BEACH RESTORATION: sandy and muddy coasts

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Introduction

An attractive, high-quality beach has a long, wide and slightly curved bay-type appearance and consists of clean, yellow, well-sorted, fine to medium grained sand (0.2 to 0.4 mm); the beach slope is gentle up to a depth of about 2 m promoting spilling, breaking waves rather than plunging waves, which should not be much larger than about 1 m in the summer period. Rocky outcrops may be present on both ends protecting the beach against too strong wave attack from oblique directions. However, touristic beaches along erosion-dominated coasts often are relatively narrow strips of sand, protected by various types of structures (groins, breakwaters, etc.) resulting in small pocket-type beaches crowded by people in the summer period, see **Figure 1**.

Figure 1
Left: Mediterranean coast near Carrara (Italy) Right: Golfo de Morrosquillo near Covenas, Colombia

Sandy coasts

Narrow sandy beaches suffering from coastal erosion generally are mitigated by beach nourishments, artificial structures or both. In some coastal countries (USA, Denmark and The Netherlands) with sufficient sources of sand coastal erosion is primarily mitigated by intensive schemes of beach nourishment in line with the concept of 'building with nature' resulting in long, wide, attractive beaches.

At other locations with insufficient economic availability of sand, the presence of coastal structures often is a necessary solution to prevent or reduce long-term beach nourishment. However, these stuctures generally are seen as unattractive, visual elements blocking the view of the tourists. Furthermore, rip currents may be generated close to the tip of structures during windy conditions due to variations in wave set-up resulting in dangerous swimming conditions. The inefficiency of many traditional groin field systems in protecting the coastline, along with a much higher social importance nowadays given to environmental, recreational and aesthetic values, have caused a shift in beach developments. Modern landscaping ideas are focussed on the design of long and wide beaches with a minimum number of structures enhancing the natural appearance of the beach. Structures should be designed and planned as multifunctional facilities.

Some countries (Spain, Italy) around the Mediterranean have launched initiatives to adopt a new coastal policy of replacing the traditional small-scale groin fields by large-scale, more open recreational beaches, see **Figure 2** (Gómez-Pina, 2004) and **Figure 3**. This policy basically consists of the removal of ineffective and non-aesthetical coastal groins in combination with new beach fill operations, while keeping the terminal groins combined with a submerged or low-crested breakwater in the middle of the beach to give sufficient protection against wave attack. Such a design might offer a much better aesthetic solution at many places. This may also improve bathing safety as the larger waves will break on the low-crested, detached breakwater in the middle of the beach. Wave diffraction around the terminal groins will promote shoreline curvature towards both ends of the beach, creating a visually, attractive crescent bay-type beach.

Beach restoration requires close collaboration between coastal engineers and landscape architects to arrive at an attractive, sustainable coastal beach in harmony with its surrounding. Essential for a successful beach restoration project is a clear understanding of the local natural processes and environments, local societal demands and economical issues as a basis for the design of an attractive, high-quality beach.

Figure 2 *Example of the removal of a coastal groin system in Compostela beach (Spain) before (left) and after beach restoration (right); fill nourishment is included.*

