Risk management of extreme flood events

Bundesministerium für Bildung und Forschung

STABILISATION OF RIVER DYKES WITH DRAINING AND STABILISING ELEMENTS

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Universität Karlsruhe (TH)

Fachgebiet Geotechnik
Institut für Geotechnik und Geohydraulik
Universität Kassel

Sächsisches Textilforschungsinstitut e.V.
an der Technischen Universität Chemnitz

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Outline

- Objectives of the Project
- Project structure
- Working Programme and Tasks
  - . *Part Geohydraulics*
  - . *Part Stability*
  - . *Part Development of Novel Drainage Elements*
- Installation Tests
- Summary and Outlook

PROBLEMS:

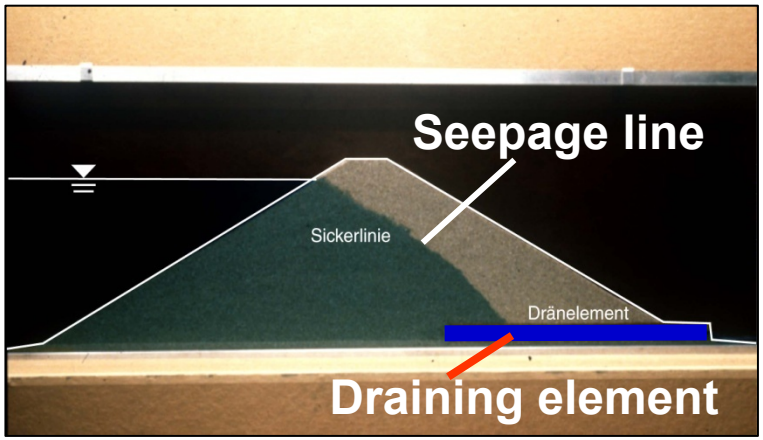
- **Ageing and bad design of traditional dyke structures**
- **More or less homogeneous old dykes are in general not stable due to seepage inside the structure (outer slope)**
- **Overall rehabilitation of the dyke systems: time consuming, cost-intensive, medium- and long-term measures only**

