



Journée d'étude - Studiedag

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IMPACT OF GEOLOGICAL AND ENVIRONMENTAL CONDITIONS ON THE PERFORMANCE OF MICROTUNNELLING

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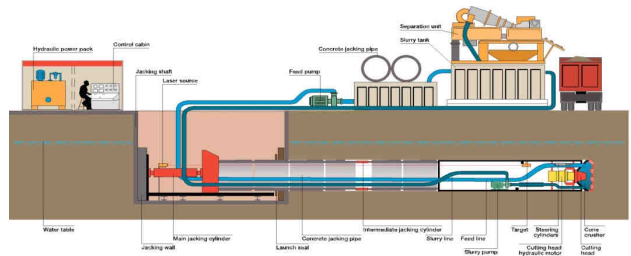
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Impact of geological and environmental conditions on the performance of microtunnelling

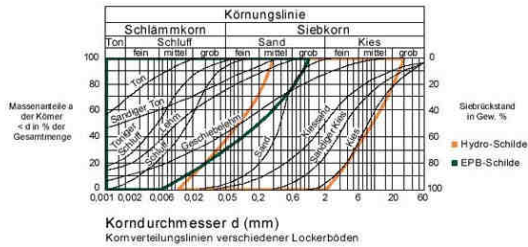


Turbot



Environment

Microtunnelling techniques

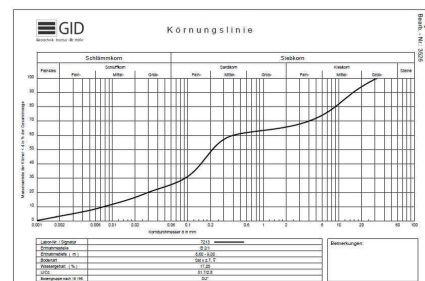
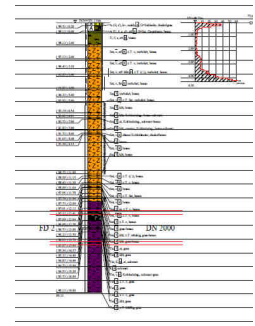


Geology



CONTENT

- Introduction
 - Design of microtunnelling needs detailed research
 - geological conditions
 - environmental conditions
- Fish farm project in Portugal
 - Jackings record length – 1500 m DN3000
 - Sea-outfalls
- Sewer collector Dortmund
 - Variable geology
- Conclusion



Fish farm project in Portugal General description



- Seafood company Pescanova
- Largest turbot aquaculture plant worldwide
- Location Mira (Portugal)
- Investment : 200 million Euro
- Annual production : 7.000 tons
- 99% export to Europe
- Client : Pescanova
- Microtunnelling operations : K-BORINGEN



Fish farm project in Portugal
General description

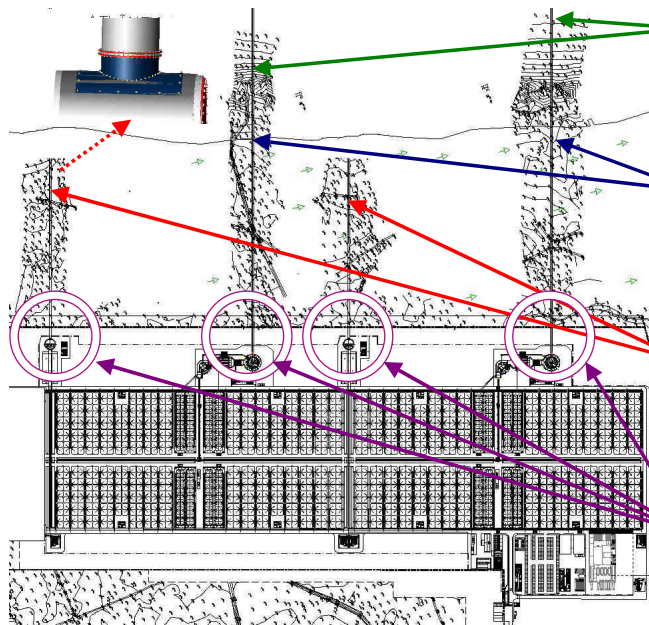


Fish farm

- Fresh seawater : 25 m³/s
- Minimal environmental impact
 - Coastal protected area
 - Microtunnelling
 - Pipe factory on site
- Start : November 2007
- Surface : 57 hectares



