A History of Beach Drainage Technology Development, 1940 - 1995

The following text provides an independent review of the history of beach drainage technology from its origins in the 1940's up until 1995. It has been taken from a USACE report*: "Construction Productivity Advancement Research (CPAR) Program, Field Evaluation /Demonstration of a Multi-segmented Dewatering System for Accreting Beach Sand in a High Wave-Energy Environment"* William R. Curtis, Jack E. Davis. CPAR-CHL-98-1 (134 pages), July 1998.

"According to the detailed literature review reported by Turner and Leatherman (in preparation[i]), the origin of the beach dewatering concept can be traced back to landmark coastal research investigations conducted in the 1940s. In the work of Bagnold (1940), laboratory experiments were described in which the infiltration of wave uprush on the beach face was inhibited, resulting in a more energetic backrush. Bagnold's experiments implied that with enhanced infiltration of wave uprush on the beach face, onshore transport of sediment may be facilitated while the offshore transport of sediment is reduced.

In the work of Grant (1946, 1948), it was qualitatively documented that the beach water table can have a significant influence on the morphological dynamics of the shoreline. Grant concluded that a permeable beach with a low water table is more stable than a beach with a high water table. For a beach with a low water table, waves uprushing in the active swash zone rapidly infiltrate the permeable beach above the unsaturated beach-water table interface. This infiltration results in a reduction of wave uprush velocity and backrush velocity. As velocities drop below a critical value for transport of the beach sediment, deposition of sediment entrained in the wave uprush occurs. With continued infiltration, reduced velocities facilitate sediment deposition and reduce seaward transport of sediment with wave backrush. Grant also concluded that backrush velocities may be enhanced below the active seepage face of the groundwater outcrop, as groundwater discharge is added to the wave backrush.

Emery and Foster (1948) conducted field surveys of beach groundwater, investigating the relationship between the elevation of the beach groundwater and the phase of the tide. Emery and Foster observed that, as the tide began to flood, the beach groundwater outcrop on the foreshore of the profile became elevated. Similarly, the groundwater outcrop dropped in elevation following the onset of the tidal ebb. Emery and Foster also noted that, with the falling tide, groundwater discharge was observed, aiding sediment erosion at the beach toe.

Following upon insight gained from previous researchers, Duncan (1964) investigated the cyclic patterns of beach-face erosion and accretion as influenced by the tide. Duncan confirmed the concepts of his predecessors. With a flooding tide and elevated groundwater, the infiltration of wave uprush was inhibited until the uprush advanced over the unsaturated beach, depositing sediment at the top of the foreshore profile. On the ebb tide, the elevation of the groundwater outcrop lagged behind the ocean-water elevation leaving a subaerial, yet saturated, beach face. Limited wave backrush infiltrated during the ebb tidal phase. The motion of the groundwater discharge functioned to reduce the threshold for incipient particle motion of the sand during the wave backrush, aiding foreshore erosion.

Since the 1940's, the influence of groundwater elevation on swash zone dynamics and subsequent erosion and accretion of the beach face has been investigated in the laboratory and field. However, the interactions between beach groundwater, swash dynamics, and sediment transport quantitatively remain poorly understood. Although sediment transport processes in the swash zone remain poorly understood, decades of research have confirmed that the influence of beach groundwater can be significant to the erosion and accretion of sediment on the foreshore region of the beach profile.

Machemehl, French, and Huang (1975) conducted the first experimental test of engineered artificial manipulation of beach groundwater. In a two dimensional wave flume with varying monochromatic wave heights, the investigators lowered the elevation of the beach groundwater by means of a polyvinyl chloride (PVC) drain installed in a shore-parallel orientation. The objective of the experiment was to study the drain's effect on the foreshore accretion. They observed that beach drainage greatly enhanced the rate of sediment *deposition on the foreshore and accelerated the rate of profile recovery following an erosive event.*

Kawata and Tschuiya (1986) observed similar results when applying a sub-sand filter system to induce foreshore stability in a wave flume. Accretion of beach material occurred on the drained beach for both solitary and monochromatic waves. Other laboratory investigations addressing the effect of groundwater manipulation on foreshore sediment transport processes have been published in the literature and include the work of Sato (1990); Ogden and Weisman (1991); Herrington (1993); Sate, Hata, and Fukushima (1994); Weisman, Seidel, and Ogden (1995); and Kanazawa et al. (1997).

Generally, laboratory simulation of beach face drainage has enhanced sediment accretion on the beach face under varying wave conditions and under tidal and non-tidal conditions. To date, all laboratory experimentation has produced only a qualitative measure of beach profile response to artificial manipulation of the groundwater. Profile response and operational parameter measurements derived from small-scale physical model experiments cannot be scaled from wave flume to prototype (Sato et al. 1997). Turner and Leatherman (in preparation[i]) caution that wave flume experimentation does not represent the unconfined aquifer existing below many natural beaches. Rather, the physical model experiments depict the beaches as a thin veneer of beach material superimposed on an impermeable surface. The degree to which the "unnatural" underlying impermeable layer contributes to accelerated seaward transport of sediment during undrained model tests cannot be determined.

The application of beach dewatering technology in the field has taken several forms. Chappel et al. (1979) first made the transition from the laboratory to prototype scale, as a series of mechanical beach dewatering wells were installed on the southern coast of New South Wales, Australia. Chappel et al. report qualitative evidence that the accretion of beach material on the foreshore of the profile can be induced by lowering the near-coast groundwater elevation. Due to the highly dynamic shoreline, the investigators were unable to quantify the influence of the wells on the morphologic response of the beach.