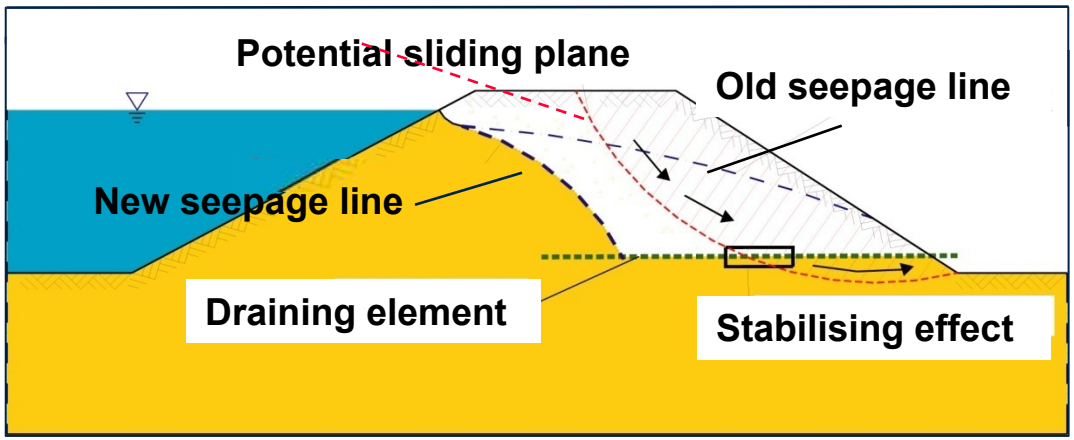
Objectives of the Joint Project

- Solutions for short-term refurbishment

Stabilisation of old dykes at low costs and with minimum installation effort

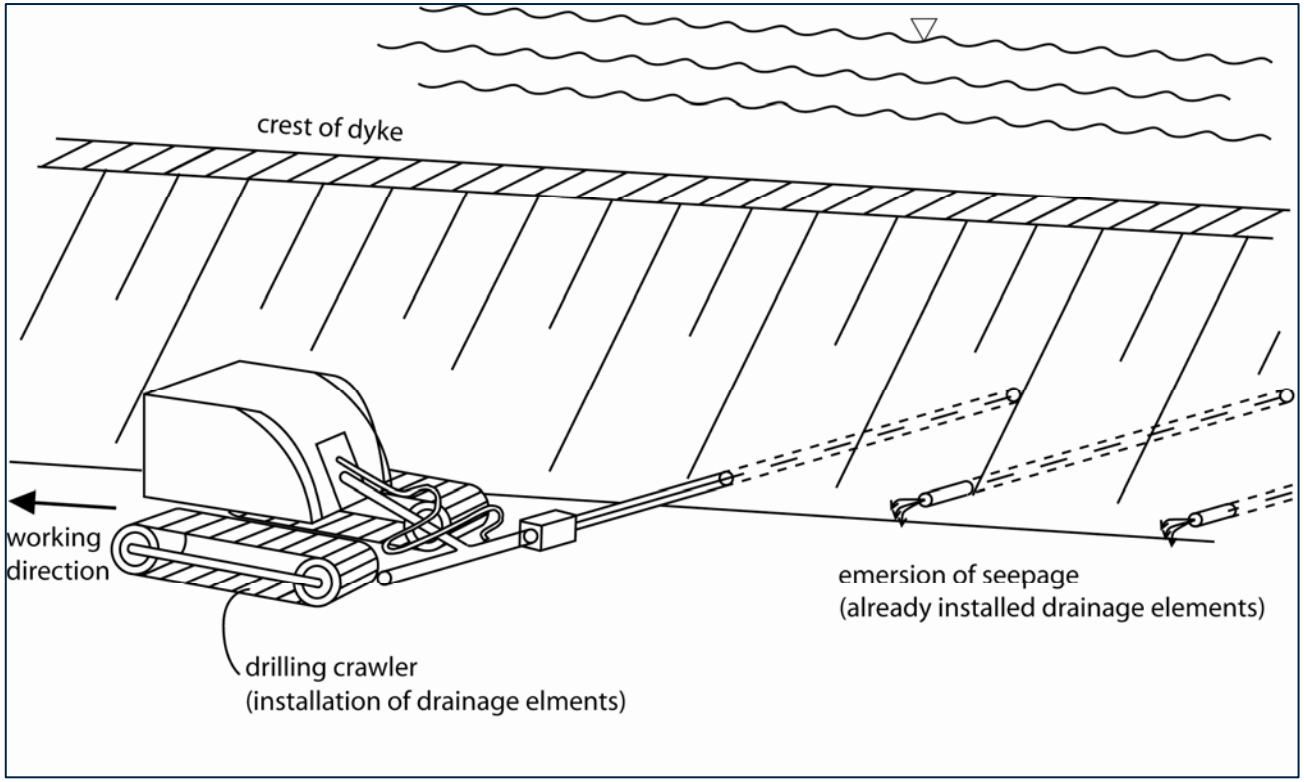
by **installing** **draining elements** for the control of seepage water and for reinforcement (before and during flood events)





Stabilisation of unstable dykes by means of wellpoints (flood at the Oder river 1997)

Approach:



Stabilisation of river dykes by means of installing draining elements

PROJECT STRUCTURE

Universität Karlsruhe

Institut für Bodenmechanik und Felsmechanik

Universität Kassel

Fachgebiet Geotechnik Institut für Geotechnik und Geohydraulik

STFI

at Chemnitz University of Technology Dep. Technical Textiles / Woven & Knitted fabrics

Geohydraulics

Stability

Draining elements

Field tests

Working programme:

- **Investigations into the hydraulic effects of installed draining elements**
  - ***Increasement of stability by drainage and reinforcement effects***
  - ***Effects of soil suction on dyke stability caused by drainage elements***
- **Development of an engineering method for planning purposes**

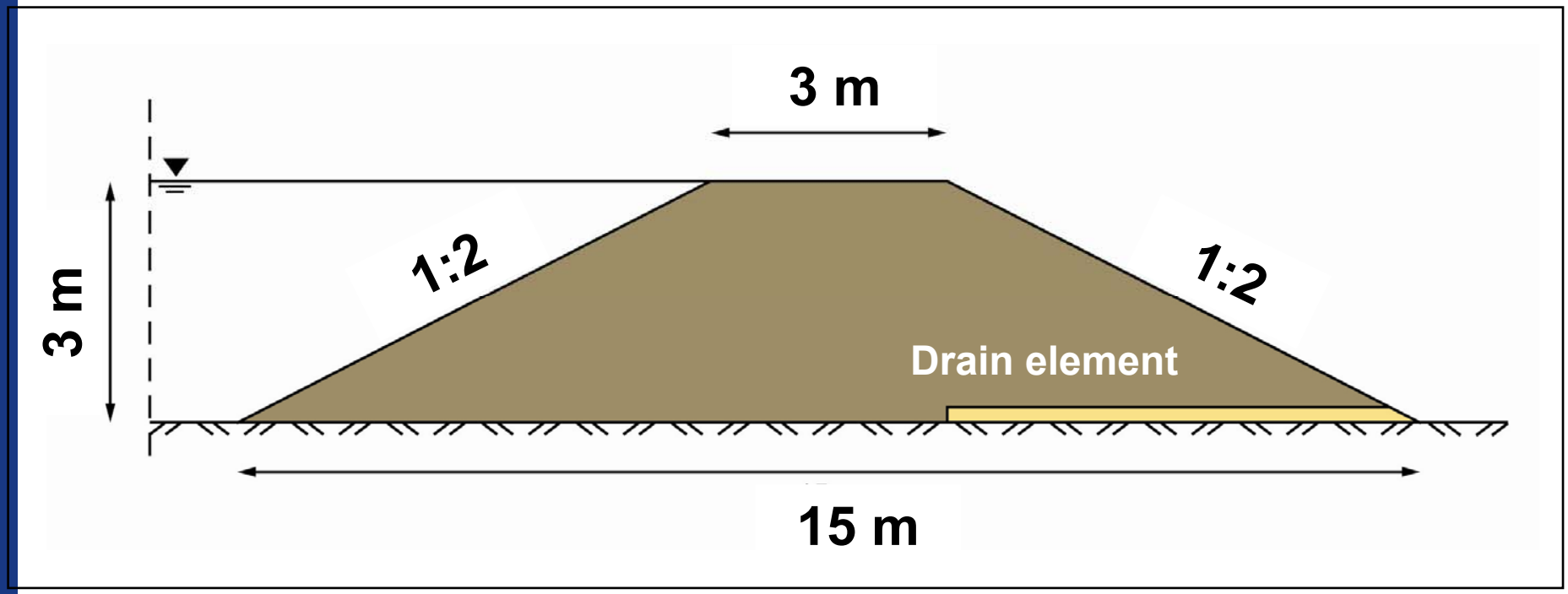
- **Modification of commercially available and manufacturing of filter stable draining elements**

