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Attenuation of groundwater pressure due to surface waves.

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For tideless seas, the groundwater flow in shallow water is governed entirely by the surface wave dynamics on the beach. As waves propagate towards the shore, they become steeper owing to the decreasing water depth and at some depth, the waves lose their stability and start to break. When waves break, waves energy is dissipated and the spatial changes of the radiation stress give rise to changes in the mean sea level, known as the set_up. Longuet-Higgins demonstrated that the mean on-shore pressure gradient due to wave set_up driver a groundwater circulation within the beach zone. Water infiltrates into the coastal aquifer on the upper part of the beach near the maximum run_up, and exfiltration occurs on the lower part of the beach face near the breaking point. The velocity of the flow as well as the amount of water circulation within the permeable beach is important for the biological status of the organisms inhabiting the beach sand, transporting organic matter and dissolved oxygen to beach body , influence on sediment transport at shallow waters and stability of engineering structures.

The paper is organized in two main parts. The first part of the paper is dedicated to the formulation of the mathematical model for attenuation of pore pressure in shallow water zone when wave breaking is present. Solution of system of nonlinear equations for wave propagation on permeable beach is compared with experimental data.

The main purpose of the experimental part of the paper is dealing with the analysis of sets of good quality data on pore pressure data which will serve for comparison with theoretical results. In particular, two set of data are discussed, namely data obtained during measurements in the shallow water at the Coastal Station Lubiatowo (Poland) in Southern Baltic Sea and data from the large scale laboratory experiments in the Grossen Wallenkanal in Hannover (Germany).

In the first case, the set of transmittance functions between the surface waves and pore pressure in the soil at various levels and transmittance functions between the pressures recorded at different levels are compared with the developed theory.

During the laboratory experiment in Hannover two components of pore pressure were clearly distinguished i.e. in the zone of non-breaking waves only so called phase resolving component induced by surface waves is observed and in the surf zone two types of pore pressure are present : phase resolving and so called phase averaged , induced by set-up phenomena (mean water level rising). The total pressure recorded by the pressure gauges is a summation of the phase-averaged and the phase-resolving components.

The pore pressure gradients provide also valuable information on the kinematics of groundwater flow in the beach body. In the experiment we are not able to measure the flow velocity in a straightforward manner, but the flow velocity can be estimated from the recorded pressure gradients using the formulas resulting from the theoretical solution.