In 1981, the Danish Geotechnical Institute (DGI) installed a water filtration system in the beach at Hirtshals in Torsminde, on the northern coast of Denmark (Vesterby 1991; Ovesen and Schuldt 1992; Schuldt 1992a; Vesterby 1994). The filtration system was designed to pump seawater from below the swash zone to provide water for heat pumps and aquaria located at the Danish North Sea Research Center (DNRC). The filtration system pumped approximately 400m3/hr, and originally consisted of a 200m section of 0.2 to 0.3m perforated PVC pipe buried in a shore-parallel orientation 2.5m below mean sea level (MSL) 5m landward of the shoreline. Following 6 months of operation, the volume of water supplied to the DNRC by the filtration system discharge pumps was substantially reduced. A site inspection of the beach revealed that the shoreline in the vicinity of the drain pipe had prograded 20 to 30m seaward, lengthening the filter path and subsequently decreasing discharge yield by 40 percent. To increase discharge, a second 220m drain line was installed as an extension of the first. The result of the extension was that the shoreline, composed of well-sorted, medium-grain sand, in the vicinity of the horizontal wells prograded seaward, even during the winter storm season.

In 1983, a second site (termed Hirtshals East) was chosen by DGI to field test the effect of beach dewatering on shoreline response and was located 1km from the DNRC site. A 20m drain pipe was installed in a beach composed of mixed fine grained sand, silt, and clay. The Hirtshals East project was terminated after 8 months of operation. During the 8month evaluation period, the system was unable to prevent severe storm-induced erosion of the beach. However, the system did function to accrete beach material even under less-than-ideal soil conditions. Shoreline response to mechanical beach dewatering at the Hirtshals sites was deemed encouraging and prompted the first full-scale demonstration of beach dewatering technology as a shoreline stabilization method.

DGI installed a 500m-long, 0.2m-diam perforated drain pipe at Torsminde on the west coast of Denmark in 1985 (Vesterby 1991, Ovesen and Schuldt 1992). The drain pipe was buried at an elevation between -2.0m and -2.5m in a shore-parallel orientation in a beach composed of gravel and well-sorted, medium-grained sand superimposed on a layer of fine-grained *lagoonal deposits occurring below -3.5 to -5.0m. The Torsminde system operated until 1991, when the demonstration was intentionally terminated. Monitoring of the demonstration by DGI revealed that after 7 years of operation, the dewatered beach accreted approximately 30m3/m of beach material, while neighboring control beaches experienced approximately 25m3/m of erosion. Monitoring of the system also revealed that the drain had an effective length 100m to 200m longer than the actual drain pipe, and that no negative environmental effects were observed.*

The performance of the beach dewatering systems designed by DGI led to commercial interest in the technology as a shoreline stabilization method. DGI is presently holder of U.S. patents covering beach-face dewatering technology and actively commercializing the technology as the Beach Management System. In the United States, the Beach Management System is marketed under a patent license by CSI using the product name STABEACH.

In 1988, under patent license to DGI, CSI installed a 580-ft-long STABEACH system at Sailfish Point (Stuart) on the Atlantic coast of Florida in a shore-parallel orientation (Terchumian 1989, 1990; Ovesen and Schuldt 1992; Schuldt 1992b; Lenz 1994). The system was installed in a beach composed of medium-grained sand and initially yielded approximately 75liters/second (l/s) of discharge. The system was comprised of a 0.46m-diam collector header with 1.2m long horizontal well points attached on 3.lm centers. Following 11 months of operation, Dean (1990) concluded in an independent evaluation that it was not possible to differentiate between system induced and naturally occurring morphologic changes, and that there were no adverse effects of the system on the beach. Subsequent monitoring of the Sailfish Point installation led Dean to conclude that the STABEACH System had a positive effect on the shoreline. Dean observed that the system induced moderate accretion on the dewatered shoreline, while adjacent non-dewatered beaches experienced erosion, and the dewatered beach was considerably more stable than adjacent non-dewatered beaches. Again, Dean observed no adverse effects on beach dynamics within the system's influence.

In 1993, CSI installed a second beach dewatering system at Englewood Beach located on the Gulf Coast of Florida (Lenz 1994). The system consisted of a series of well points along a 600-ft reach of shoreline. Following a limited operational period, the system was rendered inoperable by a series of storm events, and not replaced.

In 1994, newly constructed European commercial beach dewatering installations included a 600m-long Beach Management System installed by DGI at Eno Strand on the south coast of Denmark, and a 180m-long Beach Management System at Towan Bay, Cornwall, UK. The Towan Bay system was constructed by MMG Beach Management Systems, UK, Ltd., under patent license to DGI (Dredging and Port Construction 1994, 1995; Burstow 1995). In an early evaluation, Burstow (1995) reported a general accretionary trend of beach material on the foreshore at Towan Bay. To date, it is too early to draw definitive conclusions regarding system performance at the most recent European installations.

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For information on the development of beach drainage technology in the eight years since 1995, please refer back to the Shoregro website www.shoregro.com.

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[i] TURNER, I.L. AND LEATHERMAN, S.P. (1997): *Beach dewatering as a "soft" engineering solution to coastal erosion – A history and critical review.* Journal of coastal research, Vol. 13, No. 4, pages 1050-1063.