REVIEW OF PRESSURE EQUALIZING MODULES (PEMs) FOR SHORE EROSION CONTROL

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Pressure Equalizing Modules (PEMs) are briefly described in material presented by EcoShore International, Inc. (EcoShore) as independent permeable drain tubes installed vertically into the foreshore to build a beach or reduce erosion. According to EcoShore, the PEMs have been tested over three years on the heavily eroded Danish West Coast by an independent Danish University. The test showed a fast build-up of sand with PEMs. After one year, the PEMs area had gained 8.4 cubic yards per shore yard.

According to EcoShore, PEMs form a naturally functioning draining system. The modules are vented in the top and tiny slits let water in and keep sediment out. They connect the different layers of groundwater in the beach which leads to a reduction of groundwater pressure. The result is a beach that is more permeable than before. The waves penetrate more easily and leave more sand on the beach than they take back to sea.

Coastal Engineering Consultants, Inc. (CEC) conducted a cursory review of the natural coastal processes or mechanism(s) that may operate or be influenced as a result of PEMs installation and that might be responsible for the beach accretion results indicated in the EcoShore literature. In that effort CEC has reviewed information provided by EcoShore regarding the PEMs design, installation methods, EcoShore's postulated performance mechanism, pre and post installation surveys, installation photographs, and monitoring data that describes the performance characteristics of the system. In addition, CEC has performed a preliminary literature search with regard to the coastal processes, such as winds and waves, that act on sandy beaches and may be responsible for the forces that influence PEMs effects on sediment transport and beach systems that drive beach erosion and deposition.

Numerous lines of evidence have been investigated by a variety of authors to evaluate the effect of pore pressure and shear stress in the surf zone and on groundwater on beaches. The influence of tidal forcing on beach groundwater levels has long been observed, as has the effect of additional forcing from waves.

Relatively little attention has been given to the response of coastal aquifers to storm waves. Cartwright, Li and Nielsen (2004) presented a storm wave field dataset from a sandy beach aquifer at Brunswick Heads, in northern New South Wales, Australia. The response of the aquifer was dominated by a moderate increase in shoreline water levels induced by a 4m increase in offshore significant wave heights. The resultant increases in groundwater levels were 1m at the seaward boundary of the salt-freshwater interface and 35m further landward, a 40cm rise is shown.

This is a clear demonstration of the reaction to lateral hydraulic pressure from storm wave action. Thus, PEMs placed in such an environment might "feel" the influence of such forces. The groundwater elevation from this lateral pressure response is influenced by the permeability of the soil. If permeability is increased, then pore pressure is reduced and shear strength at the beach is increased, retarding sediment transport. If permeability is slightly increased, then infiltration can be accommodated. Pressure equalization by the PEMs may be considered equivalent to a point reduction in friction or a new open water cavity in the saturated free aquifer and such friction reduction is equivalent to increase in permeability through open flow space.

Several projects in the United States have shown that beach accretion can occur in areas where ground water is pumped below or just landward of the surf zone. This process creates a local reduction in pore pressure and increase in intergranular friction. This process can make erosion of the sediment more difficult or enhance deposition of sediment passing over the area (Cartwright, et al., 2004).

Several authors (Nielsen, 2002; Nielsen, et al., 2001) have investigated effluent and influent groundwater impacts in the surf zone and show that dewatering or reduction in pore pressure increases intergranular friction and shear stress by retarding erosion and actually contributing to deposition. If the PEMs allow a resultant increase in permeability in an otherwise uniform isotopic saturated sand under waves or high-tide circumstance along the coastline, the principles established by Nielsen may be applicable in explaining sedimentation when the system is installed.

Water waves lose energy into bottom sediments when the water is relatively shallow. The porous media damping effect was first derived by Reid and Kaijura (1957) based on small values of the dimensionless permeability. This process is further described by Dean and Dalrymple (1991) and Liu and Dalrymple (1984) wherein an increase in bottom sediment permeability can lead to energy loss by waves passing over the surface, reducing wave height. This process could contribute to reduced erosion or accretion depending on sediment availability. If the PEMs contribute to increased permeability by pressure release, then this wave energy damping could result.

Additional studies and comparative analysis with control beaches are warranted on beaches with PEMs installed to further evaluate and understand their influences on changes in hydraulic and sediment transport processes.

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