Bundesanstalt für Wasserbau
Federal Waterways Engineering and Research Institute

ICSE6 Paris - August 27-31, 2012

Prevention of Internal Erosion by Cut-Off Walls in River Embankments on the Upper Rhine

Bernhard ODENWALD, Kerstin RATZ

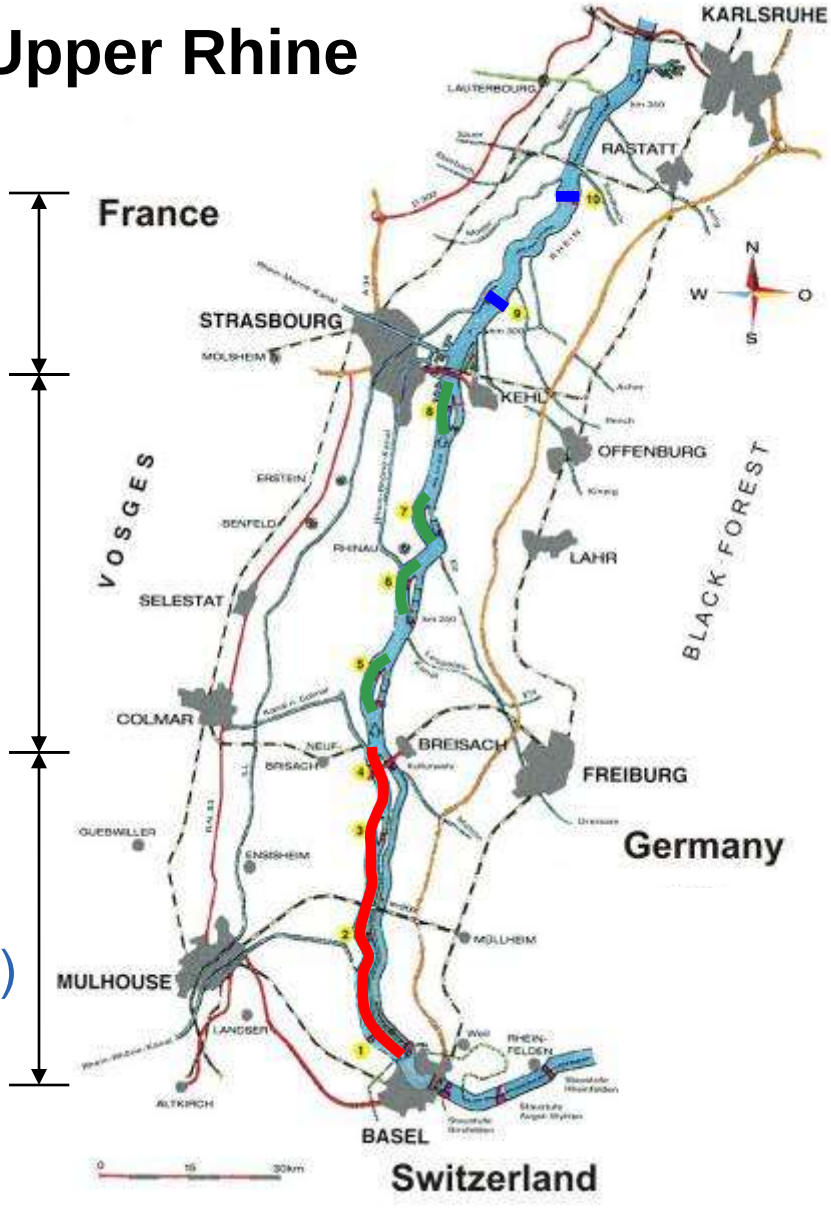
www.baw.de

Barrages in the Upper Rhine

barrages in
the River Rhine

barrages in
short lateral canals
(canal loops)

barrages in
long lateral canal
(Grand Canal d'Alsace)



