

BEACH FILLS IN EUROPE - PROJECTS, PRACTICES, AND OBJECTIVES

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ABSTRACT: *The beach fill situation in five European countries is highlighted and discussed with respect to the general situation, project type and objectives, design and evaluation procedures, legal framework, and financial aspects. As expected, significant differences were found between the investigated countries. In general, the study shows that it would be very profitable for south European countries to learn about the Dutch and German practices, particularly regarding the long-term coastal management and the regular monitoring of the coastal morphology. On the other hand, recent Dutch experience has shown that their legal system is a bit too rigid leading to automatic local renourishments that are unnecessary to reach the global objective.*

INTRODUCTION

The present study is a part of a project called SAFE (*Performance of Soft Beach Systems and Nourishment Measures for European Coasts*), sponsored by the European Commission. The overall objective of the SAFE project is to develop a sound and improved methodology to predict the medium and long-term performance of artificial nourishment schemes by introducing reliable and validated numerical modeling tools (Hamm 1998). As a part of this project, an inventory of and a comparison between the major nourishment countries involved in the SAFE project was performed.

The objective of this particular study is to compile, disseminate and exchange national information on a European level concerning beach fill operations for coastal protection, projects involved, and practices used. Below follows a tour through the participating countries in Europe, in no particular order, to reveal the present situation. For each country, the general situation is briefly discussed together with an overall description of

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project types, objectives, design, and evaluation. In the concluding section at the end of this paper, a comparison between the different countries is presented, where common features as well as differences are discussed. This includes the more detailed design aspects - methods, considerations, constraints, and fill types, methodologies, and equipment.

BEACH FILLS IN GERMANY (DE)

Up until 1950, shore protection in Germany was mainly achieved through hard structures. The first fill in modern times was performed in 1951 on the Island of Norderney. Since then, there has been a gradual change from hard to soft protection measures in sandy coastal zones. After the first fill, more than 130 fills have been performed at 60 different sites (Figure 1) adding up to a total fill volume of about $50 \cdot 10^6 \text{ m}^3$.

The mainland of the German North Sea coast is protected by seadikes. Beach fills are carried out at sandy beaches which are predominant on the Eastfrisian and Northfrisian Islands in the North Sea and along the coastline of the Baltic Sea. The islands have to be maintained, because their existence is considered as large scale-natural barriers which protect the mainland.

Project Types and Objectives

Because the federal states in Germany have different protection policies, the project objectives may vary depending on location: 1. Soft protection of seawalls and revetments against local scour through toe nourishments. 2. Strengthening of dunes and beaches in order to keep shorelines at their 1992 positions (Dette 1987). 3. Preserve at all times a minimum natural dune width of 40-45 m. 4. Erosion mitigation. 5. Compensation of leerosion caused by coastal structures. These five types of projects are carried out in the framework of legal coastal protection by coastal authorities. In addition, local communities take initiatives to improve their beaches for recreational purposes.

Design and Evaluation

The design methods to meet the various objectives can all be classified into the category of generic templates. Refined design stage methods are at the very beginning of being considered as design tools. For the protection of the Westerland seawall on Sylt three unusual design types were developed (Dette and Gärtner 1987) including 1. a successful spit-type fill which extended seawards more than 350 m from the seawall, 2. a less successful, linear, 1.0-km long fill up to 3 m above MHW, and 3. the combination of both previous designs called a "girland-type" fill with satisfying results.

In general, coastal protection in Germany is done within a well-developed longterm strategy for actions along the coast. For most projects the responsible authorities are implementing follow-up programs. However, serious overall performance evaluation programs are still not used to any extent, but only in some special cases.

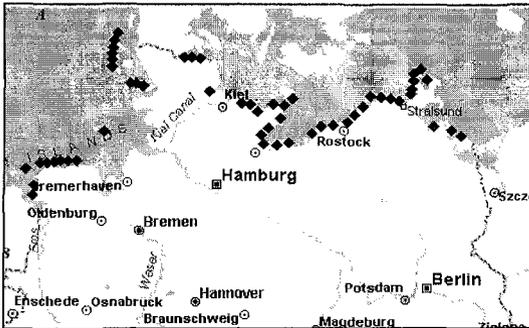


Figure 2. Documented beach nourishment sites in Germany. The ◆ denotes a beach fill site.

these regulations differ in certain aspects, the national Government has not yet made any use of the Conflicting Legislation Act.

