

CHAPTER 108

New types of shore protection. Possibilities of application along the coast of France

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ABSTRACT

The first part of this article gives an overview of the development works that have been carried out to date along the French coast, covering types, operating principles and impacts. A "philosophy" is identified with regard to the schemes implemented so far and those recommended for the future: rather than static structures that resist the action of the sea, it would often be preferable to substitute dynamic structures and schemes that work in harmony with it. Much research is being carried out on designs of this type. An analysis and summary of this work is given in the second part of this article. Most such work is currently at the experimental stage and no "miracle" solution has been found so far. Local conditions must be examined carefully before deciding to use any of the new alternatives being proposed.

1. INTRODUCTION

Until now, shore protection works on the French coast have usually involved the use of:

- rockfill, for transverse structures (groynes) and longitudinal structures on the upper beach (sea walls) or at sea (breakwaters),
- masonry or concrete structures (groynes, sea walls),
- beach nourishment, sometimes combined with stabilisation works (groynes, breakwaters).

The side-effects of these structures are not without drawbacks (for example, beach erosion), while blending them into the environment may pose problems.

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In order to combat these negative features, various new solutions have been proposed in outline and even implemented in different parts of the world.

The Service Central Technique des Ports Maritimes et des Voies Navigables (SCTPMVN) commissioned SOGREAH firstly to carry out bibliographical research into the various new types of protection and to make an objective critical analysis of them, and secondly to examine the possibilities of applying them along the coast of France.

The operating principles of the various processes have been grouped under five headings: action on the hydraulic medium, use of geotextile, artificial seaweed, gentle methods, miscellaneous.

2. THE FRENCH COAST: TYPES OF SCHEME - OPERATION

2.1 The need for development works

Coastal development works (other than at ports) have various aims:

Natural processes:

- protection against sea erosion (e.g. cliffs in the Caux region),
- protection of low-lying areas against flooding (e.g. Ile de Ré),
- protection against changes in shoreline (e.g. La Coubre spit),
- reclamation and polder construction (e.g. Mont Saint Michel).

Human activities:

- Development linked directly with tourist and resort activities, namely sea fronts (e.g. La Baule, Royan, Les Sables d'Olonne) or artificial beaches (e.g. Prado, Mourillon, Larvotto).
- Coastal defence works (sea walls, dikes, groynes).

2.2 Overview

The French coast comprises 3300 km of soft terrain (i.e. 59% of the total, including 2000 km of beaches and 1300 km of marshland) and 2300 km of rocky formations.

The structures built along the coast include:

- 1300 transverse structures (groynes), totalling 125 km,
- 800 longitudinal structures (sea walls and bulkheads), totalling 375 km.

The total length (500 km) represents about 10% of the entire coastline (5500 km), i.e. a mean density of 50 m/km. On the basis of 5000-10 000 French francs per linear metre, the present cost of these works would be 3-5 billion francs.

The greatest density of structures is found in regions where loose formations are prevalent and where there is intense resort development, for example 175 m/km in Lower Normandy and 155 m/km in Languedoc-Roussillon and the central Atlantic coast. It is lowest in regions with loose formations but little development, such as Aquitaine (85 m/km) or a broken rocky coastline, such as Brittany (63 m/km). In Provence, where the coast consists mainly (75%) of hard rocks, the density of 100 m/km corresponds to a great extent to artificial beaches.

2.3 Operation

It is particularly important and instructive to analyse the operation of these schemes. Indeed, such an analysis must form the basis for future designs and justify the use of new methods.

The schemes may be divided into two basic categories, namely static ("hard" structures, such as bulkheads and sea walls that are "opposed" to the sea) and dynamic works (consolidation, by-passing, dune development, which are an attempt at compromise). Until recently, static methods were the ones most commonly used. They have often had negative impacts connected with two main factors:

- insufficient knowledge of the natural phenomena involved, resulting in inappropriate, wrongly sized or badly situated schemes,
- consideration of problems at the wrong scale, i.e. by taking into account administrative and not sedimentological areas.

The following points should be stressed in particular:

- Longitudinal structures have broken the beach-dune links that helped to regulate beach evolution and contribute to beach nourishment. They have disturbed both transverse and longitudinal balances by introducing resistant points that have finished by creating protrusions which then suffer preferential wave attack.
- Sea walls and bulkheads are often located too close to the sea and have given rise to erosion as a result of wave reflection and breaks in the natural equilibrium profile of the sea bed.
- There are serious problems of erosion on the down-current side of groynes because of a shortage of sediment supply. This problem is never solved correctly.

