Protections

chapter 11

ct 4310 Bed, Bank and Shoreline Protection

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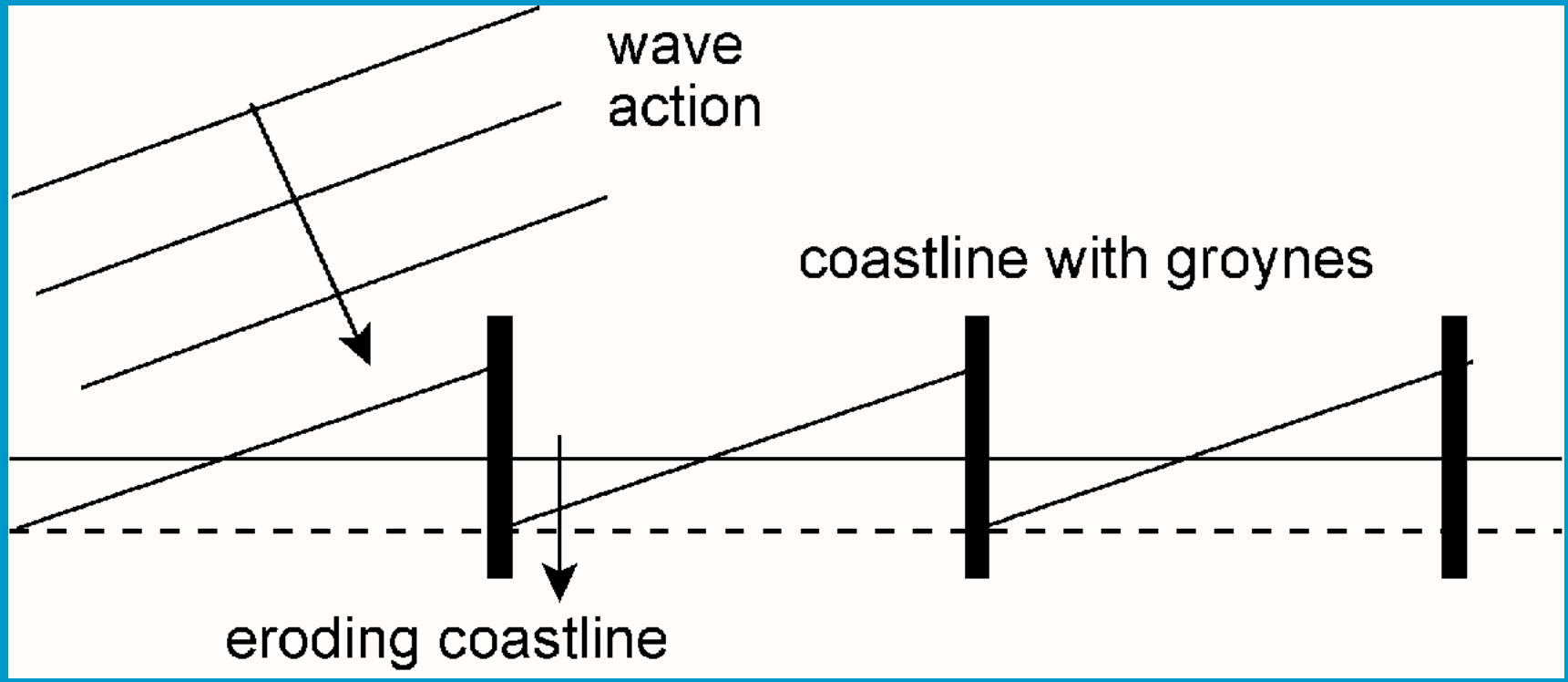
Section Hydraulic Engineering

If erosion occurs,...

- Do nothing….
- Take away the cause of the problem….
- Supply sediment….
- Reduce the loads….
- Increase the strength….

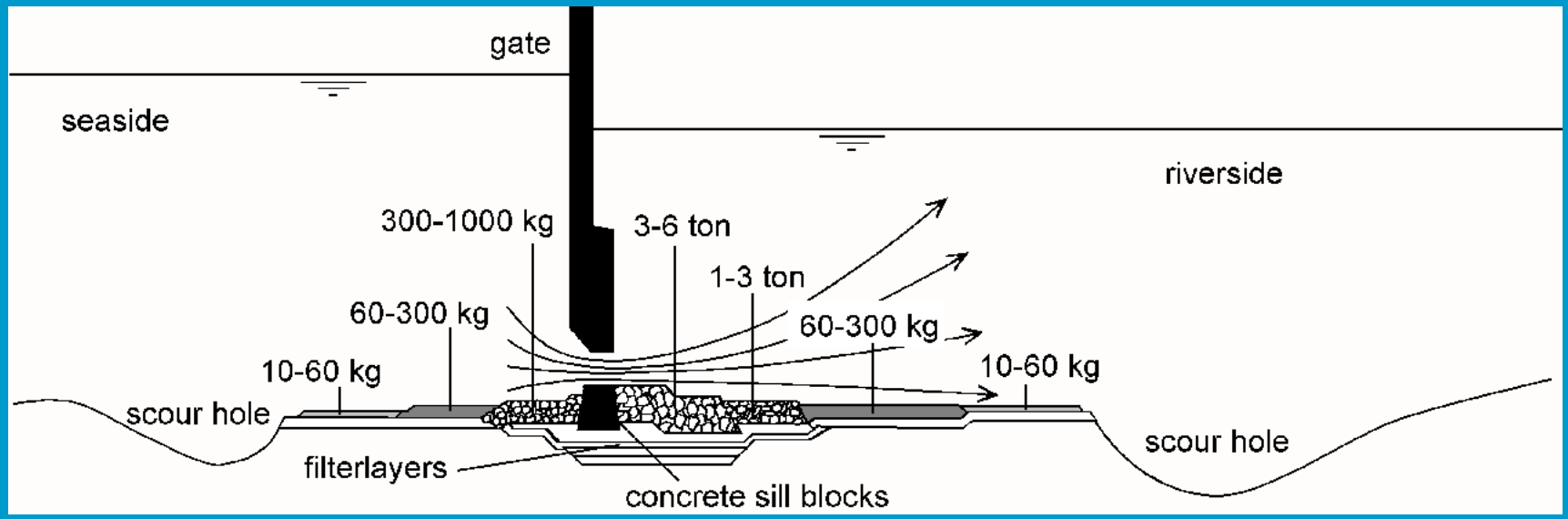
Taking away the cause of the problem



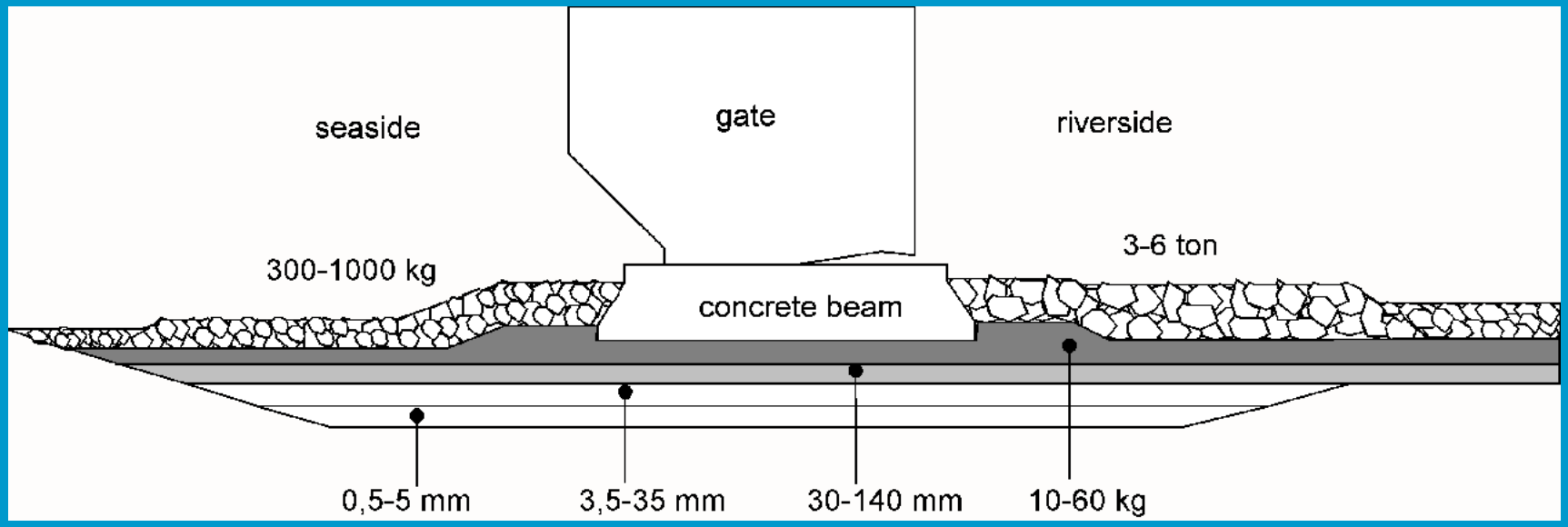
Bed protections

- loose rock solutions
- fascine mattresses
- composite mattresses

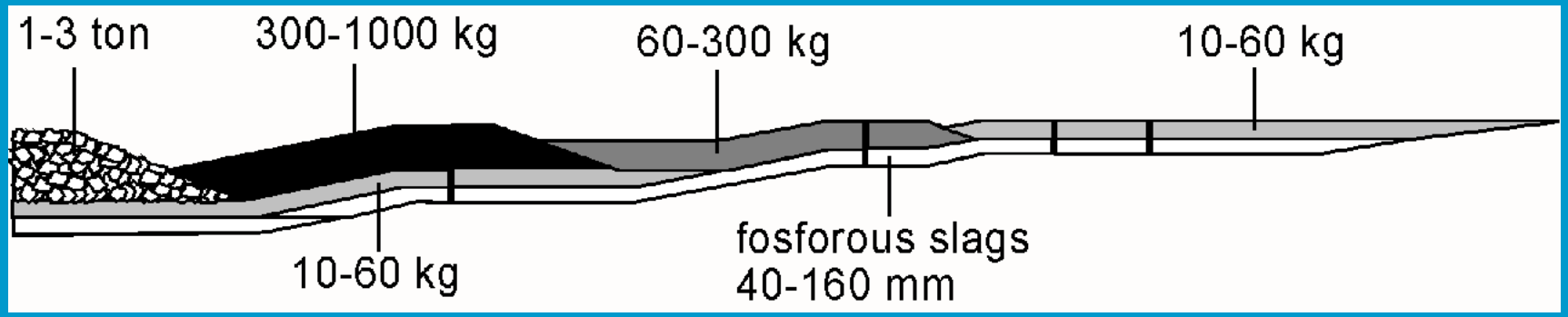
cross section bed protection Barrier Rotterdam Waterway



