Case study: Les Sables d'Olonne (France)

Technique: Beach drainage

Location

Les Sables d'Olonne is one of the most famous seaside resort of the Atlantic coast, known for his fine sand and protected beach. Localised on the Atlantic coast of France, it extends at bottom of a bay open to the south.

Coastal morphology and dynamics

On the west, the bay is closed by a headland and by the west pier of the harbour. They both protect the bay from the west dominants swells. On the ESE, the bay is closed by another headland. The length of the beach is approximately 1500m between the pier of the harbour in the west and the rocks of the red light house in the east. A continuous seawall from west to east is built on the upper-shore aimed to protect from flooding. The slope of the upper-shore is around 4-7% and the slope of the shoreface is around 2%. The seepage point is between these two parts of the beach. The seepage of the water table, very important, is due to the clay layers located one meter below the shoreface.

The site is including on the south of the Britain Massif. This region of the littoral is a metamorphic plateau plunging into the Atlantic Ocean, notched by several rivers. The littoral have evolved during the quaternary with the sea level variations. The estuaries of the rivers, and the marshlands were filled up with fine sand and mud. In the downstream side of the rocky headlands, the sandy arrows had progressively closed the estuaries and marshes. This point could explain the presence of clay layers one meter bellow the shore face. The sediments characteristics of the beach are fine sand: $150\mu m<D50<250\mu m$ and very homogeneous.

The marine bottoms are few depth due to the continental shelf which extents 100 km in the west of the coast. Off-shore, some rocky-shoals close the bay to the south swells. The entire bay is well protected from the most dominant swells, but the whole of the littoral drift of the Atlantic coast can not bright sediments into the bay. The bay has to live with an autonomous stock of sediments.

The dominant winds are south-west to north-west. The wind speeds more than 8 m/s represent 10%. The spring tidal range is about 5,6 meters. The main driving current is the tidal current. The flood current go to the south-east with a speed around 0,4 m/s and the ebb currents go to the west-north-west with a speed around 0,25 m/s. Only the swells from south-east to south-west could penetrate directly into in the bay. The swells from the west to north-west are diffracted by the headland and the shoals.

The cross-shore and long shore transport is around 1.000 cubic meters per year. The main action of the transport is cross-shore, between the lower and the upper beach. The bay, closed by the headlands and the rocky shoals is an homogeneous sedimentary cell where the input and output of sediment are possible but very weak. The stock of sediment on the beach is not being improved by the littoral drift, but only by the cross-shore transport.

The reflection of waves on the seawall, and the cross-shore transport due to the action of waves have increased erosion. In the 60's the beach disappeared at high tide. The foot of the seawall were regularly damaged.

Purposes of beach drainage and expected results

The beach drainage system installed in the beach of Les Sables d'Olonne is the one developed by the Danish Geotechnical Institute. The system consists on a gravity drain which forces the lowering of the water table under the beach. The beach is unsaturated in water when the waves break on the shore. The infiltration of the water in the sand is improved. The water speed in the swash decreases and the sand transported is laying on the shore face. As a great part of the water down into the beach, the volume of sand in the backwash is less. The accumulation of sand increases and the erosion is stopped. The water flows by gravity from the drain to a pumping. The water is then pumped and thrown into the sea or used as filtered water in marine swimming-pool, aquaculture, fisheries, marine therapeutic center, aquarium…

Basic principles

The swash/backwash motion, i.e., wave run-up and run-down in the swash zone, provides the driving force for swash sediment transport. The upwash moves sand on-shore while the backwash transports it offshore. The hydrodynamics of these processes are very complicated, involving highly non-linear transformations of broken and unbroken waves on a sloping beach. Moreover, the wave motion interacts with the beach groundwater flow. Seawater may infiltrate into the sand at the upper part of the beach (around the shoreline) during swash wave motion if the beach groundwater table is low. In contrast, groundwater exfiltration may occur across the beach with a high water table. Seawater infiltration under a low water table was found to enhance on-shore sediment transport, whereas groundwater exfiltration under a high water table promote offshore sediment transport. (…). Sediment size influences the transport process of sand indirectly through the groundwater. A large sediment size results in a large permeability and hydraulic conductivity of the porous medium. This will increase the infiltration/exfiltration rate and hence affect wave motion that provides the driving force for sediment transport (L. Li and D. A. Barry).

