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Backfilling of the Eastport in Bremerhaven/Germany Organic Harbour Mud as Construction Material

27. May 2008

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Backfilling of the Eastport in Bremerhaven

Organic Harbour Mud as Construction Material

620 m sheet pile wall
king and batter piles
PSP 800 to PSP 900

Placing of approx.170.000 m³ silt

Placing of approx. 100.000 m² loaded geotextile

Placing of approx. 260.000 m³ sand
with spraying method approx. 85.000 m³
with flushing method ca. 175.000 m³

Consolidation acceleration
approx. 70.000 pieces of vertical drains
Vacuum surcharge (optional)

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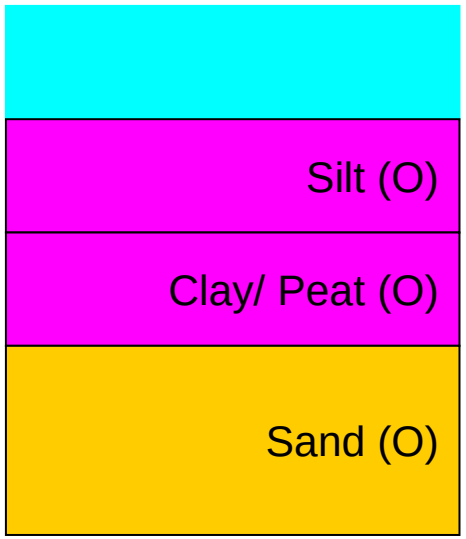
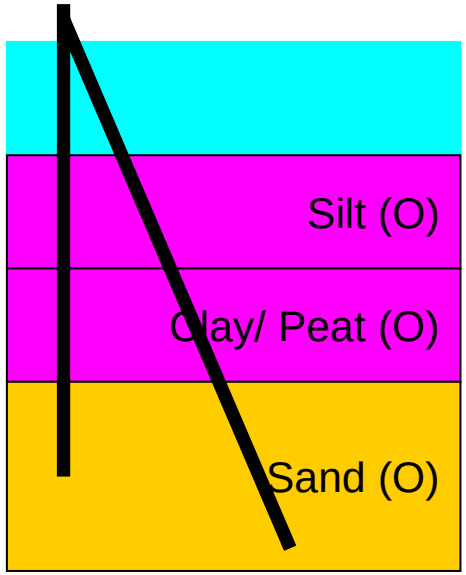
Construction progress – as planned

