Stability of non-cohesive Soils with respect to Internal Erosion

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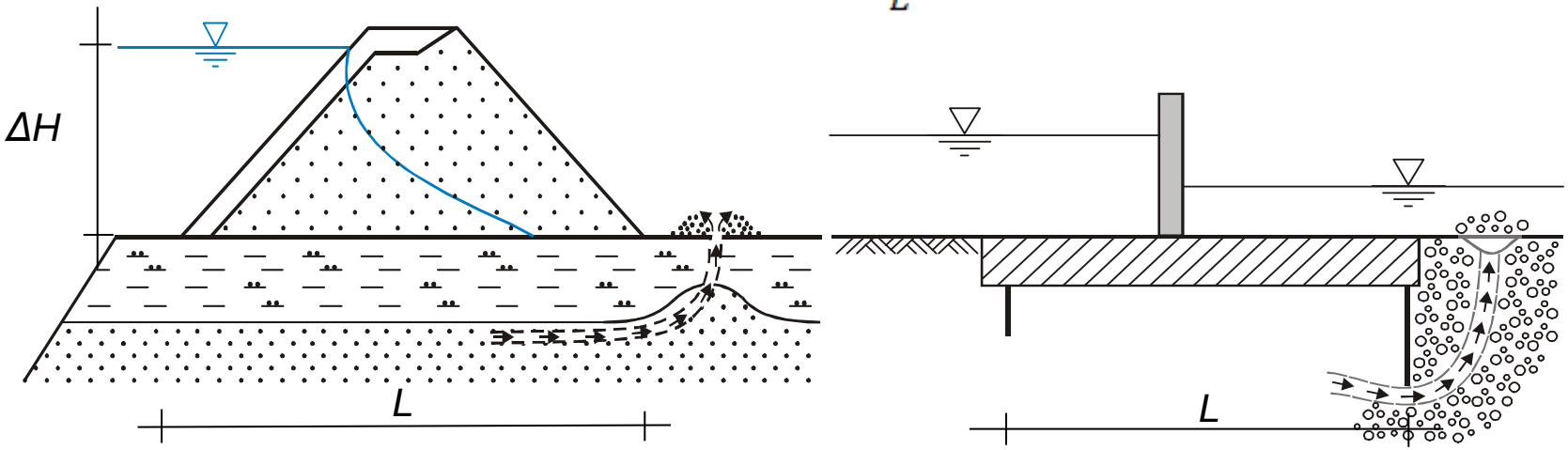
$$i = \frac{\Delta H}{L}$$



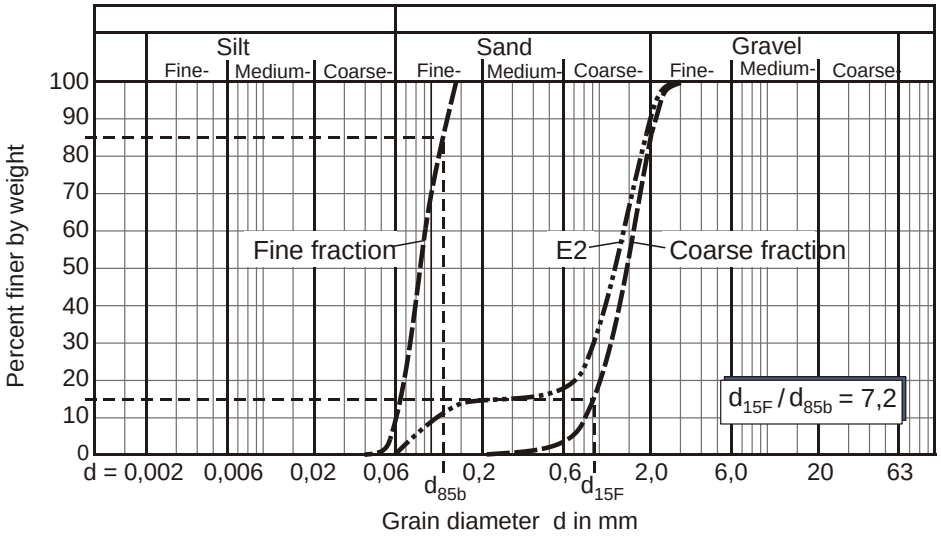
Schematic sketch of piping channel occurring at the downstream end of a dycke (left) and a river barrage (right)

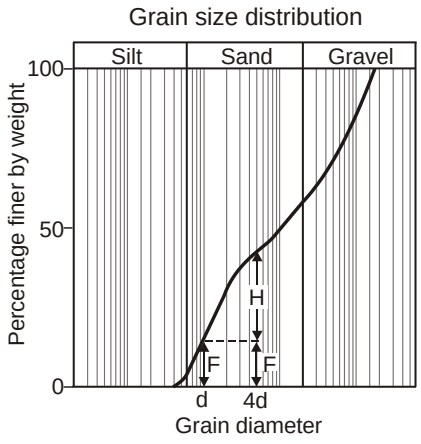
Criteria for the Evaluation of Internal Erosion