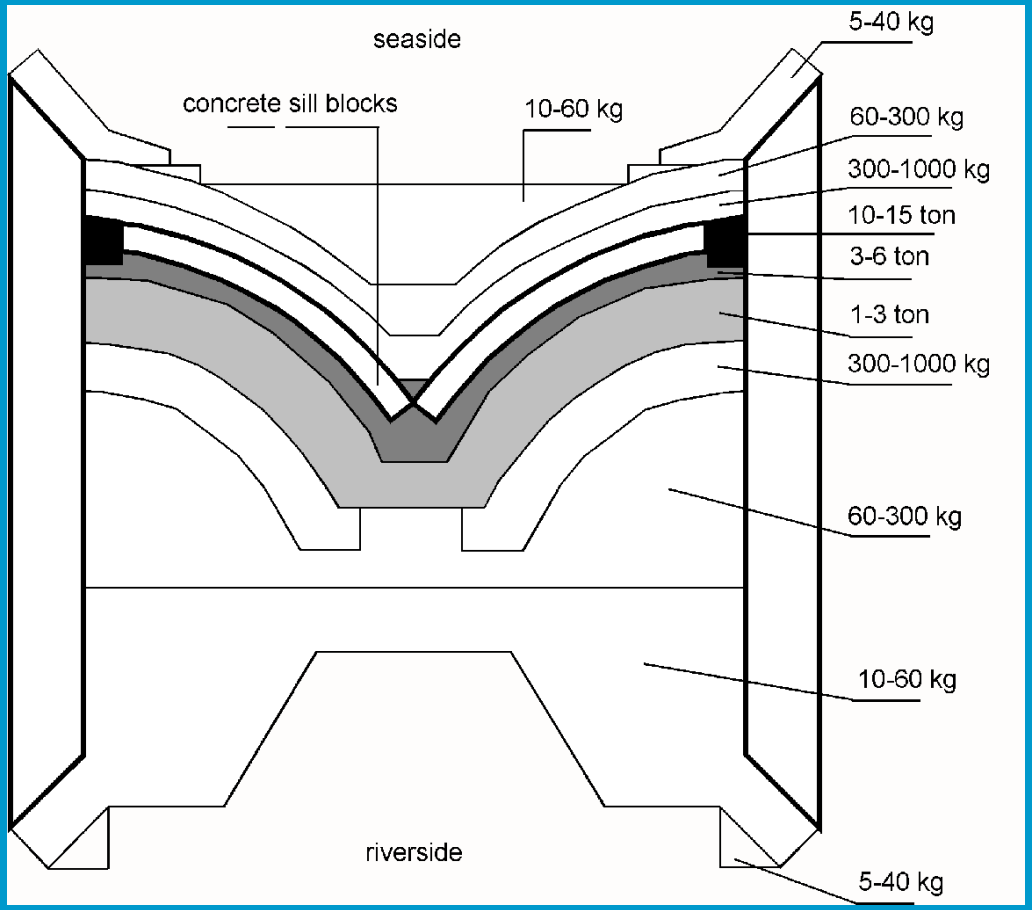
cross section sill
Barrier Rotterdam Waterway



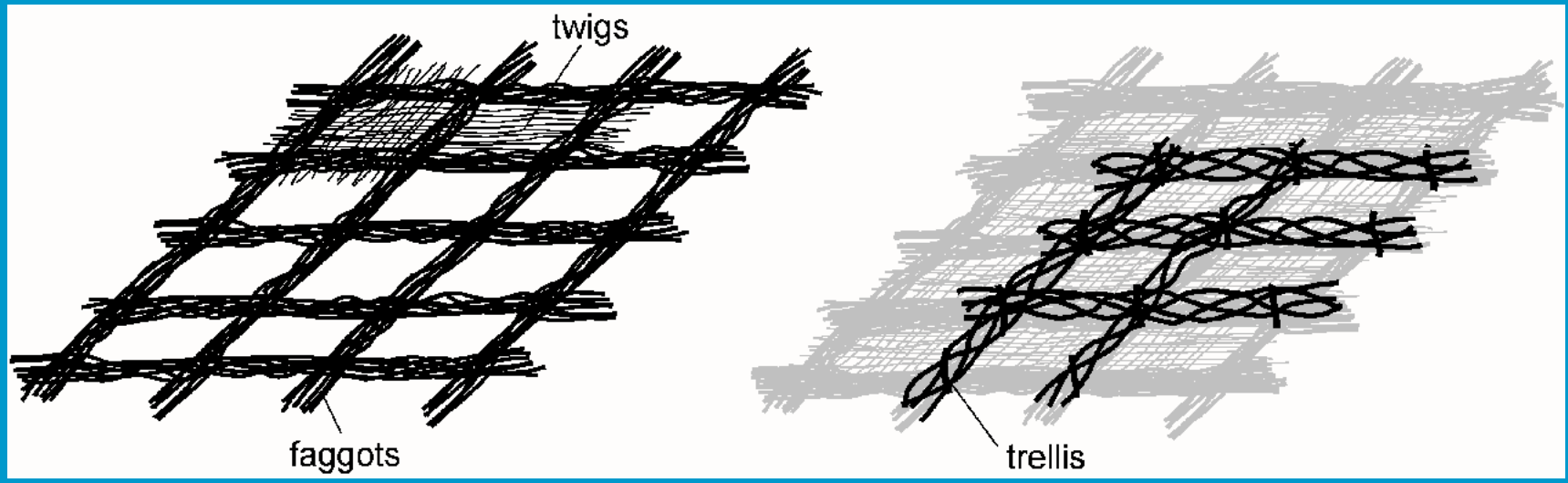
cross section bed protection riverside



top-view bed protection Barrier Rotterdam Waterway



Fascine Mattresses

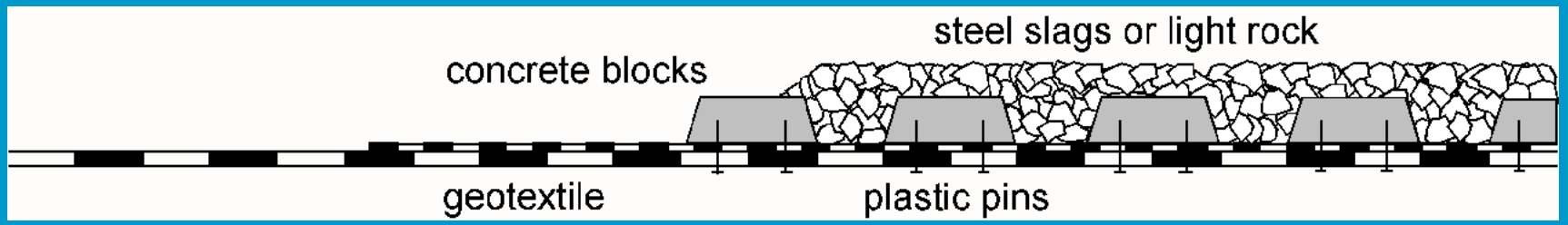


faggots = wiepen
trellis = tuinen

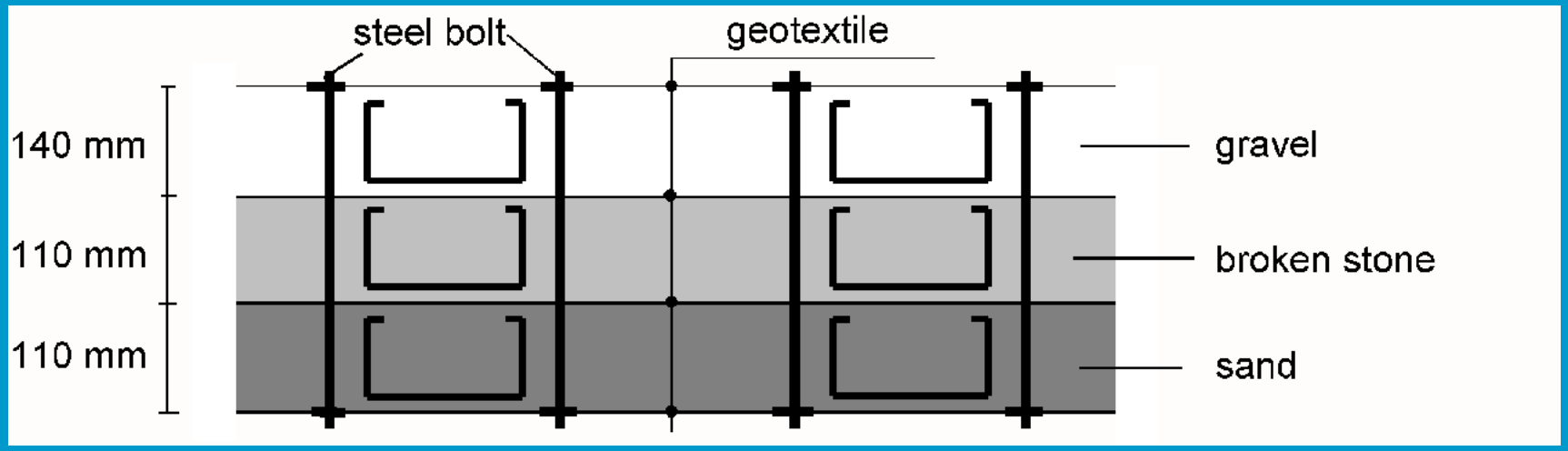
A faggot is a bundle of sticks or branches, usually meant for use as firewood. It derives through the Old French fagot and the Italian diminutive fagotto from the Latin Fasces ("bundle", also the origin of the word Fascism), coming into Middle English no later than 1279.

Note: Faggot, in modern North American and Australian English is a word, and generally a pejorative slur term, for a gay or effeminate man.