Fish farm project in Portugal General description



Extension intakes

HDPE-pipeline
ID : 2 x Ø 2,0 m
L = 4 x 1.300 m



2 intake tunnels (T1, T2)

concrete pipes
ID : Ø = 3,0 m
L = 1.500 m each



2 outfall tunnels (V1, V2)

concrete pipes
ID : Ø = 3,0 m and 2,6 m
L = 1.350 m each

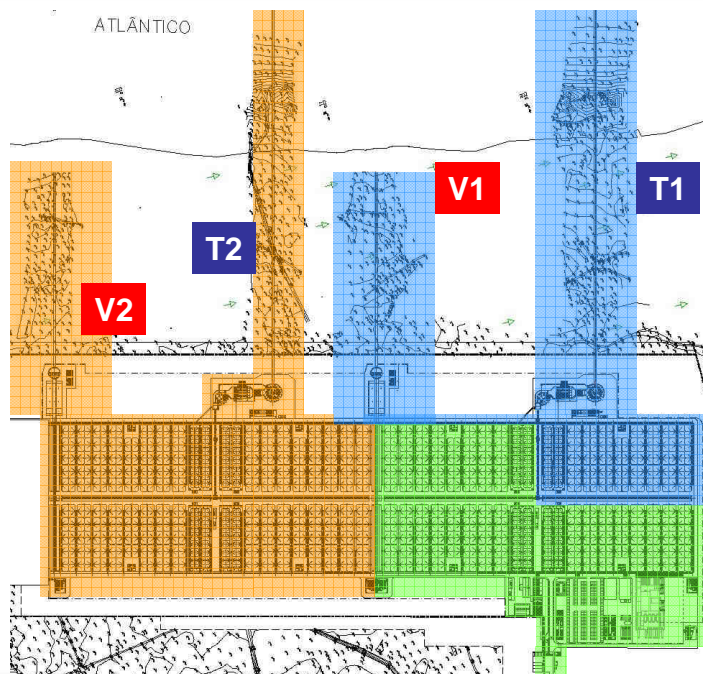
4 launch shafts

ID : Ø = 20 m, depth = 10 to 15 m
diaphragm walls, 32 m deep
Reaction wall : 3000 tons / Soft eyes GFRP



Fish farm project in Portugal

Challenges / critical points



- Length of the jackings
- The tight time schedule
Start : december 2007

Phase 1a November 2008

Phase 1b February 2009

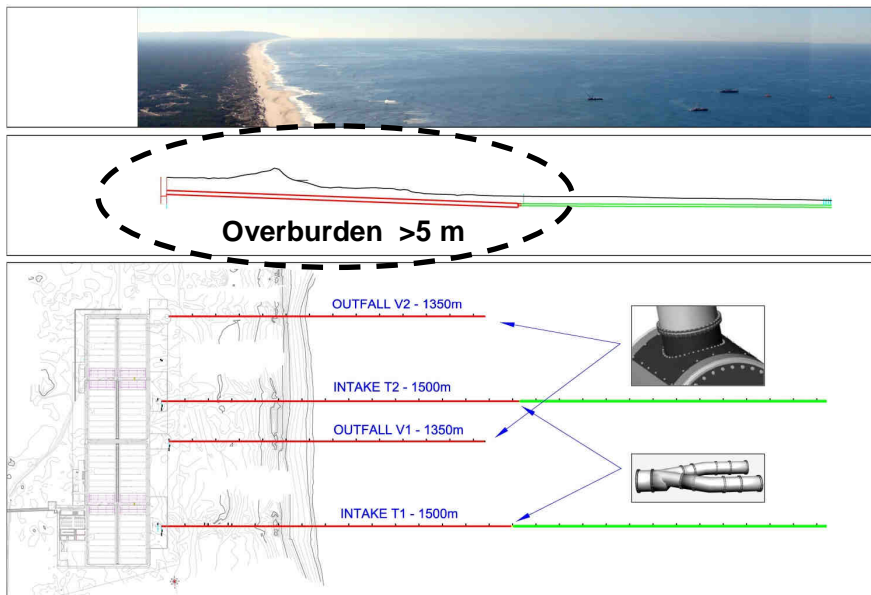
Phase 2 February 2010

- Geology (lack of data)
- Longitudinal profile (depth, curve, overburden beach)
- Influence of the sea



