BEACH RECOVERY ACCELERATION BY NATURE-ASSISTED BEACH ENHANCEMENT TECHNIQUES

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INTRODUCTION

Marine storms erode sand from the subaerial part of the beach profile. When these events are especially strong and/or frequent the dry beach is eroded and even the dune can be damaged. Therefore, the sand volume on the dry beach and the dune constitutes a sediment budget to fight against winter erosion.

During calm weather periods, the sediment eroded is slowly recovered through accretion processes. Depending on the magnitude of the erosion produced, the full recovery of the sand may take months, several years or remain unachievable without human intervention.

Nature-assisted beach enhancement (NABE) techniques were born as working with nature actions to help beach recovery. Beach scraping (Bruun, 1983) is the most extended technique of this type. It consists of skimming sand from the intertidal area by terrestrial machinery and placing it on the subaerial part of the beach (Carley et al., 2010). Some authors (Smutz et al., 1980) affirm that the morphologic changes produced by the borrow area in the beach profile generate a morphology more prone to accretion and therefore this technique enhances the accretion produced by nature. A recently developed technique of this type is beach ploughing, which has been tested in the field (Gainza et al., 2019) and laboratory (Pellón, 2023; Pellón et al., 2023) with promising results. This technique consists of shoreline-parallel ridges and furrows mechanically generated on the intertidal area. These bedforms modify bed roughness and enhance the bed load and the suspended load of onshore sediment transport.

PHYSICAL EXPERIMENTS

Five geometries of NABE techniques were tested against the natural (control) geometry at the Directional Wave Tank (TOD) at IHCantabria facilities. The experiments were performed at a reduced scale of 1:8 with simultaneous simulation of waves and tides. The tank was split into 10 channels that received the same marine dynamics (Figure 1). Four channels were used as aisles and 6 for the different testing geometries. The morphologic evolution of the subaerial part of the beach was measured by a laser profiler at the centre of each channel.

The scaling design was performed by achieving the similitude of Froude, Shields, grain Reynolds and Rouse dimensionless numbers. The use of synthetic sediment of reduced density (d_{50} = 0.37 mm, ρ_s = 1500 kg/m^3) was required to achieve the similitude in the model and prototype.

Figure 1 - Image of TOD facilities during the experiments

Three tests were performed. The setup of the sandy bottom for each test was achieved through the simulation of slightly energetic waves (typical of a spring storm) with the simultaneous effect of tides. This generated a dissipative beach profile and the NABE techniques were applied over it. The technique simulated on each channel and the location of the borrow and filling areas for scraping actions are shown in Figure 2. Then, successive tidal cycles of calm waves were simulated until the maximum accretion was achieved on the beach berm. This procedure was repeated three times, one for each test.

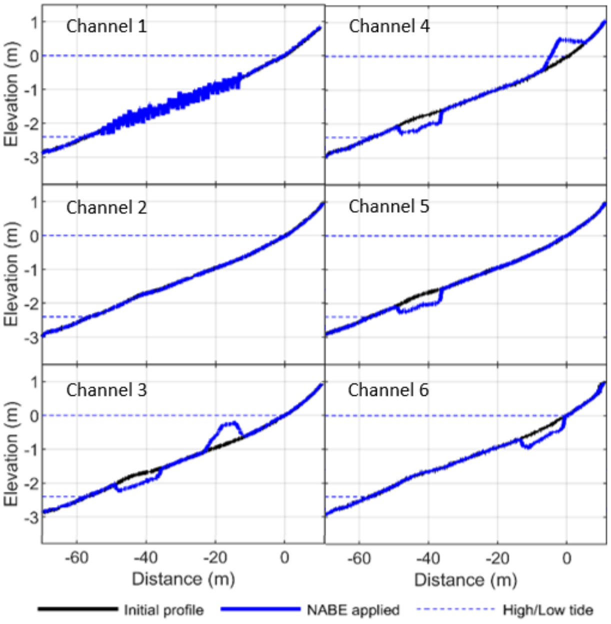

Figure 2 - NABE technique simulated on each channel. The filling area of channels 5 and 6 is the dune

