Large amplitude edge waves on a beach

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1. Introduction

Edge waves have been studied in the last decades in reference, mainly, to the rhythmical longshore patterns that appear on some beaches when suitable conditions are met with. The theory of excitation of edge waves by a normally incident wave train was carried out by many researches in the seventies of the past century. The names of Guza, Inman, Bowen, Davis and many others have much significance on this respect, though we know that Stokes already gave a general formula for edge waves (zero mode) in 1846.

Edge waves and the effect on beach topography can be small or very important depending on the wave amplitude and other characteristics (for instance, if they are progressive or standing waves). Pelinovsky and others pointed out the existence of freak edge waves that can generate topographic beach features and even flooding on nearby zones.

Recently on our northern coast (Asturies) we have come across an episode of a very large amplitude edge waves on Salinas Beach. This beach is bounded by a sea wall defending a promenade. After a period of very stormy maritime climate there was a severe erosion along the beach.

2. Antecedents

Salinas Beach is located in the Cantabrian Sea. Lately it has been suffering a severe erosion. In past years the effects of edge waves were also marked. The picture shows a beach cusp system in 1992.(The level of the sand was higher than at present).

Figure 1. Salinas beach

Figure 2. Beach cusp in 1992

3. Theory

We have tried both, full theory (Ursell 1952) and shallow water theory, modes 0 and 1. Excitation of edge waves by incoming waves has been considered after Bowen(1976)

$$\varphi(x,z) = Exp(-Kx\cos(\beta)+Kz\sin(\beta))+$$
$$A_{11}\left[Exp(-Kx\cos(\beta)-Kz\sin(\beta))+Exp(-Kx\cos(3\beta)+Kz\sin(3\beta))\right]$$

$$A_{11} = -\frac{\tan(\beta)}{\tan(2\beta)}$$

$$\omega^2 = gK\sin(3\beta)$$

$$a_e = \frac{0.77\tan(\beta)}{K_e}\varepsilon_i^{\frac{1}{2}}$$

$$\varepsilon_i = \frac{a_i(2\omega)^2}{g\tan^2(\beta)}$$

$$a_c = 0.24L_c\tan(\beta)$$

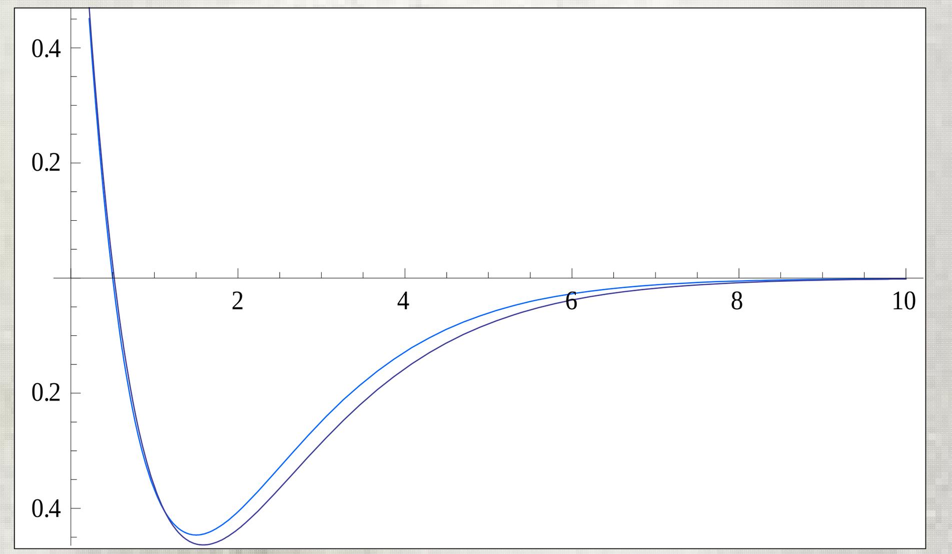

Figure 3. Edge waves mode 1. Light blue, shallow wáter, dark blue, full theory

4. Edge waves in 2009

Large amplitude edge waves, 1.58 m., were presented in 2009. A coherent interpretation of the data according the theory of resonant excitation of edge waves by normally incident waves was checked.
Average beach steepness was 0.0114.
Figure 4 shows the September 2009 bathymetry compared with the September 2008 one. The rhythmic patterns are clearly apparent. The same happens with the pictures.