Fish farm project in Portugal

Longitudinal profile



Fish farm project in Portugal

Geological information

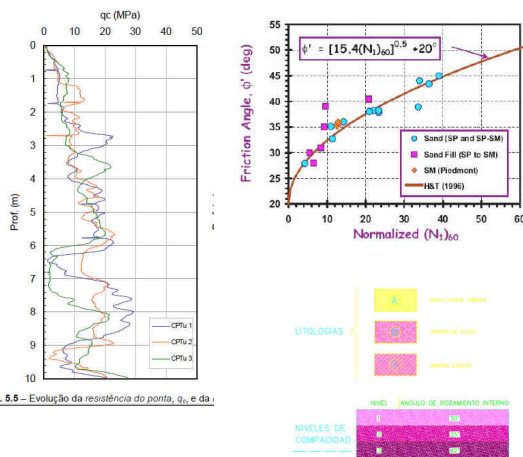
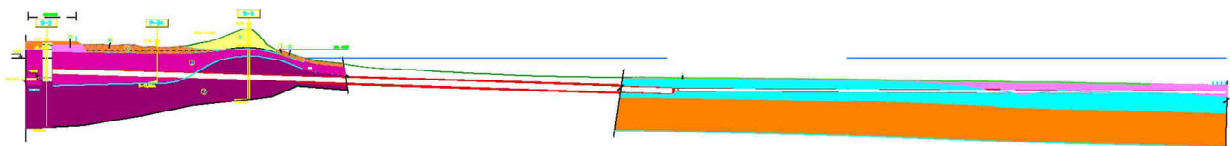


Fig. 5.5 – Evolução da resistência do ponta, q_c , e da

- Area of plant + sea with waterdepth > 5m : borehole probing + trial pits, particle size curve, SPT, f, ...
- For each jacking geological information for 3 or 4 locations on land (500 m)
- Black box between dunes (500m) and 1350 m
 - Uncertainty presence rockbed
 - Additional investigation with divers requested by K-Boringen



Fish farm project in Portugal
Microtunnelling equipment



TBM with OD 3800 mm
AVND 2400 HK with extension kit



Cutting wheel



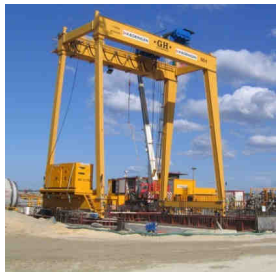
Integrated air lock chamber



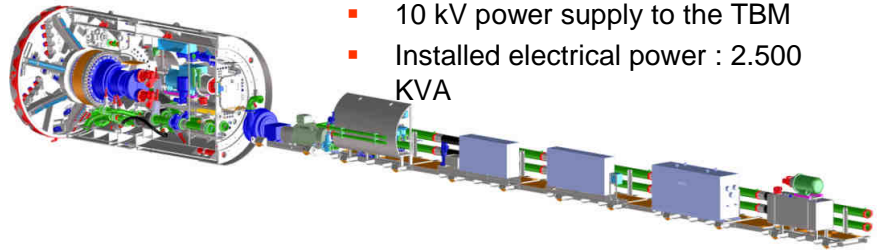
Main jacking station



Fish farm project in Portugal Microtunnelling equipment



50 tons gantry crane



- 400 kW electric motor
- 10 kV power supply to the TBM
- Installed electrical power : 2.500 KVA



Bentonite lubrication system



Step down transformer



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Fish farm project in Portugal Jacking pipes



Welding



Moulds



Pipes



IJS



- Temporary on-site pipe factory : environmental impact of transport by road
- Pipe ID 3000 mm :
length 4,0 m
weight 43 tons
- Wall thickness 40 cm
!! 20 m water pressure
!! Buoyancy
- 1400 Pipes + 38 IJS + special pipes (9 months)
- Severe quality program



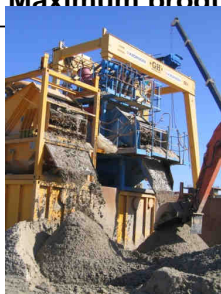
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Fish farm project in Portugal