The national Government, being aware of its overall responsibility, financially supports the coastal protection works of the coastal federal states. This support is subsidiary, i. e., national funds are only granted if matched by funds from the concerned federal states.

In 1969, Article 91a was amended to the Constitutional Law of 1949. In this Article the co-operation between the national Government and the federal states was legally established by means of "Joint Tasks". Such tasks have to be classified as being of national importance and as being necessary for improving the standard of living. Coastal protection has been identified as such a Joint Task and, thus, included in article 91a. The national financial share in these tasks was fixed at 70 per cent.

The protection of sandy coastlines against storm surges and erosion by means of repeated beach fills and nourishments is handled individually by the coastal federal states in terms of "General Protection Guidelines" or site specific master plans. Since 1950 more than 95 % of all nourishment sites in Germany have been benefiting from those regulations. The rest, e.g. small fill projects for mostly recreational purposes, are financed by local authorities on the basis of their own interest. Within this legal scheme, the economy of coastal protection projects is not dealt with. Until this day economic justification of such projects is not obligatory.

BEACH FILLS IN ITALY (IT)

In Italy, modern beach fills have been practiced since 1969. During this period about 50 fills have been performed at 36 sites (Zaggia, 1998) adding up to a total fill volume of about $15 \cdot 10^6 \text{ m}^3$ (Figure 2). A large majority of these fills are small-size interventions around $100 - 150 \cdot 10^3 \text{ m}^3$. The exceptions are four large interventions at Cavallino and Pellestrina near Venice ($7.6 \cdot 10^6 \text{ m}^3$), Ravenna in the Po river delta ($1.4 \cdot 10^6 \text{ m}^3$), Ostia close to Rome ($1.4 \cdot 10^6 \text{ m}^3$), and Bergeggi on the Italian Riviera ($2 \cdot 10^6 \text{ m}^3$).

Legal and Financial Aspects

German coastal protection is regulated by the Constitutional Law in terms of a Conflicting Legislation Act. The national Government may apply this right, if a matter is not regulated effectively by federal law or if the legislation of one state interferes with the legislation of other states or that of the entire nation. The five coastal federal states have formulated special regulations for coastal protection in their federal legislation. Although



Figure 2. Documented beach nourishment sites in Italy.

Project Types and Objectives

Almost all projects comprise of a combination of sand nourishment and hard structures (Benassai *et al.* 1997). These different projects may be attributed to one of the following general objectives: 1. Erosion mitigation at local scale. 2. Enhanced recreation at very small scale. 3. In southern Italy there is often the need to safeguard the coastal railway. These interventions may, almost generally, be regarded as remedial (counter-active) rather than preventive (pro-active) measures, i.e., emergency-type actions are taken as problems are identified along the coast without any

long-term planning or overall strategy.

Design and Evaluation

Most projects are based on a generic design with a combination of hard and soft structures. Most minor projects are designed by simple scoping methods utilizing crude evaluations of shoreline retreat rate together with an evaluation of the equilibrium slope. In larger projects, somewhat more refined design methods are used, where a crude evaluation of the longshore sediment transport rate is combined with detailed computations of the volume budget. In addition, the Dutch CUR (1987) manual is consulted for determining longterm trends, renourishment intervals, *etc.*

Physical model tests are quite common in larger projects. However, numerical models are not used, with the exception of the Pellestrina and Cavallino projects where, to some extent, such models were used. These projects were, however, undertaken in the particular framework of the Special Law for the Safeguard of Venice. In general, monitoring is only limited or not done at all. Also, there is no established methodology for maintenance schemes and no actual performance evaluation is made for the projects.