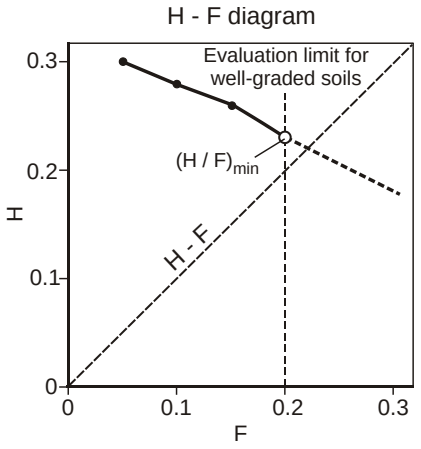
Geometric criteria

- Kezdi (1979): Splitting up of the grain size distribution into fine fraction and coarse fraction

- Kenney et Lau (1985-1986):
  H-F-Diagram
  H/F ≥ 1,0 for interne stable soil







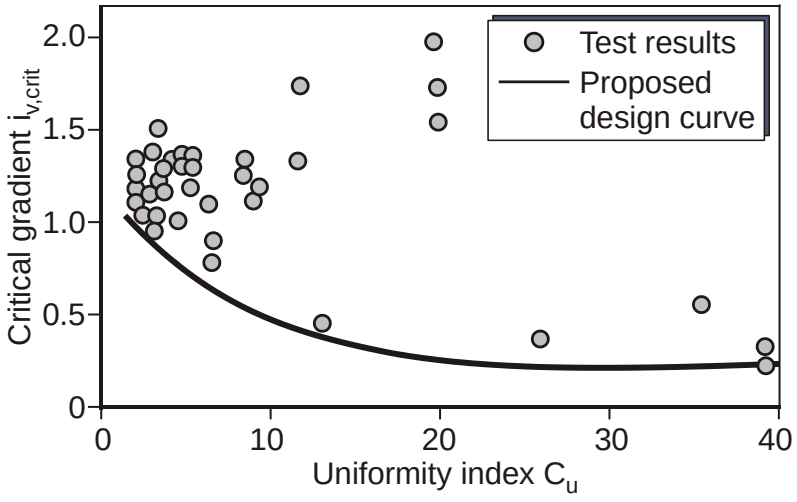
$$\frac{d_{15F}}{d_{85b}} \leq 4 \qquad U_F < 2 \qquad U_b < 2$$

Hydraulic Criteria

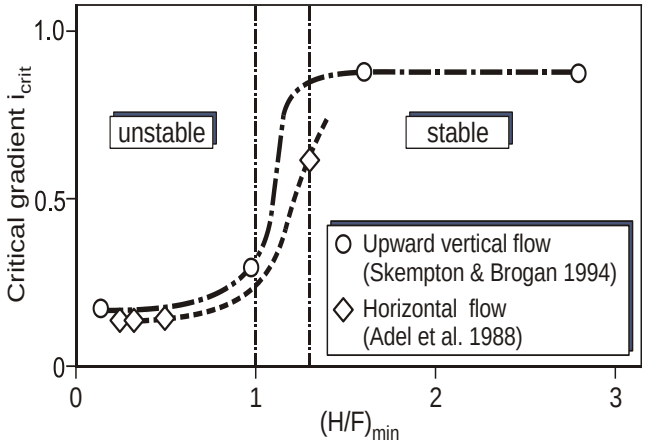
- Terzaghi et Peck (1961): Approach for vertical upward seepage

$$i_{krit,v} = \frac{\gamma'}{\gamma_w}$$

- Istomina (1957)

