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Beach Drainage System

Wave Climate and Erosive Forces

Beaches are temporary geological features composed of an accumulation of rock and shell fragments, ranging in size from fine sand to large boulders. Because the accumulation can be moved by changing wave action, the beach morphology is a dynamic one.

Many shorelines throughout the World are experiencing shoreline retreat due to damaging actions related to storm waves and their resulting generated currents.

The height of wind-driven waves depends on the wind speed, duration, fetch length and water depth. The wind waves, however, loose their energy when they move into shallower water near the shore. The wave period remains constant while the forward speed and wave length decrease. The wave height slightly increases and wave front steepens when the wave begins to 'feel the bottom' and its gently rolling shape sharpens to a series of pointed crests with intervening flat troughs.

When the wave height is about 80 percent of the water depth, the wave can no longer steepen and it is forced to break. After the break the wave flattens out and surges up the beach face in the swash zone. The location of the break point is a function of the wave height, period, water depth and the slope of the bottom. Consequently the larger storm waves break further offshore making the surf zone wider, but leaving the wave height in the inner surf zone according to the local water depth.

It is therefore not correct to attribute the abrupt beach erosion in a storm directly to the height of the offshore wind waves. However, during a storm the wave height in the inner surf zone will often reach maximum resulting in maximum water quantity in the swash zone with maximum set up and surge height on the beach face before the wave energy is dissipated.

Steep nearshore bottom slopes allow larger waves to break almost directly on the fore-shore with great force.

The waves themselves and the current generated by them are the primary reasons for the littoral transport. The transport of sediment material – both as suspended load and bed load - is associated with the dissipation of excess wave energy.

Longshore transport is caused by the longshore current and the swash motion on the beach face induced by the waves striking at an angel to the shore-line different from the rectangular.

Onshore / offshore sediment transport is associated with oscillatory wave motions and bed material movements induced by the oscillatory bottom boundary layer.

During periods of high waves, the return flow and / or the rip current carry suspended sediments offshore in increasing amounts. The net result is an offshore transport of sediments during storms (higher waves), creating an offshore bar near the breaking line and a flattening of the beach foreshore. During periods of milder waves, sediment is carried back to the beach face making it steeper again and reducing the size of the bar depot.

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When an incoming oscillatory wave breaks or spills in the surf zone, it at first propagates itself past the point where the water table intersects the beach face and then it surges up the foreshore to a surge height determined by excess energy, slope of the beach face, roughness and permeability of the beach deposits.

During the swash / surge there is a diminution of the uprush velocity which decreases the transport power of the surging prism of water until the point of zero uprush velocity is reached. Towards the termination of the surge the uprush velocity will become so low that the flow will change from turbulent to laminar resulting in a rapid deposition of sediment on the beach face.

After the wave run up has reached its surge height, the backwash begins. At first the backwash velocity is low and the flow is laminar, but as the flow velocity increases, the flow becomes turbulent and sediment will become re-entrained.

For the range of beach slopes normally experienced in sand, the duration of the surge activity exceeds the incoming wave period and therefore interaction between swashes occurs. Such interaction often results in curtailed wave run up.

When the water table in the beach deposits is very high caused by flux from the hinterland or elevations due to tidal fluctuations or percolated water from the swash zone, the backwash volume and thereby flow velocity may be increased by water seeping out of the beach face. The seepage force also dilates the sand and propels the fine grain into the turbulent flow. This enhances the erosion of the foreshore.

In case of a low water table, water from the swash percolates rapidly into the unsaturated beach face and reduces the uprush mass as well as the backwash mass and flow velocity facilitating deposition of sand over the swash zone where the flow is laminar.

A dynamically working Beach Drainage System causes artificial interplay with nature's morphology by moderate lowering of the ground water table along the shoreline whereby an unsaturated zone is established and maintained beneath the beach face. This facilitates percolation of water from both the uprush and backwash as mentioned above. With less water in the backwash and reduced surge height less sand will be brought back to the surf zone than was brought up in the surge volume.

The zone of lowered water table furthermore cuts off the local ground water flow towards the sea and the seepage through the beach face and dune toe. Thus stabilizing the slope and reducing the backwash quantity and velocity, the Beach Drainage System decreases the erosional effect of backwash and seepage and leaves more sand on the beach face.

The efficient function of the Beach Drainage System requires wave action but is not depending on the wave climate itself. However, the wave climate, the slope of the beach face and the nearshore sea bottom are parameters to be evaluated and adequately used during the design of the site specific System. As pointed out it is not the normally monitored offshore wind-wave height which is applicable to the design but the storm surge height on the beach face.

During storm events some erosion in front of implemented Beach Drainage Systems will normally take place, but due to the storm much sand will be in suspension nearshore. This will contribute to a quick healing of the storm scars by the accomplishment of the function System.