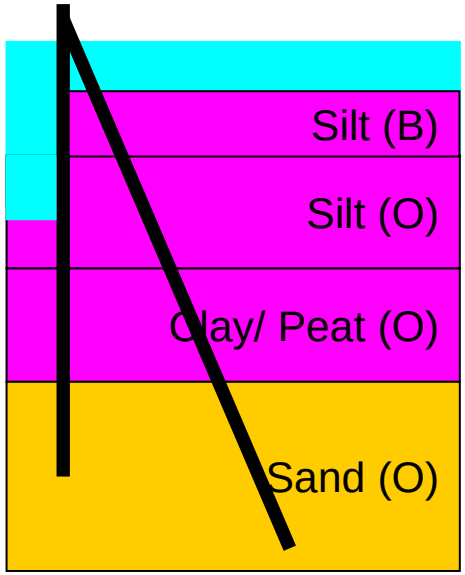
Initial situation



Installation of sheet pile wall



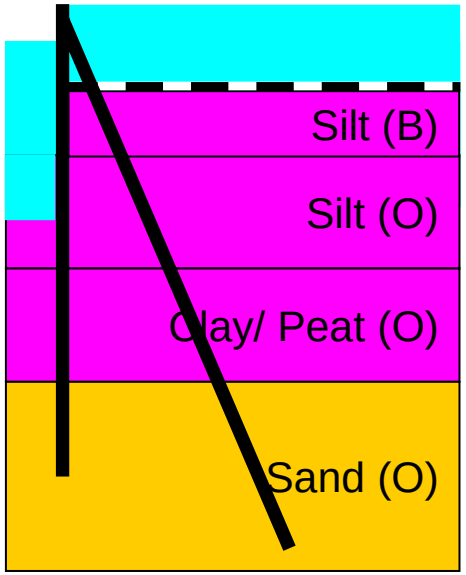
Replacement of harbour mud



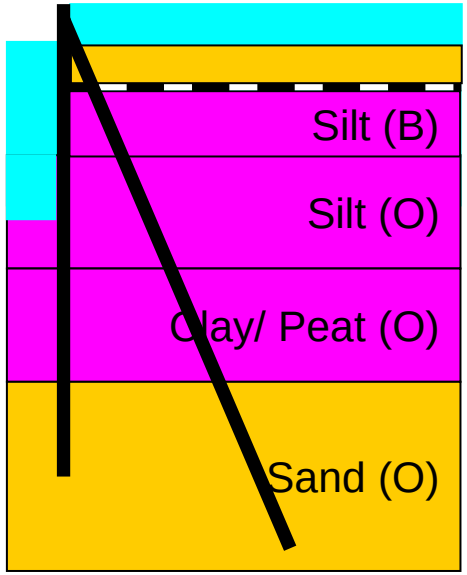
(O): originally; (B): backfilled; (SP): sprayed; (SF): flushing

Construction progress – as planned

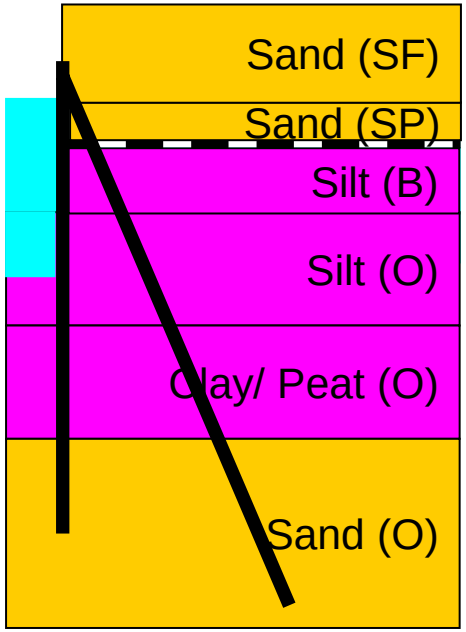
Installation loaded geotextile



Sand installation (spraying)



Sand installation (flushing)



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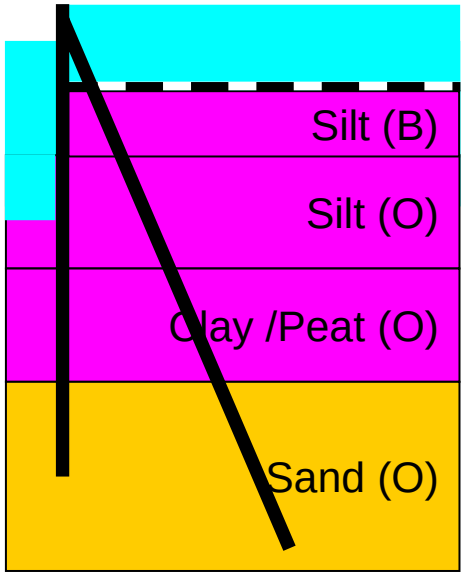
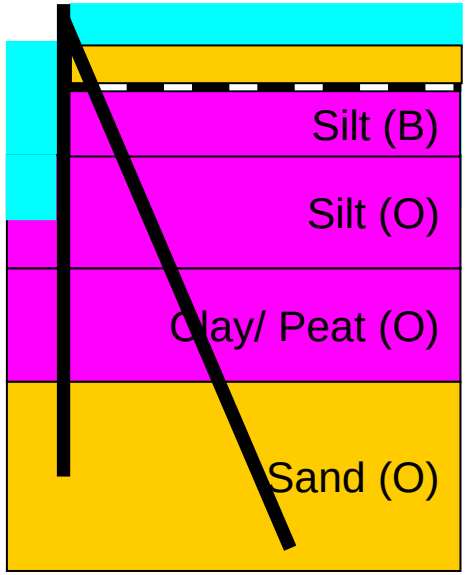
Construction progress – as planned

