IKT Pipejacking Symposium

Recommendations of the German Working Group on Design and Calculation of Shield Machines

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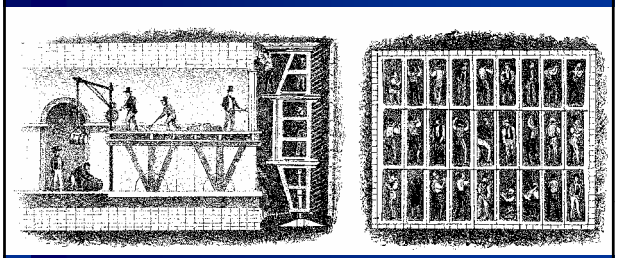
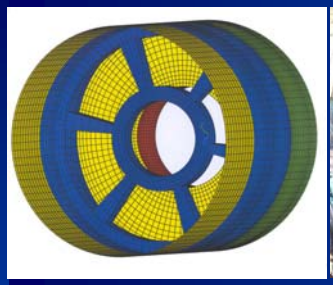
Simple Shield Constructions …



Brunel's shield tunnelling underneath the river Thames 1824-1842
Lithographic print in „Museum of History" from 1830

… have become High-Tech Machines!

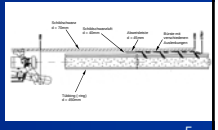


Reasons and Aims

- A concept for a shield machine has to consider structural and economic factors
- Sensitisation for design assumptions for shield machines has increased
- No existing recommendation
  ➡ Demand for refences

Structuring of Recommendations

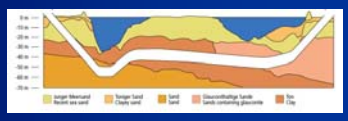
- Safety concept
  - Verification aims
  - Verification of load-carrying capacity and serviceabilitiy
- Influences
  - Choice of calculation section
  - Loading actions caused by the construction ground
  - Soil and rock parameters for the preliminary draft
  - Load actions in special situations
- Calculation
  - Details on scheme creation and bedding



Safety Concept according to DIN 18800

- Verification of Load-carrying Capacity
  - Partial safety coefficients
  - decisive for tension verifications
  - incidental deformations are not decisive
- Verification of Serviceability
  - characteristic impacts ($\gamma_F=\gamma_M=1,0$)
  - decisive for deformation (shield tail!)
  - prevent calculative contact of tail skin on tubbing segment
- Tail skin sheet iron thickness: Comparison with experience
  - constructive safety must be maintained even under minimal loads
  - no shortfall of approved sheet iron thickness

Load Actions - further mentioned in this presentation



- **Soil**
- Rock
- Groundwater
- Surface buildings and traffic
- **Unscheduled steering movements**
- Construction ground data for the preliminary draft
- Special situations

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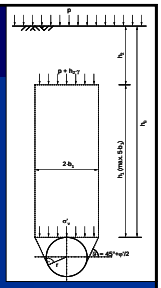
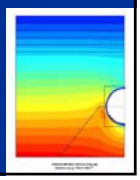
Load Actions in Soil

- Earth pressure with reduction according to Terzaghi's silo theory
- Reduction not until 1 D overburden
- Recommended lateral pressure coefficient inside the silo $k_{silo} = 0,8$
- Possibility of calculating the earth pressure according to Houska or numeric model





Load Actions deriving from unscheduled steering movements

- Curve restraints in scheduled curves to be avoided by geometrical design
  - Overcut / cutting wheel kinematics / conicity
  - shield tail joint
- Curve restraint is still possible in unscheduled operational situations
  - consideration of the additional load within the verification of load-carrying capacity.
  - Exceptional effects: No verification of serviceability necessary

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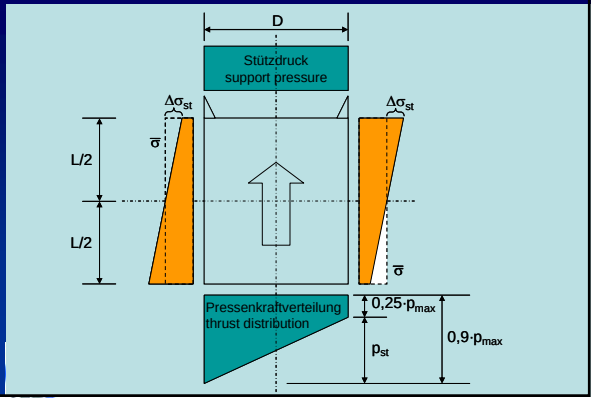
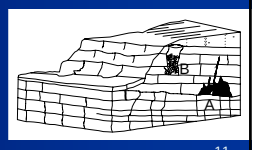
Unscheduled Steering Movement: Scenario



Load Actions in Special Situations

- Only general details for special situations, specific treatment required in individual cases
  - closely neighbouring tubes
  - lateral excavations
  - swelling ground properties
  - karstic ground properties



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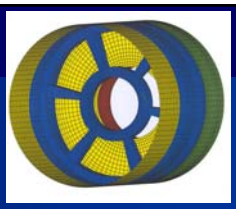
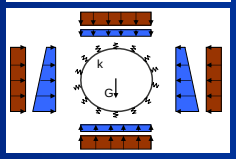
Calculation Schemes

- Shield machine calculation with numeric 3-D model (FEM)
- Calculation usually with the embedded shell model
- Calculation of machine + construction ground possible by using a 3D continuum model





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Relevance to Pipejacking

- Germany: ATV A161
  - Radial static soil + water loads covered: evenly distributed
  - Axial jacking loads covered: unevenly distributed
  - constraint and shear forces covered
- Uneven dynamic embedment reactions during jacking not explicitely covered
- 3-dimensional stress state
  - Uneven stress distribution parallel to axis due to jacking forces in curves
  - Uneven stress distribution rectangular to axis due to uneven embedment reactions
  - possible non-linear effects in superposition of axial and radial stresses: 3D-analysis important

Complete references were published in Nov. 05 issue of "Tunnel„

Thank you and „Glückauf“

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