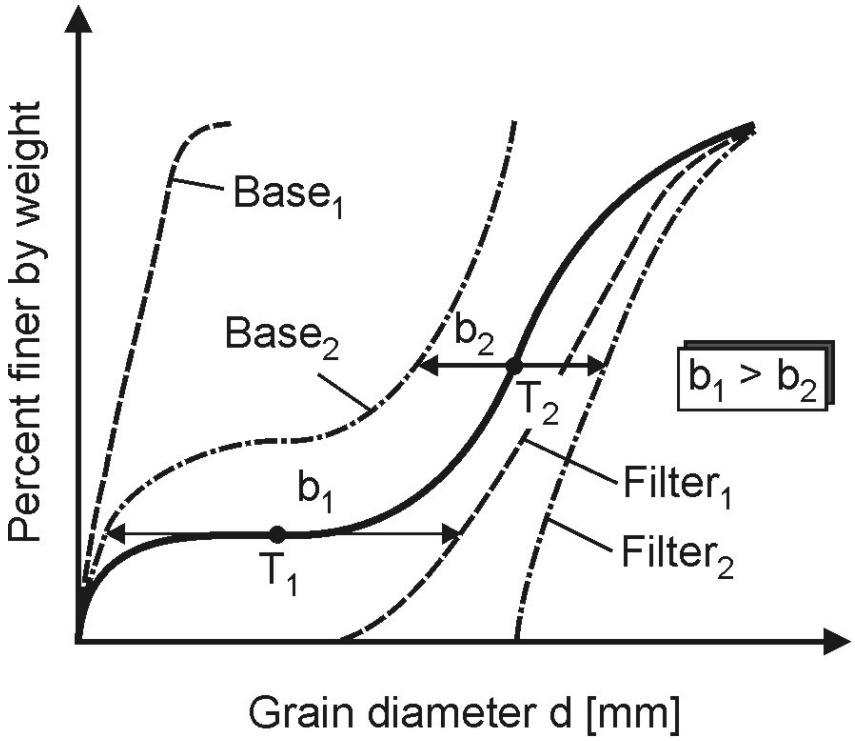


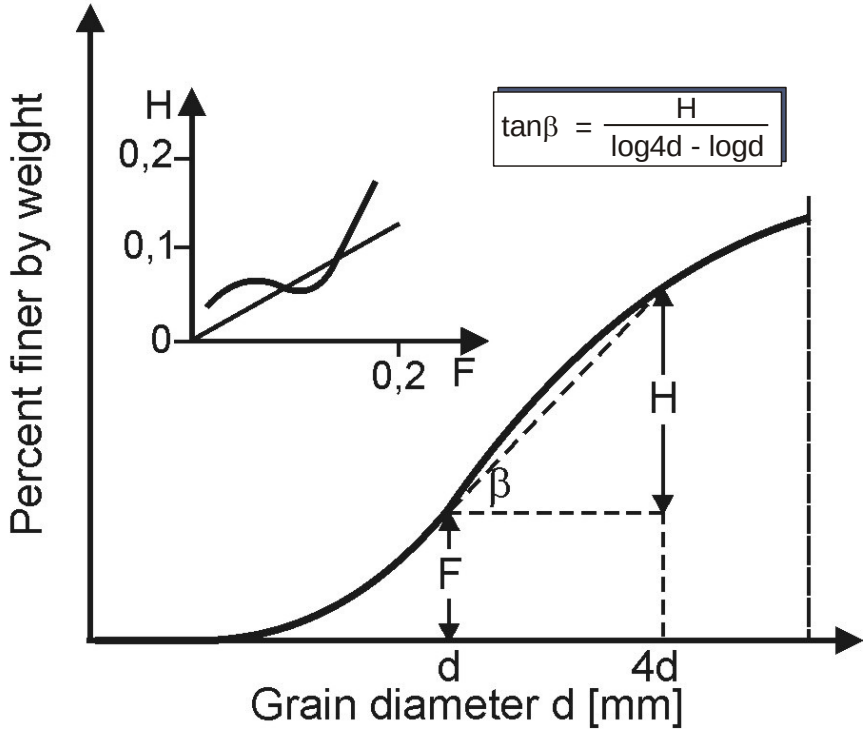
- Skempton et Brogan (1994):
  - Suffosion in Sand-Gravel
  - Upward vertical seepage
  - $i_{krit} = (1/3 \text{ to } 1/5) \cdot i_{krit,theo}$



$$i_{krit,v} = \alpha \cdot \frac{\gamma'}{\gamma_w} \quad \text{with:} \quad \alpha = \frac{\sigma'_{m,f}}{\sigma'_{m,G}}$$

