2021 TRENCHLESS MIDDLE EAST

Selection of slurry separation equipment based on project parameters

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1

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FUNCTIONS OF BENTONIT SLURRY

- ✓ Carry excavated solids out of tunnel
- ✓ Support the face by generating filter cake
- ✓ Packing and sealing the bore hole
- ✓ Lubricate and cool the cutter tools

2

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RESTORE THE RHEOLOGICAL PROPERTIES OF THE SLURRY

Rheological Properties of bentonite slurry:

- ✓ Density
- ✓ Viscosity
  - Plastic viscosity
  - Yield point
  - Gel Strength
- ✓ Filtration and filter cake

3

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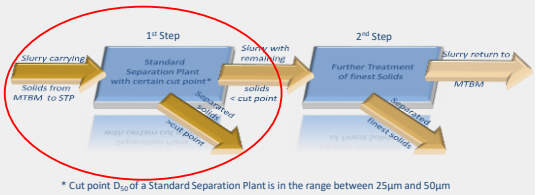
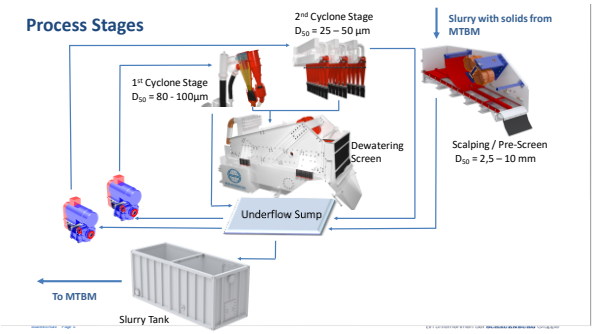
Slurry Treatment

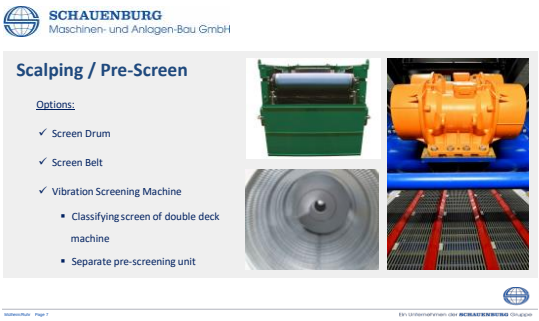


* Cut point D_{50} of a Standard Separation Plant is in the range between 25µm and 50µm

4


Process Stages
2nd Cyclone Stage
D50 = 25 – 50 µm
Slurry with solids from MTBM
1st Cyclone Stage
D50 = 80 - 100µm
Dewatering Screen
Scalping / Pre-Screen
D50 = 2,5 – 10 mm
Underflow Sump
To MTBM
Slurry Tank

5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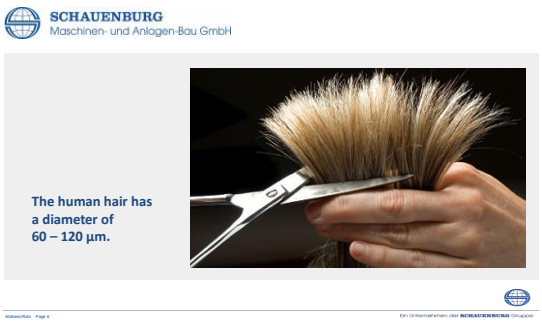
Scalping / Pre-Screen
Options:
✓ Screen Drum
✓ Screen Belt
✓ Vibration Screening Machine
▪ Classifying screen of double deck machine
▪ Separate pre-screening unit

7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The human hair has a diameter of 60 – 120 µm.

6

8

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Scalping / Pre-Screen

Standard soil conditions

Bottom deck of double deck machine

9

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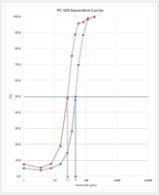
Cyclone operation and Cut point



11

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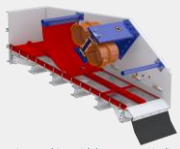
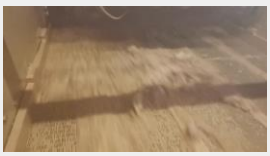
Scalping / Pre-Screen

high plasticity clay soil





Screening machine with large screen inclination

10

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Urethan Cyclones - Sizes & Capacities

Diameter	Liquid capacity	Cut Point D_{50}
mm	m³/h	µm
50	0,9 ~3,8	5 ~10
75	5 ~11	8 ~ 20
100	9 ~21	15 ~ 25
125	14 ~ 25	18 ~ 30
150	20 ~ 45	25 ~ 40
250	40 ~ 84	35 ~ 60

12

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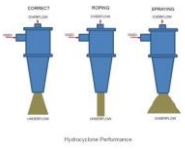
Standard Cyclone



