Damping of water waves by bottom-mounted porous structures

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Breakwaters and wave absorbers are structures constructed in the coastal areas to protect harbours, inlets and beaches by attenuating incoming wave energy. Different types of breakwaters can be constructed such as caisson type breakwaters where the vertical side is backed up with vessels, rubble-mound breakwaters that consist of different layers of materials, preferably sand and gravels on the outermost layer, to absorb most of the energy and inner concrete layer in order to block water to transmit. Breakwaters may also consist of metallic foams formed from different types of metals and alloys.

We mainly study oblique water wave scattering by a vertical porous structure placed on (i) an elevated horizontal bottom and (ii) a multi-step impermeable bottom in the presence of a rigid vertical wall. Linear water wave theory is considered along with time harmonic motion. In both cases, governing equation, boundary conditions and dispersion relation for flow inside the porous structure are derived. For the horizontal bottom case, a linearized friction factor is calculated to damp the motion whereas the friction factor is taken as fixed for the multi-step bottom.

First, a rectangular shaped porous structure, attached to a rigid vertical wall, is placed on an elevated horizontal impermeable bottom. Oblique waves are incident on the porous structure. Some part of the waves gets reflected by the sea-ward face of the porous structure and the rest of them passes through the porous structure before getting reflected by the rigid vertical wall. Inside the porous structure, the reflected and transmitted waves are reflected back and forth. It is observed that the propagating mode controls the reflection phenomenon up to a certain wave number beyond which the evanescent modes start affecting reflection. The value of the reflection coefficient decreases with an increase in the height of bottom elevation as well as in the values of porosity. Moreover, minimum reflection is observed for a fixed range of angles of incidence. Further, the problem is extended by placing the porous structure at some distance from the rigid vertical wall. In this case, the transmitted waves coming out from the porous structure pass through the water region between the porous structure and the rigid vertical wall, and get reflected by the wall. Here the dimensionless amplitude of the transmitted wave is also calculated by using the matching conditions along the vertical boundaries and subsequently, energy loss of the waves due to passing through the porous structure is obtained.

Secondly, a multi-step bottom under the vertical porous structure is considered to study the scattering of oblique ocean waves. With an increase in the number of steps, oscillation in the reflection coefficient is observed. But the oscillation in the reflection coefficient for lower values of friction factor disappears with an increase in the number of steps. This problem is also extended first by placing the rigid wall at a distance from the porous structure; and later by removing the rigid wall and considering the water region to the rear side of the porous structure to be unbounded. In the case of the unbounded water region to the rear side of the porous structure, the reflection is very small compared to the case when the wall was present for a thin porous structure. Moreover, the oscillations in the reflection coefficient and energy loss do not exist when the rigid wall is absent.

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