Legal and Financial Aspects

In Italy, coastal waters and beaches are State owned. This means that initial costs have generally been attributed to the State, while the regional Governments are responsible for maintenance and associated costs, at least formally. Exceptions to the attribution of the maintenance costs are the rule, typically based on the occurrence of extreme events which require the support of emergency measures (with funds coming from the State). Revenues go to the Municipalities. In the past there were hardly any cost-benefit analyses of

projects. What is most evident is, thus, the discrepancy between who is paying and who is receiving the benefits. The situation is anticipated to change in the future.

The Law of 1907 distinguished between two types of coastal defenses, those to protect built-up areas and those to halt beach erosion. Concerning the former, the local planning authority is in charge and can obtain financial support from the Ministry of Public Works, once its operative sections have considered the works to be technically feasible. In the second case, both the Municipality and the Port Authority can apply for financial supports from the Ministry of Public Works in order to build up the defenses.

The Decree Law of 1985 restricted development to 300 m inland from the high water mark. The regions were requested to issue territorial and landscape plans aimed at regulating the uses of these areas and at ensuring their sustainable exploitation. Stabilization of the dunes in order to protect the hinterland is now being considered.

New legislative developments are expected by the application of the so-called "Coastal Plan", currently under preparation by the Ministry of the Environment. Other new legislative developments, that could eventually go in the direction of "Coastal Zone Management" are also expected following the possible adoption of the Strategic Environmental Assessment for the coastal zone and the transfer of competence from the State to the Regions (Law of 1997).

BEACH FILLS IN THE NETHERLANDS (NL)

In the Netherlands, modern beach fills have been practiced since 1970. During this period about 150 fills and refills have been performed at about 30 sites adding up to a total fill volume of about $110 \cdot 10^6 \text{ m}^3$ (Figure 3). Since 1991 the average fill volume amounts to about $6 \cdot 10^6 \text{ m}^3$ per year.

The Netherlands have struggled for many centuries to safeguard its territory from flooding. The western part of the country is below mean sea level. Large portions of the Dutch coast are receding since long. Historically, this recession has been stopped at some places with dikes, whereas at various other places no strict measures have been taken, or the recession has merely been slowed down with groins and fences. Thus, in general, the policy was previously one of selective retreat. The disastrous flooding in 1953 of large parts of the south-western part of the Netherlands led to a change of this policy. New legislation concerning minimal safety standards for the coast against flooding was adopted.



Figure 3. Documented beach nourishment sites in the Netherlands.

A further step in this direction was taken in 1990 when the policy of Dynamic Preservation was adopted. This was based on the presumption that it is technically and economically possible to compensate natural erosion of sandy coasts by nourishment. Prior to this policy, most nourishments were done for reinforcing dunes against breaching.

Project Types and Objectives

After adopting the Dynamic Preservation policy, the overall objective has been to preserve the 1990 coastline location through nourishments on a national scale. Thus, policy implies that the future coastline should nowhere be landward of the 1990 position. When required, sand is nourished to warrant the latter.

Design and Evaluation

The responsibility for coastal protection in the Netherlands is divided between national (Rijkswaterstaat which also have local offices) and regional authorities, so-called Water Boards. A local Rijkswaterstaat's body designs the nourishment and produces a blue print covering all aspects to be taken into account by a contractor, such as place of sand mining, shape of the nourished profile, i.e., how much sand has to be placed in each profile, in which time-frame the work should be performed, *etc.* Thus, the design is very strict and with little variation from site to site (CUR 1987).

The principal design parameters are nourishment volume, depending on the rate of autonomous erosion and the requested lifetime and the effectiveness factor of nourished sand. The latter is defined as the ratio of the autonomous erosion rate before to the actual erosion after implementation of the nourishment. Beach nourishments are designed to compensate for the natural loss of sand in a coastal stretch for a defined period of time to come. The amount of sand is, thus, calculated by multiplying the design lifetime with the annual loss derived with the regression over the previous 10 years. The amount is then corrected with a site-dependent effectiveness factor (10%-20%) to account for the possible slightly increased erosion rate after the nourishment, compared to the autonomous one.