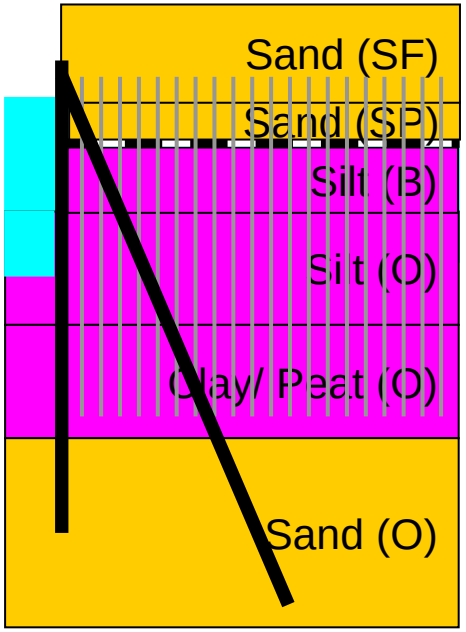
Installation loaded geotextile



Sand installation (spraying)



Installation of vertical drainage stripes



(O): originally; (B): backfilled; (SP): sprayed; (SF): flushing

Precaution in design process

- Intensive geotechnical design in the design process by 3 experts.
- Wet assembly (sand): different parallel test methods for controlling of the layer thickness.
- Geotechnical measurement project
  - testing of the silt quality during the rearrangement.
  - permanent controlling of the silt strength and the silt consolidation after rearrangement.
- Geotechnical design being regularly updated (actual and forecast).
- Comparative geotechnical design from contractor/constructor

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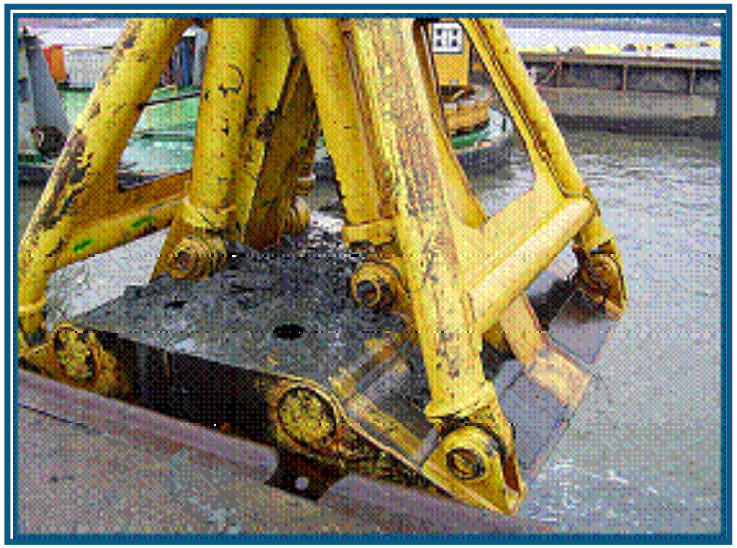
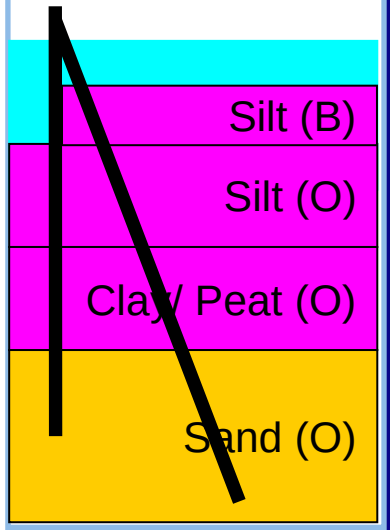


