Abstract

The present thesis deals with a class of physical problems associated with the study of surface gravity wave interaction with floating flexible structures resting on the fluid surface in the context of wave blocking. Various wave-structure interaction problems are analysed under the assumptions of small-amplitude structural response and linear water wave theory in a homogeneous fluid of finite depth. The study examines the occurrence of flexural gravity wave blocking by analysing the roots of the associated dispersion relation under varying hydrodynamic and structural parameters in the presence of a uniform compressive force. The occurrence of triad resonance of flexural gravity waves in a two-layer fluid is examined within the framework of blocking dynamics. Further, the formation of triads in intermediate water depth and the shallow-water approximation in the upper layer are investigated. Moreover, the occurrence of triad resonance of flexural gravity waves is established in the presence of a shear current with constant vorticity in a homogeneous fluid domain. Formation of triads in the absence of current, triads in the presence of linear shear current, and triads in the presence of uniform current for flexural gravity waves are demonstrated. Additionally, the thesis explores Bragg scattering of flexural gravity waves induced by an array of periodic sinusoidal bars and triad resonance in the context of blocking dynamics. The multiple-scale method is used to derive the evolution equations, and the transfer-matrix method is employed to obtain the reflection and transmission characteristics of single and multiple seabed patches under various detuning conditions. Moreover, the resonant reflection of flexural-gravity waves over a sandbar in the presence of current is investigated. Solutions for the steady flow are derived using the perturbation method. The effects of current on Bragg resonance conditions are investigated, and energy balance relations are established based on wave-action flux conservation. Scattering coefficients and hydrodynamic loads on floating structures are evaluated for a range of physical parameters, including compressive force, current values, and Young's modulus. In addition, the scattering of flexural–gravity waves by arrays of articulated floating elastic plates is studied using a generalised eigenfunction expansion method which accounts for multiple wave modes during wave blocking. Finally, the thesis examined hydroelastic wave propagation in fluid-filled pipes, demonstrating the existence of negative-energy waves and their role in flow instability. The associated dispersion relation is analysed, and conditions for the onset of instability, including comparison with Kelvin–Helmholtz instability, are discussed.

Keywords: Wave-structure interaction, flexural-gravity waves, compressive force, wave blocking, scattering, Bragg scattering, triad resonance, sinusoidal patch, detuned frequency, current, Kelvin-Helmholtz instability.