Structures of this type have therefore often produced erosion processes requiring other types of remedial work. This all has a snowball effect. A few examples may be given:

- On the regional scale, the coastal regime in the Seine-Somme area has been strongly affected by the various harbour works implemented over the last 200 years and by widespread pebble extraction. What was once a

continuous stretch of coast 150 km long is now segmented by harbours, while the stock of sediment (pebbles) has been impoverished.

- On the local scale, most large beaches developed inside bays are being eroded, mainly on account of the negative effects of coastal development works (as at La Baule, Les Sables d'Olonne and Royan).

- Numerous small harbours have produced localised disruptions, in particular when they are situated inside bays, as at Bormes-les-Mimosas, Cavalaire or Pornichet.

Until now, dynamic (or so-called "gentle") methods have been used relatively infrequently, for two main reasons:

- They do not provide any "universal" solution. The more active the coastal regime, the more difficult it is to contemplate using them. For example, they would be well suited to many small bays in Brittany but unacceptable on the coast of Aquitaine.

- In addition to the initial investment required, they usually involve maintenance, which is rarely appreciated by local and regional authorities.

3. NEW METHODS

Over the past two or three decades, the financial aspects involved (protecting 1 km of coast now costs 5-10 million francs) and increasing environmental awareness have favoured the use of "gentle" methods and at the same time encouraged research into new ones, mainly of the dynamic type. The various methods now being considered, experimented or studied may be grouped into five broad categories:

- action on the hydraulic medium,
- use of geotextiles,
- artificial seaweed and planting,
- gentle methods,
- miscellaneous.

3.1 Action on the hydraulic medium

a. Modifications in wave propagation

Investigations have concerned:

- the recomposition of waves following artificial creation of a phase shift, the result of which is a transmitted wave carrying less energy than the incident wave: oscillating wall of water (PRINCIPIA),
- recomposition of cone-diffracted waves producing a wave front parallel to the coast (SOGREAH-LCHF study),
- reflection of waves on artificial bars (sand-filled geotextile tubes) according to the Bragg principle (NCEL).

These processes have all remained at the experimental stage as far as shore protection is concerned.

b. Attenuation of wave energy

Research in this field has concentrated more on various types of breakwater:

- submerged breakwaters,
- submerged moored floating breakwaters (Japan),
- pneumatic breakwaters (Great Britain, CIS),
- discontinuous pile-mounted breakwaters (CIS),
- miscellaneous types of breakwaters: tyres, cement pontoons, articulated breakwaters (Cornic, C1000).

Most of these studies have remained at the experimental stage. Often, the structures only operate correctly under specific hydrographic and oceanographic conditions.

c. Slightly reflecting structures

The function of these structures is to stabilise the coastline by limiting wave reflection and the formation of surf, which cause coastal erosion: Jarland caissons, Igloo blocks, ARC chambers (SOGREAH), Delta breakwaters (Berger Staemfli).

The results obtained are generally satisfactory.

3.2 Use of geotextiles in beach protection

The main types of mattress that have been tested are Armorflex, Nidaplast and Enkamat. The various procedures involving structures with a geotextile envelope are Longard, Sandtex, Robusta and Cornic. Most of these procedures are derived from those used in rivers or lakes and there have been many drawbacks in using them in a maritime context, such as stability and fragility of the textiles, damage of human origin, etc.

3.3 Artificial seaweed - planting

a. Artificial seaweed

So far, there have been no convincing results, although many tests have been carried out throughout the world.

b. Planting (in particular Posidonia)

Planting Posidonia is now well understood, but there are still problems with this technique in the field of coastal protection, including growth time and area of planting.

3.4 Gentle methods

Gentle methods are meant to work in harmony with the sea. Usually, they should be considered not as a basic solution but as a complementary measure. The main types include:

- development of dunes (a new solution includes stabilisation using a gel),
- the creation of artificial coastal strips (Maguelo),
- beach nourishment, which is an attractive solution that is still little used in France and which poses certain problems in terms of the quantity and quality of material used and maintenance,
- by-passing; this technique is virtually unused in France so far; there are problems in terms of installation, maintenance and cost price.
- acceptable coastline retreat; this solution can only be envisaged under well-defined coastal conditions (in particular geographic and economic). It must be acceptable to the authorities and persons concerned.

3.5 Miscellaneous

This heading covers many different methods, many of which are still at the experimental stage, for instance:

- drainage of the foreshore (Stabeach system),
- artificial reefs created by electrolysis,
- planting on clay breakwaters (using geotextiles),
- cylindrical groynes and breakwaters (SOGREAH).

4. CONCLUSIONS

Many solutions are currently at the experimental stage. There would appear to be no "magic" solutions. In fact, it would seem rather a case of looking at the positive aspects of developing and adapting systems that already exist but that are sometimes "forgotten" because of technical or financial problems (e.g. beach nourishment, by-passing).