Rearrangement of organic harbour mud



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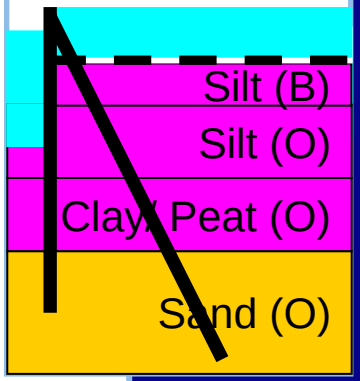
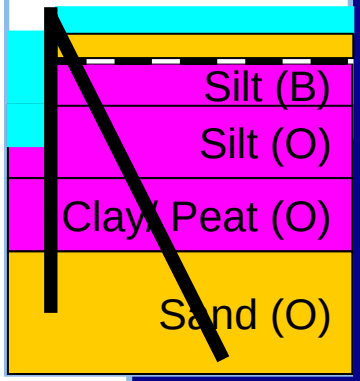
Installation loaded geotextile



Sand spraying



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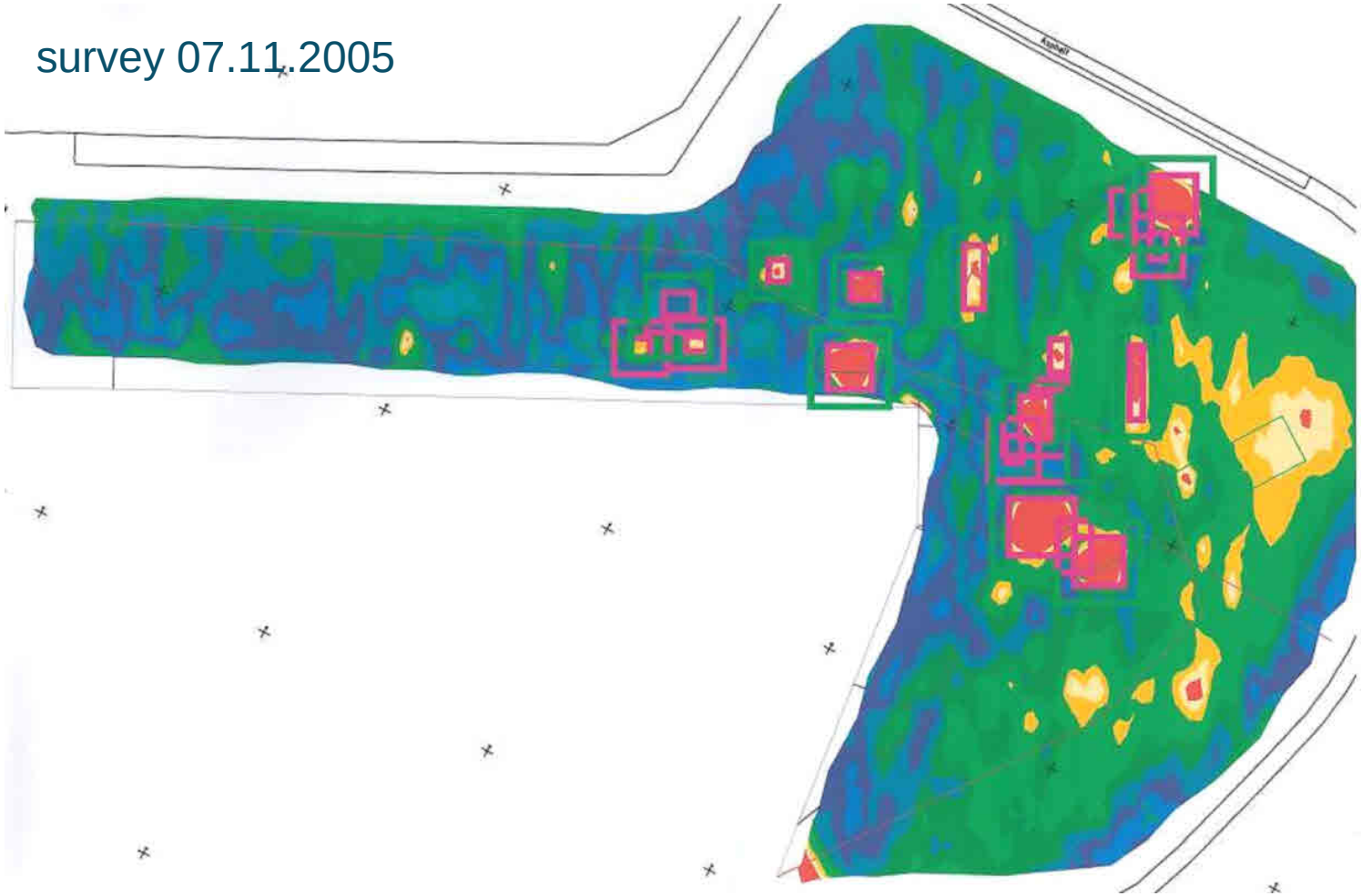
Unexpected Surface distortion