Density Underflow: ca. 1,35kg/l

Cyclone with
Discharge regulator

Density Underflow: ca. 1,75kg/l

13

15

14

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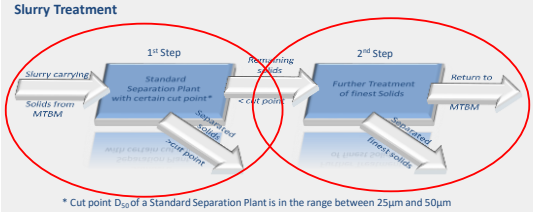
Slurry Treatment



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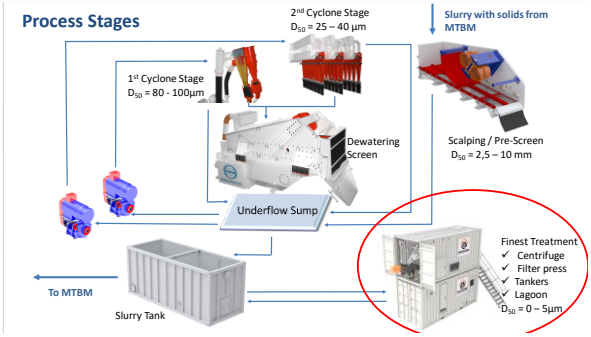
16



17

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METHODS OF SOLIDS REMOVAL

- ✓ Sedimentation
- ✓ Dilution
- ✓ Separation Plant

19

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METHODS OF SOLIDS REMOVAL

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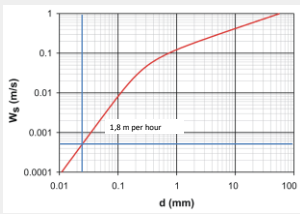

18

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METHODS OF SOLIDS REMOVAL

- ✓ Sedimentation
- ✓ Dilution
- ✓ Separation Plant

20

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Finest Treatment - Centrifuge

23

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Finest Treatment - Centrifuge

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Finest Treatment - Centrifuge

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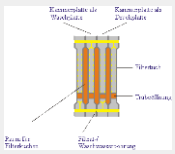
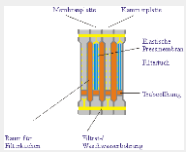
FINEST TREATMENT - Filter presses

Chamber Filter Press



Membran Filter Press



25

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FINEST TREATMENT - Filter presses

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Centrifuge	vs	Filter press
• Continuous operation		• Discontinuous operation
• Fully automatic operated		• Semi automatic operated
• Smaller foot print		• Larger foot print
• Polymers as additive		• Polymers or lime as additive
• Produces clear water		• pH-value of clear water needs to be adjusted
• Less operation personal required		• Higher need for operation personal
• Higher water content in separated solids		• Less water content in separated solids
• Higher power consumption		• Lower power consumption

29

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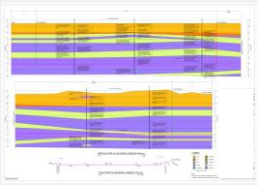
CAPACITY DESIGN OF SLURRY TREATMENT PLANT

Necessary Geotechnical Information:

- ✓ Grain size distribution
- ✓ Anticipated soils on tunnel alignment
- ✓ Soil Sticking Properties
- ✓ Abrasiveness
- ✓ Chemical properties of soil
- ✓ Contaminations



31

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CAPACITY DESIGN OF SLURRY TREATMENT PLANT

30

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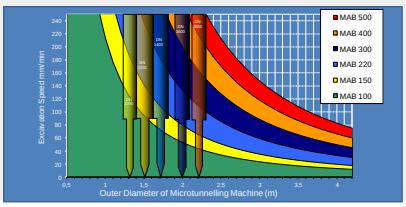
CAPACITY DESIGN OF SLURRY TREATMENT PLANT



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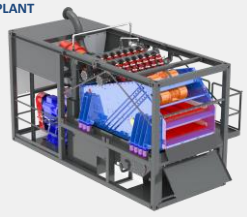
CAPACITY DESIGN OF SLURRY TREATMENT PLANT

Example for Capacity Design

Microtunnelling TBM:

Outside Diameter	2,5m
Flowrate	200m³/h
Excavation Speed	min. 6cm/min
	max. 13cm/min
Pipe length:	2 meters
Soil conditions:	Clay and Sand



33

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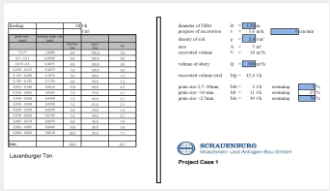
Data for Mass Balance Calculation / Estimation



35

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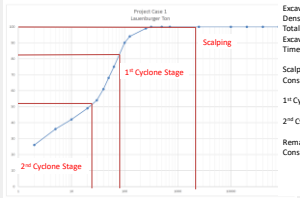
Mass Balance Estimation in Soil with high content of clay



Excavation rate:	6cm/min
Density of soil:	2,4t/m³
Total excavated Soil:	42,5t/h
Excavated length:	3,6m /h
Time for 2m Pipe:	33 min
Scalping:	0% = 0,0 t/h
Considering Clay Lumps:	30% =12,75 t/h
1st Cyclone Stage:	17% = 7,2 t/h
2nd Cyclone Stage:	30% = 12,75 t/h
Remaining:	53% = 22,47 t/h
Considering Clay Lumps	23% = 9,7 t/h

