Engineering: Building with Nature MOOC

Key aspects of a solution

Case 1: Climate-proof Noordwaard

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General Information on the solution	
Title	Wave reducing Eco Dike
Abstract	Construction of willow forest on a new river dike, resulting in a lower dike and added natural value and natural landscape.
Location	Noordwaard near Werkendam, The Netherlands
Date	2009 - 2015
Main problem owner	Dutch Ministry of Infrastructure and Environment
Companies & Partners	Deltares, WINN, Rijkswaterstaat Room for the River program, Project Bureau Noordwaard, Waterschap Rivierenland, Ecoshape
Costs	Lower construction costs as the crest height of the wave reducing Eco Dike is lower than a conventional dike. Maintenance costs are unknown, but will include regular trimming and care for the trees, as well as inspections of the dike and the willows.
Project details	The willow plantation is located on a low embankment with the lowest willow at an elevation of 70 cm above the surrounding floodplain so that the willows will not be inundated too frequently or for too long. The width of the willow stand is about 80 meter and it stretches before the dike of Fort Steurgat. The willows were planted in a staggered grid with a density of approximately 4 tree stems per m^2, resulting in hundreds of branches per m^2.
Safety level	1:2000 per year

Additional Information on the design problem

In an attempt to combat the risk of disease, it is wise to plant two species of indigenous willow *Salix alba* and *Salix viminalis* in the hope that when one is affected, the other may not be. Maintenance of the willow stand, to ensure that the vegetation is not so thick that it forms a complete blockage to flow is essential. The willows need to protect against waves, but still allow water to flow through and around them. Accordingly, the lower stems need to be kept clear of too much vegetation whereas above 0,5 to 0,7 m they can be leafy and strongly branched as this will reduce wave effects.

Calculation:

1. The design water level is the flood level, and we indicate that you may use 3,2 m to chart datum (NAP). You may have used the anticipated water levels near Fort Steurgat which are 3,7 m. This is also fine, your answer will just be 0,5 m higher.

2a. If you consulted the graph, using a fetch of between 7 to 10 km, you will have obtained a value for H_s of around 1 m. This you would then add to your design water level to get 4,2 m.

2b. If you used the formula then you have

$$h_{Wl+wave} = h + 3.75 \cdot 10^{-6} \frac{U^2}{gh} \cdot \frac{F}{2}$$

$$h_{Wl+wave} = 3.7 + 3.75 \cdot 10^{-6} \frac{30^2}{9.81x3} \cdot \frac{10\,000}{2}$$

$h_{Wl+wave}$ ~ 4,3 m to NAP

3. The freeboard to prevent overtopping and compensation for settling of the dike is given as 1,2 m.

4. So, adding the freeboard to the previous calculations, you get 5,4 m height using the graph and 5,5 m height using the formula.

This is the height of the dike that would have had to be constructed if there had been no wave reducing foreshore of willows. It would also have had to be widened far more to accommodate the increase in height.