ABSTRACT

Daily variations of rhythmic features are discussed, observed at a meso-tidal, steeply sloping beach, during the most energetic, five-month period, from coastal imagery and frequent topographic surveys. Distinct beach cusp systems were observed at different levels of the beach with the lower beach-face rhythmical patterns changing constantly and merging with the upper beach-face features. The upper beach-face pattern was shown to be persistent during the monitoring period and it re-emerged with similar spacing and alignment, despite being eroded during energetic events. The spacing of the observed beach cusp episodes ranged from \( \lambda_{c,\text{min}} = 8 \) m to \( \lambda_{c,\text{max}} = 67 \) m; these values were underestimated by the edge wave and self-organization theories and were better predicted by the Sunamura (2004) formula (Coastal Engineering 51 (8-9):697-711).

KEY WORDS: beach erosion; coastal video monitoring; beach cusps; swash zone; intertidal topography

INTRODUCTION

The beach-face is often irregular and characterized by the presence of rhythmic features including prominent, narrow horns, separated by broad, gently curving bays, called beach cusps (e.g. Almar et al., 2008; Coco et al., 2001; Masselink and Pattiaratchi, 1998). The alongshore dimensions/spacing of beach cusps is ranging from 5 to 70 m and can show high or moderate regularity (Komar, 2005). Despite the extensive literature on beach cusps and the several proposed mechanisms of their formation, the particular conditions under which such features appear and evolve remain uncertain.

Beach cusp formation has been initially attributed to standing waves, generated by non-linear interactions of incident wind waves and trapped near the shore through refraction on the sloping bed (Guza and Inman, 1975; Inman and Guza, 1982). This theory results in a predicted cusp spacing equal to:

\[
\lambda_c = \frac{mg}{\pi} T^2 \sin \beta
\]  

where: \( m = 1 \) and 0.5 for sub-harmonic and synchronous edge waves, respectively; \( g \) is the acceleration of gravity; \( \beta \) is the tangent of the beach slope; and \( T \) is the period of the incident waves.

An alternative proposed mechanism was that beach cusps emerge through self-organizing feedbacks between swash flow, sediment transport, and morphology (Inman and Guza, 1982; Werner and Fink, 1993). The self organization theory expresses cusp spacing as a function of the horizontal cross-shore swash excursion length \( S \), according to the equation:

\[
\lambda_c = fS
\]  

where: \( f \) is a non-dimensional constant estimated at around 1.6 (Werner and Fink, 1993). Comparison of the two theories against field observations derived from imagery obtained over a three-year period along a section of New Zealand coastline showed that Eq. 2 reproduced the observations better (Almar, et al., 2008).

Sunamura (2004) derived the following equation to predict cusp spacing:

\[
\lambda_c = A \phi T \sqrt{gH}
\]  

where: \( \phi \) is a coefficient related to the mean grain size, expressing the effectiveness of the sandy beach-face in dissipating wave run-up energy though friction; and \( A \) is a constant estimated at equal to 1.35.

Apart from the above theories, cusp events have been related to near-shore-normal breaking waves (e.g. Shepard, 1963; Timmermans, 1935), to narrow-banded frequency wave spectra, as well as to reflective conditions (Guza and Inman, 1975).

The aim of the present contribution is to discuss daily beach cusp evolution on the meso-tidal, exposed Faro Beach (S. Portugal), during a five-month period of video monitoring observations, covering the more energetic storm season. The study area is a dynamic, steeply-sloping beach, characterized by frequent variations in wave forcing, followed by rapid morphological response and frequent changes in the beach cusp systems.

THE STUDY AREA

Faro Beach (Praia de Faro) is located along the central and eastern parts of the Ancão Peninsula (Fig. 1a), in the westernmost sector of the Ria Formosa barrier island system (Algarve, S. Portugal). In the central part of the peninsula, the dune ridge has been almost completely overtaken by urban development, and some of the ocean front has been artificially stabilised with sea walls (Ferreira et al., 2006). These structures are often overwashed during equinoctial spring tides or under storm conditions. The central and western parts of the Ancão Peninsula show...