- **Development of low-cost stabilisation techniques for river dykes**

- **Modification of existing installation methods using small mobile equipment to enable application even under cramped and unfavourable conditions**

(A) Part Geohydraulics

- **Quantification of the impact on the seepage line (numerical parameter study)**



Representative cross section of a dyke

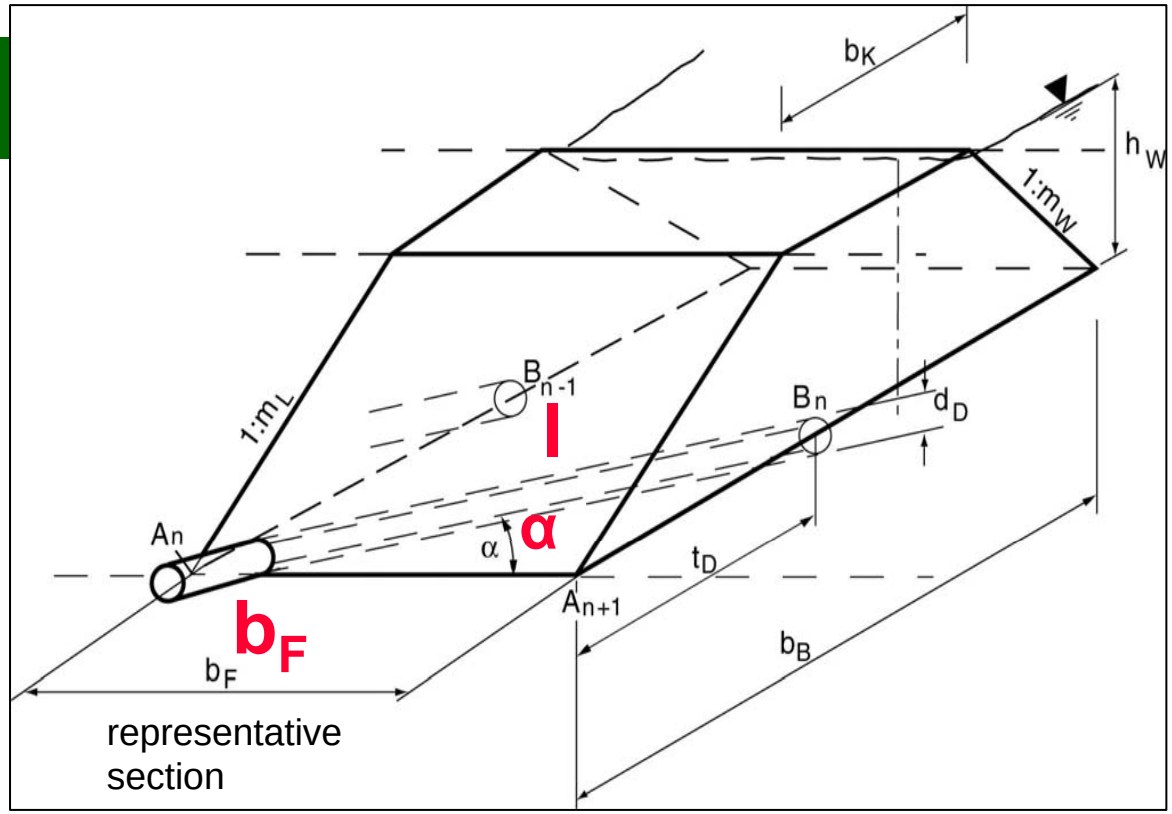
(A) Part Geohydraulics

- **Quantification of the impact on the seepage line (numerical parameter study)**

METHOD: FEM

Main Parameters:

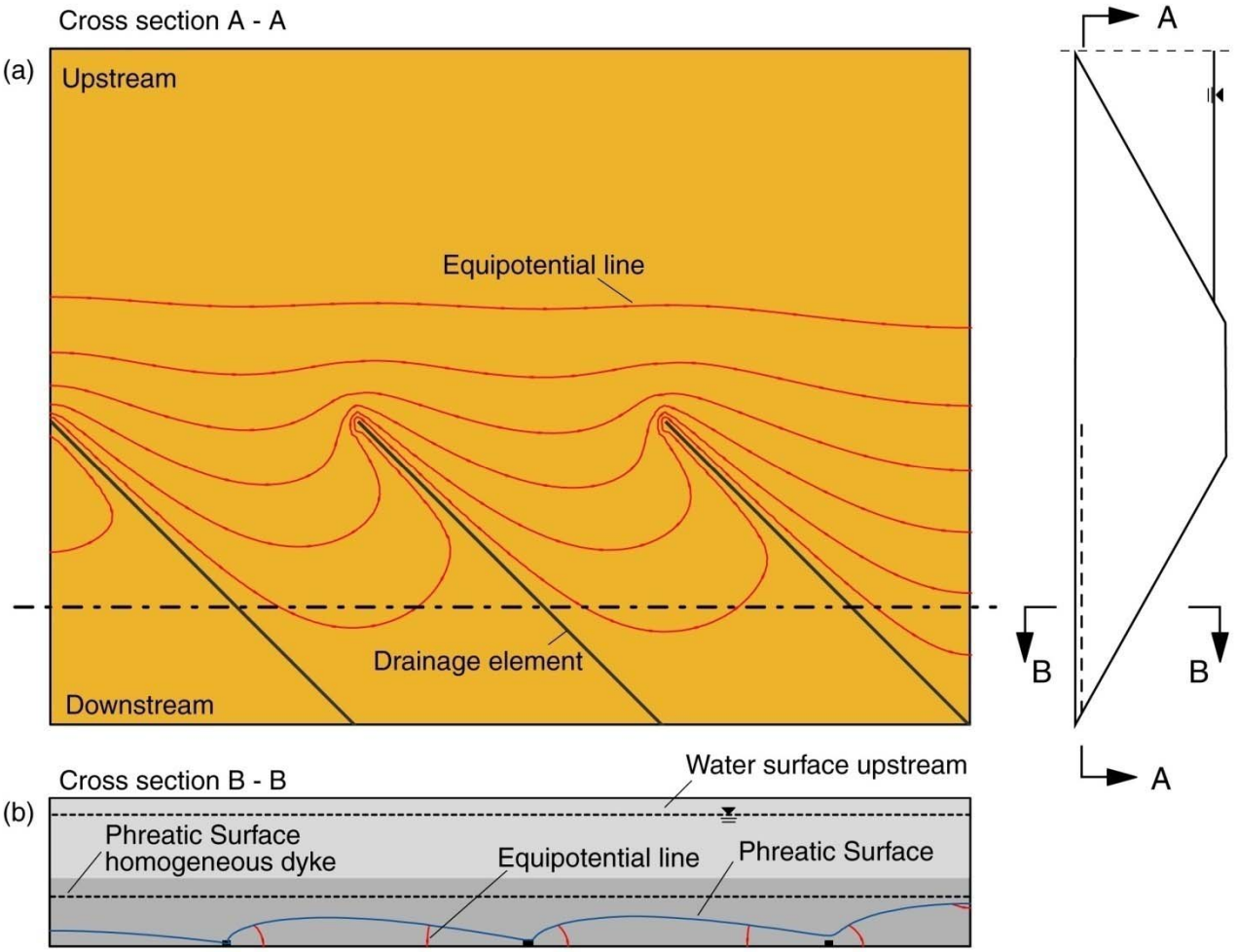
- **l** drain length
- **b_F** drain distance
- **α** angle of the draining element in relation to the dyke crest line



(A) Part Geohydraulics

- **Results**

Considerable lowering of the water table due to the installed draining elements



(B) Part Stability

- Selecting a representative dyke cross section for old dykes
- Defining soil characteristics for parametric studies
- Selection of an appropriate calculation program for a parametric study and consideration of the existing spatial conditions

PLAXIS program

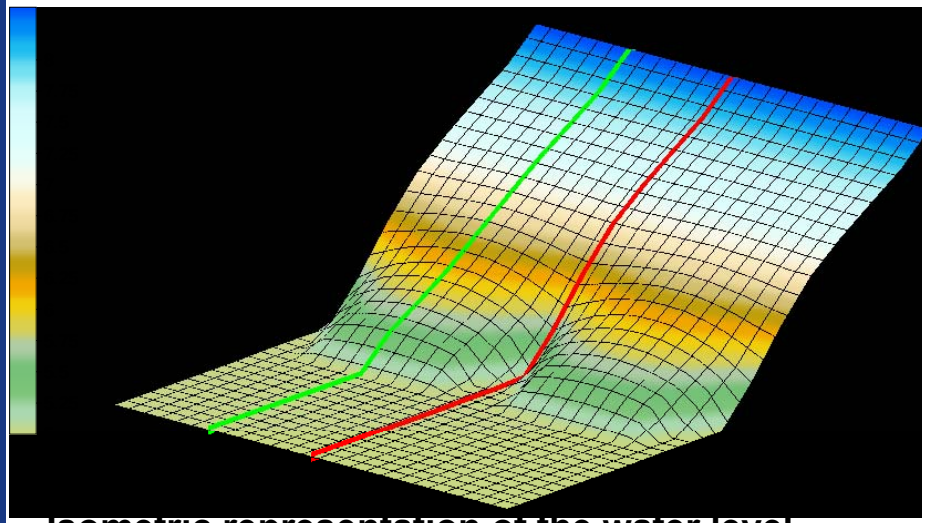
→ **analytical program, slip-circle method**