Microtunnelling operation

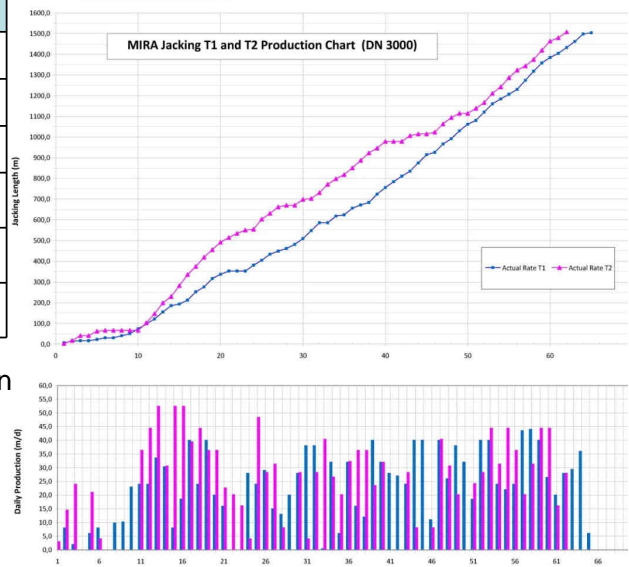
MICROTUNNEL PROJECT DATA	INTAKE T2
Total length	1.500 m
Total microtunnelling time	62 days
Average production rate	24,2 m/day
Maximum production in 24 hrs	52 m
Maximum production in 1 week	316 m
Maximum production in 1 month	912 m



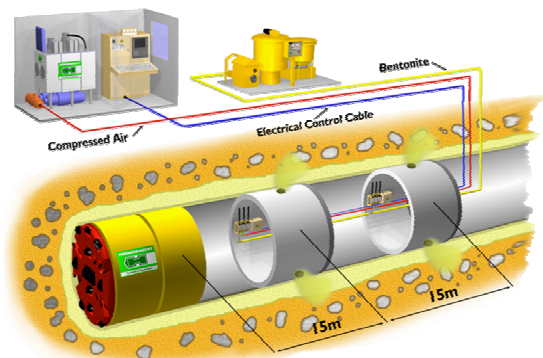
Separation plant

Advance rates : up to 15 cm/min
 → solids 180 tons/h
 Capacity of desander units :
 600 m3/h

KBORINGEN Projecto Execução Aquícola de Engorda de Pregado em Mira (Portugal)

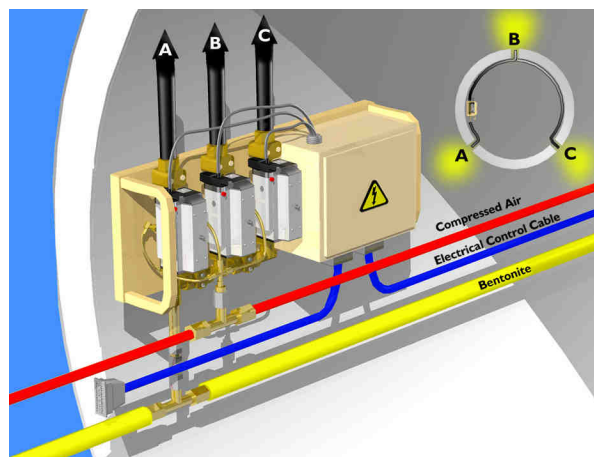


Fish farm project in Portugal Microtunnelling operation



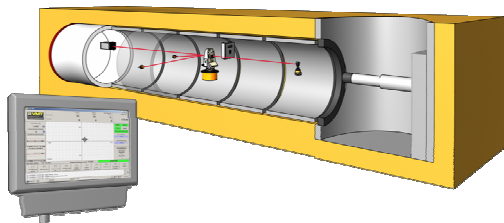
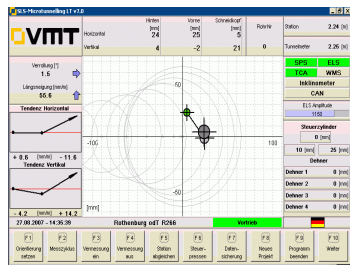
- Mixture of bentonite + additives for lubrication + face support
- Mixture adapted to :
 - Geological conditions
 - Water quality
 - Presence of salt water

