MANAGEMENT OF AEOLIAN SAND TRANSPORT ON A DIKE, DUNKIRK SEAPORT, FRANCE

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INTRODUCTION

Although effects of fencing on dune formation are well documented, no studies have been carried out on their efficiency on dikes. The aim of this study was to quantify Aeolian sand transport and to test the efficiency of sand fences on an asphalt dike in Dunkirk Seaport. Located near the Belgian border, this macrotidal north-facing coast, barred beach, is exposed to dominant alongshore to oblique onshore winds, blowing essentially from south to southwest, and north to northeast. The eastern part of the shoreline consists of a 6 km long sand dike coated with asphalt connected to a 750 m long jetty, which interrupts alongshore drift, resulting in sand accumulation and upper beach progradation. Aeolian sand transport on the upper beach resulted in coastal dune formation at the foot and on the dike crest. During strong northern winds, sand transport occurs on the dike and behind, on a road and in a maritime basin, requiring costly sand removal operations.

MATERIALS AND METHODS

Sand transport rates were estimated using wedge-shaped sand traps. Wind velocity was obtained using 12 cup anemometers, linked to a data logger, installed on 3 masts at heights of 0.25, 0.5, 1.0 and 2.0 m and positioned on the dike and on the upper beach. During each experiment, the masts were deployed perpendicular to dominant wind. Sand traps were positioned next to the masts and opened for periods of ten minutes. The weight of sand obtained was converted to a rate in $kg.m^{-1}h^{-1}$. Sand accumulation on the dike was tested using sand fences (wooden slats spaced 30 to 40 mm apart) and synthetic fabrics, both having a height of 1.2 m and a porosity of 50%. Ten experimental sand trapping structures were deployed at different locations in February 2011: dike toe, dike windward and leeward slopes. Topographic surveys were carried out every month using a differential global positioning system to monitor sand accumulation in each structure. Digital Elevation Models were generated and volumes have been calculated

RESULTS

Eighteen sand transport experiments were conducted between February and May 2011. Under oblique onshore winds, vertical wind velocity profiles revealed an acceleration of wind flow on the windward slope of the dike, while a decrease in wind speed was observed on the lee side. Such wind speed-up was already observed on dune slopes (Christiansen & Davidson-Arnott, 2004). Transport rates were highly variable, ranging from 4 to 95 $kg.m^{-1}.h^{-1}$, and were almost always higher on asphalt than on the upper beach. This was related to source of sand for Aeolian transport. Wind blown sand trapped on the dike originating from the coastal dunes developed at the dike toe. Aeolian sand transport on the upper beach was restricted by surface moisture and topographical variations. On these macrotidal beaches, complex intertidal bar-trough topography (ridge-and-runnel beaches) induces fetch segmentation and limited sand transport (Anthony et al., 2009).

Considering these high rates of sand transport on asphalt, the potential accumulation of sand on that kind of substrate was investigated. After ten months of monitoring, the amount of sand captured in the different structures is ranging from 0.03 $m^3.m^2$ to 0.41 $m^3.m^2$. The most efficient windbreak was a wooden slats fence located at the beach-dike contact. This structure was rapidly filled with sand, which allowed vegetation and embryo dunes to develop on the upper beach.

On the windward slope of the dike, a cross-shaped structure in synthetic fabrics was the most efficient one (fig. 1), capturing sand transported under various wind direction.

Although the location of the windbreaks seems to play a major rule on the amount of sand captured, it appears from these preliminary results that fences and synthetic fabrics usually deployed on sandy surfaces are also able to trap windblown sand on a seaport dike. This could limit sand deposition in the maritime basin behind and enhance dune development on the dike. Furthermore, the formation of vegetated dunes could improve the natural aspect of the site.

Figure 1 - Evolution of an experimental cross-shaped structure on the windward slope of the dike

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