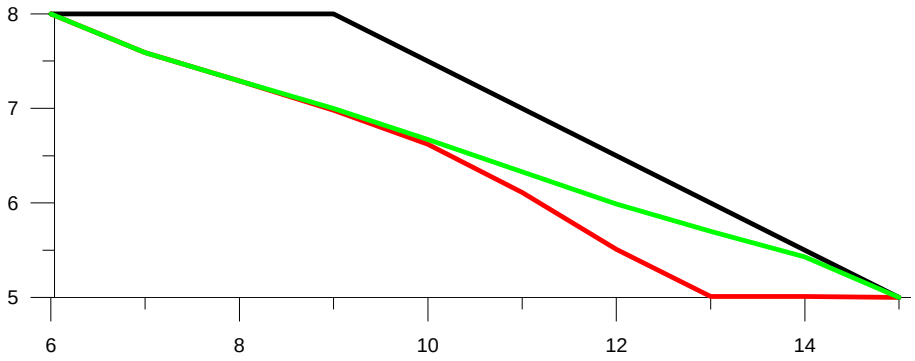
(B) Part Stability

- **Advantages of the calculation program used:**
- 3D seepage lines can be represented correctly

Input (seepage lines) from the stability model

Maximum seepage line
Minimum seepage line





Isometric representation of the water level surface (a = 5 m / l_R/l_v = 0,50)

(B) Stability

Results

- **Validation of the calculation program**

  - 2 dimensional conditions: very good conformity to several different analytic and numeric programs (criteria: reliability, coordinates of the central point)
  - 3 dimensional conditions: for infinitely expanded failure forms values are identical to plane conditions of loading
  - Acceptable correlation to results found in literature

(B) Stability

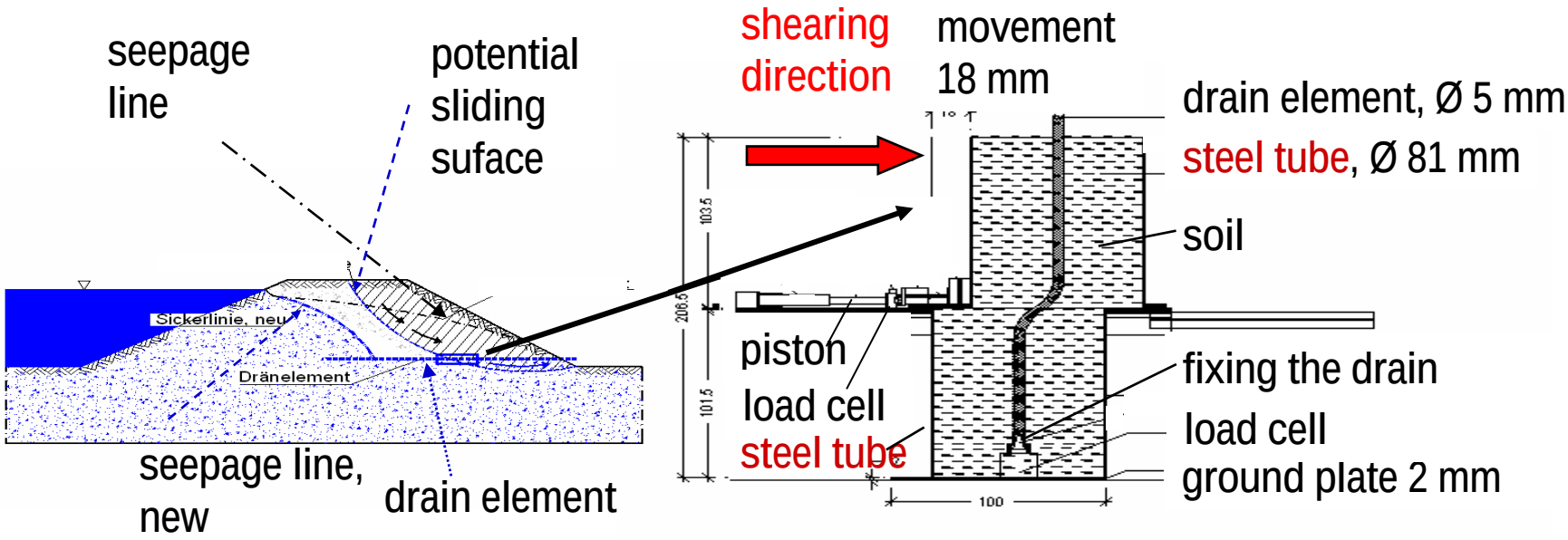
- **Parametric study**
  - Calculations for different drain lengths and distances for 2 different types of soil (up to now: without consideration of suction).
  - In a following step suction effects will be considered.

- **Aim:** Development of a design method

(B) Stability

- **Investigation on reinforcing effects**

  Tests on a large scale cylindrical shear box



(C) Draining elements - 2 basic types

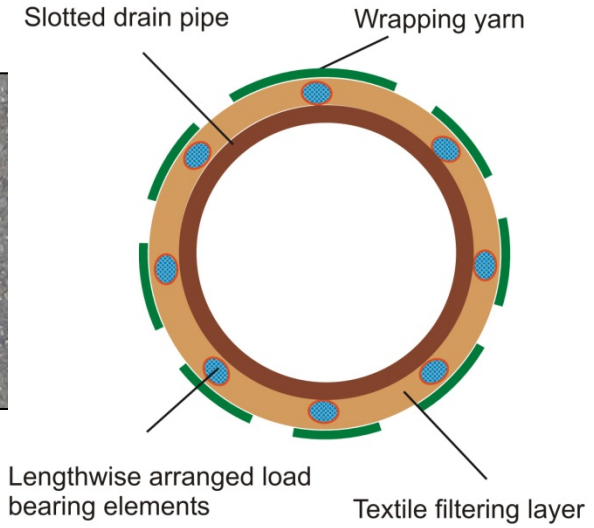
- Commercially available slotted PVC-pipes sheathing by a textile possible