Automatic bentonite lubrication system



Fish farm project in Portugal

Microtunnelling operation



Guidance system

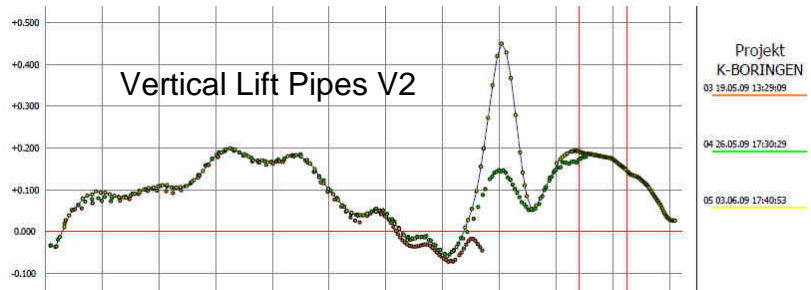


Fish farm project in Portugal Microtunnelling operation



Frac Out

- Microtunnels realised without major problems !
- Problems encountered :
 - Break down power supply V2
 - High friction forces
 - Activation interjack stations
 - Frac outs of bentonite on the beach (reduced overburden)
 - Vertical lift of the pipes in the V2 (buoyancy), up to 45 cm



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Fish farm project in Portugal

Subsea recovery

Preparation

- Emptying the tunnel
- Connecting pipe segments over first 50 m
- Closing bulkhead
- Air pressurising of the TBM
- Flooding tunnel + shaft to equalise pressure

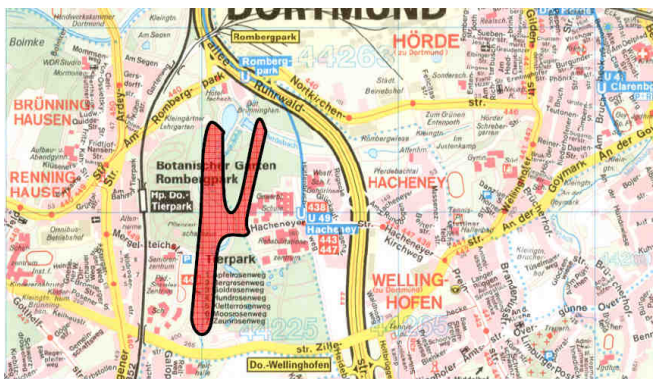


Recovery

- Dredging boat
- Meteorological conditions (waves < 1 m)
- Hydraulic jacks separate TBM from first pipe segment
- Hoisting anchors + balloons
- Towed over 35 km to harbour



Sewer collector Dortmund General description



- Construction of 1.350 m combined sewer system
- Public Area (Tierpark) / Botanical garden (Rombergpark)
- Microtunnelling
 - DN800 (450m)
 - DN1200 (220m)
 - DN2000 (580m)



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Sewer collector Dortmund

General description



Special requirements

- DWA-A125 : specification micro-T in Germany (datalogging, deviations, ...)
- ATV-A161 (Static calc. Pipes)
- Online Load Control Micro-tunnelling
- Pipes (HS Cement, concrete C50/60, mold, ...)

- AVN (slurry supported face)
- DN2000/OD2500
 - Length 580 m
 - Curve 710 m Radius (start)
 - Crossing 3 intermediate shafts
- Several geological formations (+ geological faults)

