Case study: Estela golf course beach (Portugal)

Technique: Dune rehabilitation

Location

The Estela Golf course is located in Estela, municipality of Póvoa do Varzim, approximately 9km North from the city harbour and right away South of the Protected Area of the Littoral Park of Esposende. It is established along the North Western coast of Portugal in a dunar system of approximately 3 km long (see Figure 1).

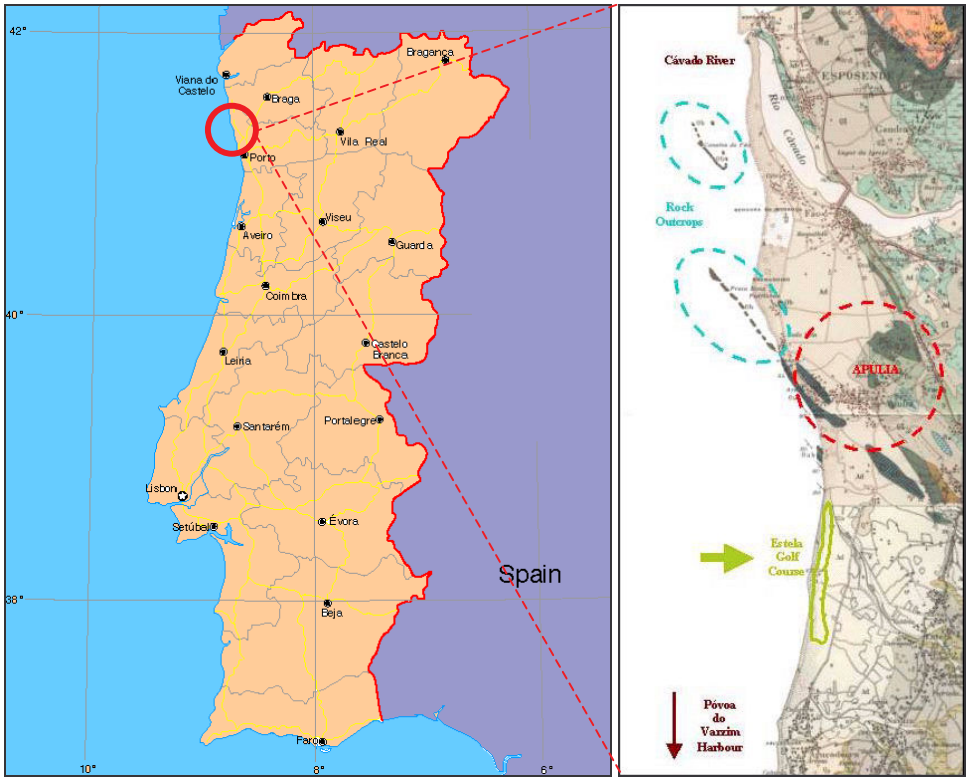

Figure 1: Location of Estela golf course in Portugal.

(Source: http://www.vdiest.nl/ Europa/portugal.htm; Estela. EUROSION case study, at http://www.eurosion.org)

Coastal morphology and dynamics

The Estela golf course shoreline stretch is a Coastal Plain of about 3km length characterised by sandy beaches with sand dunes. The wave climate ranges from 2 to 3m of medium significant wave heights, with periods of 8 to 12s and storm significant wave heights exceeding 8m, with periods reaching 16 to 18s. Almost all waves come from the N-W quadrant and the dominant wave direction is NW (~ 50%). Very occasionally there are waves coming from SW. The local wave conditions differ from the offshore ones due to the effect of the bathymetry and local phenomena, especially refraction, diffraction and shoaling. These local phenomena affect mainly the direction and height of the waves.

The tides on the Portuguese North Western coast are of the semidiurnal type, reaching a medium range of 2m and a maximum of 4m. The average tides in Leixões near Porto are + 2.00 m (HZ). The tide and wave values indicate that this is a macro-mesotidal tide-dominated coast. Meteorological tides are not significant outside enclosed waterbodies but they can contribute to increase onshore consequences when occurring simultaneously with spring astronomical tides or severe storms.

