WAVE INTERACTIONS WITH SUBMERGED HORIZONTAL FLEXIBLE BREAKWATERS

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INTRODUCTION

With the ongoing sea-level rise associated with climate changes, coastline protection is among the top priorities of national interest for many countries across the globe and particularly those in Southeast Asia with extended shorelines, and submerged horizontal plate breakwaters (SHPB) have been proposed as a possible measure for shoreline protection in the literature. Most of the earlier research works considers the material for the SHPB to be either rigid or elastic sheets (with and without perforations) (Patarapanich, 1984; Heins 1950). The wave modulation due to the presence of such structures is thus predominantly due to wave interactions, edge reflection and turbulence. In this paper, we extend the earlier works and consider the viscoelastic properties for the flexible SHPB (which can better incorporate the possible damping introduced in the field) both experimentally and analytically.

VISCOELASTIC MATERIAL

We adopt the novel laboratory approach (Sree et al. 2018) for the preparation of the viscoelastic material based on oil-doped Polydimethylsiloxane (PDMS), with proper tuning of the percentage of curing agents and while oil. In this study, the mixture ratio of PDMS and white oil was chosen such that the density of the resulting viscoelastic sheet was almost neutrally buoyant (only slightly larger than water density). The dimension of the viscoelastic sheet was 1.0 m long, 0.28 m wide and 0.01 m thick; it was prepared in the laboratory at room temperature through a very slow curing process over a 2-week period. After curing, the rheological properties of the sheet were determined using Small Amplitude Oscillatory Shear Tests in a rheometer with parallel plate geometry. Four different viscoelastic sheets with varying rheological properties were tested.

EXPERIMENTS

The laboratory experiments were conducted in an 8.0 m long transparent wave flume equipped with paddle type wave generator. The two ends of the viscoelastic sheets were clamped-fixed using horizontal mounting brackets which were movable vertically to enable the positioning of sheets at the specific depths below the mean water level. Upon the generation of incident regular waves, the transient displacement of the water surface as well as the submerged sheet were recorded using a high-resolution video camera. In addition, the vertical displacement of the water surface along the sheet length were also monitored using six ultrasound sensors with high resolutions at fixed locations.

DATA ANALYSIS

The recorded videos were first converted to digital image sequences using MATLAB. These images were then converted to grey scales and processed with edge-detection algorithms to determine the displacement history of the submerged sheet as well as the water surface. The time series of the displacements were confirmed with the ultrasound measurements at the fixed locations, and then analyzed for the wave modulation characteristics.

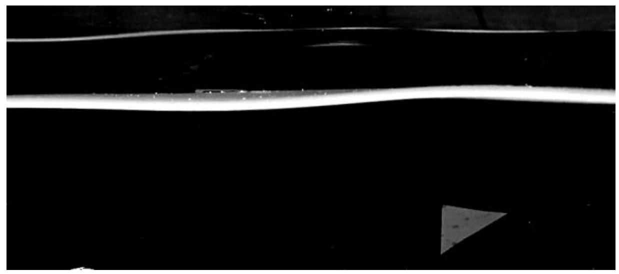

Figure 1 – Grey scale image of submerged viscoelastic sheet under wave action.

ANALYTICAL ANALYSIS

The wave interactions with finite submerged viscoelastic sheets were also investigated analytically in the present study based on the small amplitude wave theory. The submerged viscoelastic sheet was modelled by introducing viscosity into the thin Euler-Bernoulli beam theory (Mosig et al., 2015). The complex dispersion relation for this configuration with the specific edge condition was then derived using the matched eigenfunction expansion method and also analyzed numerically. The roots of the dispersion relation were determined by the Newton-Raphson method. Based on the analysis, the reflection and transmission coefficients as well as the displacements of the flexible sheet and water surface were computed and compared with the laboratory measurements.

CONCLUSIONS

Results from this study will be presented at the conference

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