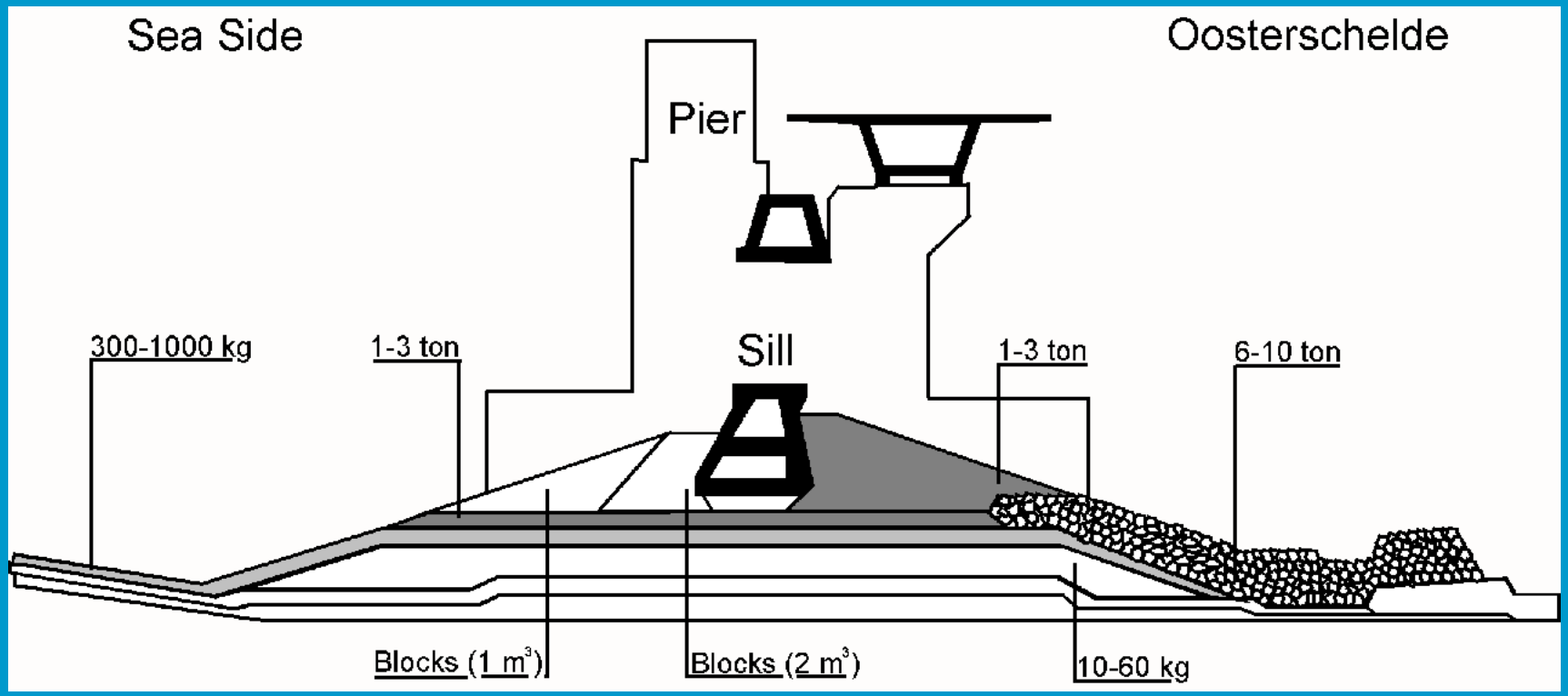
block mat of the Eastern Scheldt



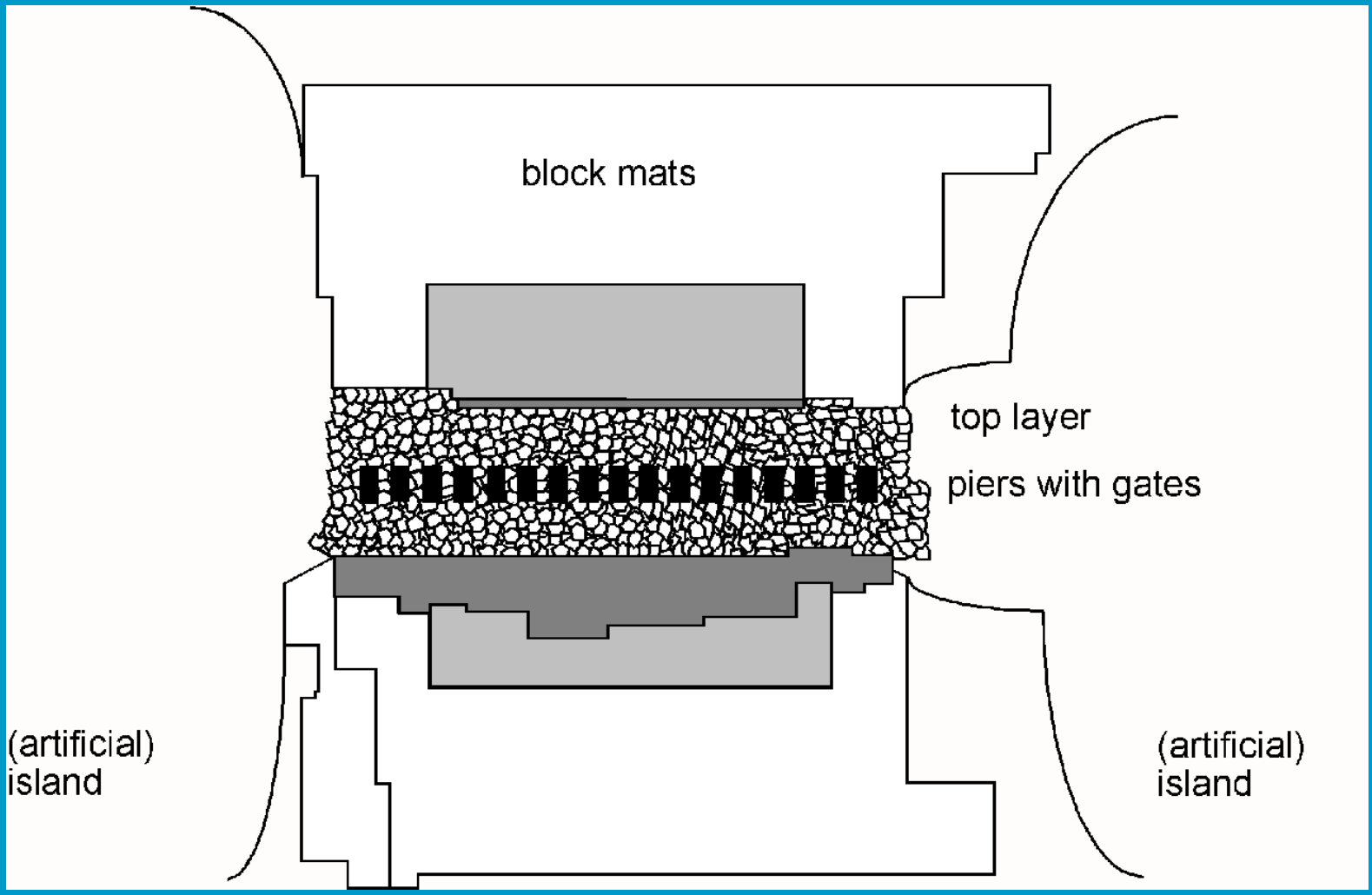
filter mat under the Eastern Scheldt barrier