10 Iffezheim (1978)
9 Gambsheim (1974)

8 Straßbourg (1970)
7 Gerstheim (1967)
6 Rhinau (1963)
5 Morckholdsheim (1961)

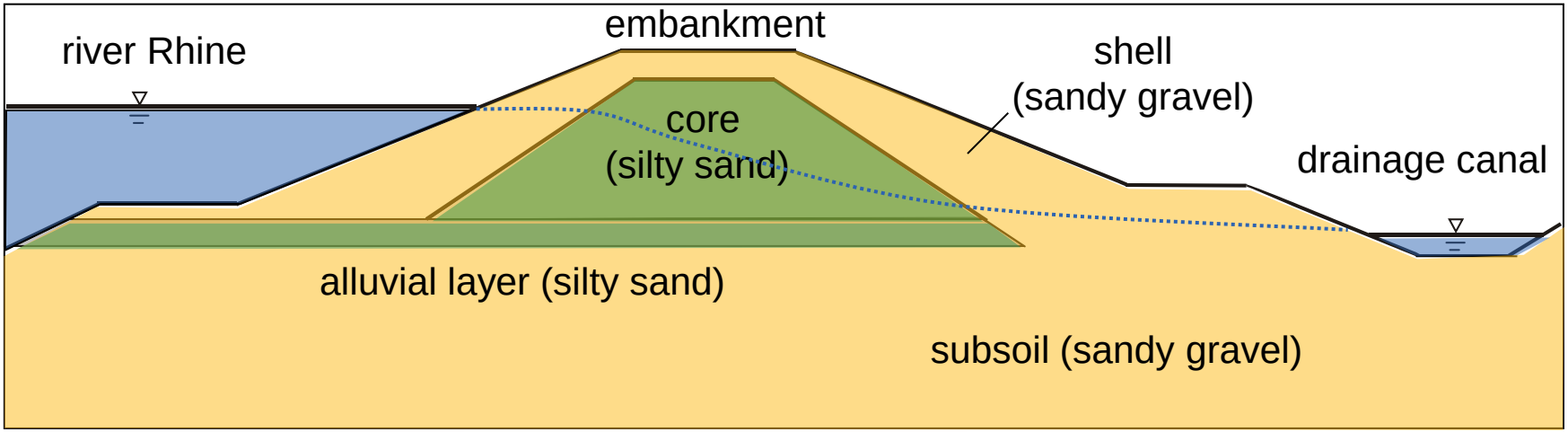
4 Vogelgrün (1959)
3 Fessenheim (1956)
2 Ottmarsheim (1952)
1 Kemps (1932)

Iffezheim Barrage

River Embankment

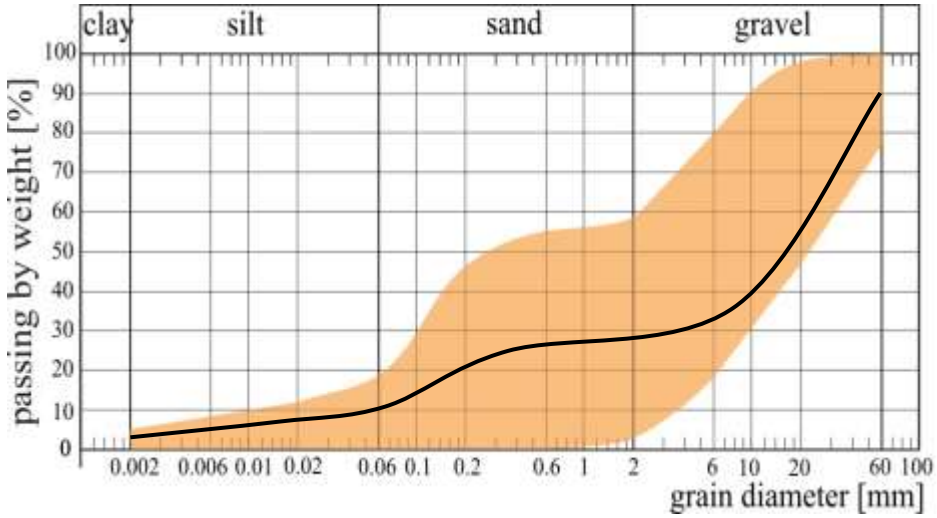
Composition of the River Embankments (German side)

impoundments between canal loops
(simplified example)