Expected benefits

Environmental benefits

No information available.

Social and economical benefits

No information available.

Technical and financial benefits

No information available.

Designing beach drainage scheme step-by-step

The engineering options chosen in the past for protect the seaside front of Les Sables d'Olonne were of hard nature. All the southern shoreline of the city is already protected by seawall and dikes which are unable to stop the lowering of beach profiles. The proposed strategy was then to work as much possible with natural processes. The beach drainage system has been chosen for its respect for the environment, the landscape, and its capacity to use the natural processes to accomplish the objectives for which it was designed for.

The April 1999, with the aim to stop erosion and stabilise the beach profiles, a beach drainage system was installed on the east part of the beach, the most exposed to the swells and the most eroded. This first system consisted on a gravity drain of 300m length, buried 70m in front of the seawall, at the line of the mid sea level. In March 2002, as the positive results of the first one shown, the local public authority decided to improve the efficiency of the first system with a second one on the west part of the beach. Then, a second drain of 300m length was installed 60 meters in front of the seawall, and a third drain of 700m length placed 30m in front of the seawall, at the line of the high tide level.

The soundings made to know the different layers of the subsoil have indicated the presence of some clay layers one meter below the shore-face. In order to improve the running system, some furrows have been dug to increase the drainage of the beach.

Following there is a scheme of the system installed in the beach of Sables d'Olonne (Figure 1):

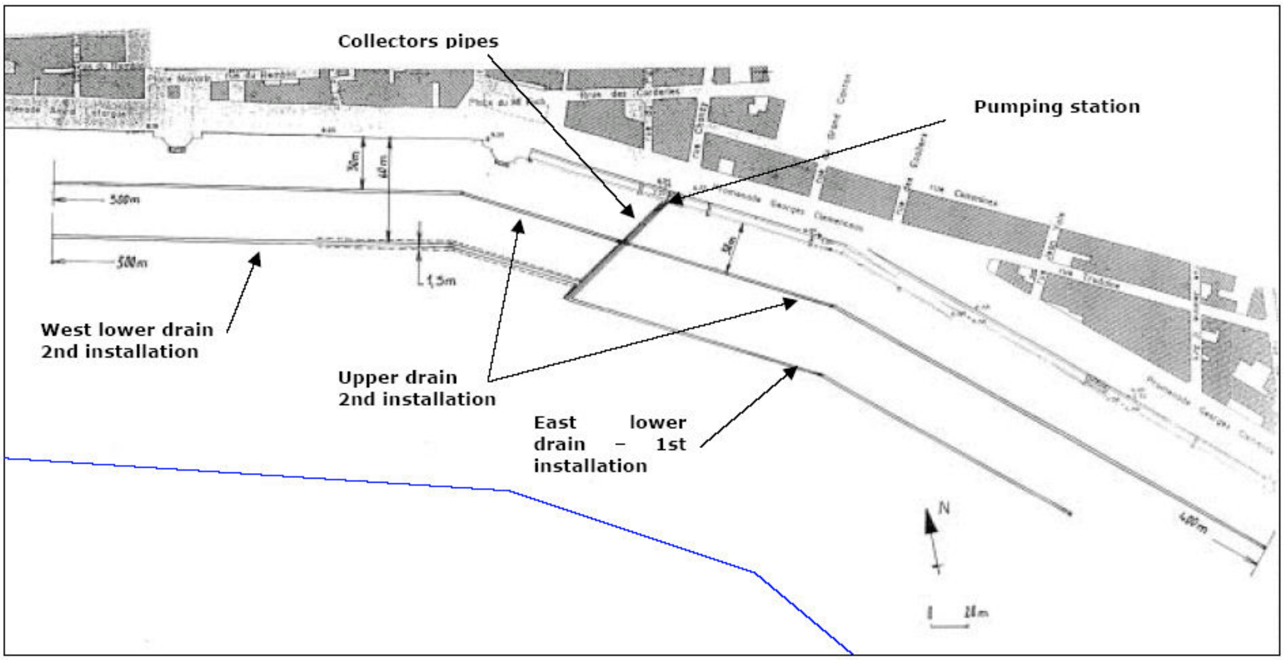

Figure 1: Map of installation of the beach drainage system in Les Sables d'Olonne (Source: Sables d'Olonne. Eurosion Case Study, in: Shoreline Management Guide http://www.eurosion.org).

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

No information available.

