Chapter 11: Design practice for breakwater cross sections

ct5308 Breakwaters and Closure Dams

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Given a quarry:

- Split the rock in three categories
  - filter
  - core
  - armour

    you make a berm breakwater
- Split the rock in many categories

  you may define more layers

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permeability / porosity

volumetric porosity: $n_v = 1 - \left(\rho_b / \rho_r \right)$

Type and shape of units	Layer thickness n	Placement	Layer coefficient k_t	Porosity n_v	Source
Smooth quarry stone	2	Random	1.02	0.38	SPM
Very round quarry stone		Random	0.80	0.36	Cur/Ciria
Very round quarry stone		Special	1.05 – 1.20	0.35	Cur/Ciria
Semi-round quarry stone		Random	0.75	0.37	Cur/Ciria
Semi-round quarry stone		Special	1.10 – 1.25	0.36	Cur/Ciria
Rough quarry stone	2	Random	1.00	0.37	SPM
Rough quarry stone	> 3	Random	1.00	0.40	SPM
Irregular quarry stone		Random	0.75	0.40	Cur/Ciria
Irregular quarry stone		Special	1.05 – 1.20	0.39	Cur/Ciria
Graded quarry stone		Random	-	0.37	SPM
Cubes	2	Random	1.10	0.47	SPM
Tetrapods	2	Random	1.04	0.50	SPM
Dolosse	2	Random	0.94	0.56	SPM
Accropode	1	Special	1.3	0.52	Sogreah
Akmon	2	Random	0.94	0.50	WL

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layer thickness

$$t = n k_t D_{n50}$$

number of elements

$$N = n k_t A\left(1-n_v\right) D_{n50}^{-2}$$

(A is a given area)

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layer thickness tests

Carlos Bosma, nov 2001

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measuring the top of the layer

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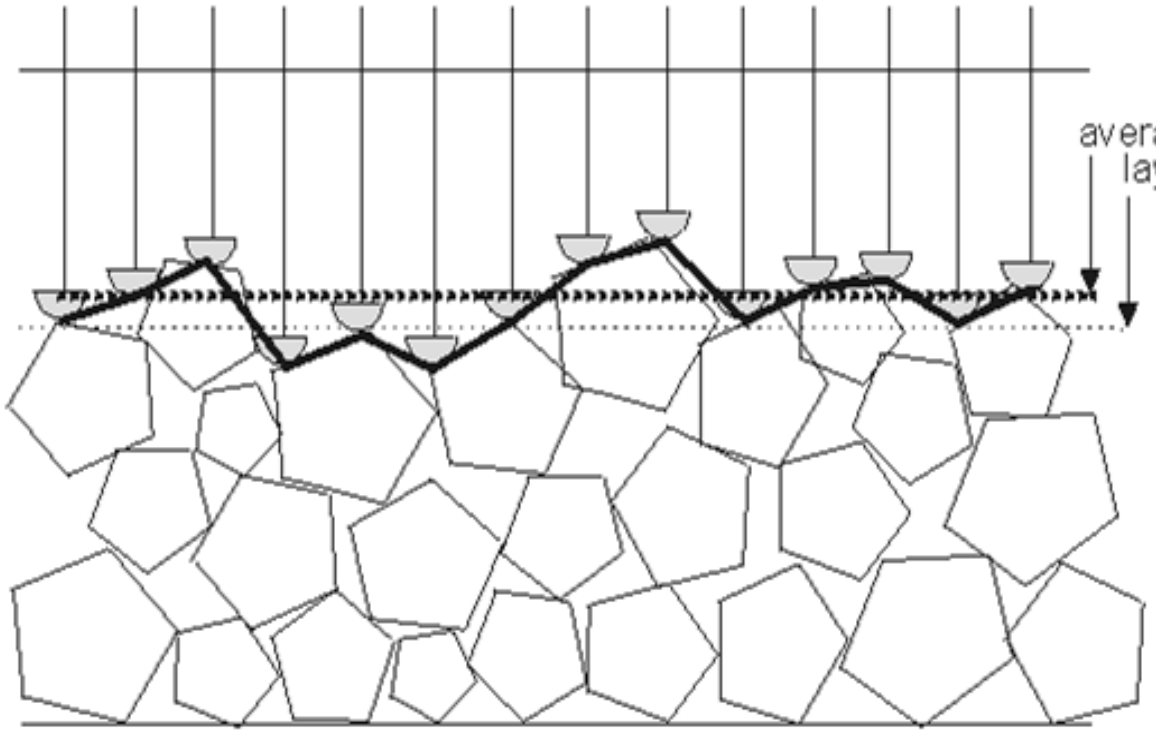
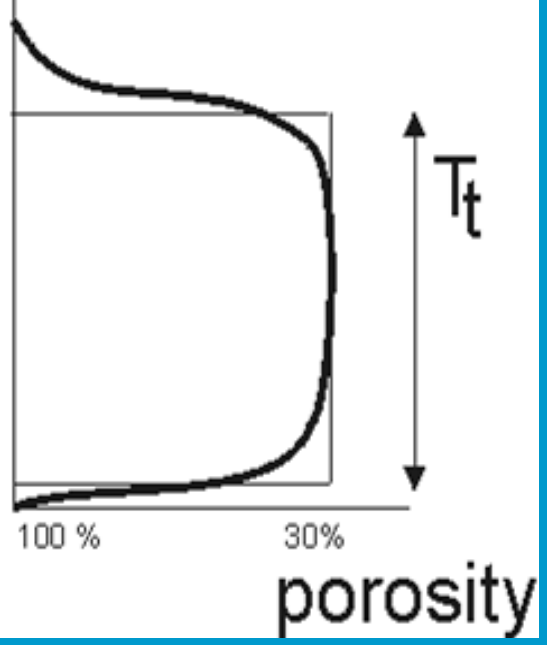
measuring the top





