BEACH BUILDINGS ON POLES AND THEIR IMPLICATIONS FOR DUNEWARD SEDIMENT TRANSPORT: A NUMERICAL STUDY

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INTRODUCTION

Sandy beaches are attractive worldwide. An increasing number of beach users induces a higher demand for buildings at the beach-dune interface. These buildings alter the local flow speed and direction which, in turn, changes the aeolian sand transport around buildings, and the sediment supply to the dunes. This study aims to understand how and to what extent beach buildings on poles affect duneward sediment transport.

MODEL SPECIFICATIONS

A 3D OpenFOAM model was developed to simulate the airflow around a row of full-scale elevated beach buildings (Pourteimouri et al., 2022). The simpleFOAM solver was used, which solves the RANS equations for a turbulent flow in steady-state conditions. The $k-\varepsilon$ turbulence closure model was applied to predict the turbulent flow structures around buildings. The mesh was generated using the snappyHexMesh utility. The domain consists of coarser grids of $1\ m$ far from the buildings, and finer grids of about $0.5\ m$ close to buildings. Figure 1 shows the model domain and boundary conditions (BC). More details on model parameters can be found in Table 1.

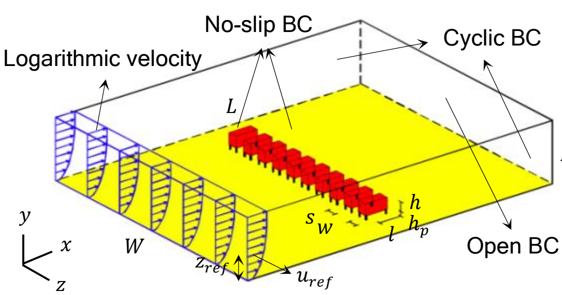

Figure 1 - Schematization of the computational domain.

Table 1 - Important parameters for the model setup.

Variable	Value
Domain dimensions ($L, W, H\ [m]$)	$150 \times 150 \times 50$
Building dimensions ($l, w, h\ [m]$)	$6 \times 2.5 \times 2.5$
Spacing between buildings ($s\ [m]$)	2.5
Poles height ($h_p\ [m]$)	$1.25 - 3.75$
Reference wind speed ($u_{ref}\ [m/s]$)	17
Reference height ($z_{ref}\ [m]$)	1.8
Surface roughness height ($y_0\ [m]$)	0.00001

Methodology

Sediment transport flux, $q\ [kg/m/s]$, is computed using the transport equation proposed by Bagnold (1937), $q = C\ (\rho_{air}/g)\ \sqrt{(d/D)}\ (u_* - u_{*th})^3$, where $C\ [-]$ is an empirical constant; $d\ [m]$ and $D\ [m]$ are the nominal and reference sediment particle size; $u_*\ [m/s]$ is the wind shear velocity; and $u_{*th}\ [m/s]$ is the threshold shear velocity. The average duneward sediment transport flux, q_c, is then calculated along a line $5\ m$ downstream of the buildings (see the white lines in Figure 2).

Results

As buildings are placed on poles (Figure 2b), the air intrudes the gap between upwind poles. Compared to buildings directly placed at the beach bed, this implies high bed shear stresses both underneath the buildings and in the gap spacing between neighboring buildings (Figure 2a). In addition, the extent at which the higher bed shear stresses occurs immediately behind the buildings and downstream of the gap spacings, increases with increasing poles height. We found that, when buildings are placed on poles, the wind that is allowed underneath the buildings significantly increases the duneward sediment transport (Figure 3).

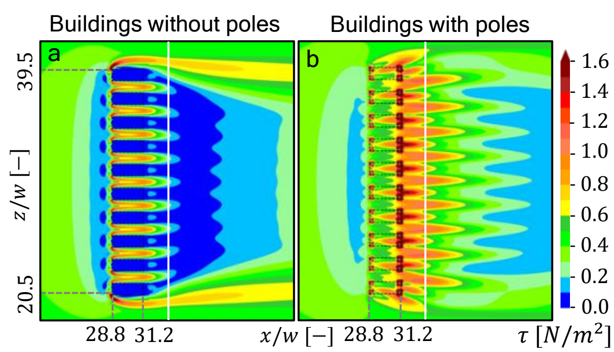

Figure 2 - Bed shear stress when a) $p_h = 0$, and b) $p_h = w$.

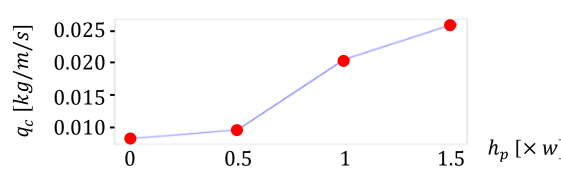

Figure 3 - Accumulative duneward sediment transport flux along a line, which is 5 meters downstream of the buildings.

REFERENCES

Bagnold, R. A. (1937): The transport of sand by wind, The Geographical Journal, 89(5), 409-438.

Pourteimouri, P., Campmans, G. H. P., Wijnberg, K. M., & Hulscher, S. J. M. H. (2022): A Numerical Study on the Impact of Building Dimensions on Airflow Patterns and Bed Morphology around Buildings at the Beach, Journal of Marine Science and Engineering, 10(1), 13.