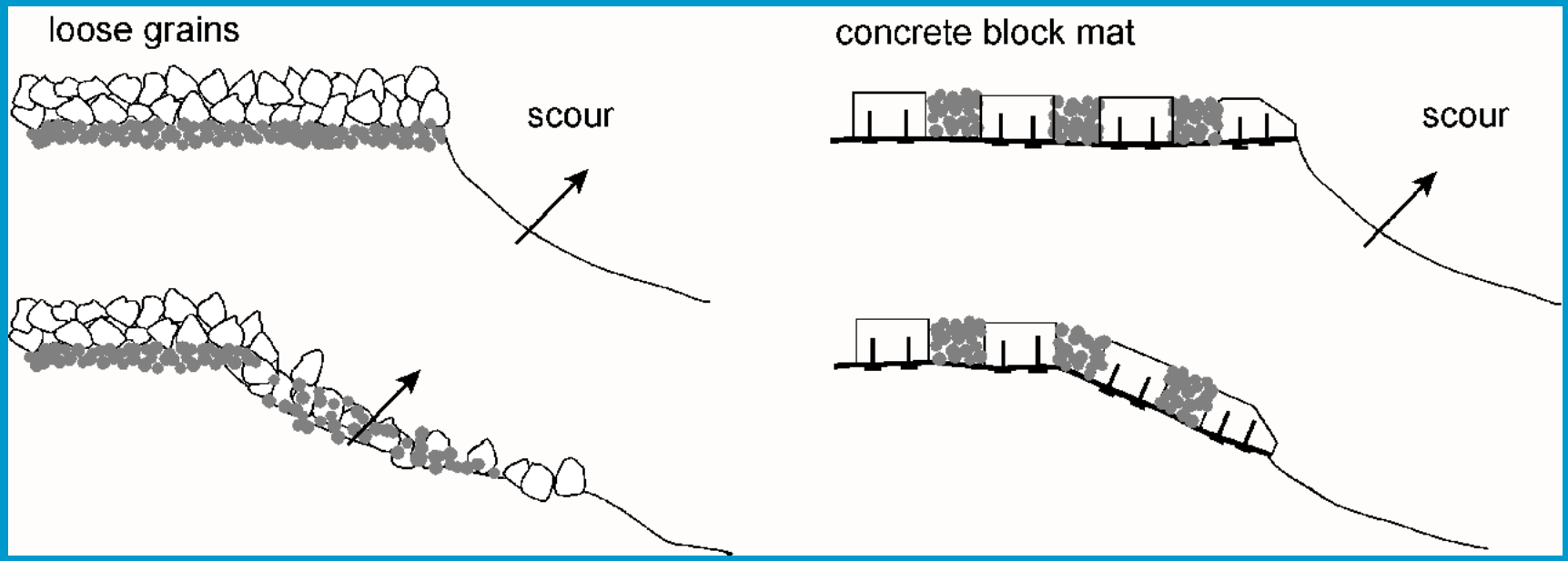
cross section of the foundation



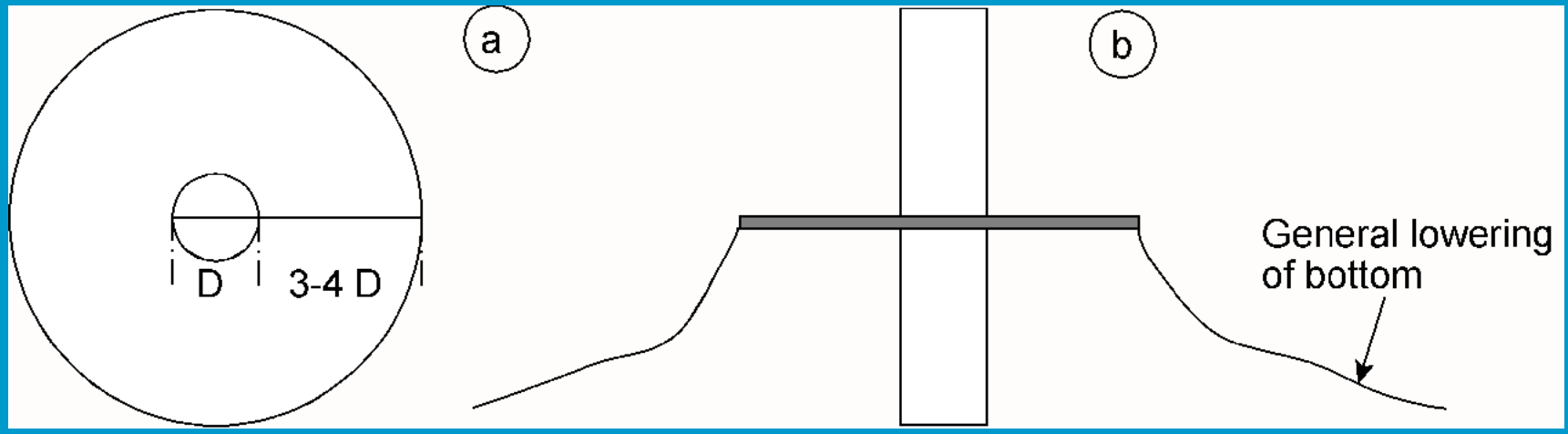
top view of bed protection



sliding of scour hole with loose and coherent protection

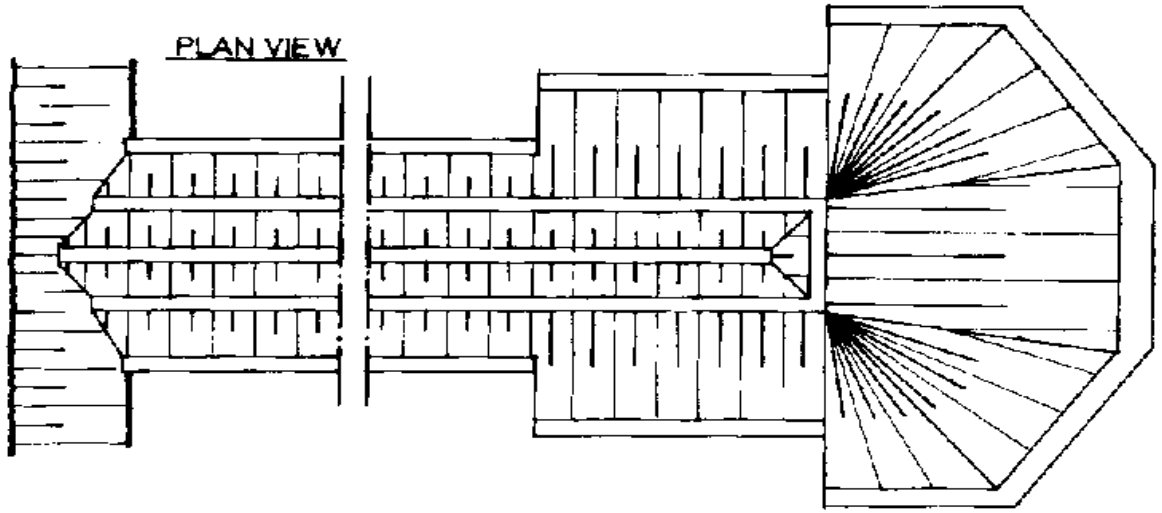


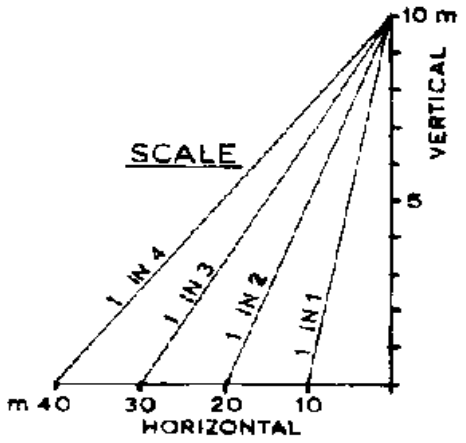
bridge pier protection

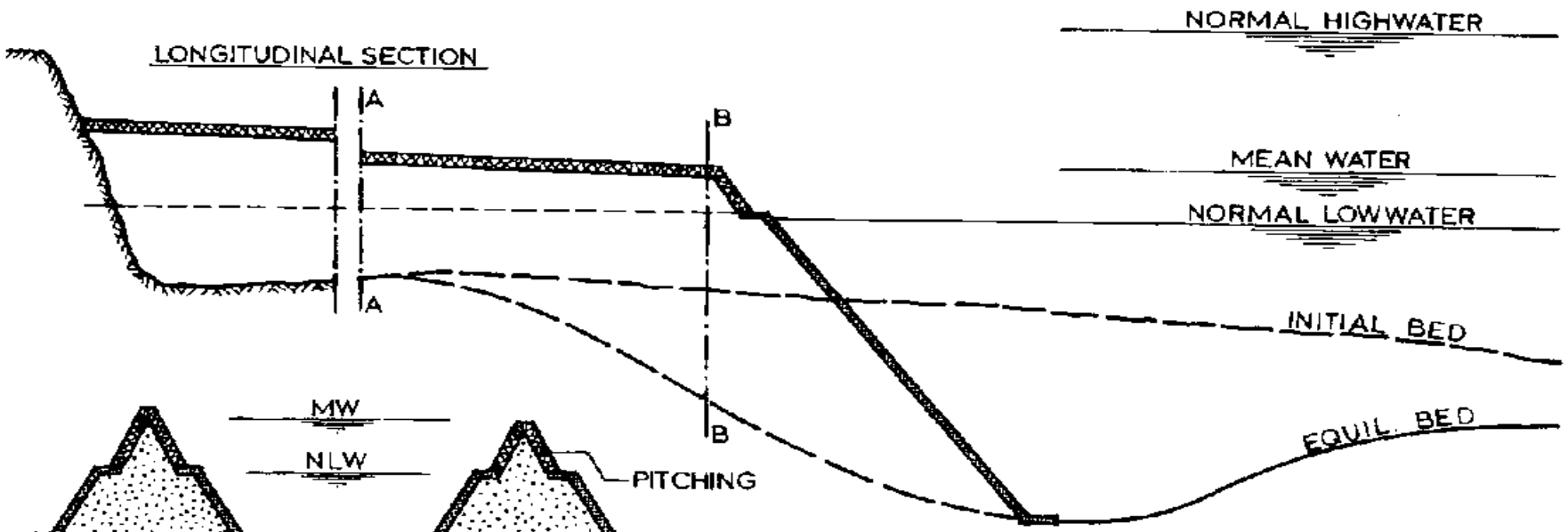


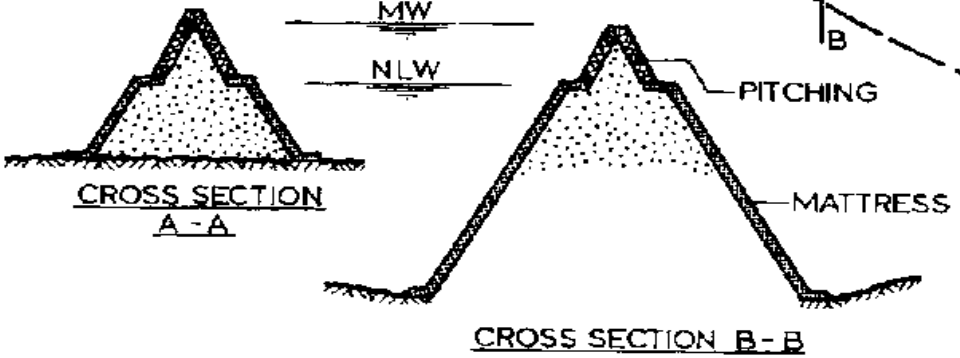
Bank protections

- Revetments
- Loose rock
- Rigid structures
- Groynes



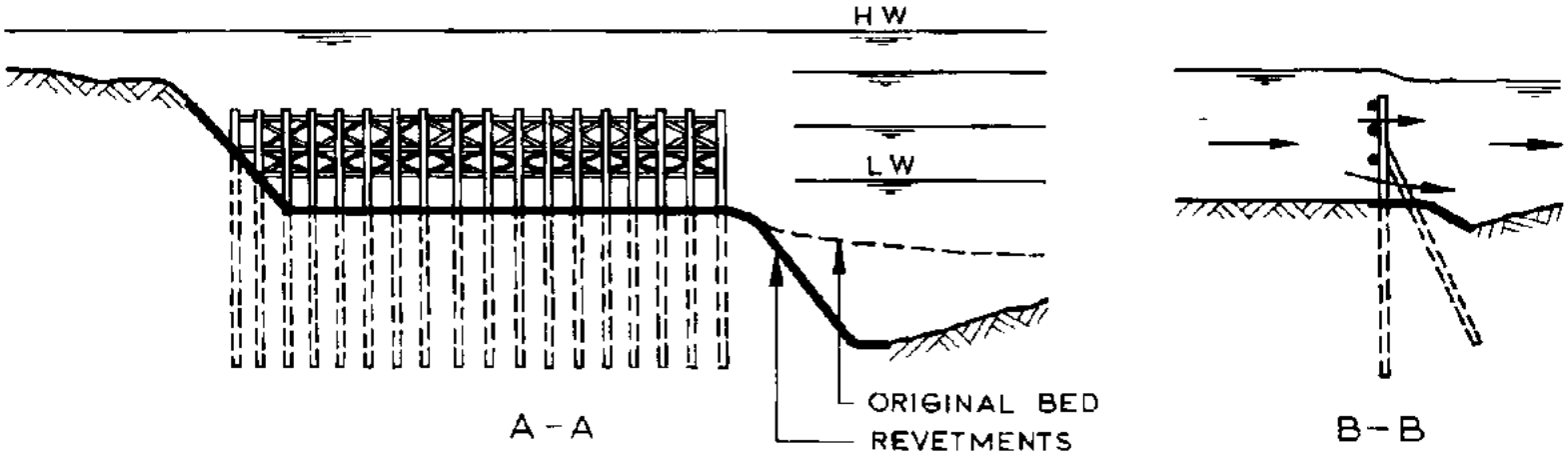






design of a river groyne