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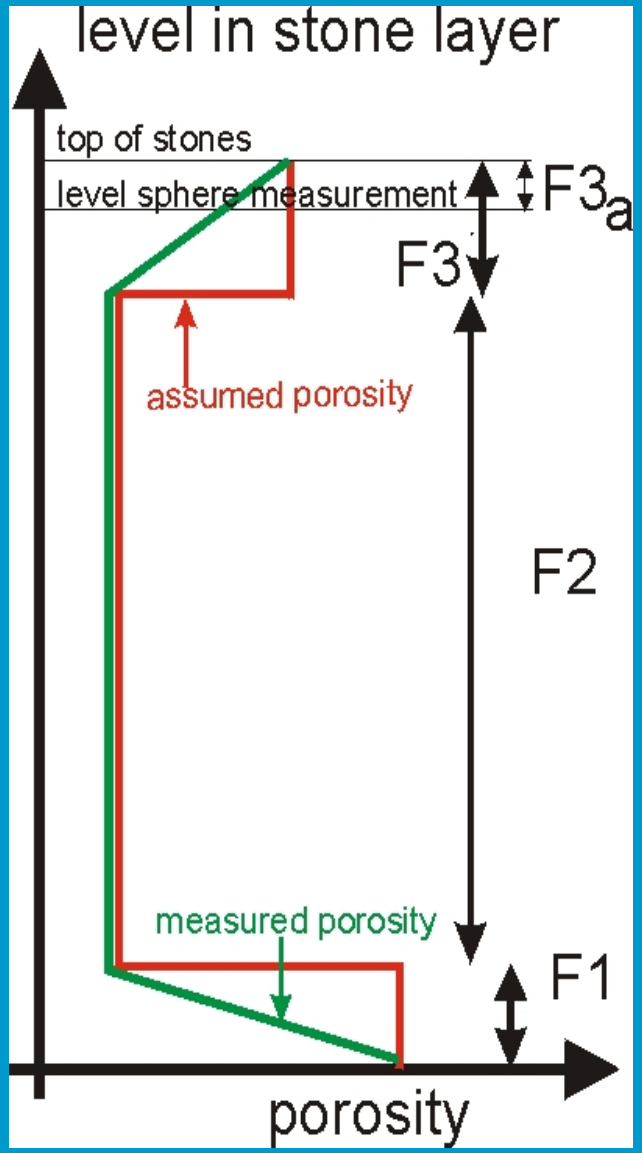

F1 = 0.275 D_n
F3 = 0.740 D_n
F3a (sphere) = 0.462 D_n
F3a (pin) = 0.667 D_n

Volumetric layer thickness:
F2 + 0.14 D_n + 0.37 D_n =
F2 + 0.51 D_n

Measured layer thickness:
0.275D_n + F2 + 0.278D_n =
F2 + 0.553 D_n

Difference: 0.043 D_n

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Heavy aggregates	Normal concrete	Heavy density concrete
Density in air (t/m^3)	2.4	4.0
Density in water(t/m^3)	1.4	3.0
10 tonnes in water (m^3)	7.14	3.33
In air this corresponds to (tonnes)	17.14	13.32
Volume decrease when using Heavy density concrete	55%	
Decrease of weight in air	22%	
@325 kg/m^3 – total cement required for 10 tonnes	3220	1082
Decrease in cement consumption for 10 tonnes of weight	1238	1082
Decrease in cement consumption in %	55%	

