

Exam Hydraulic Engineering

Exam: Hydraulic Engineering (195410300)

Date: 2 July 2012

Time: 8:45 - 12:30

Coordinator: J.J. Warmink

1 Multiple choice questions [25pt]

1.1

In Figure ?? you see some failure modes, place their numbers behind the corresponding failure mode.

3pt, 1/4 each *Answer:* A8, B4, C12, D10, E6, F1, G2, H5, I9, J7, K3, L11

1.2

Why is gate left open?

Answer: D

1.3

There is more risk for piping under a clay dike than under a sand dike, why?

2pt *Answer:* C

1.4

Behind a dike there is often a ditch, why?

2pt *Answer:* B

1.5

In figure ?? you see some different gates, place the numbers of the pictures behind the correct gates.

2pt, 2/5 each *Answer:* A4, B2, C3, D1, E5

1.6

In figure ?? you see a side view of a hydraulic structure. Calculate the needed depth of the 2 sheet piles at both sides of the hydraulic structures to avoid piping. Additional data: Water level upstream: NAP+23.4 m, Water level downstream: NAP +21.1 m, Soil properties: fine grained sand.

2pt *Answer:* C

1.7

What is the relation between the accepted chances of the failure of constructions in the Dutch regulations for hydraulic works?

2pt *Answer:* E

1.8

Considering the following statements about the results of a Cone Penetration Test:

- I The local skin friction (Dutch: mantelwrijving) of clay is generally larger than the skin friction of sand.
- II A friction number (Dutch: kleeftal) larger than 10 indicates a peat layer.

2pt *Answer:* C

1.9

Consider the following statements about resilience:

- I Resilience is the ability of the system to withstand a loading above its design standard.
- II Resilience strategies are more important for systems with low return periods than for systems with high return periods.

2pt *Answer:* A

1.10

In the design of an (offshore) wind turbine there is one important factor that has to be taken into account when calculating the strength and dimensions, which is not important for e.g. a lock. What is that?

2pt *Answer:* B

2 Open questions

For all the following questions, in case of calculations, make clear which equations you use and which steps you take to get to the final answer.

2.1 [30 pt]

- a) [5pt] Calculate the wave overtopping. Is this dikes safe with regard to overtopping?
 $\xi = 0.99$ [1pt]; $z_{2\%} = 2.77$. Runup above crest height, so overtopping occurs [1pt].
parameters (safety factors) $h_{kr} = 2.7$, overtopping + equation [1pt]; filling in
($\xi < 2$) [1pt] conclusion no problem because $0.6 < 1$ l/s/m [1pt]
- b) [2pt] Suppose that overtopping occurs and it is not feasible to heighten the dike. Give
2 possible measures that can reduce the overtopping rate.
decrease slope; add berm; increase roughness [2 pt, 1pt each]
- c) [3pt] Calculate if piping can occur for the lake dike.
Use Bligh with $C_{creep} = 15$ [1pt]; Compute length 63.5m [1pt]; dH strength =
4.23, dH_{load} = 2.55, Fill in + verdict = Safe [1pt]
- d) [2pt] Suppose that the dike is not safe against piping. Give 2 possible measures to
reduce the risk of piping.

- Add berm; Widen dike; Add soil behind dike; Use sheet piles [2pt, 1pt each]
- e) [2pt]] Using the schematized drawing in figure ??, draw qualitatively all the forces that work on the lock structure.
Kleef op piles (to prevent uplift); Weight on piles of lock; Hydrodynamic wave load; hydrostatic pressure on both doors [2pt, 0.5pt each]
- f) [3pt]] Calculate the needed height of the doors. Take into account (1) a additional settlement of 10 cm in the plan period and (2) an increase in the design water level in the lake of 0.5 m in the plan period. Assume that only overtopping is allowed (max. 2 l/s/m).
Compute $h_k = 3.21\text{m}$ [1pt]; check $h_k \leq 0.3$ [0.5pt]; $\text{height} + \text{NAP} = \text{rise} + \text{settle} + h_k + \text{SWL} = 5.9$ [1pt]; add lock level height = 8.31m [0.5 pt]
- g) [7pt]] Suppose the doors have a height of 3.5m above the SWL. Make a *quantitative* sketch (write the values in your sketch) of the hydrodynamic, hydrostatic and the total pressure on the lock door that connects the lock to the lake under design conditions *and* calculate the total resulting force on the door per meter width. To reduce the number of computations P1 (GODA) is already computed and is 23 kN/m² and the specific weight of water is 10 kN/m³. (Tip: use eq ?? and ?? to compute hyperbolic functions)
params GODA: $H_b = 2.88$, $R = 4.32$, $r = 3.5$; $L = 35.02$ [1pt]; fill in goda $a_3 = 0.73$, $P_1 = 23\text{kN/m}^2$, $P_3 = 16.77\text{ kN/m}^2$, $P_4 = 4.37\text{ kN/m}^2$ [1pt]; right drawing (P_3 , $P_4 \leq 0$) [1pt]; static pressure = 45 kN/m² (lake) 35kN/m² (canal) [1pt]; adding together (resulting force = $P_g + S_l - S_c = 137.4 + 101.3 - 61.3 = 177.4$ [1pt]
- h) [2pt]] Suppose that the bottom of the lake in front of the lock is not horizontal but sloping upward towards the lock. Describe qualitatively what would be the effect of a sloping bottom on the total pressure on the lock door.
Hydrostatic pressure is the same; wave pressure increases; waves higher if they break [2pt, 1pt each]
- k) [4pt]] The lock will be used for transporting wind turbines from the building location to the lake. For building wind turbines and tunnels, the logistics chain is of key importance. Describe the different parts of the logistic chain and explain why the logistic chain is of key importance.
Fabrication, transport, assembly/storage, transport (sea), building/placement [2pt]; Sea difficult to build other location for work [1pt], prefab cheaper, no delays in process, transport difficult so build close [1pt], pt depend on reasoning]

