The Interaction between Waves and an Overlying Airflow

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This dissertation examines the interaction between a series of progressive gravity waves and an overlying airflow. A critical review of the existing literature is made, from which it is concluded that although a large number if wind-wave interactions have been proposed, few have been verified experimentally. Furthermore, virtually no consideration has been given to the effect of the airflow on the underlying wave motion. A comprehensive experimental investigation of the interaction between wind and waves has therefore been undertaken.

In respect of the airflow, a complete set of kinematics measurements, involving both horizontal and vertical velocity data, is presented. The mean, wave-induced and fluctuating velocities are presented in a wave-following frame of reference. The flow streamlines are deduced from the measured velocity data, and the structure of the airflow examined in detail. Analysis of the velocity profiles using boundary layer theory enables the effects of the flow structure identified above to be quantified and an assessment of the surface stress made.

A corresponding set of kinematics measurements were undertaken in the underlying water flow. The wind-induced currents and wave kinematics are examined. Numerical models to predict the wave motion in combined wind-wave field are developed. The models incorporate the effects of a wind-induced current and the varying surface stresses, and allow the relative importance of each of these effects to be investigated.

Furthermore, measurements of the water surface elevation are used to investigate the modification to the underlying long wave caused by the airflow, and the nature of the superposed wind-waves. The variation in the properties of the wind-generated waves with the phase of the long waves are also examined. Finally, the fundamental mechanisms of wind-wave interaction are considered, and the relative importance of the various mechanisms assessed. The implications for the offshore engineer, in terms of wind loading, gas ventilation and wave loading are outlined.