Case Study: Millingen aan de Rijn
Wave overtopping experiment for levee with road

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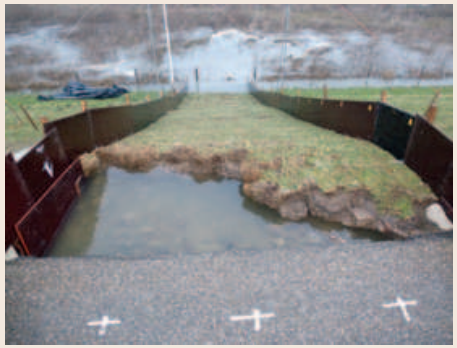
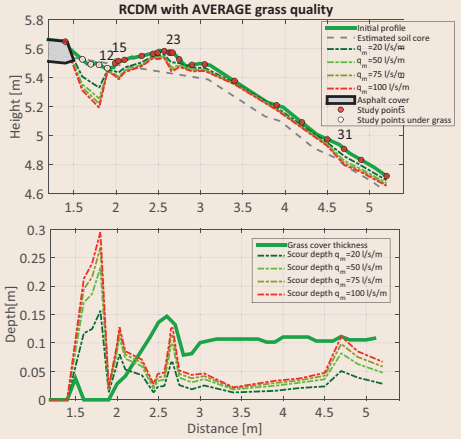
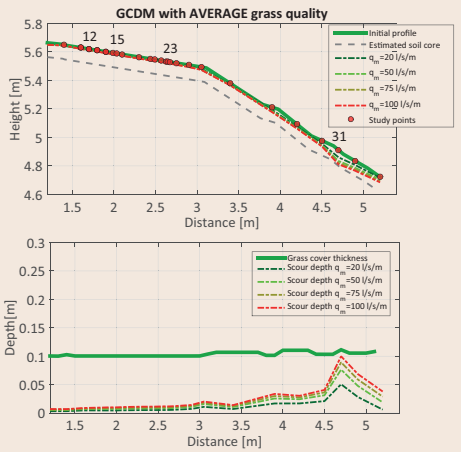
Figures 1 and 2 (below). Final scoured grass cover of a dike with a road after 100 L/s/m test in Millingen (Images by Infram bv).

Figure 3 (right four images). Model results of average scoured profiles after different overtopping storms.

Top two graphs: Road over crest dike model (RCDM). Two graphs below: Grass crest dike model (GCDM).







Juan Pablo Aguilar-López

CASE STUDY: MILLINGEN AAN DE RIJN

CASE LOCATION

In the area of Nijmegen, Rijkswaterstaat tested a stretch of dike near the village of Millingen along the river Rhine. In cooperation with the local Water Authority Rivierenland and knowledge institute Deltares, the strength of the grass cover of this dike was researched and tested for wave overflow that could occur in circumstances of concurrent high water levels and a storm.Grass on the dike contributes to its strength, but must be able to cope with waves and currents. The researchers tested which wave overflow caused the grass cover to be destroyed, and which was the impact of objects such as structures and roads on the crest of the dike. Testing was done with a wave-overtopping simulator, positioned on the crest of the dike. It repeatedly empties at once with thousands of liters of water, producing large wave forces on the dike. The wave load is increased until there is damage to the grass cover. The results allowed to calibrate and validate the FEM model and the erosion models used for estimating the probability of different scouring depths along the original profile. This experiment was also important because it included the presence of a road which is a typical MFFD example.

(Sources: www.waterschaprivierenland.nl; www.rijkswaterstaat.nl)

WAVE OVERTOPPING EXPERIMENT FOR LEVEE WITH ROAD

In the case of wave overtopping, structures constructed above the flood defense will change the hydrodynamic behavior of the overtopped waves. This will change the scouring rates of the inner grass cover.

A wave overtopping experiment of a flood defense located along the Waal River studied the effects of a structure located on top of the defense. The results of this experiment were used to build a model (Road over crest dike model, RCDM: Figure 3), capable of representing the turbulent hydrodynamic behavior of waves overtopping a dike with a road. An additional model (Grass crest dike model, GCDM: Figure 3), with the same dimensions and tested for the same storm conditions, was also calibrated and validated.

The turbulent effects created by irregular forms and variable roughness along the crest and part of the landward slope (RCDM, Figure 3) were found to have a significant effect in the flood defenses resistance to wave overtopping. In addition, we found that a smoother surface produces less energy dissipation, which means that scouring depths increase along the foreland slope (Figure 3).

For the numerical experiment, the extreme storm events are characterized by the average discharge of overtopping which have their own probability of occurrence. In the actual Dutch legislation it is not allowed to have more than 10 L/s/m of overtopping discharge. The numerical method of combining FEM with surrogate modelling allowed to test both dike conditions (with road and without). The main conclusion from these simulations is that the actual existent MFFDs (road+dike) may withstand larger storm events than previously expected. However, for very extreme storms, the presence of roads may not be beneficiary for the wave overtopping reliability. This information was already known but the innovative part is that the present method allows to associate failure probabilities to the scouring profiles.

Figure 4. Wave overtopping experiment at Millingen aan de Rijn (Photo courtesy Juan Pablo Aguilar-López).