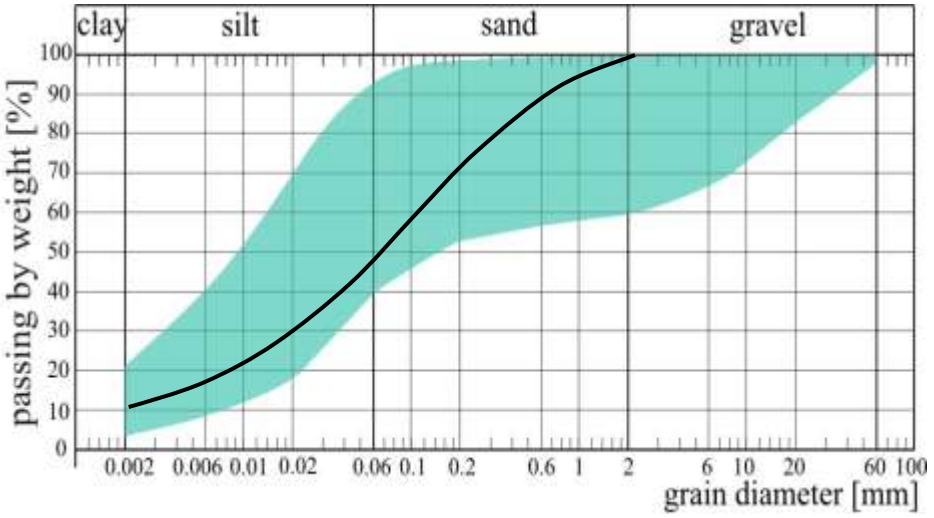


Construction (In-Place) Soil Material

embankment shell, subsoil:
sandy gravel

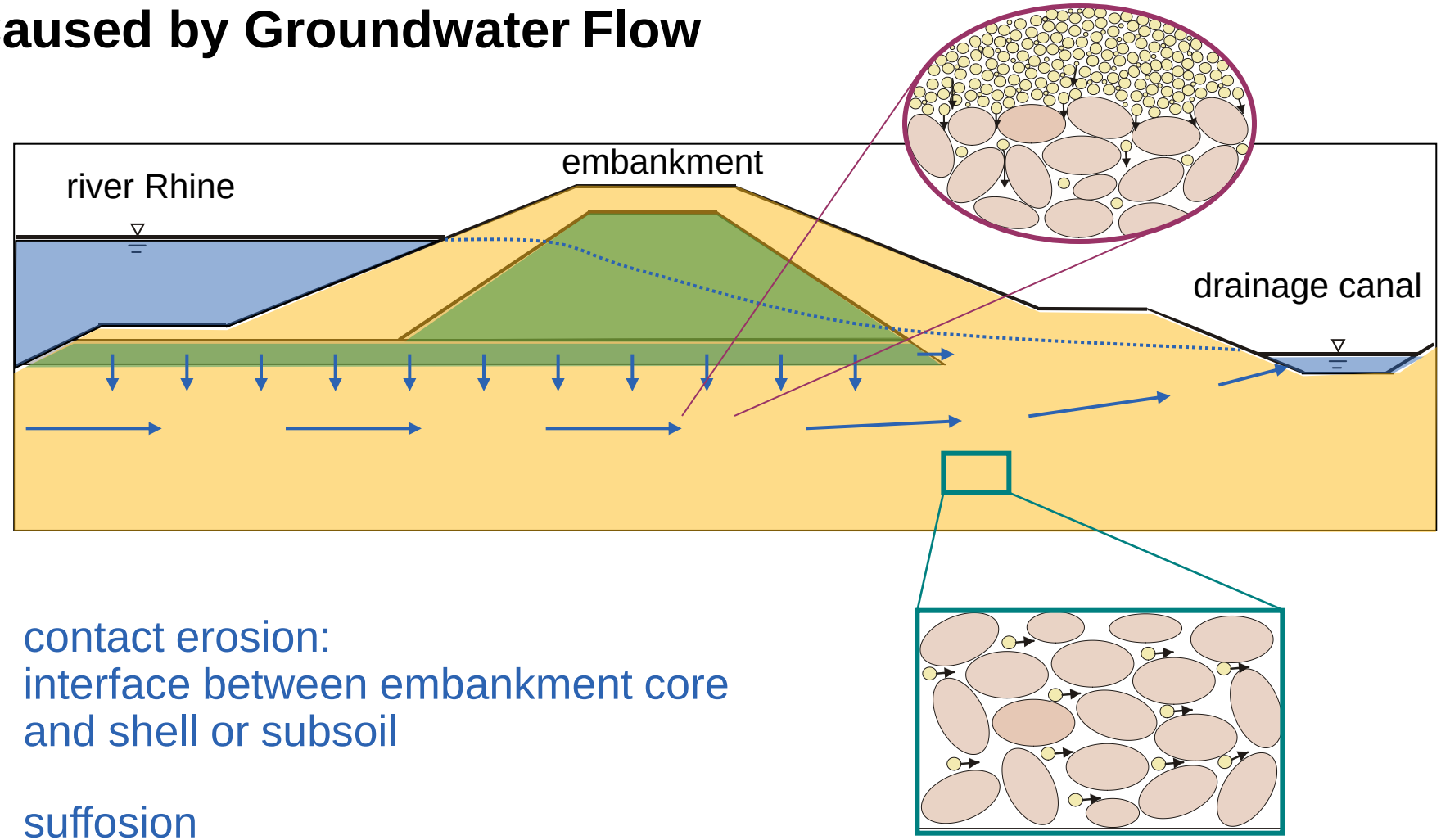


embankment core, alluvial layer:
silty sand (sandy silt)