- At the installation of the 5th sand layer during the spray coat method (D = 20 cm),
- “unexpected surface distortion“ in the field,
- circular bulges (silt),
- slipping of the sand layer in the area of the circular bulge,
- non failure of the geotextile,
- slowdown during approx. 10 days,
- big areas of construction site being affected almost at the same time.

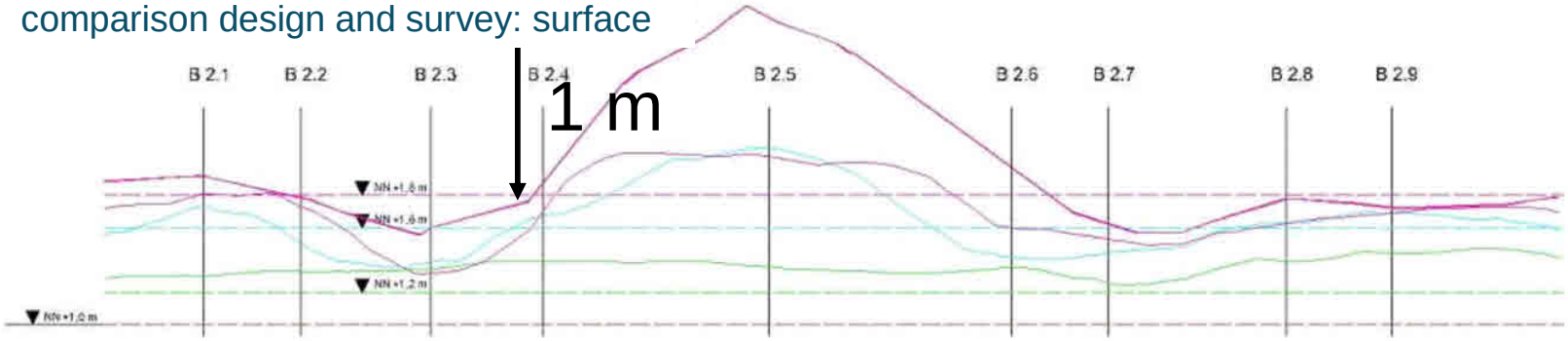
Unexpected Surface distortion

survey 07.11.2005



Unexpected Surface distortion

comparison design and survey: surface



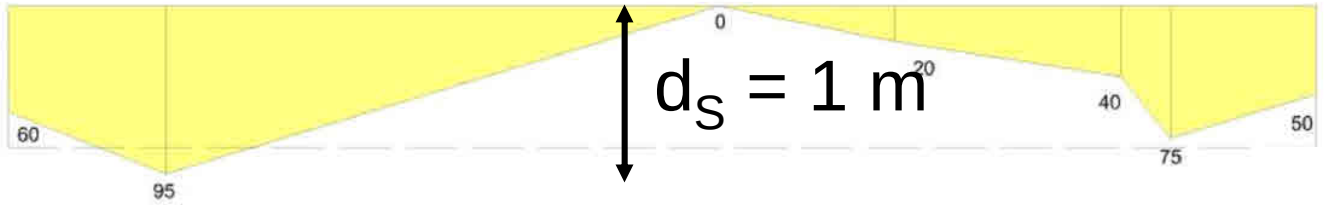
Field enquiry

- Analyzed parameter:
  - shear strength of the silt,
  - homogeneity of the silt,
  - thickness of the existing sand layer,
  - position of the geotextile.