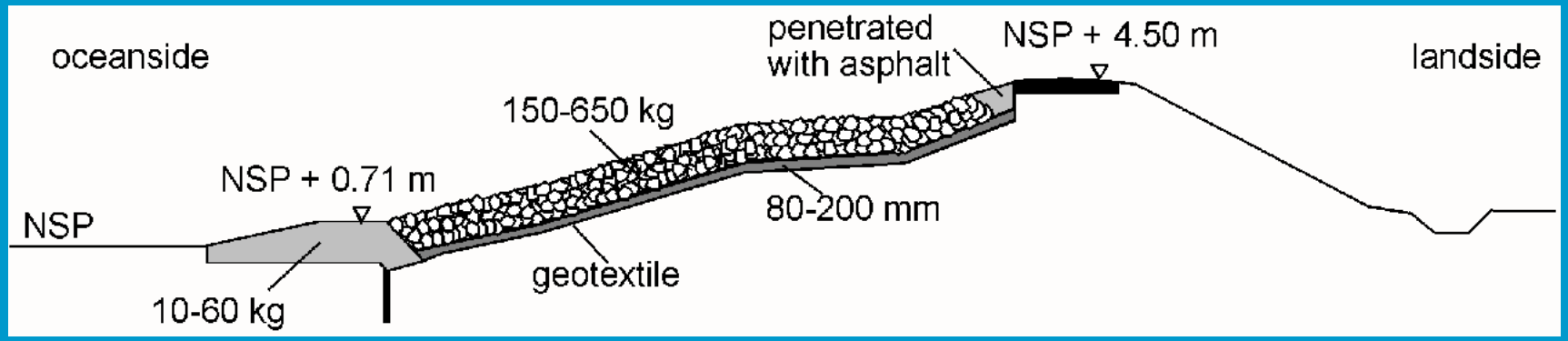
pile screen in a river



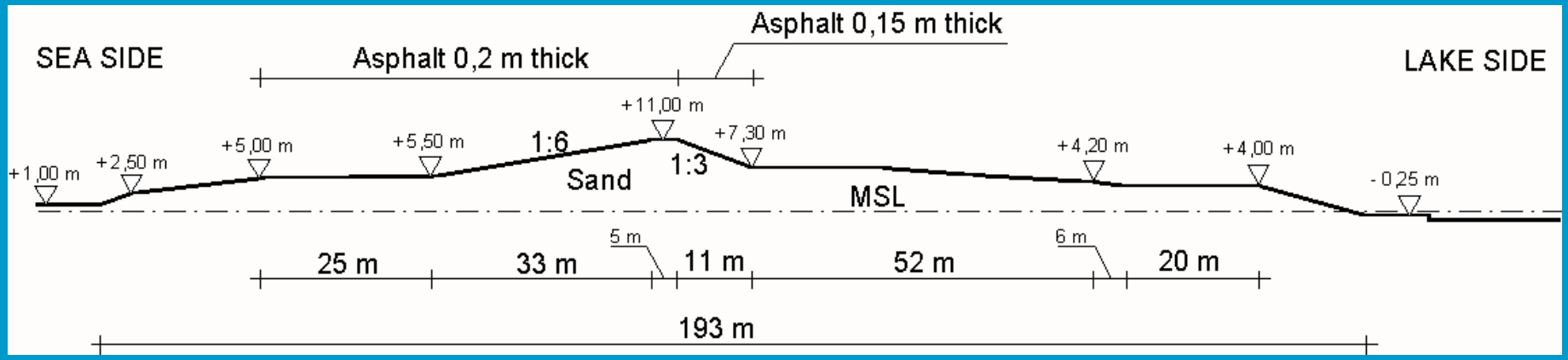
Shore protection

- Revetments and dikes
  - loose rock
  - placed blocks
  - asphalt
  - grass
- Groynes and breakwaters
  - breakwaters
  - groynes

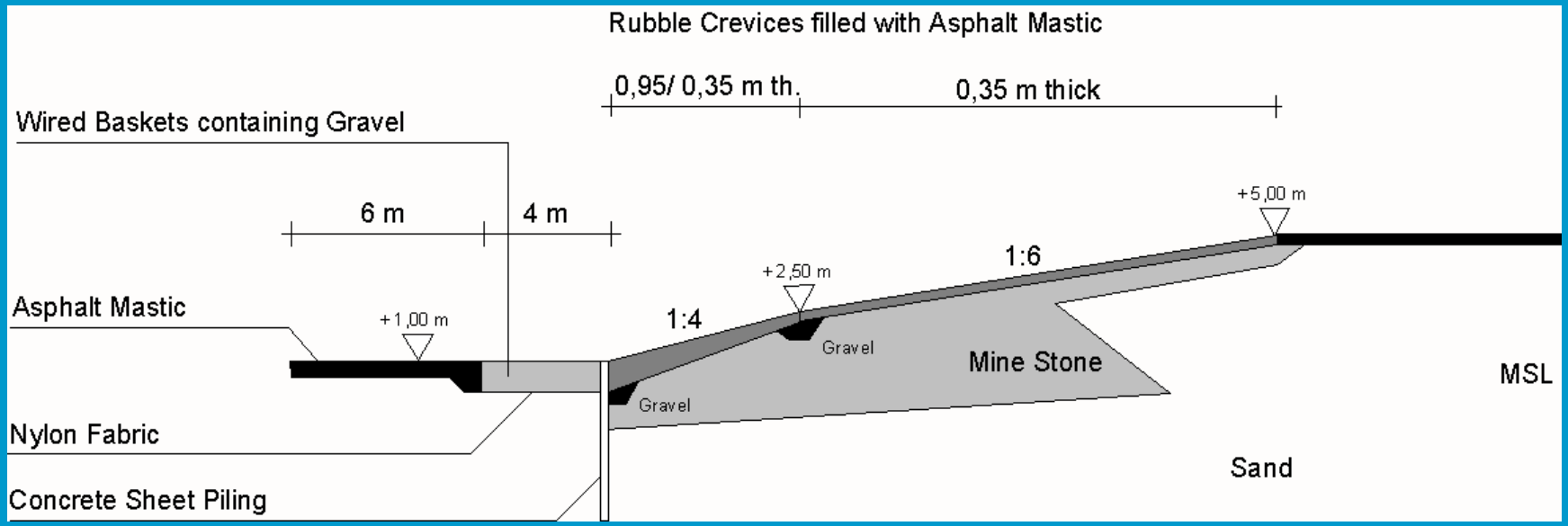
rip rap revetment (Nickerie, Suriname)



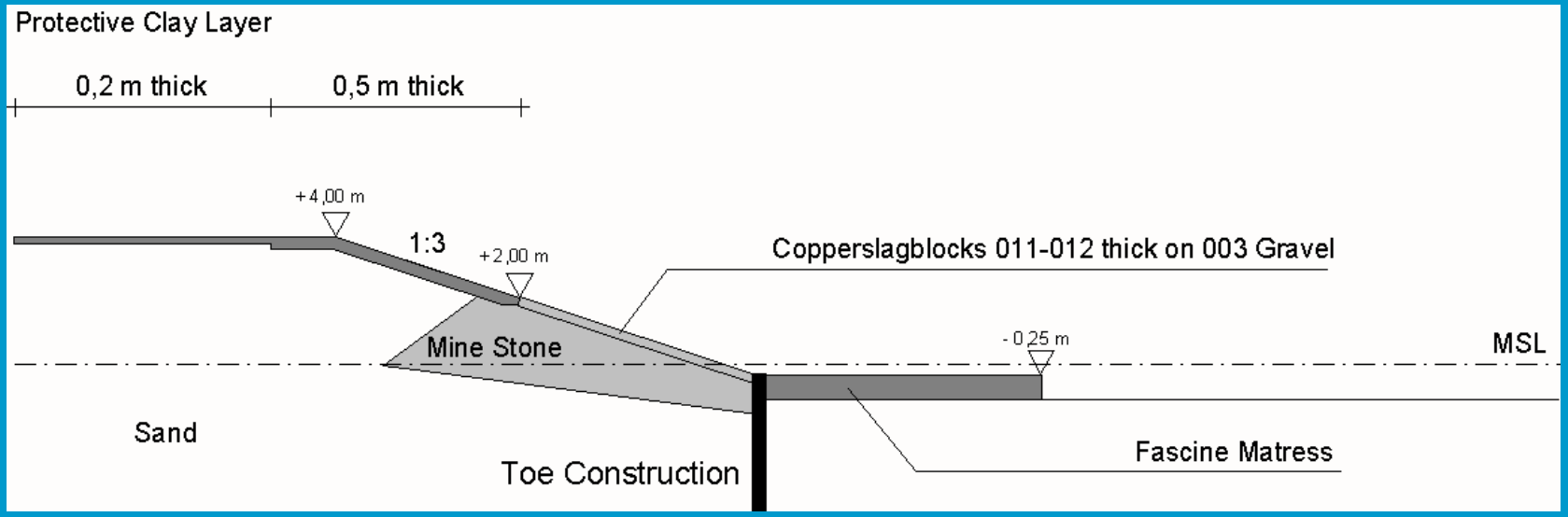
asphaltdike (Brouwersdam)



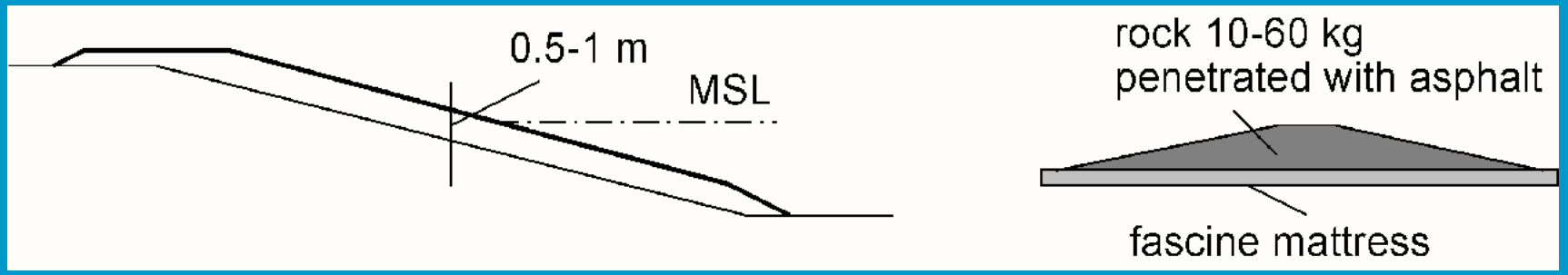
asphaltdike (sea side)



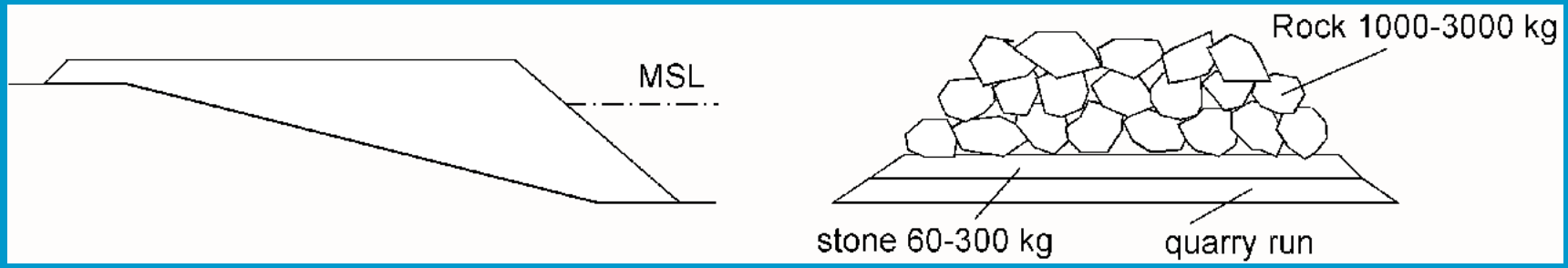
asphaltdike (lake side)