- shell, subsoil: grain size gap for coarse-grained sand and fine gravel
- No filter stability between embankment core and shell or subsoil

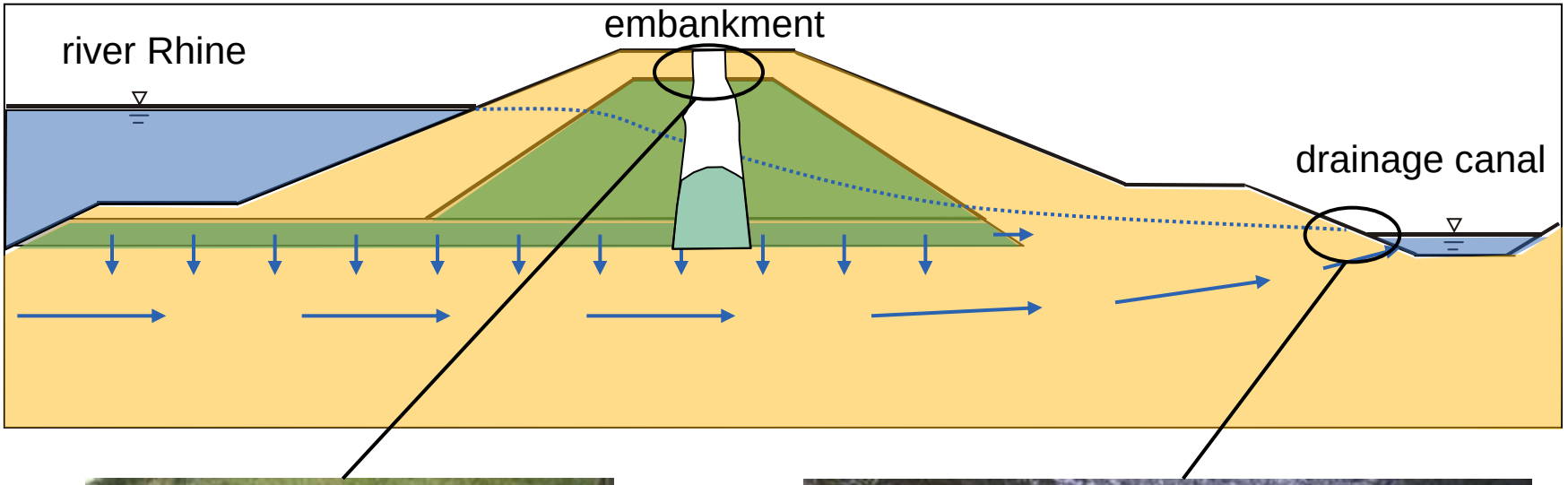
Internal Erosion
Caused by Groundwater Flow



