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Cross-references

Beach Nourishment
Beach Use and Behaviors
Coastal Zone Management
Demography of Coastal Populations
Economic Value of Beaches
Human Impact on Coasts
Sea-Level Rise, Effect
Shore Protection Structures
Small Islands
Tourism and Coastal Development

DIKES

Introduction

Dikes, especially sea dikes, are coastal constructions build to avoid flooding. The risk of flooding is detrimental to the safety of people and economic, cultural, and ecological values. This aspect has been of great importance since people first thought about defending their dwellings against flood hazards. In the distant past, dwelling mounts were built to protect families or small communities from the sea. They are known from several low-lying coastal areas in the world, for example, from the North coast of Germany and the adjacent Dutch coast, where they have been occupied ever since 2500 BP, as well as from the chenier coast of Suriname, where they date back to 1800 BP.

Population increase urged to a more active method of flood prevention. The people started to construct dikes to keep the water out of whole regions, thus protecting lives and properties against the sea. In the Netherlands, dikes have been built as a community activity from about AD 1100. Ever since, coastal defense has become more and more an engineering activity. Presently, the design criteria for sea dike construction are determined by three important groups of aspects: hydraulic, subsurface, and construction. The first two groups mainly determine the required height and strength of the dike. The last group of aspects is particularly important for the dike's duration of life. Details about the various aspects are given by U.S. Army Corps of Engineers (1984).

Hydraulic aspects

Hydraulic factors influencing the marine water level at small temporal scales are the tidal range, wave height, wave run-up, and the setup of the water level due to wind conditions. Because dikes have to be calculated for extreme water levels, especially a coincidence of extreme conditions of these factors are at stake, for example, high-water spring tide and wave characteristics and setup of the water level during storms. For the establishment of extreme water levels, high-water exceedence frequency curves are used. This method is based on the finding of a systematic relation between the height of a flood-tide level and the number of times this specific level occurs in a century. Extrapolation of the high-water exceedence frequency line enables a probability calculation for the chance that an extreme high-water level, not observed before, may occur. Moreover, the effects of long-term changes in sea level and storm frequency must be taken into consideration.

The final height of a sea dike is determined by the degree of risk of flooding, within the applied economic constraints, the community is willing to accept. In the Netherlands, for instance, the sea defense system is at "Delta height." However, for the distinguished coastal sections of the Dutch coast this "Delta height" has different values. For the uninterrupted West-coast, which protects the most densely populated and economic heart of the country, the minimum height of the dunes and dikes is determined by a water level exceedence chance of 1 in 10,000 years. For most of the barrier islands in the north of the country the "Delta height" corresponds with a high-water exeedence chance of 1 in 2,000 years.

Subsurface aspects

Subsurface aspects like subsidence and tectonic movements codetermine the behavior of the sea level. The Netherlands, for instance, are suffering from a relative rise in sea level, which is the combination of the eustatic sea-level rise and the subsidence of the land (Jelgersma, 1961). Subsidence in this case is mainly due to the isostatic rebound after the last glaciation and the dewatering of the peaty subsoil in the coastal area for agricultural reasons, resulting in compaction. Especially in the past, this drainage has contributed to the general subsidence. At the same time, the central part of the Dutch coast is influenced by a graben system.

In the decision-making of the final height of a sea dike, the compaction of the subsoil due to the weight of the overlying dike body has also to be considered, as well as some compaction in the dike body itself.

The composition of the subsoil is relevant with regard to groundwater flow. A dike is meant to be impermeable for water. However, groundwater can be pressed to flow through the subsoil underneath a dike, due to a difference in hydrostatic pressure on both sides of the dike. The flow velocity depends on the volume of the overhead and on the permeability of the subsoil. This seepage causes saltwater intrusion landward of the dike. In case the currents are sufficiently strong to erode the underlying sediment, this process affects the stability of the dike and ultimately may result in the collapse of the dike.

Construction aspects

The construction of a dike requires building material. In the past, the preferably clayey material was locally dug. Nowadays, however, dikes usually have a sand nucleus, covered by clay to make it impermeable. Suitable clay usually is scarce, whereas sand occurs in large quantities. The advantage of this method is that sand not necessarily needs to be transported on a truck, but can be supplied in suspension by pipeline.

Because of the difference in hydrographic pressure on both sides of a dike, a groundwater table is formed in the sandy dike body. Although the clay cover has to be impermeable for seawater, it must simultaneously be able to let an excess of water from inside the dike through.

Generally, dikes have a delta form. To reduce the effect of wave run-up, the slope of the seaward bank of a dike has to be small. On the contrary, the width of a dike increases in that case. A balance has to be found between cost and safety.

