

## **Beach Drainage System**

# **Tidal Dynamics and Erosive Forces**

A breaking wave carries sand as it swashes up the foreshore. During the uprush, the momentum decreases until a velocity of zero is reached and all sand is deposited on the beach face. As the prism of water accelerates down the foreshore, sand is picked up and moved back to the surf zone. The net result under a specific set of conditions may either be erosion or accretion.

The elevation of a coastal water table is partly determined by the prevailing hydraulic conditions, such as the surge height of the waves, tidal range and rainfall, and partly by the characteristics of the beach deposits that are determining the permeability; e.g. grain size distribution and corresponding porosity.

When the water table within 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 the velocity may be increased by water seeping out of the seepage face between the actual medium water level in the sea and the exit point of the ground water table.

The seepage force also dilates the sand and propels the fine grain into the turbulent flow. This enhances the erosion and flattens out the foreshore.

In case of a low ground water table compared to the medium water level in the sea or the level of the surge, water percolates into the beach face and reduces the uprush mass as well as the backwash mass. The thereby reduced velocity facilitates deposition of sand over the swash zone where the flow is laminar.

As the slope of the beach face is increased by greater deposition of sediments on the upper part of the foreshore, the equilibrium slope is gradually reached and the backwash velocities prevent further net accretion. The foreshore below the actual exit point will be subject to erosion.

When waves run up and down on the beach face, providing the mechanism for the sediment transport, they interact with the ground water beneath the beach face. During the flood tide, the beach water table is low compared to the sea level. Water percolates into the deposits when the waves surge up and down above the exit point of the ground water table. Conversely, a relatively high water table exist in the beach deposits during the ebb tide and water will seep from here towards the sea within the seepage zone.

The water table profile beneath the swash zone caused by the accumulated water from the percolation will have a maximum level and slopes towards the hinterland or the sea or in both directions depending on the tidal interaction and the permeability of the beach deposits. During ebb tide the edge of the water table generally slopes seawards, while during flood tide it slopes landwards.

The ground water level response to the tidal changes varies asymmetrically rather than sinusoidally over time.

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The building up of elevated water table as well as the release is retarded compared to the tidal cycle. The water table continues to rise after the tide begins to ebb and continues to fall after the tide begins to flood. The maximum point of the water table profile will move landwards during rising tide and seawards during falling tide. Furthermore, during rising tide, the head gradient causes the water table to rise more rapidly than it will fall during ebbing tide. The changes are governed by the transmissivity and storage coefficient of the sand deposits.

In general tidal beaches are experiencing shallow surface gradients. The water table of the falling tide will consequently move faster seawards on the foreshore than the elevated water table can drain out. Much of the beach face above the actual shoreline will consequently remain saturated and disposed for erosion and often covered by a film of free running water seawards of the exit point.

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 the toe caused by the elevated water table from the wave run up and flood tide

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 which will appear dry within the zone of influence from the System.

For optimizing the efficiency of the Beach Drainage System the site specific fluctuations of the water table below the beach face corresponding to the tidal cycle and wave surge height shall be recorded. The depth and location of the drain structure shall ensure that the cone of depression is covering the area seawards of the maximum interstitial water table in order to move the exit point as far seawards as possible under the actual conditions.

Beach Drainage Systems installed in wider, flatter 'tidal' beaches (dissipative beaches) tend to distribute a given volume of captured sand over a wider area due to the larger swash zone. For this reason the response time may visually appear slower than beaches with steeper faces.