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Sines breakwater (110 ton Antifer blocks)

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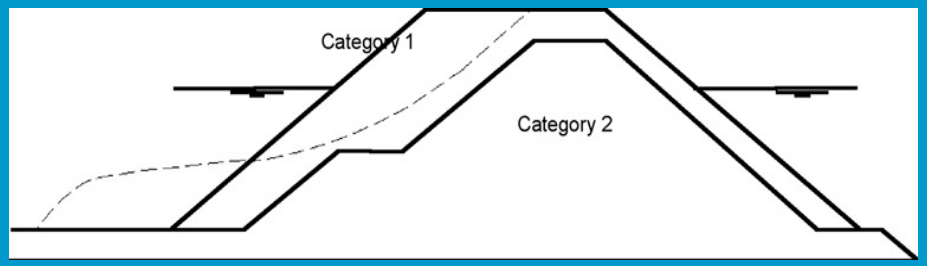
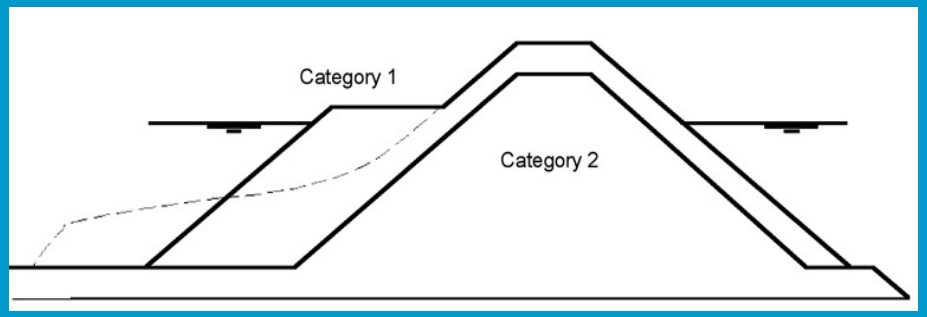
breakwater and berms



high berm



berm at msl

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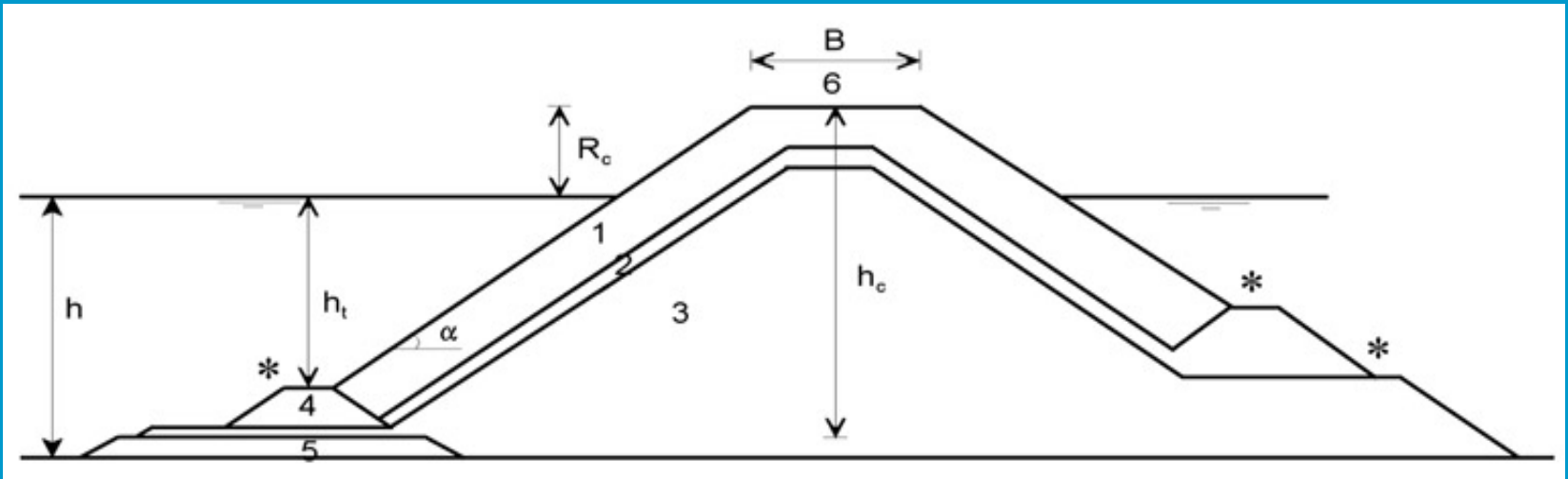
definition sketch of cross section