The coastline is obtained from a measured sand volume rather than from an observed horizontal line such as the MLW. This volume is contained in a horizontal layer and is bounded by the profile and a fixed vertical reference line. For some places one has deliberately defined another position, more seaward, to ensure that the safety or a required beach width is automatically warranted as long as the coast line meets the 1990 criterion. In addition, the safety against flooding is checked every year, on the basis of the measured profiles. The evaluation of nourishments is based on annual surveys, performed along the entire Dutch coast since 1965, with cross-shore profiles 200 to 250 m apart. During the operations the treated sections of the nourishment site are surveyed before and soon after their treatment, in order to achieve proper nourishment volume values.

Legal and Financial Aspects

The Sea Defense Law of 1996 regulates the responsibility for maintaining the safety against flooding and the division of tasks between Government and regional authorities. Maintenance of the primary sea defenses is handled at a regional level, through the Water Boards who are supervised by the provinces. Because of the national interest of safety, the

Minister of Transport, Public Works, and Water Management has the overall supervision. For dune systems, a large part of the profile is considered to make up the primary defense, from the shoreface to the landward side of the first dune. The local Water Boards are in first instance responsible for the dunes while the Government has to maintain the coast line. This approach obviously requires close collaboration between the two levels, which takes place on a provincial level in the so-called Provincial Consultative Bodies (POK's), each consisting of representatives from the province Government, the local Water Board(s), and the Rijkswaterstaat. The provincial authorities chair the POK's to ensure that the coastal management is in line with the regional planning policy. According to the Sea Defense Law, the dune profiles are measured each year and whenever the standards are not met, measures will be taken with a high priority.

The local Rijkswaterstaat's authority is also responsible for numerous permits needed. They have to be granted by local municipalities, Water Boards, *etc.* They concern amongst other things permission to work in the areas, such as installing pipelines and pumping stations. There may be regional differences. For example, in one province the beach has remained under the jurisdiction of Rijkswaterstaat, for the specific reason of controlling the permits to work there, while in another it has become part of the Water Board's responsibility. Fortunately, with the present day experience, obtaining these permits is a routine operation.

In the policy of Dynamic Preservation the Minister of Transport, Public Works, and Water Management has to inform parliament every 5 years about the results of this policy. A first (interim) report was provided in 1993, a first full report in 1995, while the next one is foreseen for the year 2000. The policy will be continued for the time being. With the maintenance scheme built into the legal structure, little economic justification is necessary for individual projects.

BEACH FILLS IN FRANCE (FR)

In France coastal defense works are quite significant but nourishment is only a marginal technique adopted to control the erosion. A recent inventory (Hamm *et al.* 1998) showed that modern beach fills have been practiced since 1962. During this period about 115 fills and refills have been performed at 26 sites adding up to a total fill volume of about $12 \cdot 10^6$ m³ (Figure 4). This very limited quantity reflects that most coastal defense works in France still comprise the construction of groins, seawalls and detached breakwaters.

Project Types and Objectives

The French approach of beach nourishment is traditionally to couple it with hard structures as supporting measures to minimize sand losses and maintenance. In addition, in the most important nourishment projects, the nourishment option was chosen on the basis of the desire to get rid of available sand dredged to maintain navigable depths in a nearby harbor. A slight change of policy may possibly be reflected in two recent projects representing a new approach with much less supporting measures and allowance of an annual loss of material (implying some periodic renourishment).

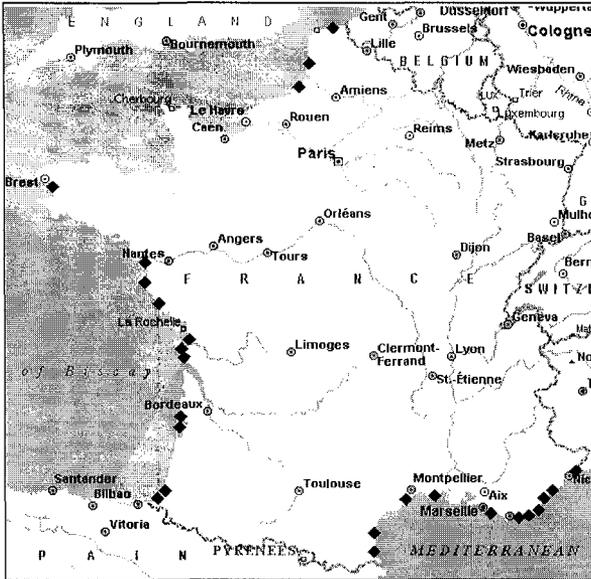


Figure 4. Documented beach nourishment sites in France.