Proposed approach for Splitting Up

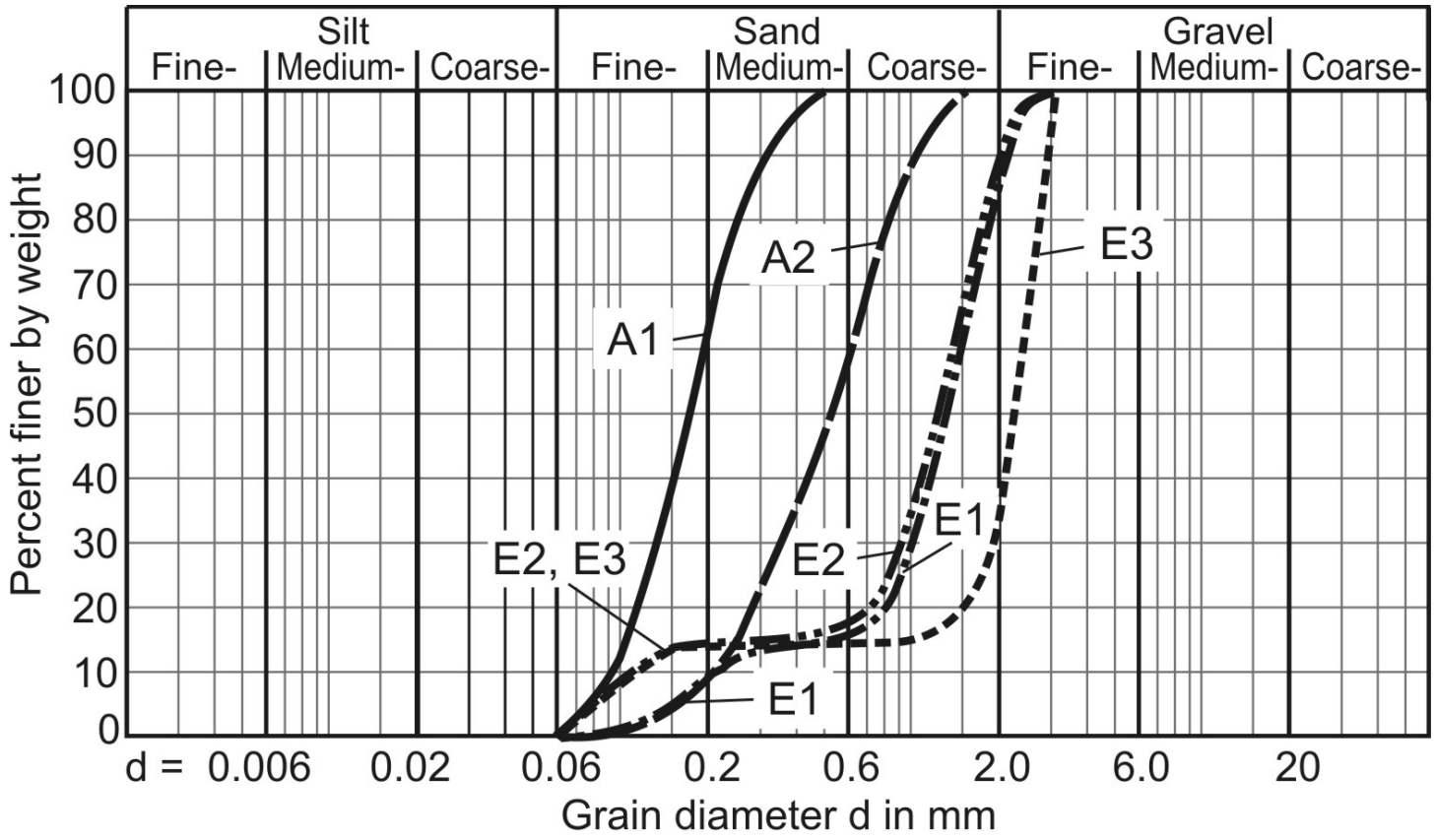




β minimal ⟹ H minimal

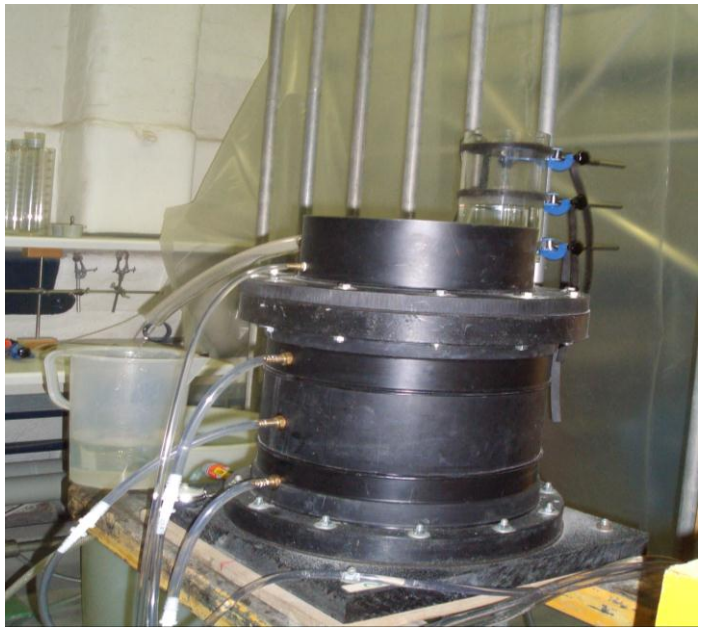
(d15F/d85b) = (d15F/d85b) at (H/F)min

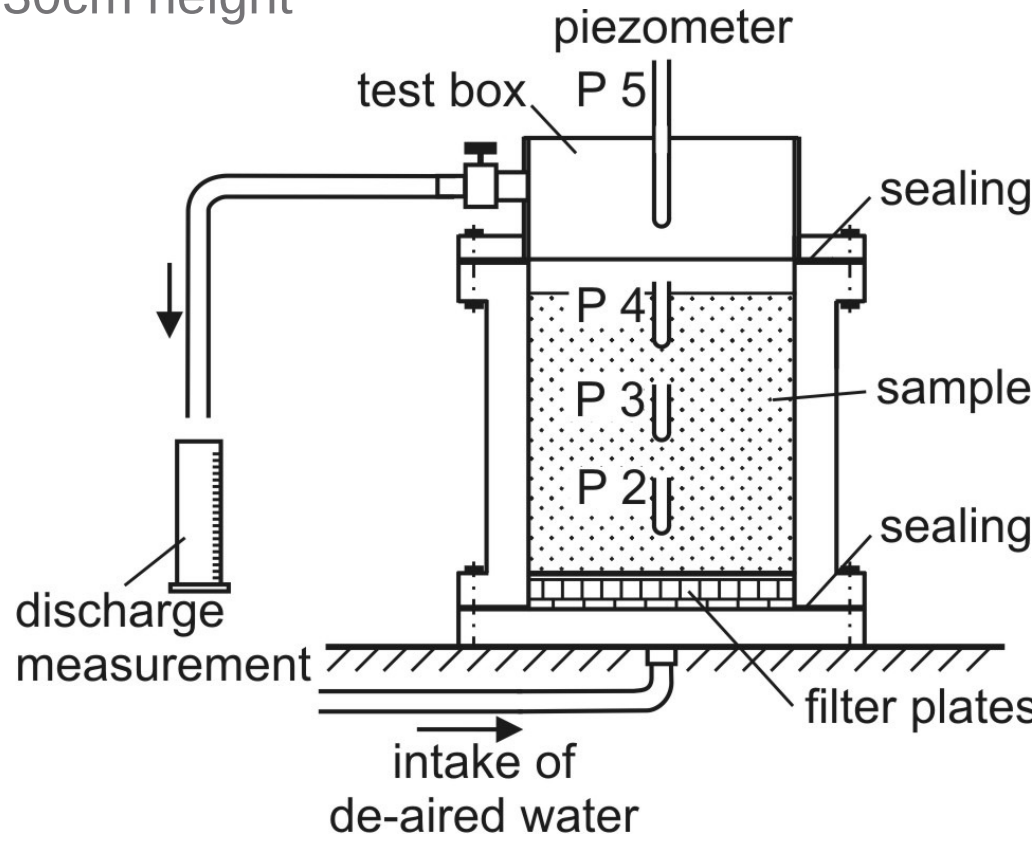
Investigated Soils Grain Size Distribution



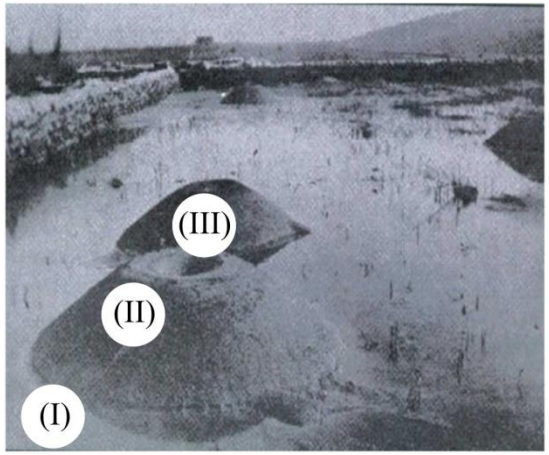
