Vertical pressure gradient and particle motions in wave boundary layers

The present study covers both a numerical and experimental investigation of the processes in the oscillatory boundary layer. In the first part a direct numerical simulation (DNS) is conducted to study the vertical pressure gradient, and its role in relation to laminar to turbulent transition and its role in the fully turbulent boundary layer. The pressure in the flow is obtained from the flow fields of the oscillatory boundary layer. What differs, the vertical pressure gradient, from other turbulent quantities, like e.g. velocity fluctuations is that it can detect newly generated turbulence. This is in contrast to velocity fluctuations that are diffusive, so they can also contain residual turbulence from the previous half cycle until they are dissipated. Furthermore, the magnitude of the mean value of conditionally averaged vertical pressure gradient (for $\frac{-\partial p}{\partial x} > 0$) is compared to the submerged weight of sediment. This reveals that the upward directed vertical pressure gradient on average has a magnitude that yields in a contribution to the force needed to overcome the submerged weight of the water-sediment mixture.

Secondly particle motion in the oscillatory boundary layer is investigated. The experiment is conducted in a oscillating water tunnel, for both smooth bed and rough bed. The particle motion is determined by utilizing particle tracking base on a video recording of the particle motion in the flow. In the oscillatory flow, in contrast to steady current, the particle motion is a function of phase. Therefore the particle will settle towards the end of each half period, and after flow reversal, when the turbulent intensity becomes large enough it can be suspended. If the particle is light enough it can be maintained in suspension, otherwise it will settle before it is resuspended. The governing parameter for the particle motions after after it is brought into suspension, the Rouse parameter ($\beta = \omega_s/(\kappa U_f)$, $\omega_s$ the settling velocity, $\kappa = 0.4$ Karmans constant). For large values of the Rouse parameter, the particle tend to stay near the bed while for smaller values the particle spends more time away from the bed.

General information
Publication status: Published
Organisations: Department of Mechanical Engineering, Fluid Mechanics, Coastal and Maritime Engineering
Contributors: Jensen, K. L.
Number of pages: 242
Publication date: 2014

Publication information
Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark (DTU)
Original language: English
(DCAMM Report).