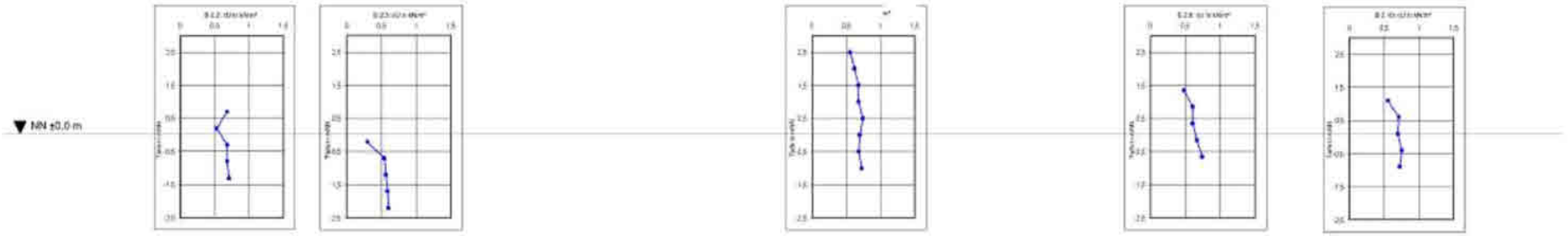
- "building blocks" of causes taken into consideration:
  - (local) lower silt strength than assumed in design process,
  - inevitable tolerance transgressions in the construction process,
  - large density differences in the silt in connection with (partly) high salt contents,
  - „mud flow“ in the harbour during and prior construction phase,
  - ground liquefactions during the construction process,
  - impetus in the silt by gas (bulbs),
  - strongly reduced permeability of the geotextile by hydrocarbons in a multiphase flowsystems,

Unexpected Surface distortion

Thickness of sand layer (survey 11.11.2005); design thickness: 80 cm



Measured shear strength (11.11.2005)



c_u = 0,5 kN/m²

Change of construction progress

➢ **Requirement:**

- **safe construction and rapid progress of construction works,**
- **consideration of causal components,**
- **usability of the refilled area,**
- **limiting the additional expenses to the best economic level.**

⇒ no further loading of the surface

⇒ lowering the pressure in the silt layer (gas/water).

Change of construction progress

- **Design and construction implementation:**

- **installation of vertical drainage from floating equipment,**
- **installation of low pressure dewatering (BeauDrainS-method),**
- **intensive inspections on construction site (visual and measuring tech.),**
- **permanent update of the stability calculations on the basis of the field measurements and laboratory tests (actual and forecast; constructor and contractor parallel),**
- **application of the observation method according to DIN 1054,**
- **installation of sand; first dry setting with PistenBullies, later by flushing with “extreme lightweight equipment”.**