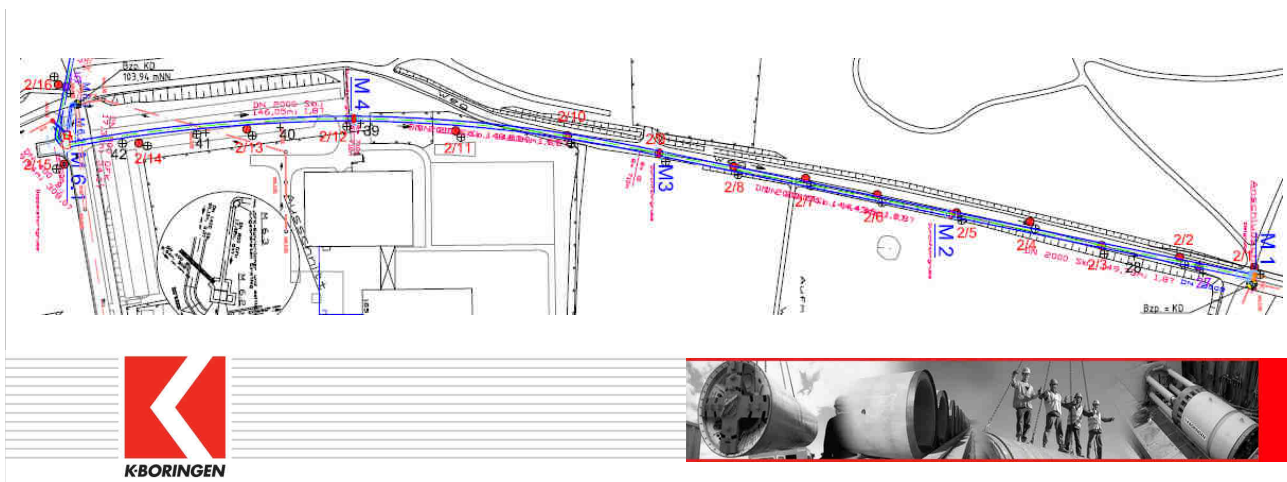
- Depth > 20 m
- Groundwater



Sewer collector Dortmund

Geological information

- Bodengutachten Dr. Höfer
 - Very detailed description of geology and hydrogeology based on :
 - Geological map
 - Soil investigation
 - Borehole probing every **25 to 30 m**
 - particle size curve, SPT, f, ...
 - Groundwater observations and chemical analysis
 - Abrasivity (CAI), Sticking potential



Sewer collector Dortmund Geological information

- Bodengutachten Dr. Höfer : Soil described according to DIN18300 + 18319
 - DIN18300 soil is defined in 7 soil and rock classes
 - DIN18319 defines soil and rock classes for trenchless technology
 - Soil and rock types summarized into 5 main classes
 - In addition division for 12 soil classes and 8 rock classes and 4 classes for stones

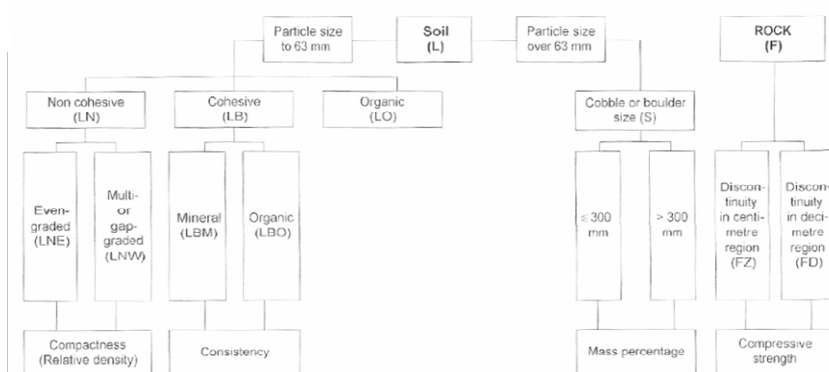
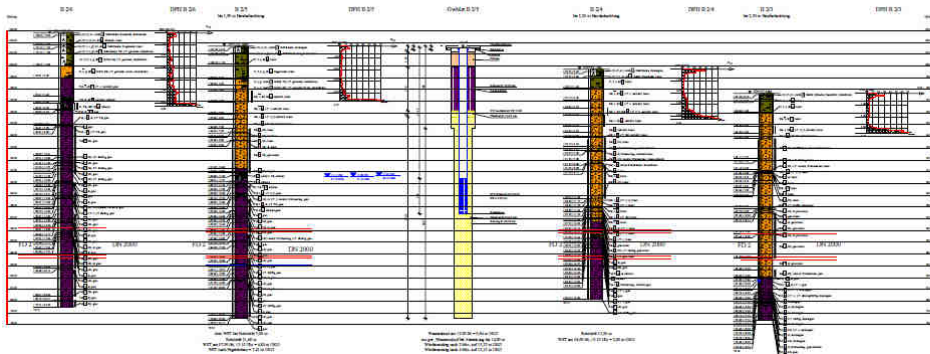


Table 4-39 Classes F: Rock material [4-50]

Uniaxial compressive strength [N/mm ²]	Rock classes	
	Discontinuity spacing in the Decimetre region	Centimetre region
To 5	FD 1	FZ 1
Over 5 to 50	FD 2	FZ 2
Over 50 to 100	FD 3	FZ 3
Over 100	FD 4	FZ 4

