Converting seawalls into gravel beaches, Marina di Pisa, Tuscany - IT

1. Policy Objective & Theme

- ADAPTATION TO RISK: Preventing and managing natural hazards and technological (human-made) hazards
- SUSTAINABLE USE OF RESOURCES: Preserving coastal environment (its functioning and integrity) to share space

2. Key Approaches

- Knowledge-based
- Technical

3. Experiences that can be exchanged

The new strategy adopted has been promoted with the slogan “Back to the Beach”. It aims to quit building hard structures to defend coastal settlements and infrastructures from the shoreline retreat, and to improve the use of soft engineering (beach nourishment), allowing the removal of the existing hard structures. The replacement of hard structures by gravel beaches should provide a gradual return to a more “natural” landscape along the coast.

4. Overview of the case

In line with the tendency towards a softer approach in defending the coastline, some projects converting hard structures into gravel beaches have been carried out in recent years in Italy. A new coastal protection scheme has been developed at Marina di Pisa, Tuscany Region, lowering the existing detached breakwaters down to -0.50 m below m.s.l. and constructing a gravel beach in front of the seawall to absorb the energy of the waves over-topping the external structure.

5. Context and Objectives

a) Context

More than one third of Toscana beaches are affected by coastal erosion. Marina di Pisa is located on the southern arm of the Arno river delta (central Tuscany). The town was built in the 19th Century as one of the first coastal tourism settlements in Italy. The severe erosion characterising the area is a consequence of the reduction in the Arno River sediment load, from about 5.1 Mm3/year estimated between the XVI and the XIX Centuries, to about 100,000 m3/year in the last 10 years. Beach erosion began during the mid-XIX century at the delta apex and gradually expanded to adjacent beaches. Since 1881, along the unprotected northern arm of the delta, the shoreline has retreated approximately 1.3 km, reaching local peak values of 20 m/year between 1993 and 1997. At Marina di Pisa different types of breakwaters and seawalls were built during the XX century in order to stop shoreline retreat and to defend the town and the coastal highway from over-washing during storm events. The coastline of Marina di Pisa was artificially stabilized for 2.5 km by a continuous seawall structure close to the coastal road and by 10 detached breakwaters; a few groynes divide the protected coast into five cells of different sizes. As a result, over 5 km of hard structures defended 2.5 km of coastline. Nevertheless, although the coastline was stabilised, the nearshore was still eroding and in the offshore side of the detached breakwaters the sea bottom deepened to more than -7 m.

b) Objectives

The objective of the project was to create a more efficient and durable form of coastal defence, able to face the coastal

erosion and to prevent flooding of the coastal area during severe storms, but also to improve the resilience of the system and ameliorate the landscape. The project aims to prevent offshore dispersion of sediments, reducing wave reflectance, and to gradually return to a more natural coastal landscape replacing the hard structures built in the past.

6. Implementation of the ICZM Approach (i.e. management, tools, resources)

a) Project Management

The project was initiated in 1996 by the national agency for coastal defence (Ufficio del Genio Civile Opere Marittime – Ministry of Public Works), and was carried out with a joint effort of the regional government (Regione Toscana), local administration (Comune di Pisa) and University of Florence researchers.

Following changes in the Italian legislative framework, in 2006, the project was concluded by Provincia di Pisa administration with a Tuscany Region funding, implementing the original design with the results of a 3D physical model carried out at the Politecnico di Bari and financed by the Arno River Basin Authority.

b) ICZM tools

In the southern part of Marina di Pisa before the start of the works, laboratory wave channel experiments were performed by the University of Florence in order to prove the performance of the system even under extreme wave conditions. The first action was the construction of a gravel beach in front of the 330m long seawall downdrift of the breakwaters. This experiment provided a unique opportunity to study the morphological adjustment of gravel fill placed on a sandy shore to see if the reduction in wave reflectance helps transport sand onshore and see whether an unprotected gravel beach is stable in this coastal sector. Nearshore morphology seaward of the seawall was surveyed in October 2001, prior to the nourishment. Surveying was repeated in March 2002, two weeks after the nourishment was completed, and in January 2003. Topographic surveys were conducted from the backshore to a depth of 9 m along eleven cross-shore transects, spaced every 25 m. These data permitted comparison of shoreline position and cross-sectional profile change. In 2003, a new project started in the central part of the town consisting in the lowering of two detached breakwaters and the construction of two beaches in front of the seawall. Unfortunately, a 30-year recurrence-time storm hit the area in October 2003, when only 50% of the nourishment had been performed. Although detached breakwaters were not lowered yet, gravels were transported inland over the adjacent coastal road and due to this reason, the project faced strong opposition from residents who had to deal with this unpleasant and even hazardous situation, preventing its conclusion as foreseen.