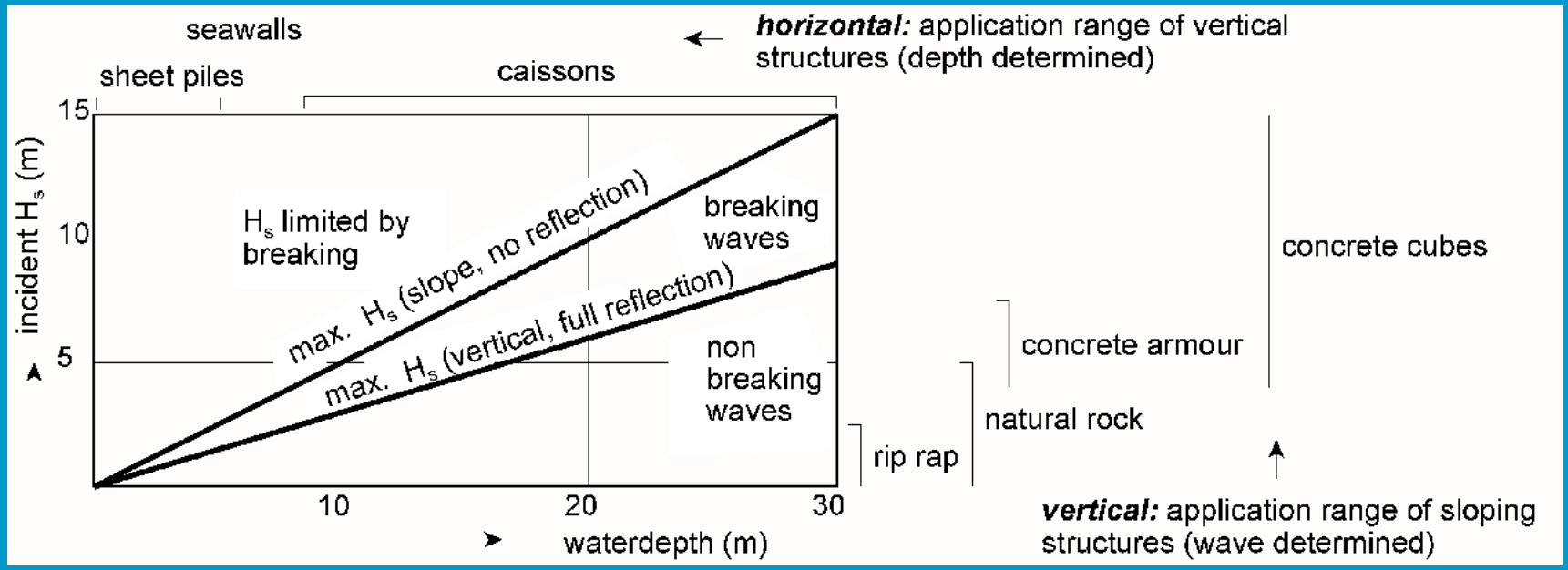
simple, low coastal groyne



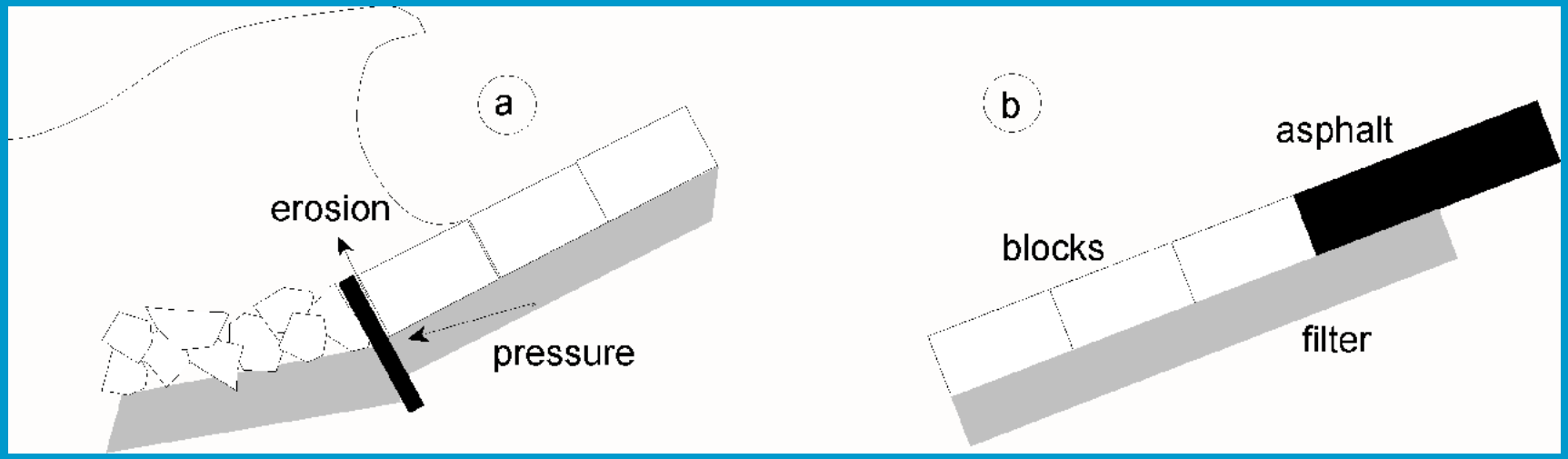
simple, high coastal groyne



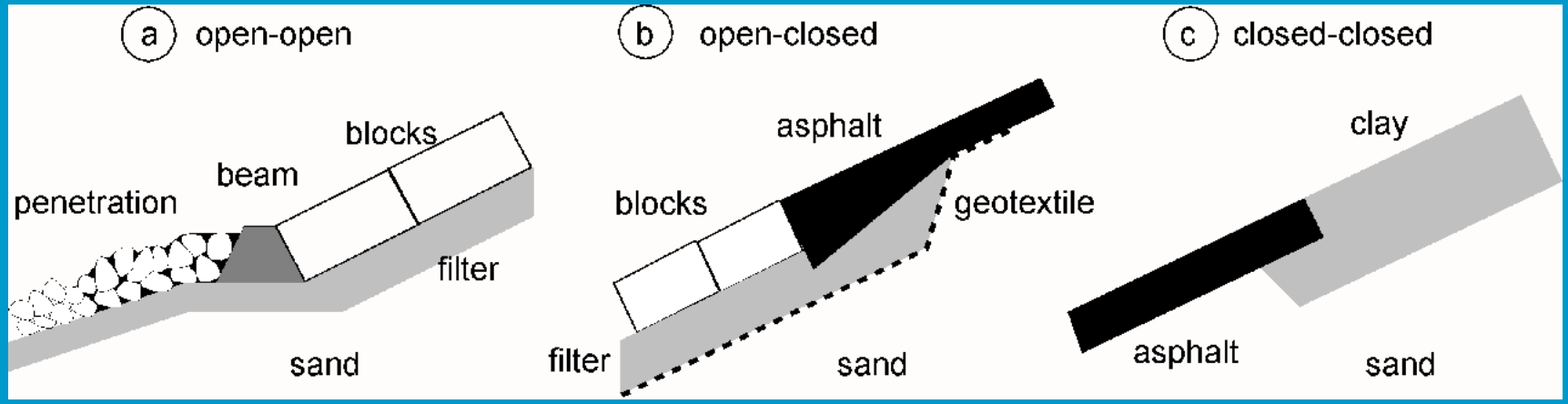
conceptual design of protection



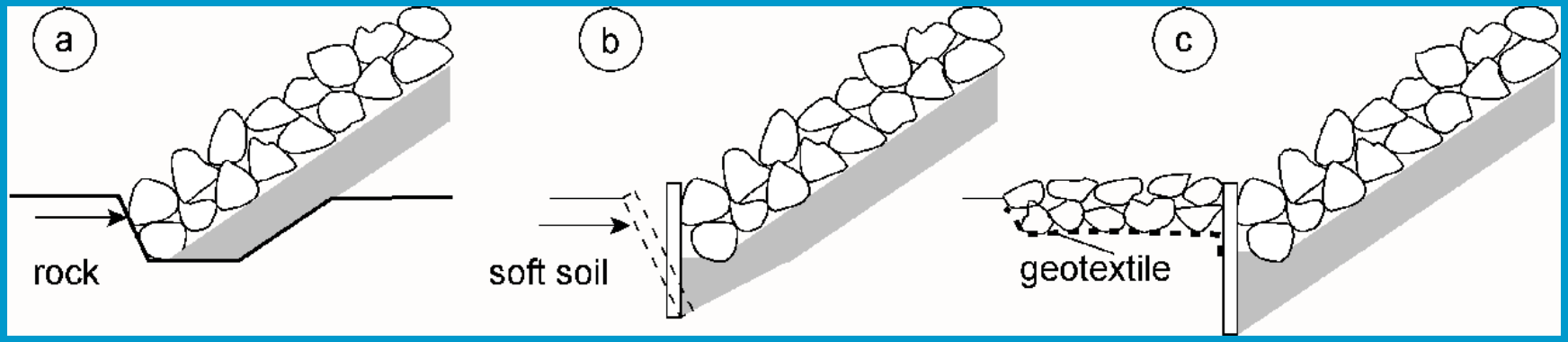
transitions - general aspects



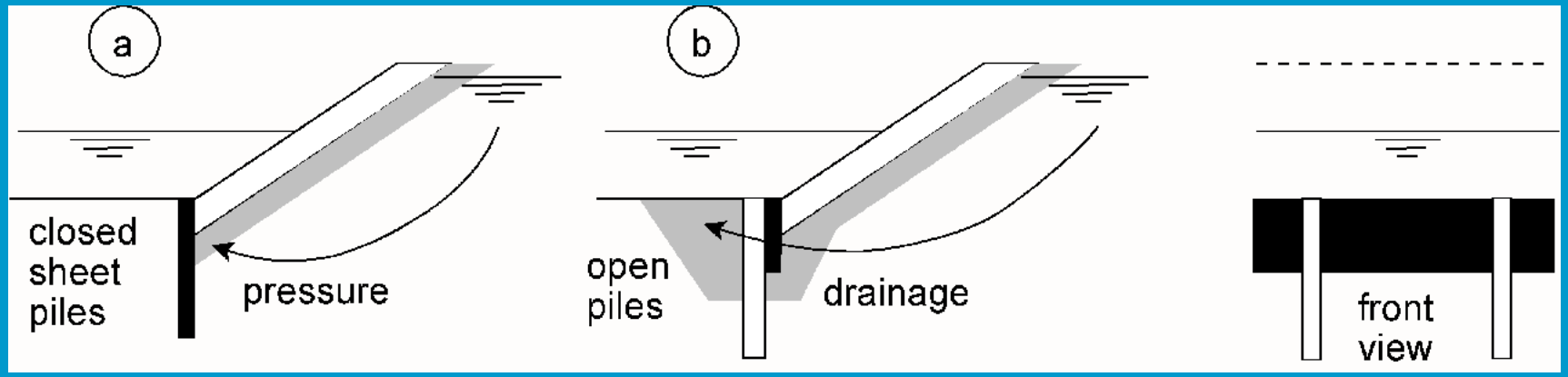
transitions between open and closed revetments