Spring tides:	**Neap tides:**
Maximum high tide: + 3.88 m (HZ)	High tide: + 2.5 m (HZ)
Minimum low tide: + 0.12 m (HZ)	Low tide: + 1.5 m (HZ)
High tide: + 3.55 m (HZ)	
Low tide: + 0.45 m (HZ)	

Longshore transport is dominant along the shoreline and is mainly wave induced. The dominant direction is from North to South. The sedimentary cell is about 20km long from Cávado River to Póvoa do Varzim harbour and the main source of sediments is Cávado River. Another possible source of sediments is the one provided by beaches under process of erosion.

Due to the decrease on the volume of sediments transported by the North/South littoral drift currents caused by dredging activities at the Cávado River and morphological changes on its basin, as well as other natural causes, the dunar system of Estela is being furthermore submitted to the direct action of wave run-up (IHRH, 1997). As a consequence of this direct wave action, the dune ridge is becoming more and more fragile – decrease on the beach width and dunes. The frontal dune has been shaped into a dune erosion cliff with tendency to migrate inland. This migration today is being stopped throughout dune restoration interventions.

Purposes of dune rehabilitation and expected results

The basic purpose of the IHRH's study of 1997 was to assess the state-of-the-art of the dune system, which serves as a barrier for the golf course against storm attacks, and to make proposals on how to mitigate the strong and rapid erosion that affected this coastal sector. The proposed solution, and the taken one, was to restore the lost volume of sand of the dune ridge through mechanical sand ripping from the beach outside. The intervention was successively followed by several ones. Due to the fact that the interventions made in Estela are short-term solutions, the owner of golf course is considering, as suggested by the research team of the IHRH, the acquisition of adjacent fields and the re-location of the golf course to a more inland position. These interventions are therefore considered as being rather ineffective for dune consolidation even though they mitigate the sea invasion effects.

Basic principles

No information available.

Expected benefits

Environmental benefits

The soft protection structure using geotextile sand filled containers has proven to have good potentialities that might solve, in a short term, the erosion problems existing in Estela but its effectiveness is not yet satisfying. At the moment, this case is the aim of a research study and in a near future it will be settled up a pilot study station using an improved solution of geotextile sand filled containers.

Social and economical benefits

No information available.

Technical and financial benefits

No information available.

Designing dune rehabilitation scheme step-by-step (history)

The first documented intervention, made during the period of 1st to 12th April 1999, consisted on located reinforcement of the dune toe through mechanical ripping of sand from the frontal beach and consolidation of this sand deposit with wood piles and small sand bags of 5 kg weight (see Figure 2). This intervention was simultaneously made on the critical zone 1 (CZ1), near the 5th hole and on critical zone 2 (CZ2), near the 13th hole.

It is still in 1999, during October, that a new intervention of reinforcement and dune consolidation is made on the CZ1, again using mechanical sand ripping and woodpiles and small sand bags. The aspect of the dune before this intervention was of an advanced state of erosion with the erosion cliff very close to the golf fence. Before the 1999/2000 winter there were needed two more interventions, one in January and the other in March. In addition to the used technique it was also put, transversely to the shoreline, some aeolian traps (fences) to favour the sediment trapping on the dune.

The 5th intervention near hole number 5 was made in October 2000 (see Figure 3), after the spring tides occurred in 28th and 29th September, that had as a consequence the partial destruction of the dunar system in that area which motivated once more the need to prosecute with dune renourishment works.

Figure 2: Dune consolidation with wood piles and small sand bags, April 1999.
(Source: Estela. EUROSION case study, at http://www.eurosion.org)

Figure 3: Sand ripping works near the 5th hole, October 2000.
(Source: Estela. EUROSION case study, at http://www.eurosion.org)

The 2nd intervention on the 13th hole – still using the same dune consolidation technique -, was only needed in November 2000 after having already done 5 interventions on the CZ1 near the 5th hole. In fact, it is only a year after the first intervention that the dune in this area exhibits erosion signals. This fact leads to conclude that the erosion phenomenon is significantly more severe on the North extreme than on the South one.

The winter of 2000/2001 was particularly severe with a high sequence of storm episodes happening very close one to another. In fact, even though in general wave heights with a return period higher than 10 years were not reached, the persistence of the storms generated a very unusual case of consecutive storm events in a way that it was necessary to carry on with emergency works of dune repositioning several times in the period from November 2000 to January 2001, both in the North and South limits of the golf course. In this period there were made the 6th, 7th and 8th interventions in the adjacent area of the 5th hole and the 3rd intervention near the 13th hole.