high or low crest
crest design
rock or concrete armour

tolerances
armour layer
crest
first under layer

toe berm
core
filter

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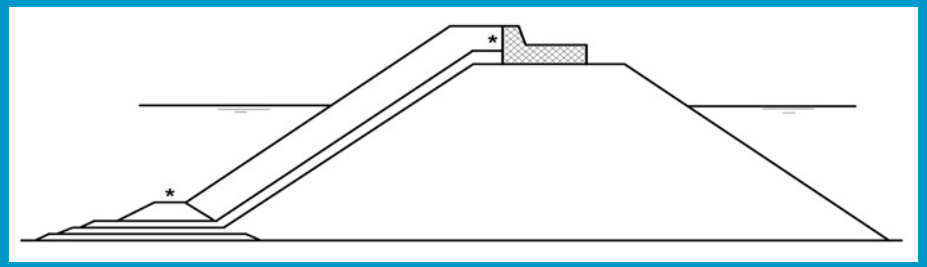
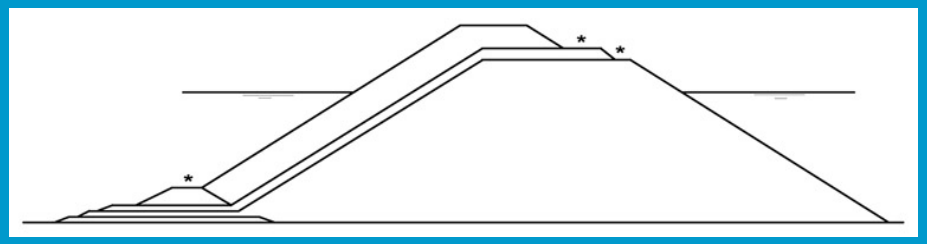
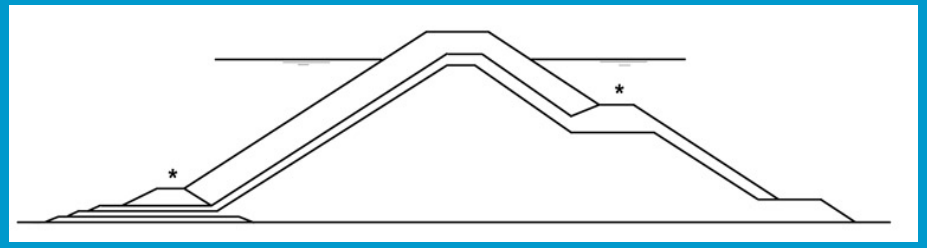
overtopping



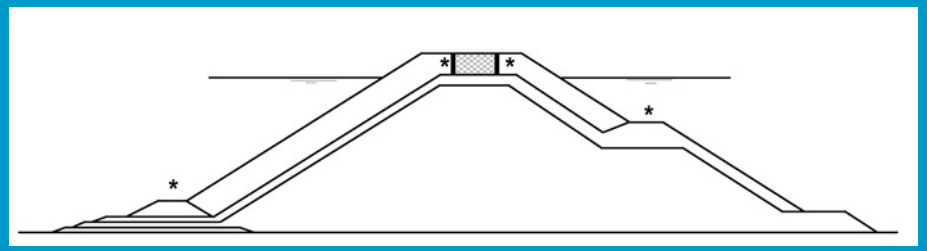
light overtopping (with cap)