In central Marina di Pisa, it was foreseen that a reduced wave reflection on the breakwater favours the elevation of the nearshore profile and a more effective wave energy dissipation; thus permitting the lowering of the structure (breakwaters) and, possibly, a decrease in the grain-size of the beach fill. The storm presented a 5.6 m significant wave height. As observed in the physical models, the limited gravel volume that had been loaded onto the beach so far was insufficient and did not give rise to a concave profile with a full developed berm crest. A convex profile formed instead, as a consequence of the water set-up generated in the area between the two existing hard structures, from where water overtopping the detached breakwater cannot easily exit. The unforeseen cessation of the project required further overall deep examination. The results were that, if the project would have been completed, the beach with the full volume of gravel required would have been able to sustain the high energy storm event occurred. An effective and constant dialogue between the University of Florence researchers, the Regional administration and the local communities (Provincia and Comune di Pisa) allowed and pushed for the project completion, which occurred in 2008.

7. Cost and resources

The first phase of the restoration works at Marina di Pisa was executed by the Municipality of Pisa in the southern sector of the town in January 2002. The marble gravel nourishment had a cost of approximately €750,000 and was financed by Tuscany Region. The first phase of the works executed by the Ministry of Public Works in the central part of the town in September 2003 had a cost of approximately €1.3 M. The second phase of the works, executed by Provincia di Pisa administration with Regional funds, initiated in December 2006 and ended in May 2008. The cost of the intervention, including gravel nourishment for 58,400 m3 (Marina di Pisa center) (116 m3/m of coastline), gravel nourishment for 40,000 m3 (Marina di Pisa south) (129 m3/m of coastline), detached breakwater lowering and new groyne construction, is approximately €5 M, including costs of project design, surveys and monitoring.

8. Effectiveness (i.e. were the foreseen goals/objectives of the work reached?)

Gravel beaches seem to be particularly adequate for urbanised areas strongly protected with hard structures. Due to their high efficiency and lower costs, artificially created gravel beaches may also prove an alternative where mass tourism needs to be redirected away from more environmentally sensible beaches. Marina di Pisa returned to have a beach again after many decades without one, and many of the local people are now re-using the area.

9. Success and Fail factors

In recent years the beach management in Tuscany has undergone an effective process of change, due to the new legislation which transferred the decision power to the Regional level. The new strategy proposes to quit building hard structures and to enhance the use of “soft” engineering (mainly beach nourishments) to prevent erosion. These interventions might only be operational in a longer time frame than the “hard” engineering ones and before their completion the area might be exposed to storms. The decision about the kind of intervention should be participatory within the local community. A morphological and sedimentological beach monitoring is presently being conducted along the entire coastline of Tuscany, with particular attention where coastal restoration interventions have been applied. This will give enough information to ensure a correct beach management and to evaluate the effectiveness of the new restoration strategies.

10. Unforeseen outcomes

The gravel beach was designed primarily as a defence structure, so the local administration did not lease space to bathing establishments and did not allow restaurant and bar owners to place umbrellas on the beach. Nevertheless, the gravel beach became intensively used during the summer season and improved the tourism receptivity of the whole area. In addition, this new beach closer to the town caused a reduction of tourism pressure on the most delicate zones in the neighbourhood. However, in spite of its high technical and economic efficiency (including the tourist added value), the choice of creating a new gravel beach to protect the coastline should be better considered within a more comprehensive scenario of coastal management where all stakeholder interests should be carefully examined.

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13. Sources

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