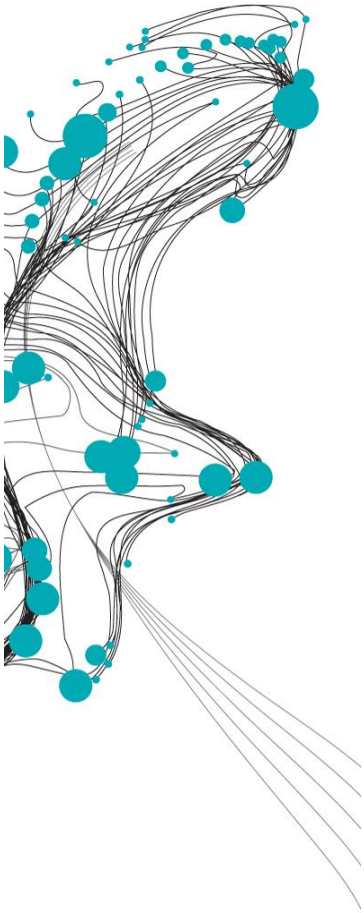
TITLE: ASSESSMENT OF THE INFLUENCE OF INCIDENT WIND ANGLE AND DUNE SLOPE INCLINATION ON SEDIMENT TRANSPORT PATTERNS IN COASTAL DUNES



For the protection of coasts, hard structures such as dikes and groynes have been important tools over the past centuries. In more recent years, the use of natural and 'soft' solutions has increased as measures to improve coastal safety, which is generally referred to as Building with Nature. For example, in the Netherlands, the artificial dune system called the Hondsbossche Dunes was designed for the improvement of coastal safety. However, the impact of dune slope inclination, longshore variability in the shape of the dunes and the influence of the dominant wind direction at the beach relative to the dunes, were not fully known and therefore estimations were made based on expert judgment.

In this thesis, research into the influence of incident wind angle and slope inclination on wind flow patterns and sediment transport patterns on dunes and steep slopes is presented. The research is done using a 3D CFD (Computational Fluid Dynamics) model in OpenFOAM. The incident wind angle (relative to the dune toe) is varied between 0° (normal to the dune toe) and 75°, with steps of 15°. The dune slope inclination is varied from 10° to 80°, with steps of 10°. A systematic procedure is used to create smooth transitions over the beach-dune profile, at the dune toe and dune crest. This is different from previous CFD studies, in which sharp edges have been used. Moreover, there has never been research fully dedicated to assessing the combined impact of the slope inclination and incident wind angle on the flow and sediment transport patterns over dunes.

The results show adequate reproduction of air flow dynamics over the dune profile, by comparing the results to previous research. Flow separation at the dune toe and on the dune crest has been shown, giving rise to three different possible flow regimes, depending on the incident wind angle and dune slope inclination. The results found on the sediment transport over the dune profile show a strong dependency on both the incident wind angle and the slope inclination. Moreover, it is shown that the combination of the two parameters can lead to different sediment transport dynamics at different locations on the dune profile. Sedimentation around the toe of an unvegetated dune is shown to be largest for a slope inclination of 20° and an incident wind angle of 0°. On the other hand, it is shown that, for most incident wind angles, a large amount of erosion on the dune slope can be expected when vegetation is not present. However, the inclusion of vegetation in the model leads to results that are comparable to the field data from the Hondsbossche Dunes project. Finally, advice is given and recommendations for further research are presented on how to use this research for practical predictions of sedimentation and erosion on a dune profile. In conclusion, this thesis results in a better understanding of both flow dynamics and sediment transport patterns over dunes and steep slopes under different wind directions and for slope inclinations.

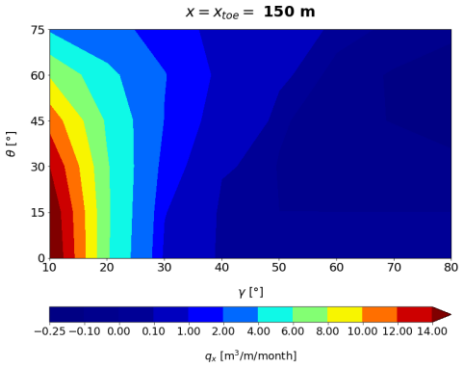


Figure 1: Cross-shore sediment transport variation (q_x) at the dune toe for all dune slope inclinations (γ) and incident wind angles (θ).

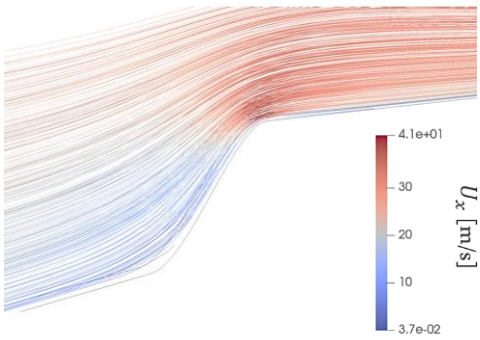


Figure 2: CFD simulation result: flow streamlines over a dune profile with a slope inclination of 50 ° with a cross-shore wind direction.

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