Channel 2 acts as a control. The ploughing technique was simulated in channel 1 by ploughing the intertidal area at each low tide. Channels 3 to 6 simulated four geometries of scraping, all of them mobilizing 3 m^3 of sand at prototype scale. The borrow area on channels 3 to 5 was the low intertidal area, and the upper intertidal area for channel 6. The filling area was an intertidal bar for channel 3, the beachfront for channel 4, and the dune (sediment extracted from the tank) for channels 5 and 6.

The characteristics of the waves and tides (at prototype scale) used for each test are summarized in Table 1.

	H_s (m)	T_p (s)	Tidal range (m)
Test A	0.48	8.50	2.40
Test B	0.32	8.50	1.60
Test C	0.26	4.72	1.60

Table 1 - Marine dynamics simulated at each laboratory test

RESULTS

The volume of sand recovered on the subaerial part of the beach was measured as the sum of the sand volumes mobilized by machinery and accreted by the wave action. This sand volume is available on the beach to fight against winter erosion. Figure 3 shows a comparison of the sand volumes obtained for each experimental channel (NABE geometry) compared to the control geometry (channel 2) for Test A.

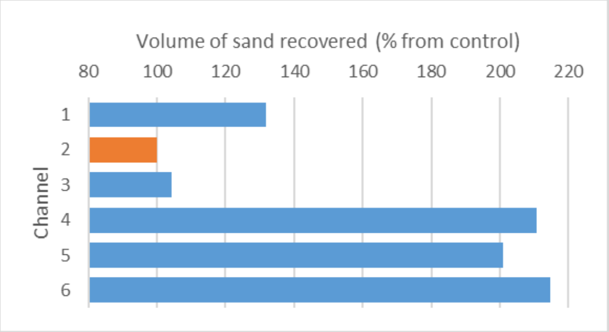

Figure 3 - Volume of sand recovered for each channel in Test A

The results show that all NABE techniques produce a bigger volume of sand recovered than the natural geometry of the beach. Nevertheless, the technique and the location of the borrow and filling areas make a difference in sediment volume. Scraping by placing the filling area above the high tide shoreline maximized the sediment budget. Ploughing produces an intermediate result. Finally, the creation of an intertidal bar by scraping produced similar recovered sand volumes to the natural profile. The results for Test B and C were similar.

The techniques produced relevant differences in dry beach width. The wider dry beach does not match the bigger recovered volume.

Channel 6 achieved the bigger sand volume recovered for the three tests performed. Therefore, the bigger sediment budget on the subaerial beach to fight against winter erosion was achieved by scraping, placing the borrow area on the upper intertidal area and using the sand for dune nourishment. Scraping the upper intertidal area generated a flatter beach profile (more dissipative), that showed greater accretion volume produced by wave action.

DISCUSSION

The design of actions is important for the application of NABE techniques. The technique and the location of the borrow and filling areas determine the effectiveness of the measures.

The dry beach width achieved after several tidal cycles of accretion varies depending on the NABE technique implemented. The results showed which is the best option to maximize the volume of sand recovered to fight against winter erosion, but this option produces a narrower beach than the control profile.

The hypothesis of Smutz et al. (1980) was verified in channel 6. Placing the borrow area in the upper part of the intertidal zone reduces the slope of the profile and accelerates beach accretion.

CONCLUSIONS

The design of nature-assisted beach enhancement actions should be performed according to the objective at each specific beach. Common objectives are to increase the sediment budget to fight against winter erosion or to widen the dry beach for touristic purposes.

When trying to increase the sediment recovered on the subaerial beach, the best results were achieved by applying beach scraping, removing the sand from the upper intertidal area and nourishing the dune.

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