- Textile wick drains (vertical drains), **STFI development**

Rope-like structures

(C) Draining elements

Type 1: Commercially available slotted PVC pipes

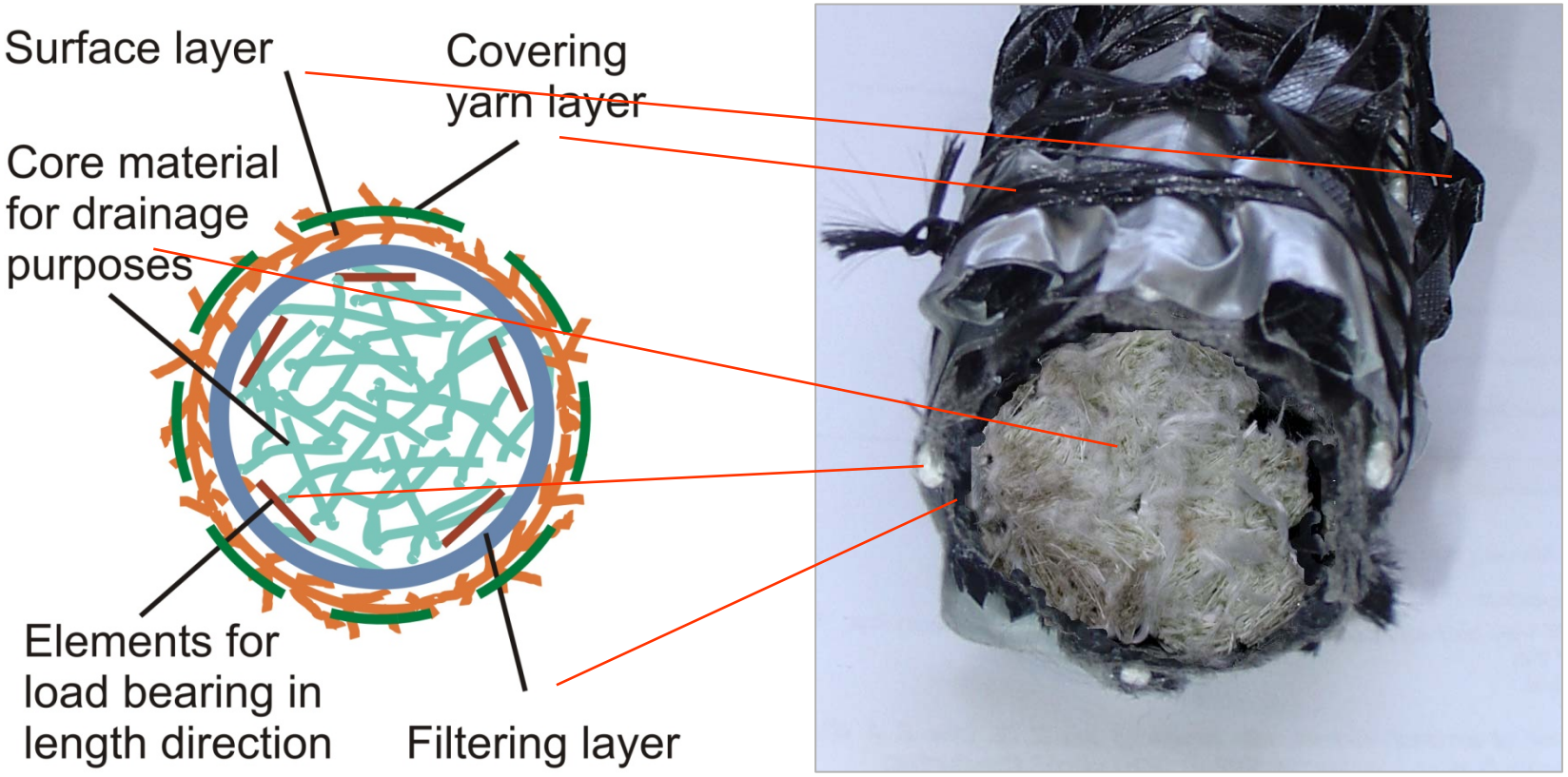


with or without textile layers

Commercially available PVC pipes
Sheathing process on a KEMAFIL® machine

Wide variety of technological parameters

Type 2: Textile wick drains (vertical drains) developed by STFI



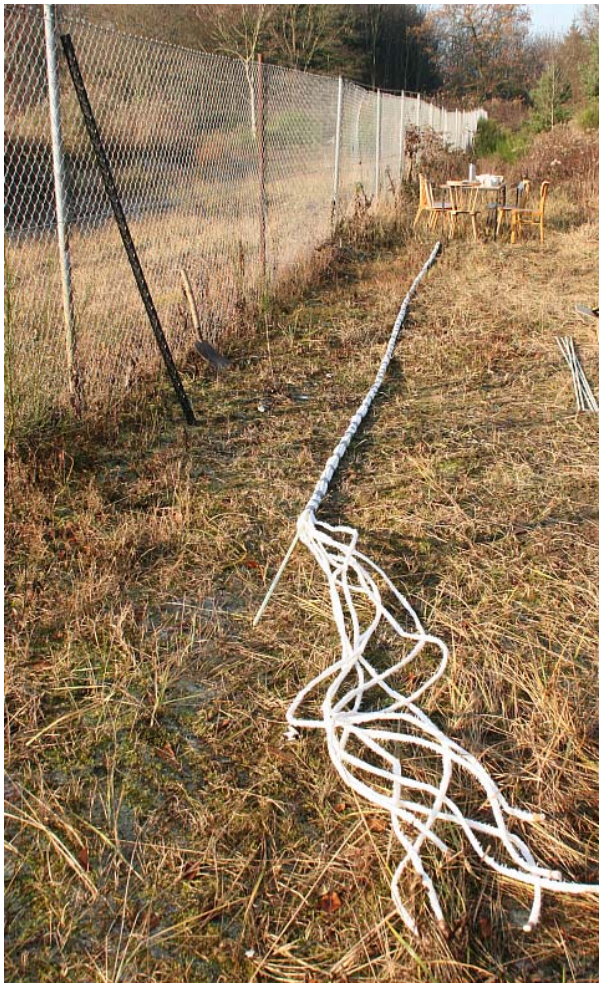
- Textile wick drains (vertical drains) developed by STFI