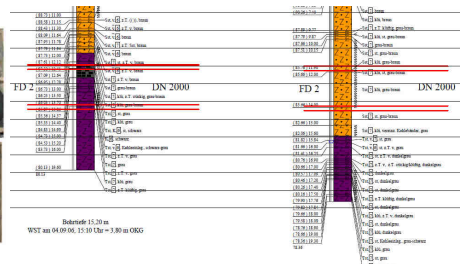
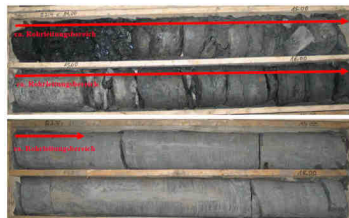


Sewer collector Dortmund Geological information



Geological profile

- ~450 m FD2,
- ~60 m FD3,
- ~30 m transition FD2 to FD3
- ~40 m transition FD2 to LBM2-FZ2



Sewer collector Dortmund

Geological information

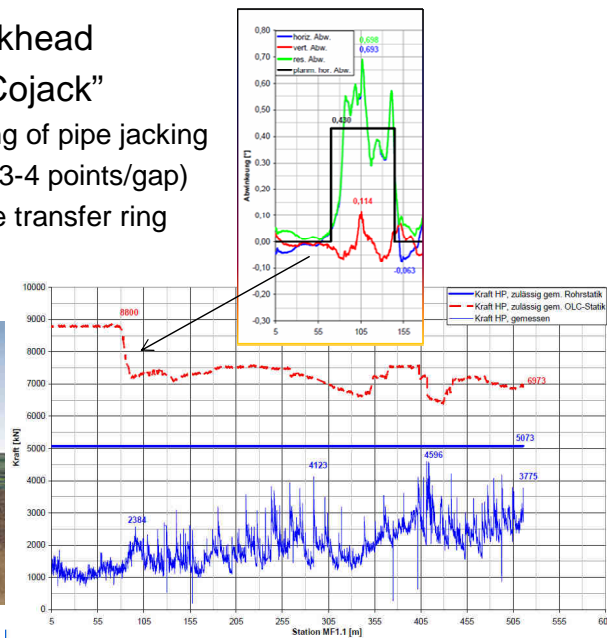
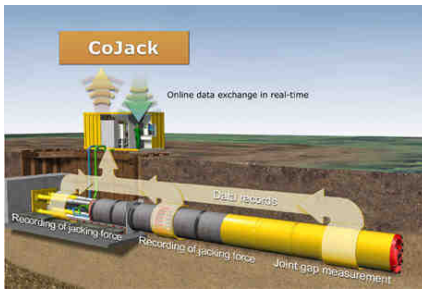
- Microtunnelling principally in Limestone “Tonstein” and Sandstone
 - Tonstein is a distinctive type of rock, composed largely of the mineral kaolin (clay mineral).
 - Tonstein is very low abrasive (CAI 0,5-1,0)
 - heavily weathered until not weathered compacted rock
 - Low sticking potential
 - According to soil investigation possibility :
 - Geological fault (Hacheneyer Sprung)
 - Influence of mining activity + coal layers



Sewer collector Dortmund

Microtunnelling equipment

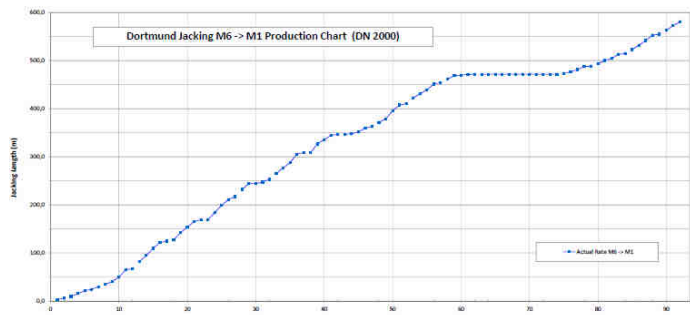
- AVND 2000 HK + Rockhead
- Online Load Control “Cojack”
 - Instrument for monitoring of pipe jacking
 - Monitoring of joint gap (3-4 points/gap)
 - Deformation of pressure transfer ring