2.2 [30 pt]

In order to protect an eroding coast, the plan is launched to build an offshore breakwaters, parallel to the coast, as shown in the figure below. Waves approach the coast predominantly from the North-North-East.

Parts of the answer in italic are required!

- a) (15 points) This question deals with the expected changes in the coastline in the initial period after the construction of the breakwater.

Explain in detail:

- how the coastline will respond to the presence of this breakwater and
- where the changes in the coastline will occur

1. Answer:

Waves approach the coast from NNE

In the *shadow zone* of the breakwater sediment will be deposited and the *coastline will progress seaward* [2pt]

To the *west of the breakwater* sediments will be eroded and the *coastline will progress landward* [2pt]

In your answer to these questions describe:

- which hydrodynamic and sediment transport processes are affected by the breakwater
- how and why these processes change as a result of the breakwater and
- how this leads to the changes in the coastline that you expect

Answer

Waves contain *energy* (which is transported in the direction of wave propagation, i.e. NNE) [1pt]

When waves *break* they *lose* this energy [1pt]

The *component* of the lost energy *parallel* to the coast drives a *longshore current* (in the surfzone). So, in this case (with waves from NNE) this is a *westward* current [1pt]

The longshore current generates sediment transport. This occurs at every position along the coast. However, waves do not (or to a lesser extent) reach the area behind the breakwater. Therefore, the *longshore current is absent or smaller behind the breakwater than in the area east of the shadowzone of the breakwater* [1pt]

Because the longshore current *velocity decreases*, *less sediment can be transported* by the longshore current, *sediment is deposited* behind the breakwater and the *coastline progresses seaward* [2pt]

Westward of the shadowzone of the breakwater, the *waves are the same as east of the shadowzone* of the breakwater. So, the *longshore current here is also the same as in the area east of the shadowzone* of the breakwater, and *emphlarger* than in the area behind the breakwater [1pt]

So, because the *increase in longshore current velocity* here, *more sediment can be transported* by the longshore current here than what is entering the area from behind the breakwater. Therefore *sediment is being picked up* from the bed and the *coastline erodes* (progresses seaward) [2pt]

Illustrate your answer with a sketch of the expected coastline in which you specify as accurate as possible where the coastline will change.

(*shadowzone* [1pt], *erosion and deposition at correct areas* [1pt])

The design conditions for this breakwater are as follows:

- water depth: 7.8 m
- wave height: 3.2 m
- wave period: 6.8 s
- wave direction: North-East

The breakwater is constructed at the shoreface, which has a slope of 1:50. The core of the breakwater consists of fine sand with a median grain diameter of 180 μm . The top layer of the breakwater consists of concrete blocks and has a slope of 1:3. Several filter layers will be applied between the core and the top layer of the breakwater.

- b) (7 points) Determine the required dimensions of the concrete blocks, such that the top layer of the breakwater remains stable under the design conditions.

Answer:

$$W_{50} = \frac{\rho_r g H^3}{5 \Delta^3 \cot \alpha} \quad (1)$$

$$D_{n50} = \left(\frac{W_{50}}{\rho_r \rho} \right)^{1/3} \quad (2)$$

$$\Delta = \frac{\rho_r}{\rho} - 1 \quad (3)$$

Correct formulae [2 pt]

ρ_r = density of concrete = 2400 kg/m³ [1pt]

ρ = density of seawater = 1000-1035 kg/m³ [1pt]

Δ = 1.3-1.4

g = 9.81 m/s²

H = 3.2 m

Slope = height:horiz distance = 1:3 [1pt]

$\cot \alpha$ = 3/1 = 3 [1pt]

Filling in values $W_{50} = 18743$ N (i.e. blocks with a mass of $W_{50}/g = 1910$ kg.)

$D_{n50} = 0.93$ m [1pt]

- c) (8 points) Give four reasons why filter layers should be applied and explain these reasons briefly

Answer (each reason and each explanation 1 pt):

Protect sub-layers from erosion due to flows. *Finer material is more easily transported by flows. To prevent this, several layers with increasing grain sizes are placed on top of the fine material (filter layers). The grading of each layer should be approximately parallel and not too far apart, to minimise segregation*

Prevent washing out of finer material *Without filter layers piping may cause finer particles of an underlayer to be washed out through the layer above.*

Provide drainage - *permeability should be sufficient to prevent local build-up of hydraulic gradients and resulting forces.*

Regulate an uneven formation layer *Placing the armour layer directly on an uneven formation layer / core may affect the stability of the armour layer*

3 Equation Form