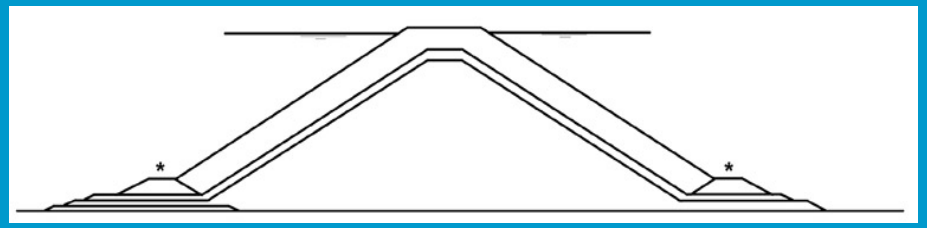
light overtopping



moderate overtopping

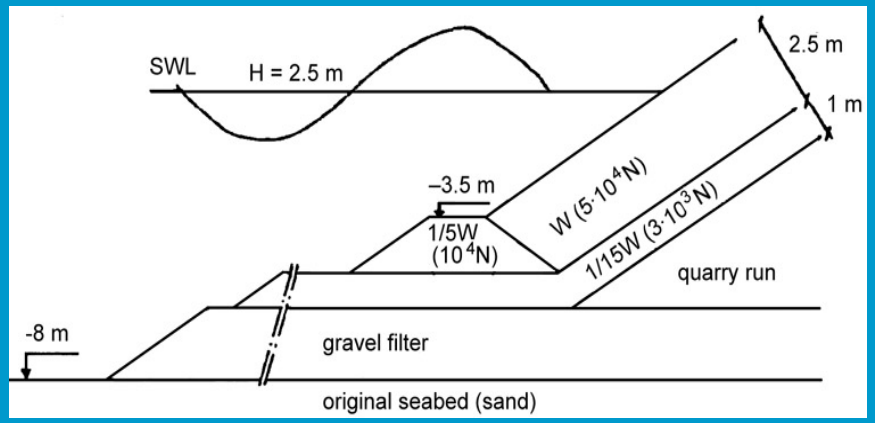


moderate overtopping (with cap)