contact erosion:
interface between embankment core and shell or subsoil

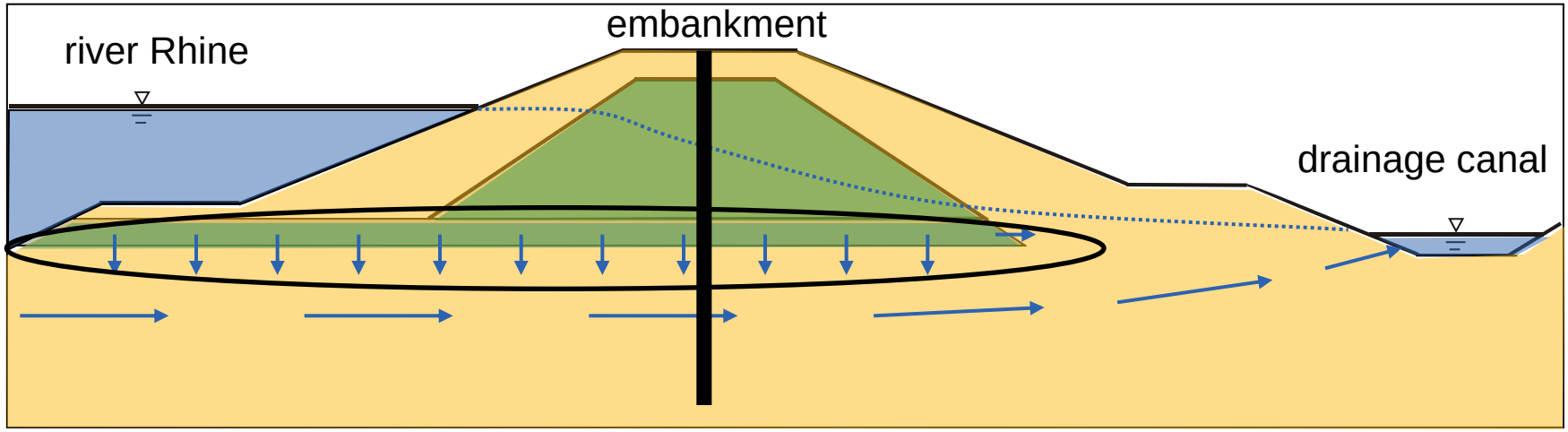
suffosion
inside shell or subsoil

Damages due to Internal Erosion



Embankment Rehabilitation with Cut-Off-Walls

- objective: reduction of the risk of internal erosion (contact erosion and suffosion)