Experiment set up for upward vertical Seepage Flow

Soil sample: 30cm diameter, 30cm height

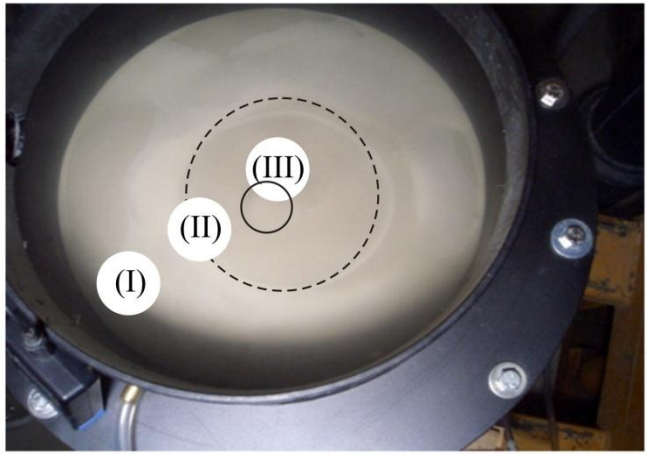




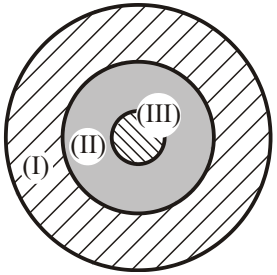
Phenomenological observation for upward vertical seepage flow



Sand boils at Mississippi river Levee (after Glynn (2004))