horizontal support of a toe

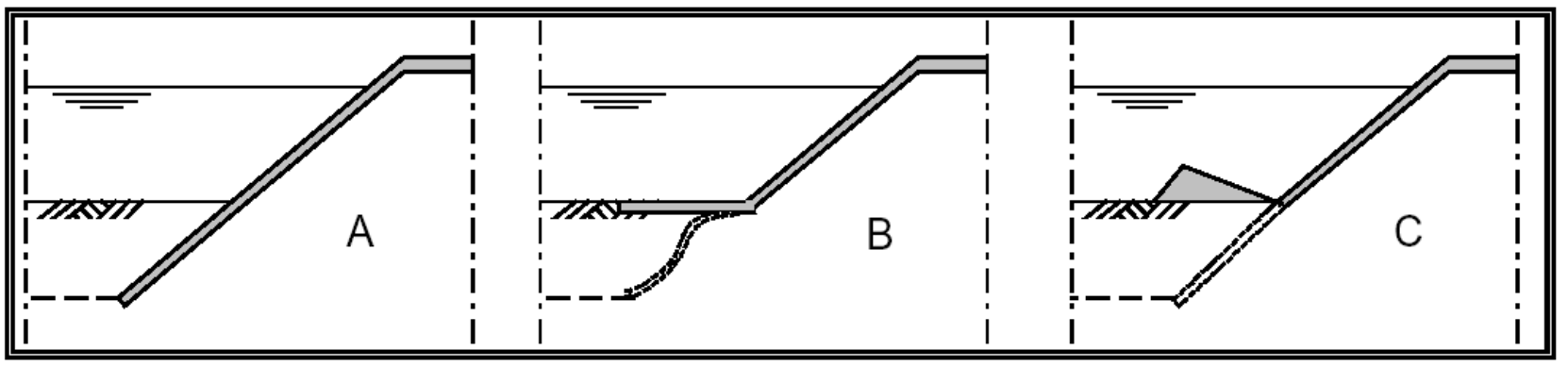


drainage at toe



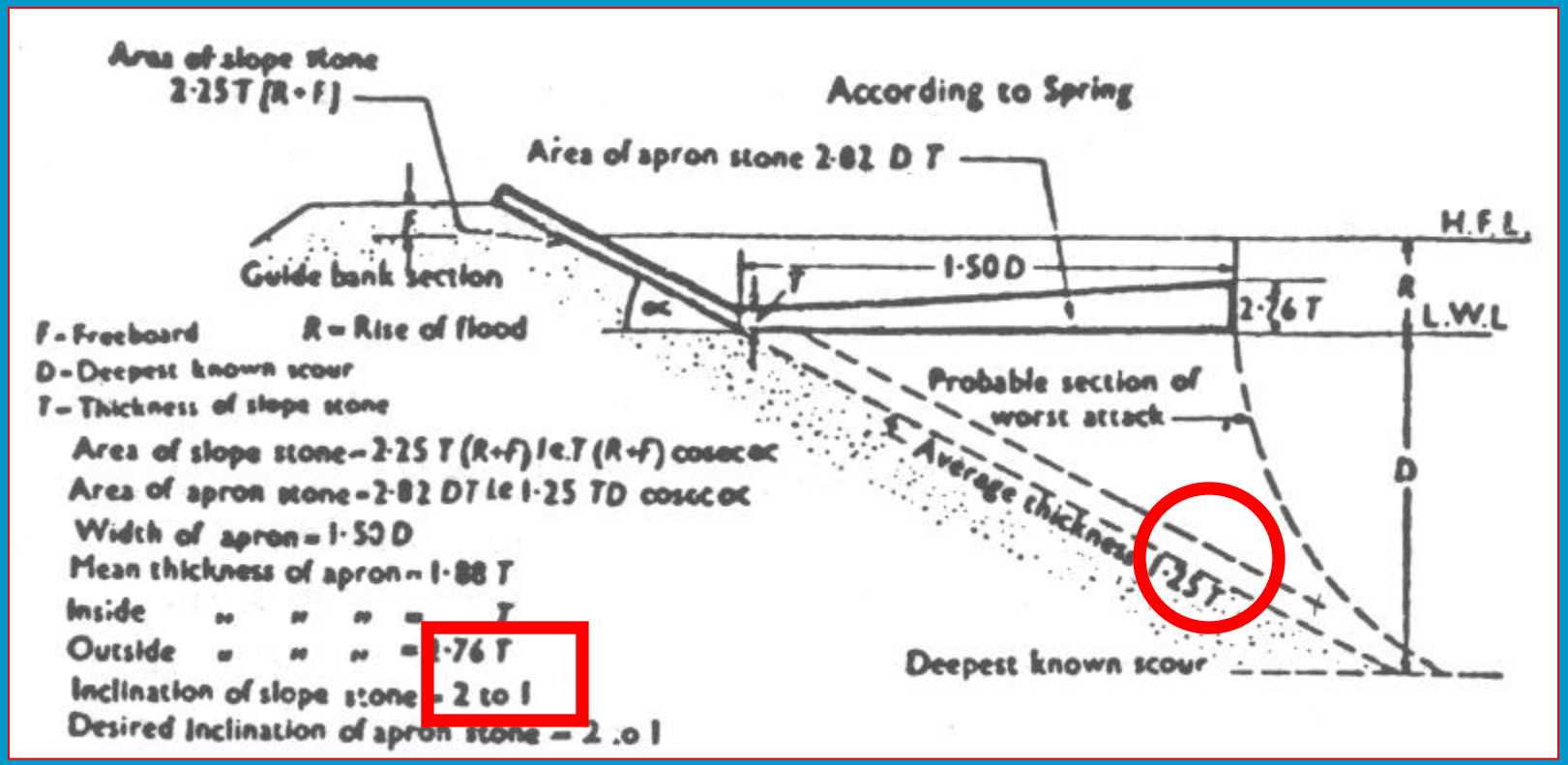
Types of slope protection

- Classical way of protection: dig and protect
- Flexible bed protection: Hanging Apron
- Loose stones which may roll down



History

- Basic idea comes from the Indian Subcontinent
- First design guidelines made by Spring (1903)



Volume calculation

- Basic assumptions:
  - Layer thickness 1.25 T
  - slope 1:2
- Apply geometry

- Later other schemes by Gales (1938) and Rao (1941)

Practical Applications

Jamuna has highly variable bed, solution here is the construction of a Falling Apron

Model tests

	Sand (d_{50})	Rock (m)			Size factor
		d_{15}	d_{50}	d_{85}	
Prototype	200 μm		0.300		1500
Model 1	100 μm	0.007	0.010	0.015	100
Model 2	100 μm	0.018	0.025	0.033	250
Model 3	100 μm	0.030	0.045	0.058	450
Model 4 (mixture)	100 μm	0.010	0.033	0.046	328

The Merwelanden Flume of Van Oord

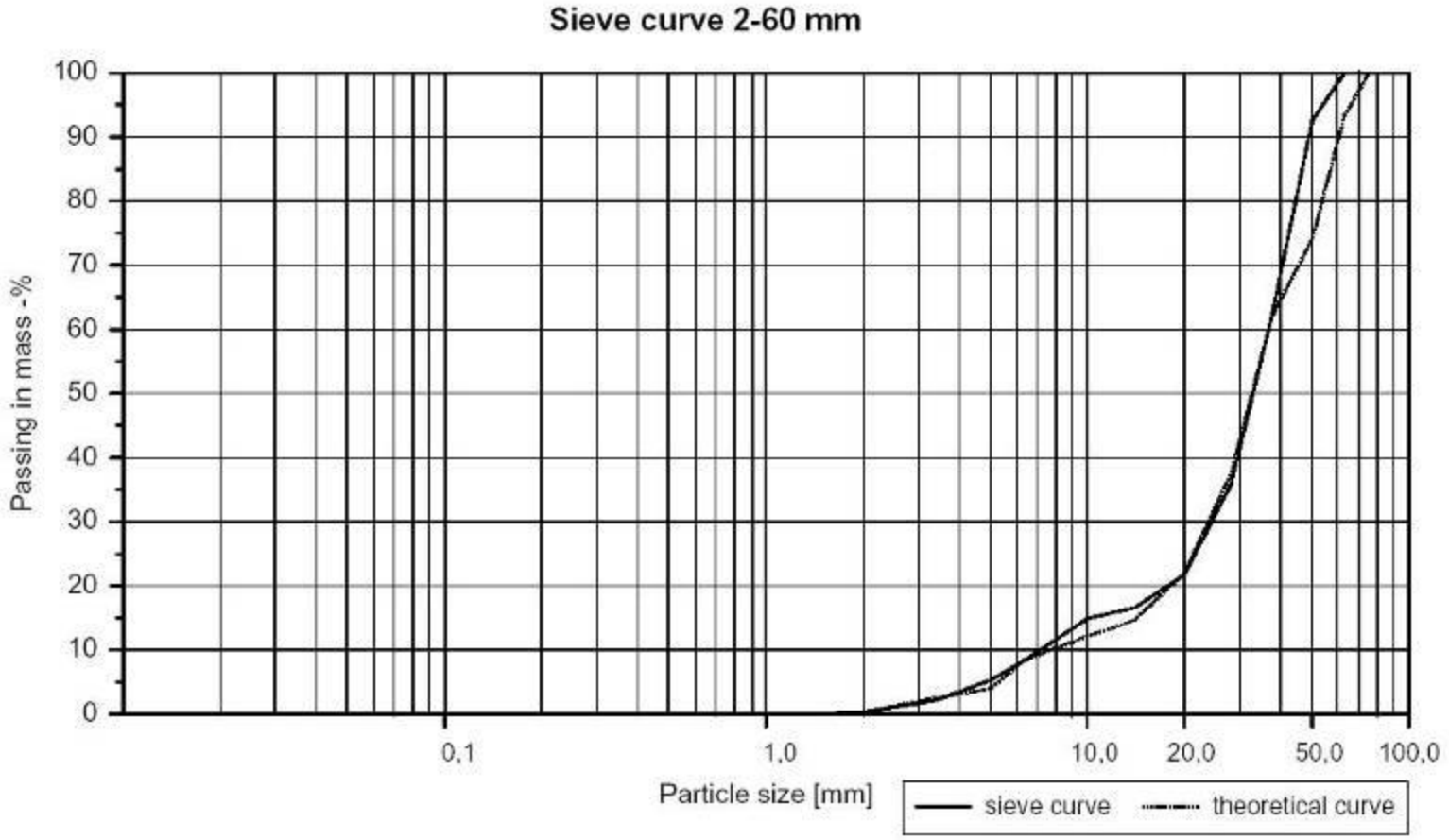
13 m long
1.1 m wide
1.3 m deep

q=100 l/s

Observations from the test

- The falling apron consisted of only a thin layer, approx. the thickness of the stones
- Angle difference between waiting apron and falling apron
- Stones did not roll over each other
- No sorting of the grading