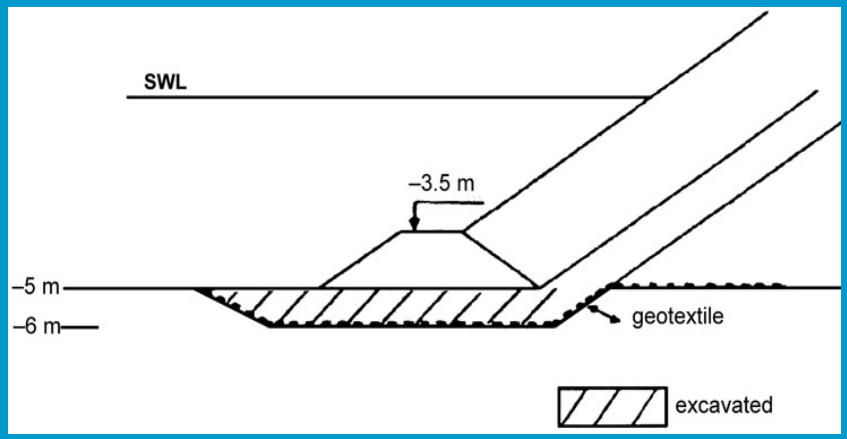


severe overtopping

various toe solutions

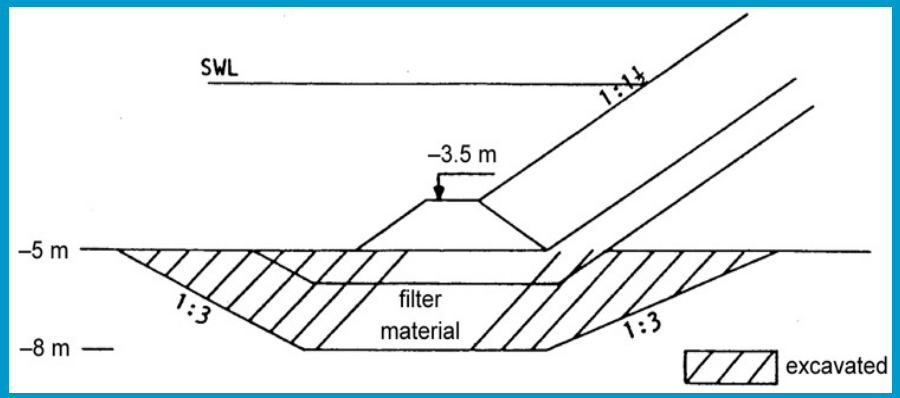


classic solution

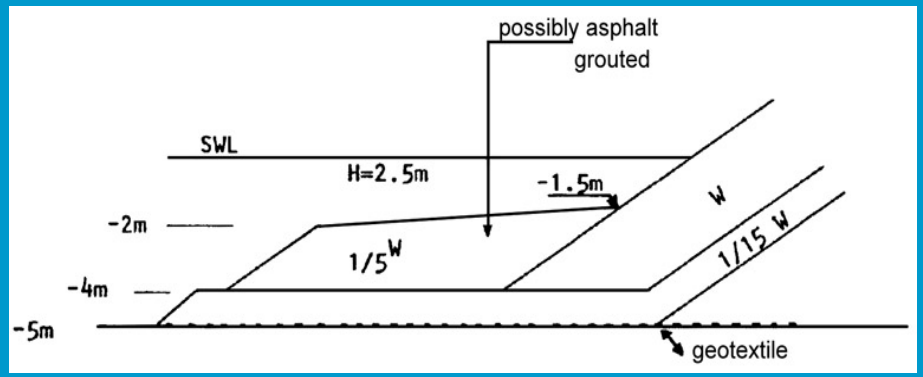


dredged trench, geotextile

dredged trench, gravel



no excavation, geotextile and increased berm



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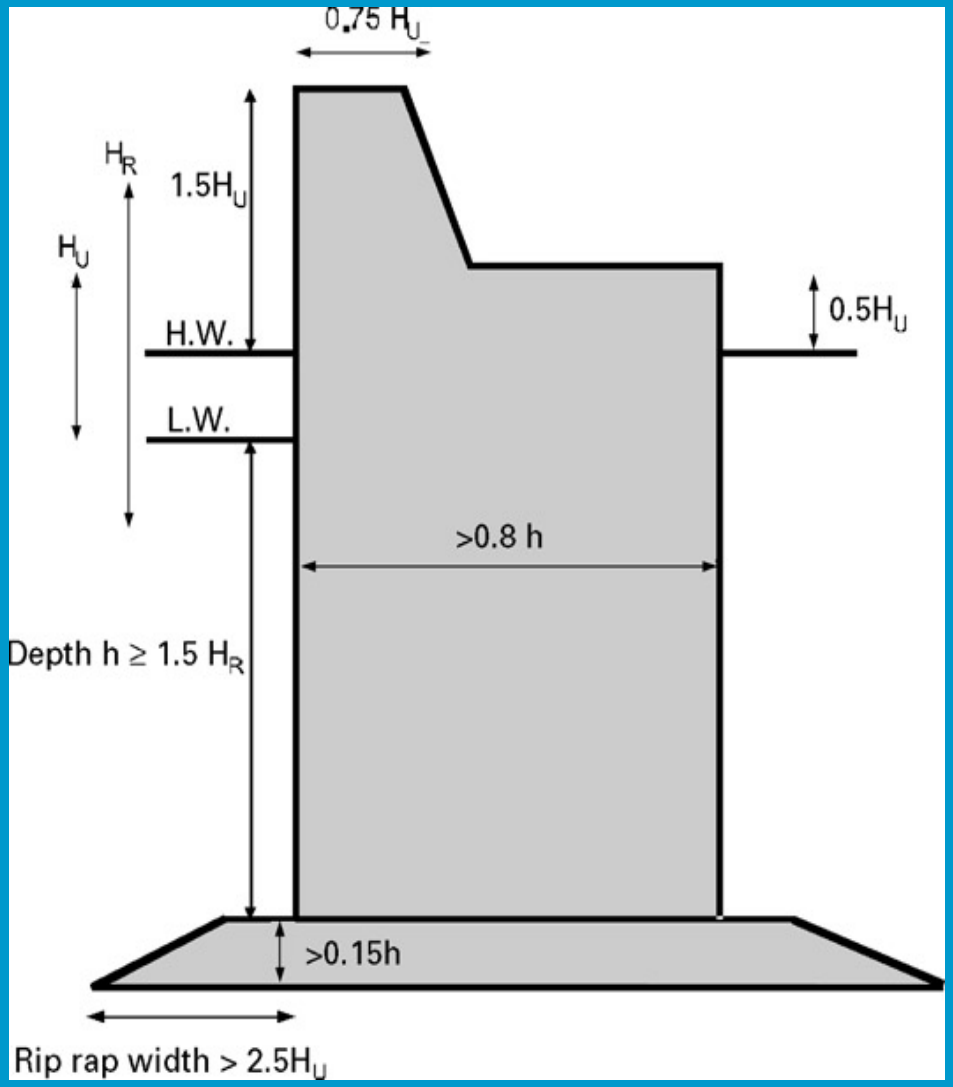

monolithic breakwater

New PIANC guidelines available

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