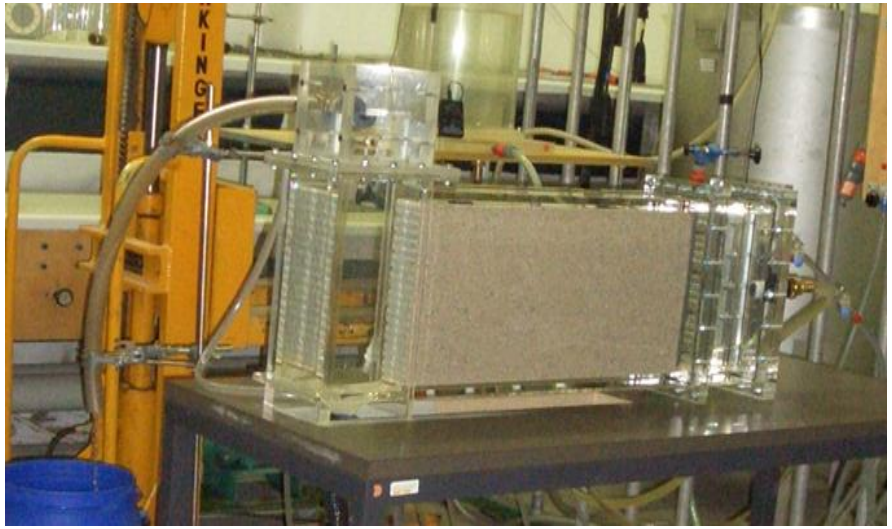
Total failure due to piping (current test for vertical upward seepage)

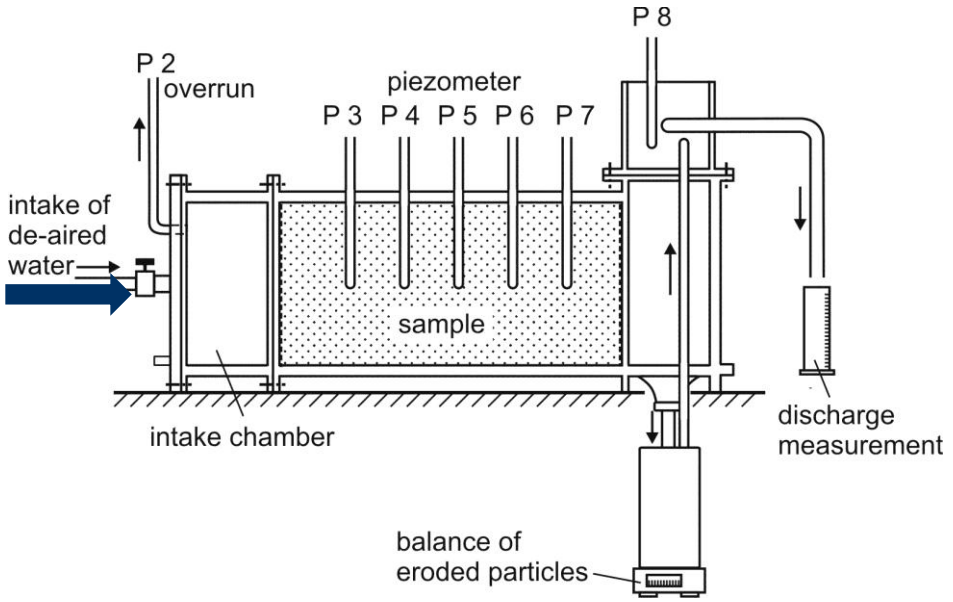


I Stable Zone
II Effectif Stress Zero - Zone
III Failure Zone

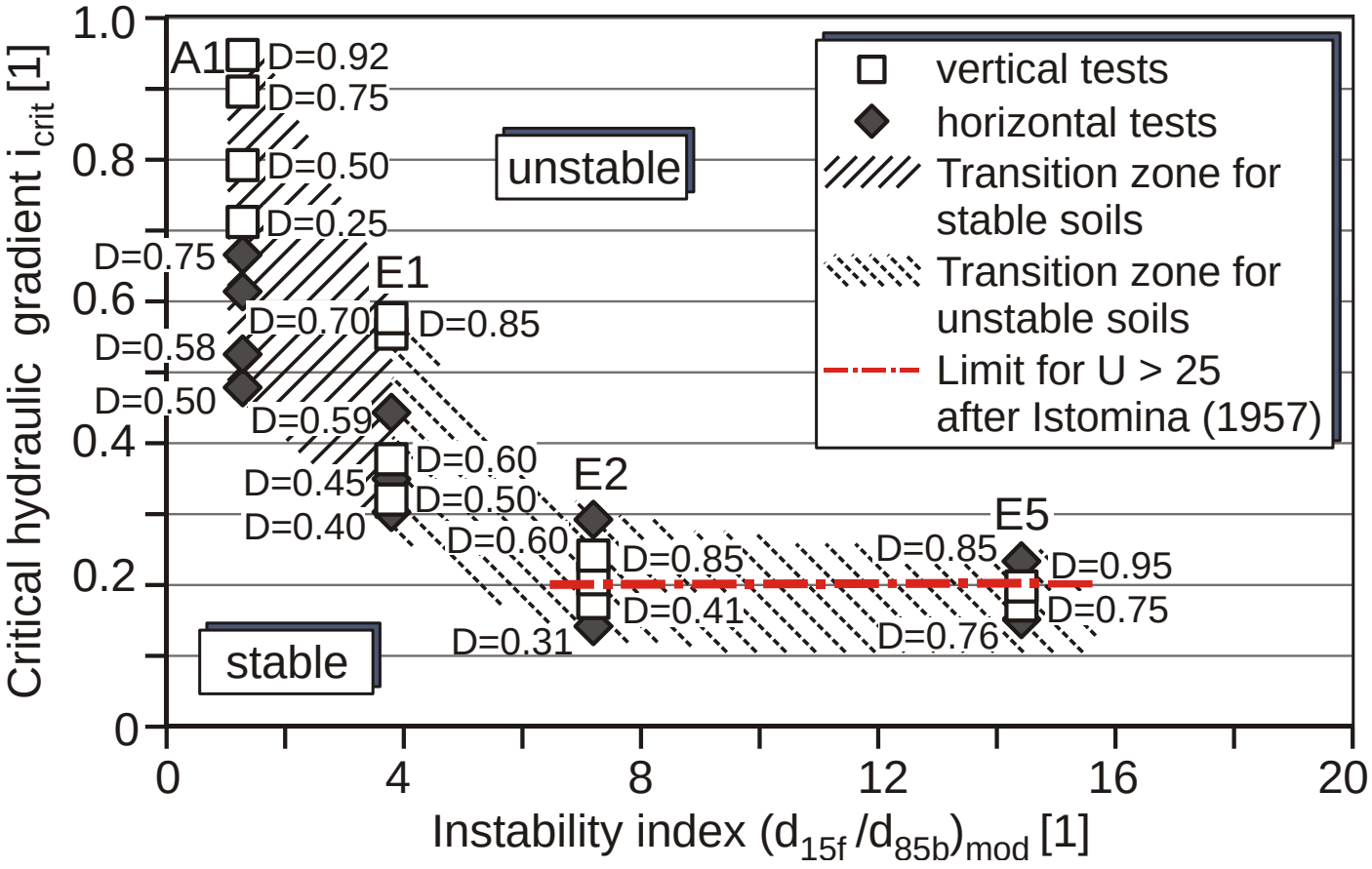
Experimental set up for horizontal Seepage Flow