In the flood disaster in the Netherlands in 1953, the effect of overtopping water on the landward side of the dikes appeared to be the most important cause of dike failure. In order to reduce the effects of overtopping water, for example, the penetration of water into the center of the dike body, various degrees of unevenness can be applied.

To avoid erosion of the banks and undermining of the dike body revetments are applied. Usually these revetments are provided with a filter layer, to prevent erosion of the underlying material. Permeable as well as impermeable revetments are applied. It is necessary that the material used is flexible and tight to follow the compaction of the underlying sediment.

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Cross-references

Cheniers
Coastal Subsidence

Geotextile Applications
Hydrology of Coastal Zone
Meteorologic Effects
Polders
Sea-Level Rise Effect
Shore Protection Structures
Storm Surge
Tides
Waves

DISSIPATIVE BEACHES

Definition and classification

Dissipative beaches are systems where most wave energy is expended through the process of breaking. Guza (1974) was apparently the first to use the term dissipative beach. He indicated that the wave-energy status of a nearshore system could be determined using the surf-scaling parameter, ε:

$$\varepsilon = \frac{\alpha\omega^2}{g \tan^2 \beta}$$

where α is the wave amplitude at breaking, ω is the wave radian frequency ($\omega = 2\pi/L$, where L is wave length), g is the gravity constant, and β is the beach slope in degrees. The proportion of incident wave energy that is dissipated by breaking increases as ε increases. When ε is less than about 2.5, most wave energy is reflected off the foreshore. For beaches where ε is larger than 20, most energy is dissipated by the turbulence associated with wave breaking. Guza (1974) designated these latter beaches as dissipative. Thus, the relative degree of dissipation or reflection of incident wave energy in a nearshore system may be used as a rationale for the classification of beaches. This is usually accomplished under the rubric of nearshore morphodynamics.

Morphodynamics

The concept of nearshore morphodynamics was developed to characterize systems where form and process are closely coupled through feedback mechanisms. On beaches, waves (*q.v.*) interact strongly with sediments and morphology, and the form of wave breaking is one manifestation of these interactions. For constant wave steepness, H/L (where H is wave height), the breaker type will change as the nearshore slope changes. On a very low gradient slope, spilling breakers would be expected. As the gradient increases, there should be a progression through plunging and collapsing breakers. Finally, on very steep beaches, surging breakers should occur (Galvin, 1968). For a constant nearshore slope, the same sequence of breaker types will occur as wave steepness decreases. Breaker type is closely associated with the expenditure of wave energy in the nearshore (e.g., dissipation or reflection) and the development of nearshore morphology. The morphology, in turn, controls breaker type. These relationships are the underlying bases for the concept of nearshore morphodynamics (see summary by Wright and Short, 1984). The recognition of characteristic sets of dynamic relationships provides the basis for using morphodynamic regimes (or states) as a means for classifying beach types. For example, spilling breakers tend to occur on dissipative beaches. This contrasts with reflective beaches (*q.v.*), where collapsing or surging breakers are common. Plunging waves tend to occur on the intermediate beach states of the morphodynamic model, where neither dissipation nor reflection dominate the response of nearshore morphology.

Characteristics of dissipative beaches

In cross section, morphodynamically dissipative beaches display the classic forms of "storm" or "winter" beach profiles (e.g., Sonu and Van Beek, 1971). According to Wright and Short (1984), other distinguishing characteristics include low gradient nearshore and beach slopes—about 0.01 and 0.03, respectively, and with relatively fine sediment sizes. Dissipative beaches tend to have a substantial sediment volume and at least one linear nearshore bar, although multiple bar–trough systems are common. In dissipative systems, the beach and nearshore zone will exhibit minimal alongshore variability—the system is approximately two-dimensional. Incident wave energy is maximum at the break point, and decreases shoreward. The classic dissipative system displays several coincident sets of spilling breakers (Figure D36), and there is minimal energy remaining at the landward extremity of uprush. Infragravity motion dominates the inner surf zone, and frequently causes linear scarping of the foreshore (e.g., Short and Hesp, 1982). On meso- and macrotidal beaches, the nearshore may be dissipative only at lower tidal stages and reflective at high tide (Short, 1991; Masselink and Hegge, 1995). Short and Hesp (1982) have also linked the dissipative beach state to the formation of large-scale transgressive dune sheets—at least in the Australian context. This linkage was a key development for the derivation of later models of beach–dune interaction (e.g., Sherman and Bauer, 1993).

Douglas J. Sherman

Figure D36 The dissipative beach system at Rossnowlagh, Co. Donegal, Ireland. Note the low-gradient beach slope and multiple lines of spilling breakers. Maximum breaker height is approximately 1.5 m, and period is about 7 s.