Sewer collector Dortmund

Microtunnelling operation

MICROTUNNEL PROJECT DATA	M6->M1
Total length	580 m
Total microtunnelling time (working schedule 5 days/week)	92 days
Average production rate	6,3 m/day
Maximum production in 12 hrs	18 m
Maximum production in 1 week	63 m
Maximum production 1 month	215 m

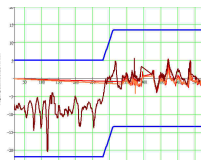


Factors influencing the performance

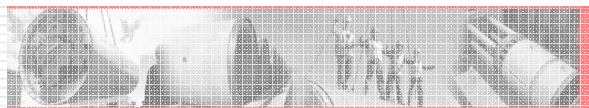
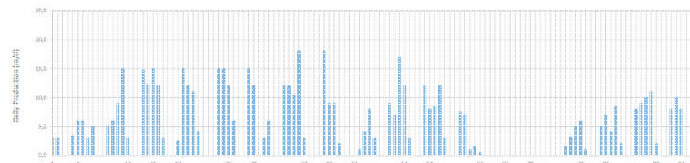
- Crossing intermediate shaft
 - Downward tendency of TBM in 1st IS
- Geology -

Production rate

- 0 - 50 m : weathered rock – softer clay – RP (separation)
- 60 – 320 m : harder formation – HP
- 320 – 360 m : softer region – RP
- + 400 m harder compacted material – HP



ing stuck



Sewer collector Dortmund

Microtunnelling operation

Pipe jacking stuck

- Before 17/09/2009 pushing mainly with main jacking station
- Activation IJS2, high pushing force between IJS1 - IJS2
- 21/09/2009 – TBM 465m
 - Cracks in pipe 32-33-34 (around 100 m behind TBM)
 - Inform Client
- Inspection of tunnel
 - Longitudinal + radial Cracks
 - width cracks 0,1–1,4 mm
 - Opening bentonite injection holes
 - Bentonite under pressure
 - Top against rockformation
 - Underneath 6 cm overcut
 - Material in overcut



Sewer collector Dortmund Microtunnelling operation

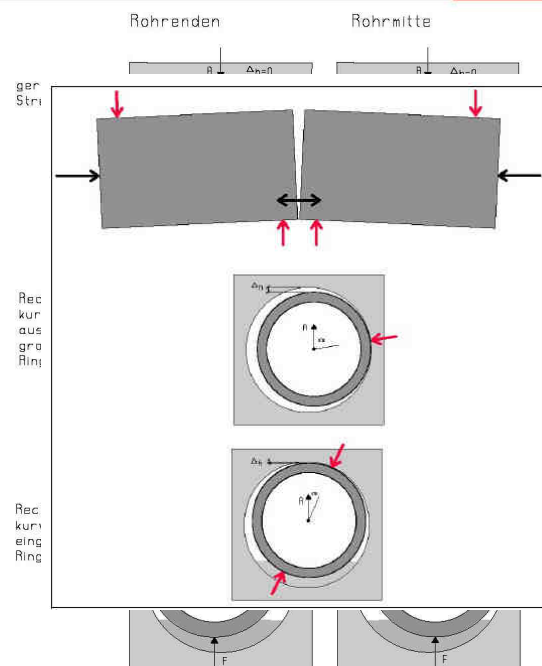
Pipe jacking stuck

- Core drilling DN150 (pipe 31 – 35)
- Removing material annular space
 - By hand + wash out under high pressure
- Pipe jacking free
 - 12 days of standstill
 - 10 to 15 days reduced production
 - Cracks closed / no new cracks



Sewer collector Dortmund Microtunnelling operation

- Explanation cracks
- Reason pipe jacking stuck
 - Material from geological fault in annular space
- Repair cracks after finishing pipe jacking



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Conclusion

- Geological survey is necessary to make correct price / technical offer
- Despite extensive geological survey still unexpected phenomena because of interaction between soil and pipe jacking
- Ces exemples illustrent qu'une campagne géologique est indispensable mais pas en soi un garantie de succès. Dans le monde de microtunneling on ne peut pas y avoir de triomphe sans perte et pas de victoire sans souffrance.



Impact of geological and environmental conditions on the performance of microtunnelling