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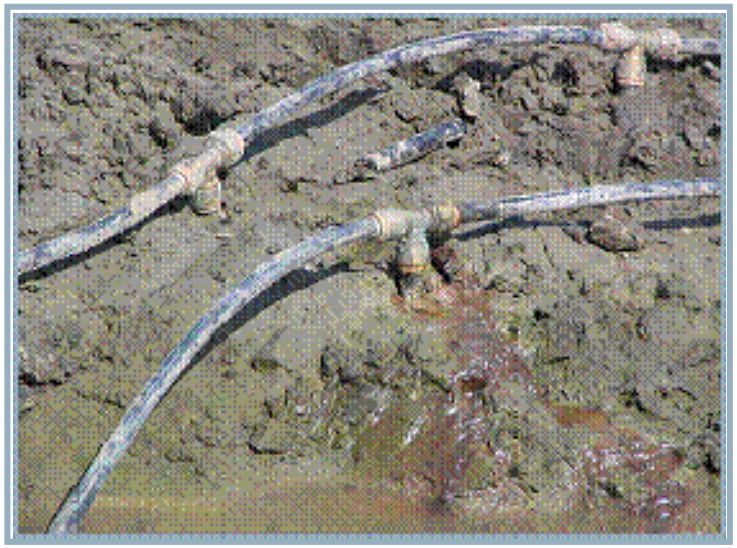
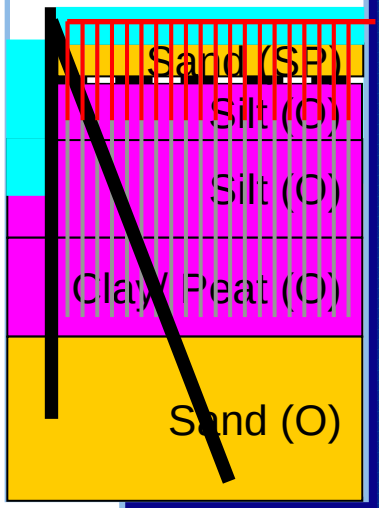


setting and assembly BeauDrain-S



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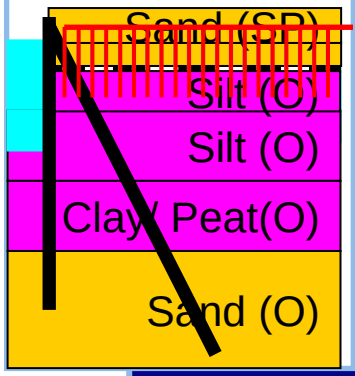
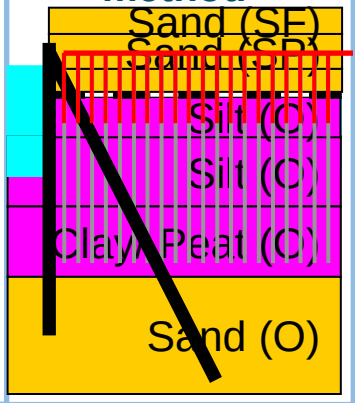
placing of (dry) Sand by PistenBully



placing of sand flushing method



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spring 2005

autumn 2006

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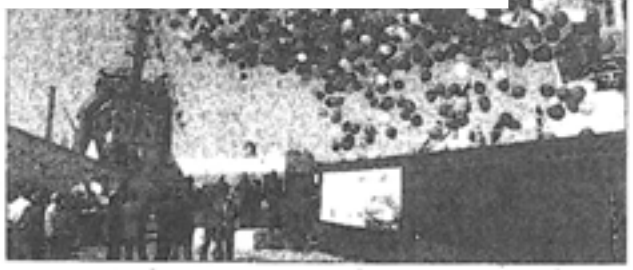
NORDSEE ZEITUNG

BLG muss länger auf den Osthafen warten

Übergabe von neuen Flächen und Liegeplätzen verzögert sich um Monate

Auch Chef-Ingenieur Woltering „würde es wieder so machen". Schließlich habe das innovative Verfahren Millionen gespart. Wäre der Schlick nicht verbaut worden, hätte man ihn auf einer Bremer Deponie entsorgen müssen. 24



...ärts

...he im Osthafen übergeben

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Consequences for future "silt", projects.

- **The disadvantageous influence factors like microbial and ground mechanical qualities of the silt should be more examined.**
- **Large density differences and cavities by gas formation must be taken into account on stability forecasts.**
- **Reconsideration of the method for the land reclamation / backfill with sands and optimizing the installation time for the vertical drainage.**
- **All used components should be tested before under conditions similar to the construction site as best as possible.**
- **The “restart of microbial processes” in the silt at the time of the rearrangement must be taken into account.**

Thanks a lot for your attention.

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