Poorly sorted material

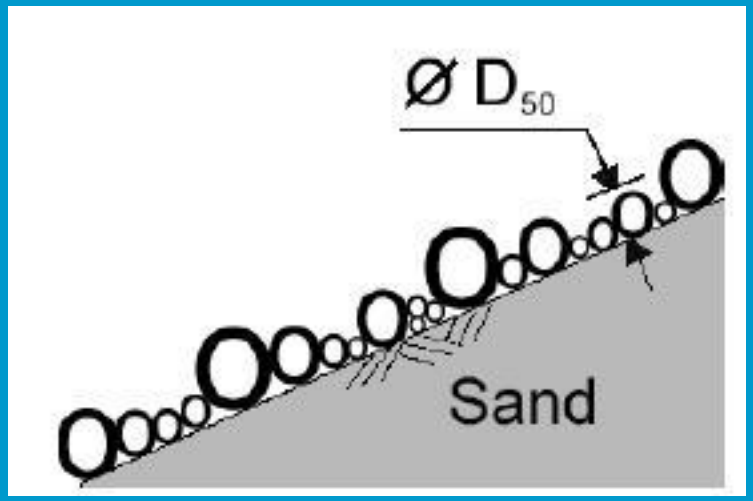


Advantage of use poorly sorted material

- Because of the fines in the material, a better filter can be build up

Results of the test with a wide grading

- Hardly any difference with the narrow grading
- Layer thickness was also in the order of D_{50}
- Slopes were not different



General observations

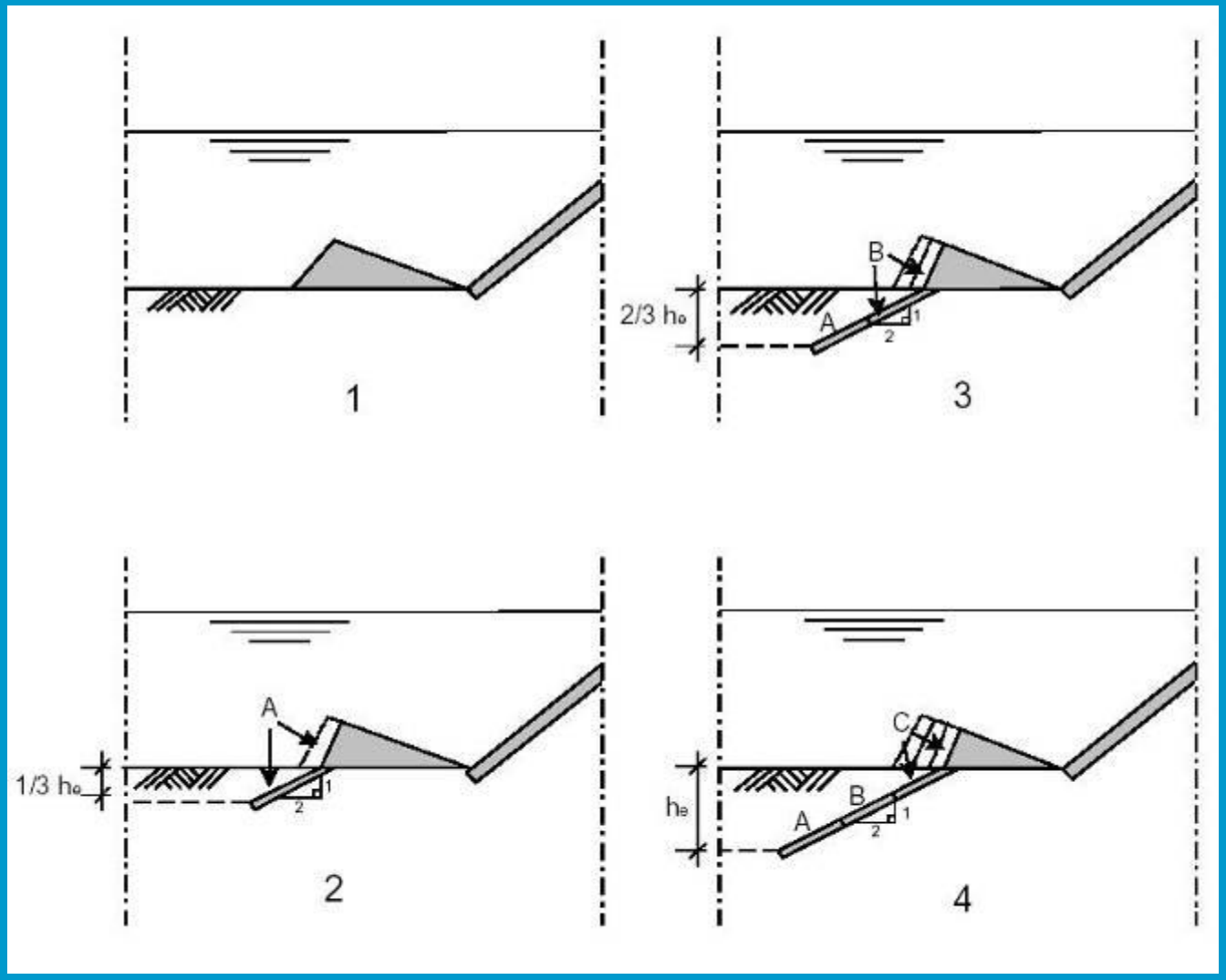
- The slope of the model came to 1:2
- The setting of the falling apron was a continuous and even process
- The flow conditions, which are not a macro instability process, dictate the setting process
- The slope angle did not depend on the size of the stone

More specific observations

- Uneven scour (due to attack under an angle) did not jeopardize the working of the apron
- Because of turbulence, stones 'sink' into the sand; the layer is therefore closely packed
- Thicker (waiting) aprons do not lead to thicker slope protection
- It seems that a poorly graded falling apron slows down the sour more effectively
- Layer thickness is equal to D_{50} both with well graded as with poorly graded material, however..

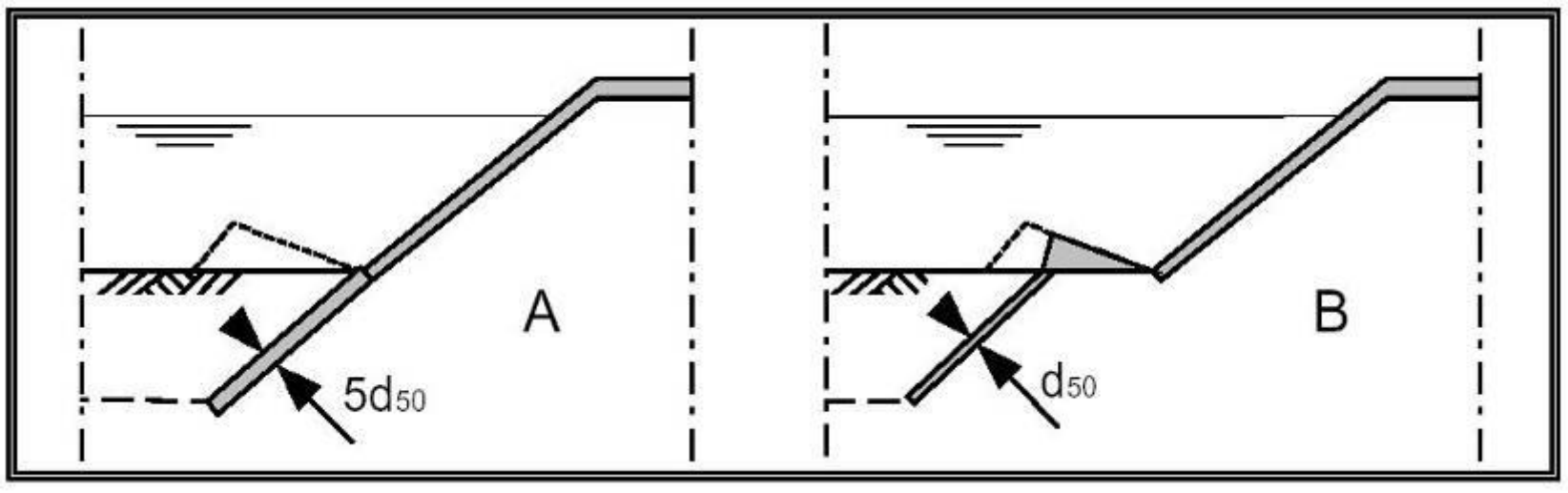
The prototype

- Falling apron Jamuna Bridge
- Yearly measurements because of maintenance contract
- Only in one observation falling apron was activated (in the next year the apron was fully covered with sand again)
- Soundings could not distinguish between sand and rock



The settling process of the apron

Expected and observed settling result

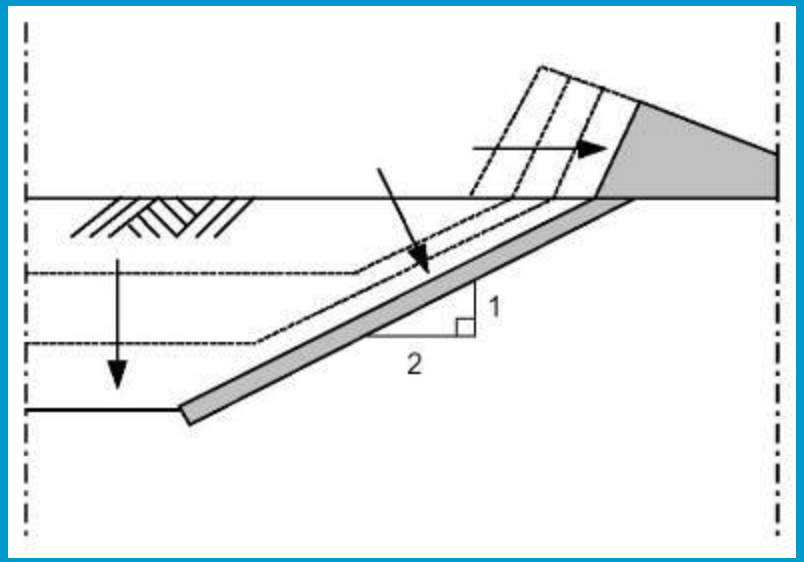


Comparison Field data and Model data

- No contradiction between field and model
- No information regarding final equilibrium (was not reached, neither in prototype nor in model)
- The original idea of Spring (thickness is 1.25 D_{50}) was not bad at all

Filter function

- Erosion occurs because of deepening
  - this makes apron longer
- Erosion occurs through the filter
  - this moves apron landward
- No stable situation is achieved



Durability

- Because of the thin layer, the falling apron does not become fully stable
- However the falling is drawn upon only during short periods
- Therefore slowing down the erosion is often sufficient, and not permanent “sandtight” construction is needed

Conclusions for design practice

- Wedge shaped design is recommended above rectangular cross section
- The use of a wide grading is expected to lead to high losses
- A falling apron always requires maintenance; how often will depend on the frequency of attack


no protection