Mandri shaft – Lesseps) and recommendation of spoil conditionig concept.

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89) Toronto/Canada: Scarborough Subway extension (ATSSE)

- Calibrating spoil conditioning system on-site (EPB ⦸11,87m) and developing tunnelling strategy after several ground collapses.

90) Stockholm/Sweden: Metro Stockholm Yellow Line (BH3)

- TBM expert for detailed design on the client's side (shielded hard-rock TBM (approx. ⦸7,2m); developing tunnelling trategies, logistic systems, cost and time plan, check of concept design.

91) Copenhagen/Denmark: Kagsaparkens rain-water tunnel (DN800-DN1000)

- 3 AVN pipe-jacks (tunnel lengths: 70m, 55m, 50m) under sensitive buildings though glacial mixed ground; construction supervision as TBM expert on the client's side.

92) Rzeszow/Poland: Road tunnel S19 Rzeszow - Babica

- Analyses of tunnelling and soil conditioning concept for a very big EPBM (⦸15,1m) on the job-site.

93) Pietermaritzburg/South-Africa: uMkhomazi water proejct

- TBM Specialist for support on construction tender design and documentation (hardrock TBM approx. ⦸4,3m) for a 34km long water transfer tunnel.

94) Tung-Hsiao /Taiwan: 2 sea-outfalls for gas-pipe-line

- TBM- and geotechnical specialist for design of 2 x 36'' sea outfalls each 800m long for a 54km gas pipe line connection in mixed ground conditons with direct pipe system (AVN800XC, pipe thrusterHK500PT).

95) Stewart/Canada: KSM Mitchell Treaty Tunnel

- Member of Tunnelling Review Board for TBM Applicabality; Feasibility study for various hardrock TBM types (single-,double-shield-, gripper-TBM) ⦸7,2m for 2x22km access tunnels for a mine in remote area (Alaska/Canada border).

96) New York City/USA: 2nd Ave Subway Phase 2

- Official checker for main bearing seal of a variable density TBM ⦸7,2m for 2x1,2km subway line in mixed face conditions under skyline of NYC.

97) Buksefjorden/Greenland: hydropower tunnel

- Feasibility study wirh focus on cost and time for a 16km long ⦸5,5m hardrock tunnel in the remote area of Grenland; The great challenge is the extreme climatic conditions of Greenland in a highly remote area.

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98) Silvan/Turkey: water transfer tunnel

- Tunnel expert for analysing critical tunnelling situation and devolping solutions due to several geotechnical risks like methane gas, H2S, karst, squeezing and swelling rock condtions. Tunnel length 13,5 km, ⦸11,3m EPB/hardrock TBM in highly heterogeneous rock conditions.

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