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

No information available.

Determining the sediment characteristics

No information available.

Determining the adequate hydro-geological drainage pattern

No information available.

Selecting the adequate beach drainage methods

Establishing environmental mitigation strategies

No information available.

Designing long-term monitoring

No information available.

Factors influencing the success of beach drainage methods

No information available.

Assessing and monitoring the environmental and social impact of beach drainage methods

A special survey for the first installation of a beach drainage system has been carried out so to understand the running of the system and the effects on the environment. The comity for the survey is composed by the "Ministère of the Equipement" (CETMEF), the University of Nantes (IGARUN),as well as the regional and local public authorities. After the first installation of the beach drainage system, in 1999, the survey made by the public authorities (Service maritime DDE VENDEE) and the University of Nantes has shown that on the treated beach:

- The beach profiles are stabilised
- The erosion is quasi stopped
- The beach is dry
- An accumulation of sand is time to time visible above the drain area
- The system is able to quickly recovery the sand lost after a storm event
- No negative impact has been recorded nor on the upstream side neither on the downstream side

The study of the results of the first installation has shown a problem of drainage on the upper-shore due to the presence of clay layers. So to unsaturate the upper beach and improve the sediment deposition in this area, an upper drain connected to the same pumping station has been installed, 30 meters in front of the seawall. After the second installation of a beach drainage system in March 2002, the survey made by the public authorities (Service maritime DDE VENDEE) and the University of Nantes has shown that the positive effects visible on the first installation are visible on the second as well. The improvement brought by the second installation with the upper drain has been established by the comity for the survey (December 2002). The upper drain is able to keep safe the summer upper-beach till December, even some severe storm events occur.

After the installation of the first drain system, the touristy capacity of the beach has been improved, due to the drying of the foreshore and the widenning of the beach during high tide. Since the installation of the system, no damage on the seawall has been recorded, the beach profiles were stabilised and the erosion has stopped.

Impact on shoreline stability

The effectiveness of the beach drainage system can only be evaluated after a longer period. The beach drainage system has shown to be effective for stabilizing the beach profiles and stop the erosion. The improvements provided by the upper beach drain show the success of the system in this commitment, even it is too early to conclude on the efficiency of the system on increase the beach width. A better knowledge of the system in the great tidal range is necessary for a successfully apply of the system

Impact on natural habitats

No impacts on natural habitats are described.

Impact on water quality

Impact on water circulation patterns

The beach drainage system installed on the upstream side of the long-shore current has no negative impact on it. The system does not block the littoral drift, like it happens with a groin. The treated beach is stabilised and the untreated beach is continuing to be eroded. The consequences of the system are only visible on the bay due to its closed morphology.

Impact on pollutant concentration

No information available at this point.

Social perception

Before the installation of the drainage system, the impacts on the environment, the landscape, the quality of sand and water, and the impacts on the neighbouring areas were assessed in the "Impacts study". Some public meetings were organised to debate and explain the different effects of the operation in the region.

Budgeting beach drainage methods

Feasibility costs

The costs of the previous studies of feasibility were around 40.000€ for each of the phases (System 1 and System 2). Total feasibility costs are 80.000€.

Environmental mitigation costs

No information available.

Investment and engineering costs

Costs of installation were around 400.000€ for the first phase and 290.000€ for the second.

Maintenance and monitoring costs

Costs of maintenance are reduced to those related with electricity used for water pumps and maintenance of the pump machine. For the system 1, the energy bill is around 10.000€ / year and maintenance is not more than 300€ / year. For the system 2, the two pumps spend around 15.000€ / year of electricity, as well as 600€ / year for machine care.

In a broad view, the total cost for the whole protected beach, including previous studies and installation, was near 760.000€ (excluding maintenance). The calculated cost for 10 years of running is around 916.000€ and 1.072.000€ for 20 years. Comparing with the maintenance of the seawall (60.000€ / year), the beach drainage system is less costly on the long term.

Limitations

No information available.

References

EUROSION (2004). *Sables d'Olonne. Eurosion Case study.* In: Shoreline Management Guide (http://www.eurosion.org)

L. Li and D. A. Barry (?). *Groundwater effects on sediment transport: a modelling study of the mechanisms underlying beach dewatering for erosion control.* School of Civil and Environmental Engineering, The University of Edinburgh, Edinburgh, EH9 3JN, U.K.