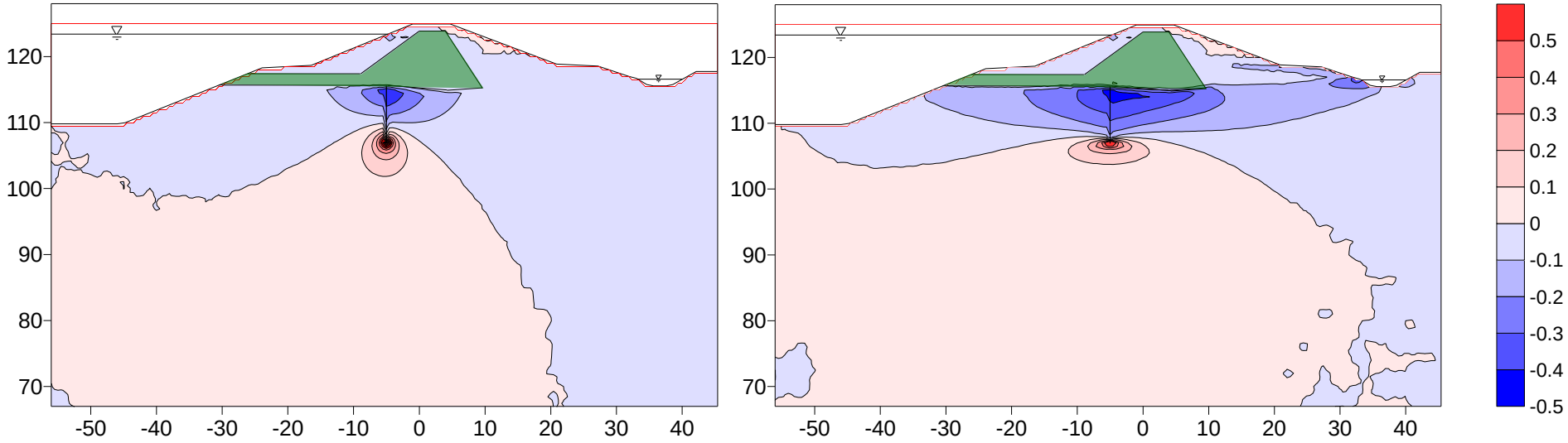


- measure: reduction of seepage flow velocity at the interface embankment core / subsoil by cut-off-walls
- conditions: quaternary sediment aquifer, thickness several 100 m, embedment of cut-off-walls in an aquiclude not possible
- cut-of-wall effective measure to reduce the risk of internal erosion?

Effects of Cut-Off-Walls

isotropic aquifer ($k_v = k_h$)

anisotropic aquifer ($k_v = 0.1 \cdot k_h$)

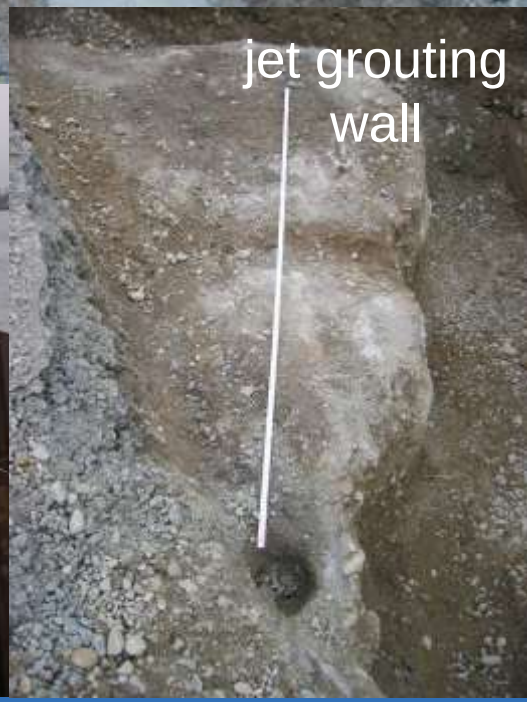


change of flow velocity [m/d] by the cut-off-wall

- anisotropic ground due to alternating deposition of fine grained and coarse grained sediments
- partially fine grained layers in ground
- meanders of old Upper Rhine filled with coarse grained soil material

➢ cut-off-walls effective measure to prevent internal erosion

Used Types of Cut-Off- Walls



Evaluation and Inspection of Cut-Off-Walls

- sheet pile walls very robust and less sensitive to hydraulic stress, but very expensive
- soil mixing, jet grouting and particularly diaphragm walls very sensitive to hydraulic stress (depending on groundwater flow velocity, cement setting rate, suspension transport in pores of soil)

➢ cut-off walls installed by using a suspension generally only suitable for ground areas with low groundwater flow velocities

- reliable method for inspection of cut-off walls: measurement of soil and/or groundwater temperature downstream wall, basic principle: different temperatures of surface water and groundwater, different conduction or convection heat transport velocities

➢ to evaluate the effectiveness of a cut-off wall: temperature measurements before and after installation of the wall, sensors at relatively short distance