34

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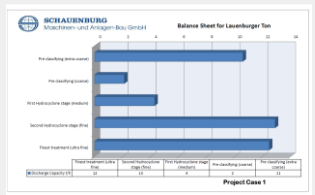
Mass Balance Estimation in Soil with high content of clay



36

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Calculation Slurry Density after Excavation

Total Slurry Volume in the circuit

MTBM chamber
and pipelines ~ 10m³

Separation Plant ~ 6m³

Total Slurry Volume in the circuit ~ Total 66m³

2 each 20ft Tanks ~ 50m³

37

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Calculation Slurry Density after Excavation

Pipe No.	Status	Density	Solids content	Solids Amount	Volume of slurry to be disposed per pipe	Volume of slurry to be disposed per meter
1	Start	1,1 kg/l	0,161 t/m³	10,6 t		
1	End	1,21 kg/l	0,342 t/m³	22,6 t	35m³	17,5m³
2	Start	1,21 kg/l	0,342 t/m³	22,6 t		
2	End	1,33 kg/l	0,524 t/m³	34,6 t		

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Calculation Disposal Volume

Daily Production: 10 pipes = 20 meters

Daily disposal volume: ~ 350 m³ /day

39

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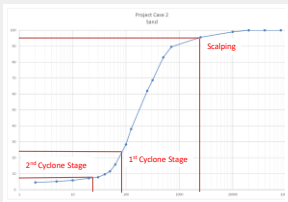
Mass Balance Estimation in Sand



Excavation rate:	13cm/min
Density of soil:	1,8t/m³
Total excavated Soil:	68,9t/h
Excavated length:	7,8m /h
Time for 2m Pipe:	15 min
Scalping:	5% = 3,5 t/h
1st Cyclone Stage:	71% = 48,9 t/h
2nd Cyclone Stage:	17% = 11,7 t/h
Remaining:	7% = 4,8 t/h

40

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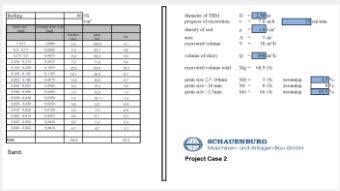
Data for Mass Balance Calculation / Estimation in Sand



41

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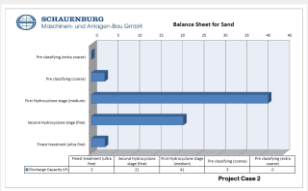
Mass Balance Calculation



42

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Calculation Slurry Density after Excavation

Pipe No.	Status	Density	Solids content	Solids Amount	Volume of slurry to be disposed per pipe	Volume of slurry to be disposed per meter
1	Start	1,1 kg/l	0,161 t/m³	10,6 t		
1	End	1,13 kg/l	0,206 t/m³	13,6 t		
2	Start	1,13 kg/l	0,206 t/m³	13,6 t		
2	End	1,16 kg/l	0,252 t/m³	16,6 t		
3	Start	1,16 kg/l	0,252 t/m³	16,6 t		
3	End	1,19 kg/l	0,296 t/m³	19,6 t		
4	Start	1,19 kg/l	0,296 t/m³	19,6 t		
4	End	1,22 kg/l	0,342 t/m³	22,6 t	35m³	17,5m³

43

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PRODUCTION LOST DUE TO DISPOSAL BY TANKERS

	Clayey Soil	Sand
No of pipe before disposal	1	4
Time for pipe installation before disposal	30min	135 min
Down time (Tankers)	60 min	60 min
Cycle time	90 min = 1 h 30 min	195 min = 3 h 15min
Daily Production with tankers	6,5 pipes	12 pipes
Daily Production with tankers	13 meters / day	24 meters / day
Max. possible production	20 meters / day	30 meters / day
Production loss (absolute)	7 meters = 3,5 pipes	6 meters = 3 pipes
Potential to increase Production (percent)	53%	25%

44

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Calculation Disposal Cost

	Clayey Soil		Sandy Soil	
Location	Middle East	Germany	Middle East	Germany
Disposal volume per meter:	17,5 m³		4,4 m³	
Costs per m³ disposal:	7 USD	55 USD	7 USD	55 USD
Disposal cost per meter	123 USD	963 USD	31 USD	242 USD

45

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Costs of Slurry Treatment

	400.000 USD	500.000 USD
Depreciation period	6 years = 72 month	6 years = 72 month
Depreciation costs per month	5.555 USD	6.944 USD
Interest (6,5%/a) per month	2.166 €USD	2.708 USD
Maintenance costs per month (5%/a)	1.666 USD	2.083 USD
Usage months (80%)	58 month	58 month
Total costs per usage month	11.733 USD	14.568 USD
Costs per meter (154 m/month)	75,66 USD/m	94,60 USD/m
Costs per meter (220 m/month)	52,96 USD/m	66,22 USD/m

46