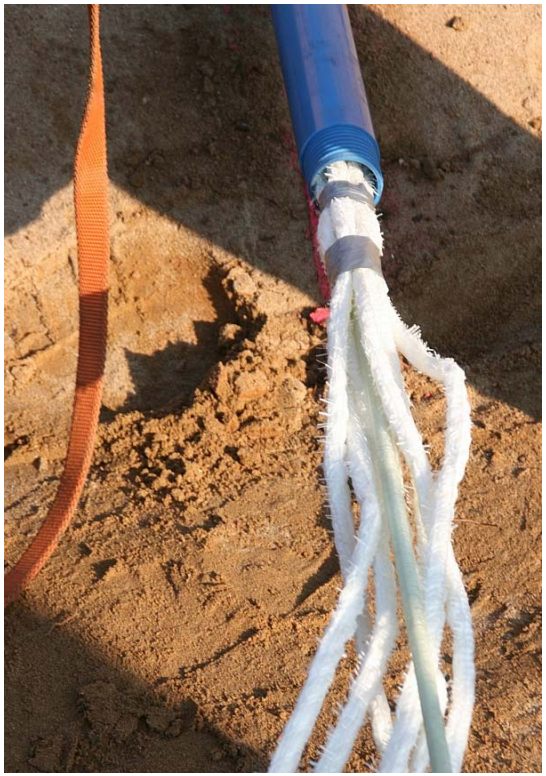
Manufacturing of a sample

Draining elements

Manufacturing of a sample

Draining elements



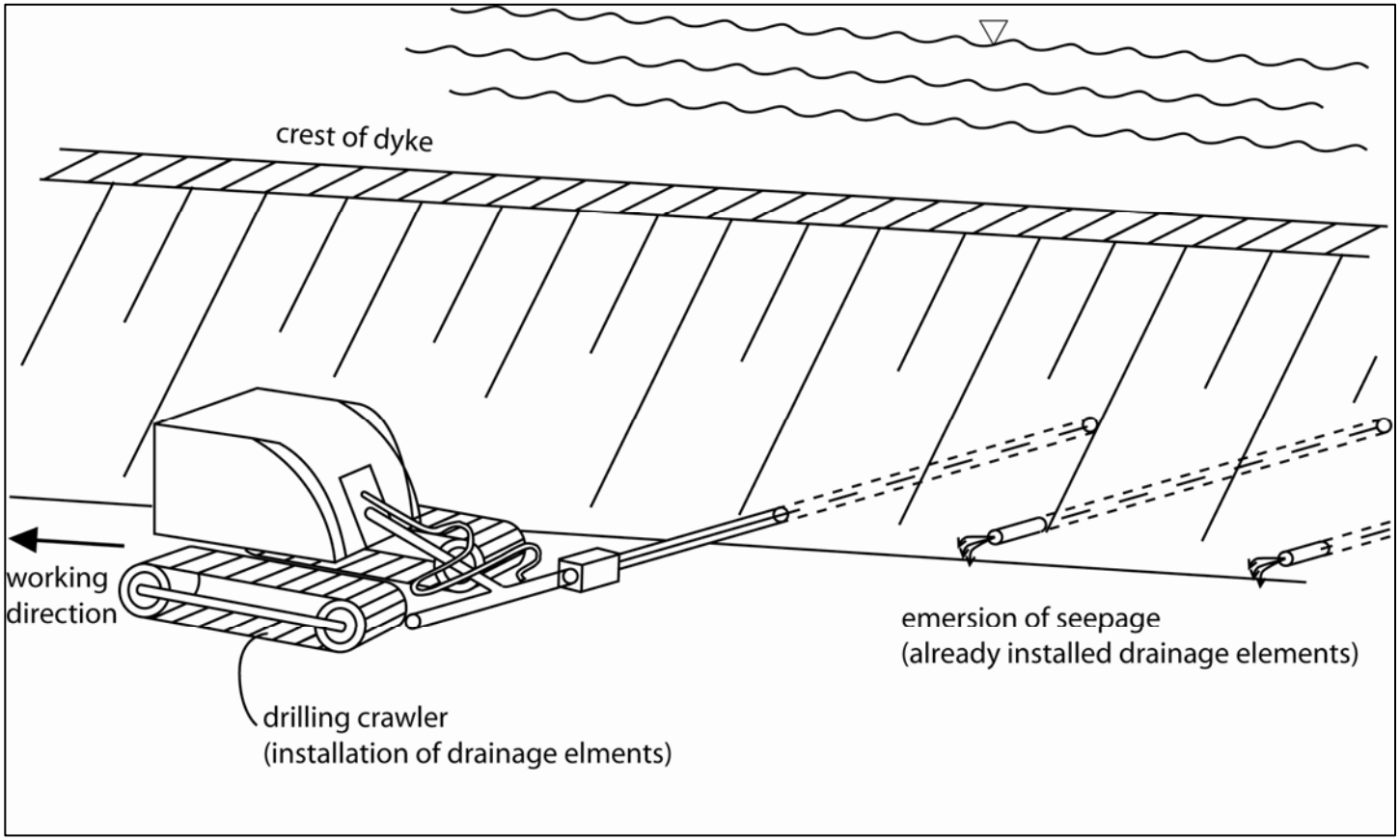


Sample containing an unflexible core

Installation of draining elements

- **Requirements**
  - Realisation by standard equipment
  - Versatile usage for different soil conditions
  - Use of commercially available draining elements
  - Preferably one-step technique
  - Suitable for horizontal installation
  - Uncomplicated and cost-effective procedure
  - Direct contact between drain element and dyke construction material (to avoid directional water and erosion)
  - Installation even under flooded conditions

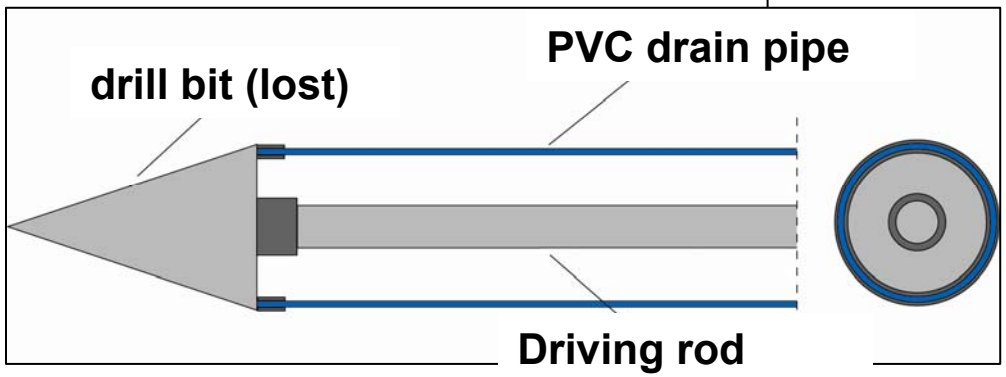
Installation of draining elements



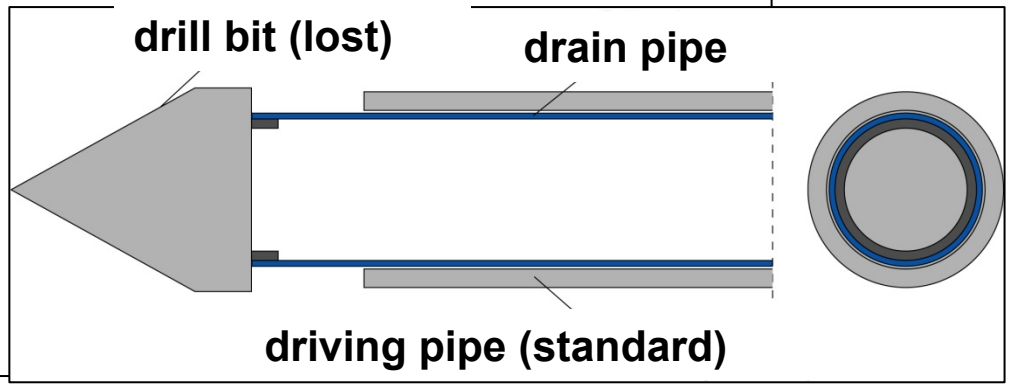
Installation of draining elements

- **Development of technologies**

  - Method 1:



  - Method 2:



Installation

Different types of drill bits

Installation tests

Tests on a dyke model on a natural scale

Dimensions:
representative dyke

15 m x 6 m x 3 m

TDR sensors
tensiometers

SUMMARY

- Different types of draining elements have been developed and tested (modified standard drains and innovative textile compound structures).
- A special rope-manufacturing technology was developed.
- Basic numerical calculations confirmed the lowering capacity of drainage elements with differing lengths and diameters.
- These results were used for 3D-stability calculations to determine the effects in terms of a parametric study.
- Tests were carried out by means of dyke models on a natural scale.
- A suitable installation technique adapted to the chosen draining elements is essential (cost effectiveness, possibility of horizontal installation at a minimum height above the dyke foundation).

Outlook

- **Further field tests using an optimised installation technology and adapted drain elements (summer 2008)**
- **Quantification of suction tension**
- **Development of a simplified design concept and simplified diagrams**

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