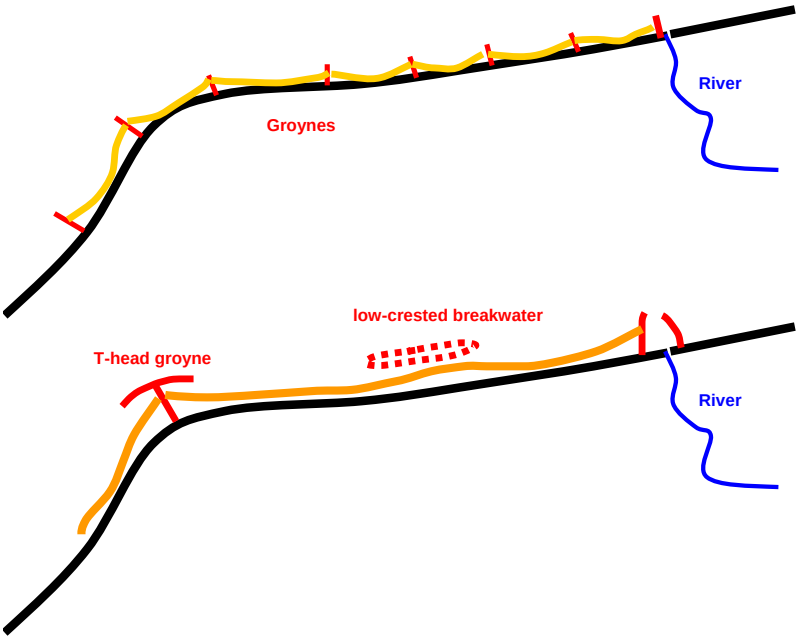

Figure 3. *Long, wide beach replacing small cell-type beaches*

The beach should be stable in planform to ensure minimum maintenance. This means that the beach orientation should be as much as possible perpendicular to the prevailing wave direction. The terminal groins should be designed to reduce wave attack on the beach and to reduce variation of the beach planform. Curved terminal groins promoting wave diffraction around the tip are more efficient than straight, perpendicular groins as they can protect a larger part of the beach while they are also more attractive from a visual point of view.

Detached or shore-parallel breakwaters can be used to protect the coastal cell on the seaward side, see **Figure 4**. These types of structures are built as offshore barriers parallel (occasionally obliquely positioned) to the shore protecting a section of the shoreline by forming a shield to the waves (blocking of incident wave energy). Emerged breakwaters cannot stop storm-induced erosion completely, as large storm waves will pass over the structure in conditions with high surge levels above the crest level.

The armour cover layer of artificial structures should consist of well-placed rocky elements rather than of dumped rip-rap materials for reasons of aesthetics, see **Figure 4**. Boulevards should be bordered by decorated ornaments of natural materials, see **Figure 4**.

Figure 4 *Groins consisting of rip-rap dumped rocks and well-placed rocks*

The selected beach fill material should be similar to that of the original beach; the percentage of fine and coarse fractions should not be larger than 1% to 3%. Well-sorted sand is prefered above graded sand because it has a much higher permeability promoting beach draining close to the water line. The water circulation and its influence on the water quality shuld have considerable attention during the design. Water circulation and wave penetration should be sufficient to prevent the gradual seasonal growth of seagrasses and/or slimey algae layers due to the deposition of fine sediments and organic materials. This may easily lead to a seabed covered

with a layer of soft sediment, which feels muddy when walking on it and which is unattractive for recreational purposes.

Muddy coasts

The coasts in the lee of barrier islands often are typified by relatively flat (1 to 200 and flatter) and muddy sand plains without much wave action (very low waves). An example of this type of coast is the Wadden coast in the north of The Netherlands and Germany. **Figure 5** shows the flat dry beach plains (low tide; tidal range of about 3 m) at the city of Cuxhaven just south of the mouth of the Elbe river in Germany. This type of coast can also be used for recreation by means of a narrow artificial sand beach (0.2 to 0.3 mm) which is situated at about 1m above the high water line. The beach width can be designed to be in the range of 50 to 100 m. The beach is protected by stone groins with a length of about 100 m and a spacing of 100 to 150 m, see Figure 5. To prevent erosion by alongshore winds, the beaches are separated by wind fenches (fagots) of 2 m high. The beach strip is backed by an elevated boulevard (width of 5 to 10 m) at a level of about +4 m above MSL. The protection against storm surges is a dike (with crest at +7 to+8 m above MSL) at the landward side of the boulevard, see Figure 5. Minor mud polution during the winter season can be mitigated by a new, thin layer of sand just before the next summer season.

Figure 5 *Muddy beach plain at low water (upper left and right) and artifical sand beach (lower left and right); Cuxhaven, Germany*