The 6th intervention on the North extreme limit of the golf course was carried out during the period of 14th to 27th November 2000, following the spring tides that occured in November in which the dune was significantly affected. The emergency intervention consisted on mechanical sand ripping from the frontal beach to the dune.

December 2000 marks the beginning of the use of a new technique of coastal defence in association with the sand ripping. The severe spring tides and storms that affected this area since October, causing a series of dune destruction events, were responsible for the decision to make use of a more solid reinforcement technique that consisted on a slope protection of the dune with a geotextile filter cloth underlay and sand containers of $1m^3$ (see Figure 4). The intervention was carried out in 3 stretches with 350, 70 and 50m and consisted on the placing of a geotextile filter cloth and sand containers along a 45º slope. During October and December 2001 and May 2002 new sand containers were placed on the dune slope, but this time the geotextile filter cloth underlay was not placed.

Figure 4: Aspects of the execution of the technical solution using geotextile sand containers, December 2000. (Source: Estela. EUROSION case study, at http://www.eurosion.org)

Collecting baseline information *(in reference to **comp 2**)*

No information available.

Assessing the "do nothing" scenario *(in reference to **comp 3**)*

No information available.

Selecting the adequate dune rehabilitation techniques

Establishing environmental mitigation strategies

No information available.

Designing long-term monitoring

No information available.

Factors influencing the success of dune rehabilitation schemes

One of the most important factors that influnce the success or fail of a dune rehabilitation sheme is the wind. When planning a dune action, the wind direction and average speed has to be taken into account for well design of dunar structures. Also, the type of sand, its grain size and moisture influences the rate of aeolian transport in the zone.

This case is being object of an in-depth investigation of the evolution of the protection techniques applied, and the experience accumulated showed that some improvements have to be made in order to upgrade the level of protection and the efectiveness of dune rehabilitation. Concerning the characteristics of the solution used in the dunar system of Estela, the following details should be improved:

- Use of non-woven geotextile sand container instead of a woven one;
- Careful design of the underlying geotextile sheet used as filter;
- The containers should be placed preferably with the long side perpendicularly to the shoreline;
- The containers should be placed like brickets in layers with a beach slope of about 1:1;
- The lowest layer should be placed beneath to the existing mean water level (at least one layer);
- The top layers should be placed above the maximum design water level (above 0.50 m freeboard);
- A sand trap fence should be placed again to keep the golf course free of sand.

Furthermore, during the research studies on the erosion control of the dunar system of Estela two basic solution will be studied. These solutions can be combined together to minimize the wave energy impacts on the dune, which consist of:

- A passive coastal protection: dune barrier made of stapled geotextile containers as second line of defence and dune stabilisation, which is covered with sand;
- An active coastal protection: construction of one or two temporary groynes made of geotextile containers (in addition it can also be investigated the suitability of a submerged breakwater made of geotextile containers).

Assessing and monitoring the environmental and social impact of dune rehabilitation schemes

Impact on shoreline stability

No information available.

Impact on natural habitats

No information available.

Impact on coastal vegetation

No information available.

Social perception

No information available.

Budgeting dune rehabilitation schemes

Feasibility costs

No information available.

Environmental mitigation costs

No information available.

Investment and engineering costs

The costs of the various interventions made is depicted in the following table:

Date	Costs (in €)
April 1999	12.500
October 1999	15.000
January 2000	10.000
March 2000	7.500
Ocotber 2000	12.500
November 2000	22.500
December 2000 – January 2001	-
October/December 2001 – May 2002	-

Maintenance and monitoring costs

As mentioned before, this is not a definitive solution for the erosion problem, so periodic interventions have to be made in order to maintain the level of protection that the dune system offers to the golf course. There is no information available for maintenance and monitoring costs.

Limitations

This is the first time, in Portugal, that a coastal erosion problem is being affronted with a coastal defence solution using geotextile containers. The fact that the incident waves on the West Portuguese coast are among all the most energetic worldwide makes people to misbelieve the potentialities of these kind of solutions, especially in cases like Estela. Nevertheless, these type of solutions can effectively control some coastal erosion problems, in a short term, but need to have a design procedure similar to any other coastal defence structure. Since this moment, there are still significant lacks of information regarding the design and behaviour of these defence techniques.

References

EUROSION (2004). *Estela. Eurosion Case study.* In: Shoreline Management Guide (http://www.eurosion.org)