Soil sample: width*height*depth=60cm*30cm*10cm

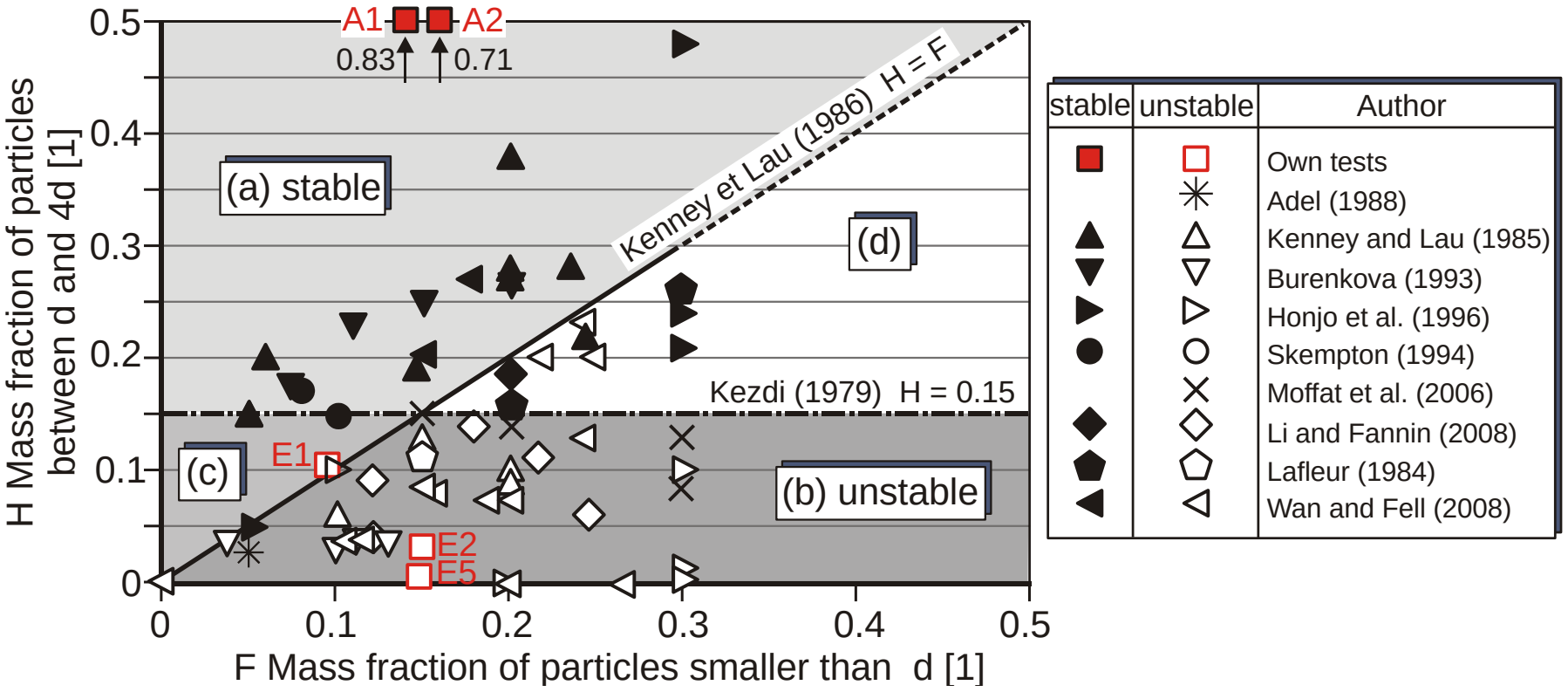




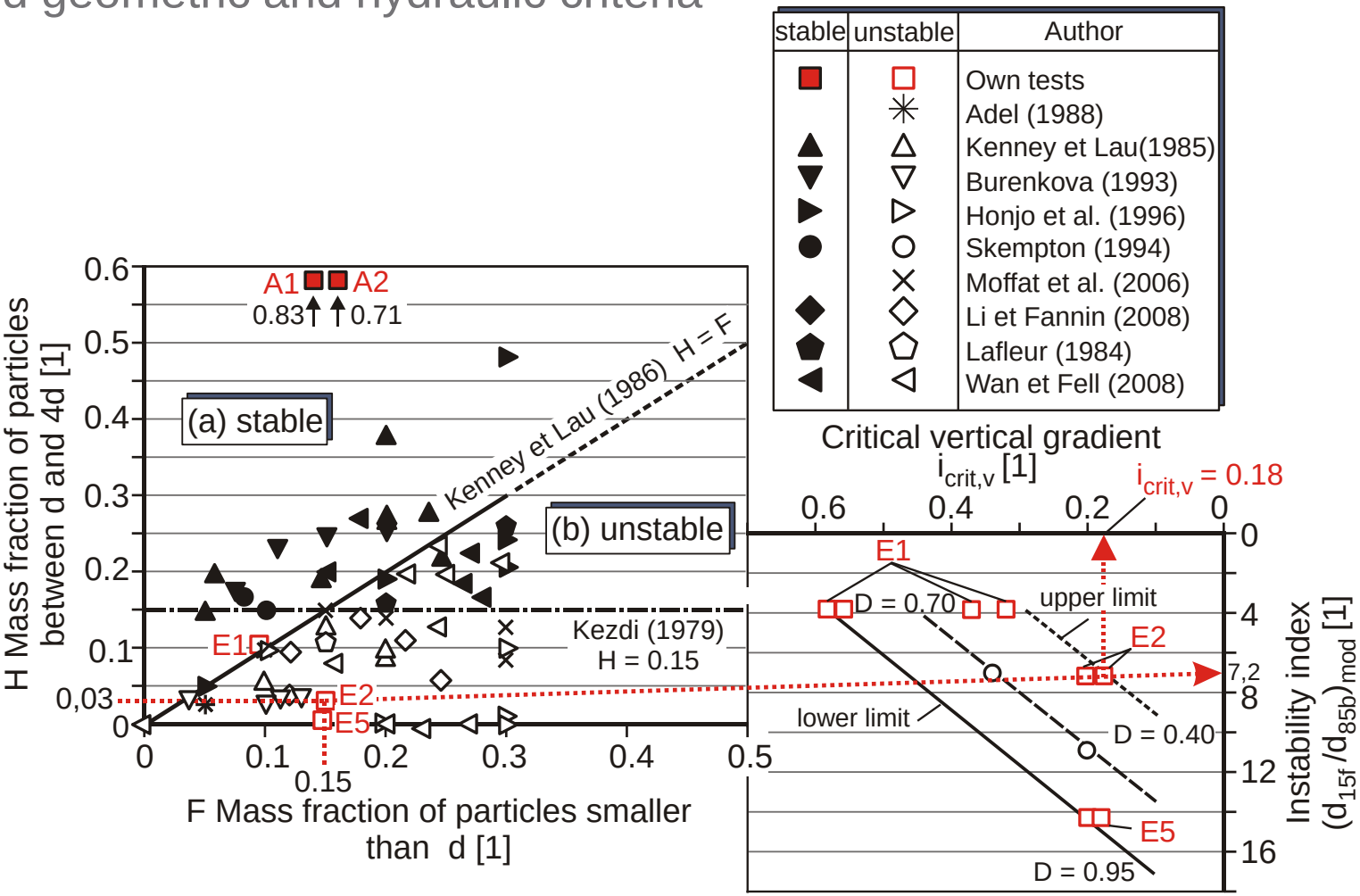
Test Results: hydraulic aspect



Test Results: geometric aspect



Combined geometric and hydraulic criteria



Problem

- Internal erosion
- Several approaches exist for the evaluation
- Approaches lead to different results

Results of current Investigations

- Controlling parameters have been idenfied by model tests
- Uniformity coefficient Cu might not be adequate for a reliable assessment of internal erosion
- Modified **(d15F/d85b) mod** is promising
- Diagrams have been proposed for the evaluation of the internal erosion stability

Thank you for your attention!

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