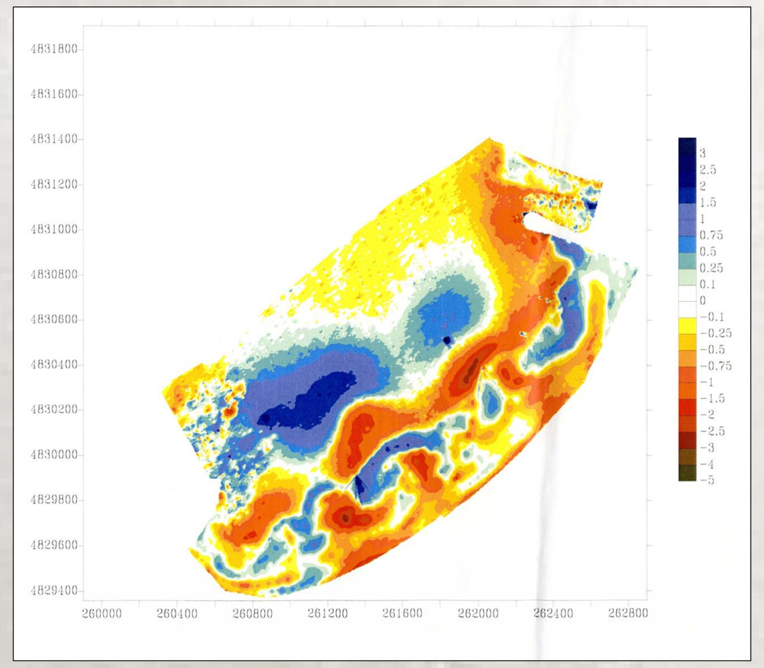

Figure 4. Bathymetry

Figure 5. Cusp wavelength

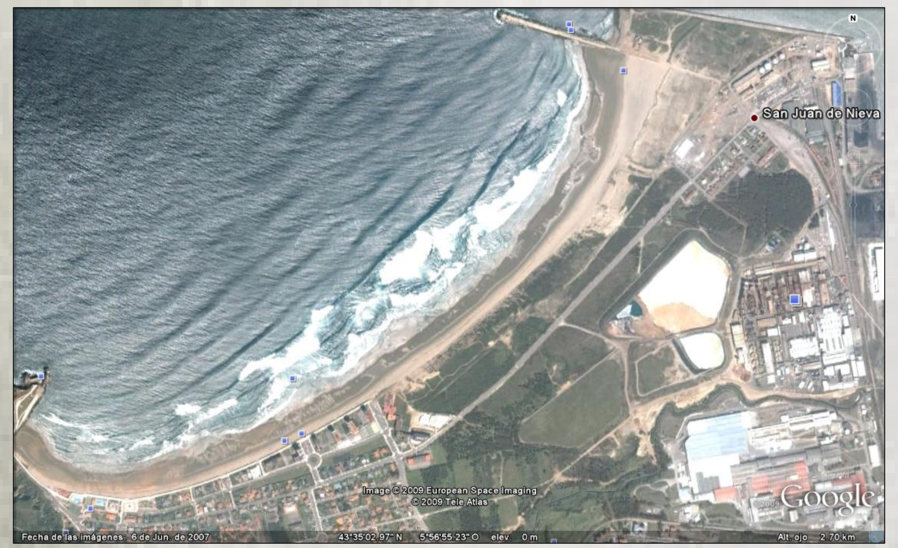

Figure 6. Breaking wave pattern

5. Beach cusps and sea wall

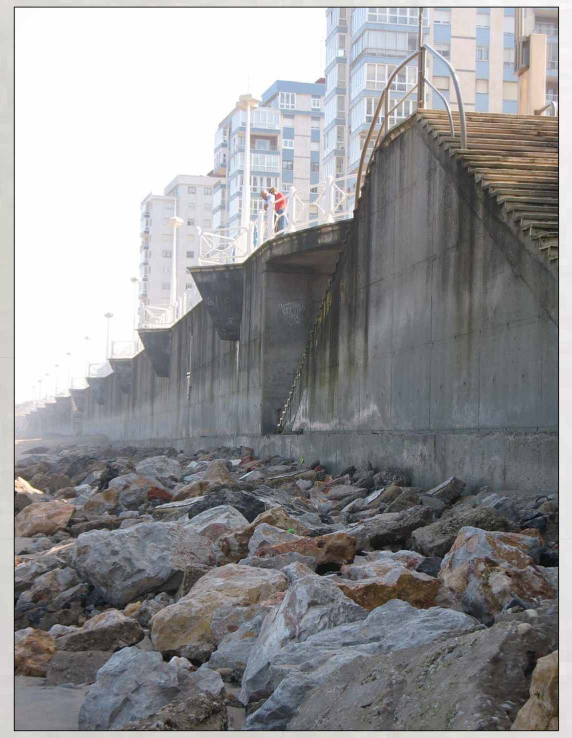

Figure 7. Trough of the "beach cusp"

The rhythmic features generated on the beach by edge waves (beach cusps with a wavelength of 400 metres) caused an adding erosion on specific locations and , as a result, the sea wall was damaged at the trough of the beach cusp system.

Low tide sand features on Salinas Beach showing a remarkable tridimensional structure.

Figure 8. Crest of the "beach cusp"

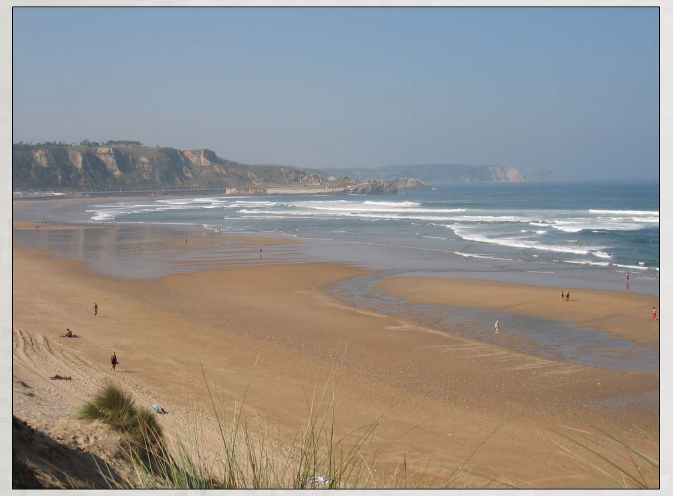

Figure 9. Low tide rhythmic pattern

6. Conclusions

In 2009 computed edge wave amplitude was, 1.58 m. and the edge wavelength, 800 m.
The measured beach cusp amplitude was 2.50 m. and the cusp wavelength, 400 m.
As the level of the sand was 7 m. below the level of the promenade, the sea wall was damaged.
The results agree with the theory of excitation of almost standing edge waves.