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# Wave interaction with semi-infinite floating membrane

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## ABSTRACT

The problem of interaction of surface water waves with a semi-infinite horizontal floating membrane having step type bottom topography is analyzed in two dimensions in the linearized theory of water waves. Combining the linearized kinematic and dynamic surface conditions on the water surface with the dynamic pressure condition on the membrane, a third order differential equation is derived to describe the membrane covered free surface condition. Using the recently developed expansion formulae for wave structure interaction problems, the scattering of waves by the floating membrane having a step type of bottom is analyzed. General wave energy relation for wave scattering by floating horizontal membrane is derived by the application of law of conservation of energy flux and alternately by the direct application of Green's second identity. In the floating membrane covered region, the wave energy density is a combination of the kinetic and potential energy density due to the surface waves and the surface energy which is due to the existence of the floating membrane on the free surface. Explicit expressions for shoaling and scattering coefficients are derived due to an abrupt change in bottom topography and by a floating membrane under the assumption of the linearised shallow water wave theory. Numerical results are computed and analyzed in several cases to understand the effect of wave scattering by a floating membrane having a step type of bottom boundary.

KEY WORDS: Surface gravity waves, floating membrane, energy flux, reflection and transmission coefficients.

## INTRODUCTION

Off late there is a need to design floating flexible breakwaters, which can be used in deep sea to protect various offshore facilities being developed and/or constructed for exploitation of various ocean resources. Major breakwaters are ineffective in long waves unless their size is comparable to the pertinent wavelength. This requires that the structural dimension of the breakwater be large, which in turn makes the construction cost high. Various wave barriers using flexible membranes have been proposed for the temporary protection of coastal regions and construction sites. The flexible membranes have the characteristics that they are easy to carry, inexpensive, reusable, rapidly deployable and removable. These barriers have minimum environmental impact on various coastal processes and therefore, can be used for a variety of coastal/ocean applications. They are mainly made of synthetic fiber, rubber or a polymeric material. Using the linear wave theory and membrane motion equation, Kim and Kee (1996) and Kee and Kim (1997) reported results for a single membrane with the latter incorporating the scattering effect of buoys numerically by using the eigenfunction and the boundary integral method and then verifying the results experimentally. They showed that almost complete reflection is possible by the vertical flexible membrane despite appreciable sinusoidal motions. Using the eigenfunction approach, Lo (1998) investigated the case of the dual flexible membrane, while Cho et al. (1998) used the boundary integral method for dual membranes tensioned by buoys. Lo (2000) further considered a flexible membrane of finite length with gaps between the membrane and the water surface and/or the bottom. Lee and Lo (2002) using the eigenfunction expansion analyzed the effect of surface penetrating flexible membranes wave barriers of finite draft protruding above the water surface such as that rising from having tension provided by frame with surface cables. Recently, Kumar et al. (2007) analyzed the scattering of surface waves by a vertical flexible membrane in a two layer fluid having a free surface and an interface. One of the major problems associated with the use of vertical membranes is the wave loading and possible blockage of current. On the other hand, a horizontal membrane barrier in return suppresses the vertical motion of water oscillation so strongly that it can reduce the wave amplitude effectively. These can be moored despite unfavorable seabed soil conditions and allow for free movement to fish/sea food and free passage of seawater and sediment transport beneath, thus being friendlier to the environment. For infinite water depths they can also be more economical being possible to fabricate on land and easier to transport and handle. Since the horizontal membrane does not directly block incoming waves and the ocean current, the diffracted and radiated waves including various elastic modes have to be properly tuned for an effective wave barrier. In line with this, Cho and Kim (1998) investigated the interaction of oblique waves with a submerged horizontal membrane by using mode expansion method and boundary integral equation method and showed that use of the horizontal membrane can improve wave blocking efficiency as compared to a rigid plate. Cho and Kim (1999) investigated the interaction of surface waves with a circular membrane submerged horizontally, while Cho and Kim (2000) studied the effect of a porous membrane in attenuating gravity waves numerically and experimentally. Sahoo et al. (2001)