Project motivations include the creation of recreational beaches, coastal defense, dune restoration, and, as mentioned above, the use of dredged sand from harbor extensions or maintenance. No difference is made in practice between protection against flooding and stabilization of the shoreline. In general - as in Italy - the measures may be classified as remedial rather than preventive.

Design and Evaluation

Design methods of coastal defense works are rather well developed in France. The survey of the

completed projects has shown that detailed design studies have been performed for 15 cases. Typical design is based on classical coastal engineering concepts (SPM 1984) but includes also environmental considerations.

The movable bed scale model is the traditional tool in France to perform morphodynamic impact investigations since 1950's. Shoreline numerical models are also being used in recent years to study large-scale evolutions. In several cases, *in situ* tests have been performed to check the design. However, the monitoring after nourishment is in most cases not systematic. The monitoring program is not planned in advance and is often not comprehensive. Topographic surveys are quite frequent for dune and beach nourishments. However, they are typically not complemented by bathymetric surveys. The wave climate is seldom recorded but international databases (synopships, satellite data) as well as hindcast techniques are used.

Legal and Financial Aspects

The Law of 1807 specifies that the Ministry of Public Works shall certify the necessity of coastal defense works. All costs incurred for coastal defense works shall be borne by the protected landowners in proportion to their interests, except in cases where the Government decides that subsidies from public funds would be advisable or merited. In practice, such subsidies have usually been extremely small, owing to the limited financial resources generally devoted to coastal defense works. This law also sets out guidelines for the so-called "compulsory" associations that are responsible for having these works carried out and maintained. It has always been difficult to put these laws into effect, which has

given rise to the saying that "France has no coastal defense system, only expenses". (De Rouville, 1954).

Since 1970, the certification is now provided by the local representative of the Government with possible funding (10 to 30%) in cases of the defense of urbanized areas. Such funding is, however, exceptional. The Law of 1973 allows local communities to take initiatives in this area when common interests are threatened. In practice, local municipalities are nowadays in charge of coastal defense works with possible partial financial support of regional authorities. As a consequence, there is no national coastal management in France and no national standard for doing beach fill design and evaluation. Each project is managed according to prevailing and local conditions. On the other hand, mentalities are slowly changing and many regional funders are now becoming aware of the necessity to think regionally before funding locally.

The Law of 1977 was aiming at the protection of nature and institutes an environmental impact assessment study when the budget of works exceeds 1 million ECU. Further legal texts improved the accreditation procedure including public inquiries, concertation and administrative procedures when the works occupy a surface over 2,000m². In practice, the financial threshold is not reached and the surface area threshold is difficult to define. Thus, nourishment projects escape to this law. So, in practice, accreditation procedures are seldom in effect for nourishment operations in France.

The so-called Littoral Law of 1986 extends the concept of coastal defense works to natural sites with an accreditation procedure when the budget of works exceeds 0.15 million ECU. It also forbids new artificial beach developments and protects the natural state of the coastline. Furthermore, the coherence between the earlier laws and the new environmental laws needs improvements which are reported to be in progress.

BEACH FILLS IN SPAIN (ES)

Practically the entire Spanish Mediterranean coast is, a sandy coast (Lechuga 1994). The principal causes of erosion along this coast is the interruption of the sand transport by numerous harbor installations. Modern beach fills have been practiced only since 1983. During the last five years alone more than 600 fills and refills have been performed at about 400 sites adding up to a total fill volume of about 110·10⁶ m³ (Figure 5). The vast majority of the projects are along the Mediterranean coast.

Project Types & Objectives

Beach fills are usually done without any supporting structures. In some cases detached breakwaters are used. In quite a few cases existing detached breakwaters have been removed in connection with the nourishment project. Being a nation with a significant portion of its income based on tourism, the overall objective of these nourishments is connected to recreational space rather than the exact position of the shoreline or concerns about flooding. Thus, the objective may be stated as: "The dry beach width must exceed 60 m at all times for recreational reasons". As for the French and Italian cases the measures are mostly remedial rather than preventive.

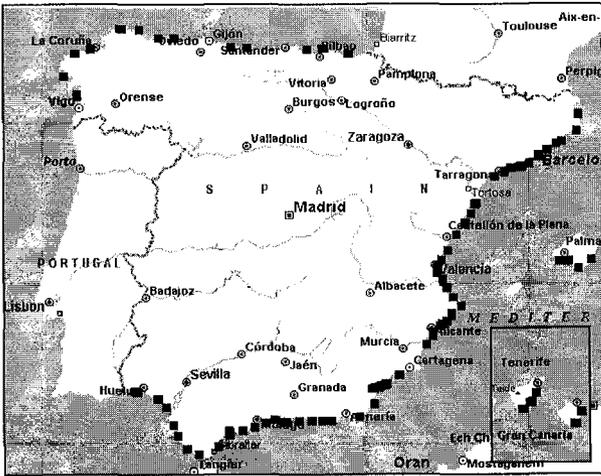


Figure 5. Documented beach nourishment sites in Spain.

Design and Evaluation

The overall Spanish design type may be classified as profile translation. Numerical or physical models have only been used in a few important projects. Similarly, follow-up studies, including annual bathymetry and grain size studies, are only performed for these major projects. In the design process, environmental concerns seem more important than engineering aspects.

Legal and Financial Aspects

The financial processes involved in beach nourishment are regulated by The Shores Act of 1989, according to which all beaches in Spain are State owned. This Act states that works within the jurisdictions of the central Government shall be financed by proper budgetary appropriations and, if applicable, with contributions from the regional Governments, local Governments, international organizations, and private parties. The Shores Act imposes severe restrictions to build and develop in a "protection zone" 100 to 200 m inland from the beach.

In practice, almost all nourishments are financed by the central Government, because, according to the Shores Act, the coastal defense is strictly its responsibility. In some projects, with a more infrastructural rather than pure protective character, such as beachfront promenades, regional and local Governments may contribute financially jointly with the central Government. In the near future, more of the coastal works are going to be considered as parts of an integrated coastal zone management process. A first example of this could be seen in the management of the Castellon coastal zone project.

COMPARATIVE RESULTS

Rates and Volumes

There are big differences in nourishment fill rates and volumes between the investigated countries. Table 1 shows number of fills, fill rates and volumes for the respective countries together with the year when beach modern nourishments were introduced on a more regular basis. As seen from the Table, Spain and the Netherlands are by far the biggest nourishing countries in Europe. The most distinguishing difference between the two is that the sand in the Netherlands is placed on a few locations, while in Spain the

sand is portioned out over a large number of smaller sites. Table 2 shows the present annual fill rates for the above countries together with estimations of the corresponding numbers for some other countries around the world.

Country (start year)	Total volume (10^6 m^3)	No. of fills	No. of sites	Average volume/ fill (10^3 m^3)	Average volume/site (10^6 m^3)	Fills/site
FR (1962)	12	115	26	104	0.5	4.4
IT (1969)	15	36	36	420	0.4	1
DE (1951)	50	130	60	385	0.8	2.1
NL (1970)	110	150	30	733	3.7	5
ES (1985)	110	600	400	183	0.3	1.5

Country	Annual fill (10^6 m^3)	Country	Annual fill (10^6 m^3)
FR	0.7	Denmark	3
IT	1	Great Britain	4
DE	3	Japan	0.5
NL	6	South Africa	0.5
ES	10	Australia	1
		USA	30

Thus, the total annual rate of the European countries adds up to about $28 \cdot 10^6 \text{ m}^3$, which is about the same volume as that for the USA.

Design Parameters

The Tables below show a first attempt to classify the design parameters taken into account in the respective countries. Table 3 indicates which wave and sediment related conditions that are included in the design process where the parameters listed are: Storm = storm surge levels, Q_L = longshore sediment transport rates, Run-up = run-up levels, D_C = depth of closure, Waves = wave height (and direction), Sed. dist. = spatial distribution of sediment grain size, and Aeolian trsp. = losses of sediment due to aeolian transport. Table 4 shows which fill properties and procedures that are explicitly taken into account in the nourishment design.

Table 3. Design Considerations for Coastline Maintenance in the Respective Countries

	FR	IT	DE	NL	ES
Storm	Y	Y	Y	N*	N
Q_L	Y	Y	Y	N	Y
Run-up	Y	N	N	N*	N
D_c	Y	N	N	N	Y
Waves	Y		Y	N*	Y
Sed. Dist.	Y		Y	N*	Y
Aeolian tpt.	N		Y	N	N

* considered for safety nourishment, not for coastline management.

Table 4. Design Elements in the Respective Countries

	FR	IT	DE	NL	ES
H_B	Y	Y	Y	Y	Y
W_B	Y	Y	Y		Y
Overfill	Y	Y	N	Y	N
Vol./m	Y	Y	Y	Y	
Transition	N	Y	Y	Y	
D_B/D_N	>1	1	>1	≥1	>1
Structures	Y	Y	N	N	Y/N
Ren. period (yr)	N	N	~5 - 7	~5	
Follow-up	N	N	Y	Y	Y/N
Perf. eval.	N	N	Y/N	Y	N

where H_B = berm height, W_B = berm width, Overfill = the use of overfills, Vol./m = volume of fill per m of beach, Transition = the use of transitions at the lateral ends, D_B/D_N = grain size of borrow material relative to the natural sediment grain size, Structures = the use of supporting structures, Ren. period = calculated renourishment period, Follow-up = the use of follow-up programs, and Perf. eval. = the use of performance evaluation programs.

OVERALL CONCLUSIONS

The Tables above are hard to evaluate as they still only present *which* parameters that are taken into account, not *how*. Countries, such as Italy, that consider more parameters may seem to perform a more thorough design than others. However, it could also indicate that these countries improvise more from cases to case than others, such as the Netherlands, that has a more consistent design. Also, the number of parameters *needed* to be taken into account certainly reflects the degree of varying conditions from site to site, which is of course smaller in the Netherlands than in Italy.

Beach Fill Practice

There are - as expected - significant differences between the investigated countries regarding 1. Engineering methods and evaluation procedures, 2. Overall coastal management strategies (which are very developed in some countries and virtually non-existing in others), and 3. Legal and financial framework. The following more specific remarks can be made concerning the different national characteristics:

- NL is the only country that has a serious overall performance evaluation program integrated into their legal framework.
- NL and DE have developed a long-term strategy for actions along the coast and are implementing thorough follow-up programs.
- ES has a fairly well-developed organization and a long term philosophy for their actions, but anticipate to run into problems of finding suitable borrow areas in the near future.
- ES, IT and FR all apply a strategy of remedial rather than preventive measures and seem to suffer from a lack of overall long-term strategy, coastal management, regular monitoring of the coastline, as well as a comprehensive survey of available borrow areas.
- IT and FR suffer from a lack of financial support for regular renourishments.
- IT experiences unclear commitments and sharing of responsibilities between the Ministry of Environment and the Ministry of Public Works.
- All investigated countries foresee a continued transfer from hard to soft measures and regard beach nourishments as an effective means of coastline preservation.
- Nourishments are expected to continue over foreseeable future in all participating countries.

The SAFE project is contributing to disseminate the experience of each of the participating countries in Europe and to promote an integrated and large-scale approach of these problems. The present study shows that it would be very profitable for south European countries to learn about the Dutch and German practices, particularly regarding

the long-term coastal management and the regular monitoring of the coastal morphology. On the other hand, the recent Dutch experience has shown that their legal system is a bit too rigid leading to automatic local renourishments that are unnecessary to reach the global objective.

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