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EXPERIMENTAL INVESTIGATION OF INTERACTION BETWEEN SURFACE SHALLOW WATER WAVES AND FLOATING PLATES

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Key Words: Water wave, MMEE, Limited floating plate, Transmission coefficient

Introduction

The present study has developed a experimental model for the analysis of interaction between surface shallow water waves and floating plates. The floud is considered homogenous, non-adhesive and non-compressive. Using a restricted floating plate as a large floating structure on the water, which was connected to the bottom of the flume via cables, the floating structure's movements and the level fluctuations of free waters was measured in various draught depths using, respectively, acoustic and impedance sensors. The results indicated that the structure's movements maintain a positive correlation with wave length and height and a negative correlation with draught depth. In the next stage the fluctuations of the free waters surface were investigated using impedance sensors both in the front and at the back of the floating plate and using the results the experimental transmission coefficient was calculated. The results show that an increase in the wave length and period results in an increase in the transmission coefficient. In addition the transmission coefficient was calculated using the method of matched eigenfunction expansions (MMEE) method, which was reasonably consistent the lab results.

Floating Structures

In the past two decades, there have been numerous solutions suggested for dealing with water wave and elastic plate interaction, most of which can be found in articles [1 - 3]. Evidently MMEE method is commonly used in the analysis of the engineering problems. This method originates from the method of the separation of variables, which contains the identification of expansion coefficients as its main stage. [4 & 5] used this method to investigate the surface wave interaction of an area covered with ice and calculated the expansion coefficients using error function method, which includes three Lagrange multiplier coefficients.

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The Initial Hypothesis Used in the Analysis of Floating Structures

There are theories in the Hydroelastic analysis of Pantoon-Type Very Large Floating Structures (VLFs) [6]. The floating structure as a thin elastic plate with free edges. The fluid is non-compressive, non-viscous and has irrotational motion which in this case, velocity potential can be dominant in this question. Both the incident wave amplitude and the floating structures movement are small and the vertical movement is significant.

Physical Model of the Experiment

The laboratory model of the floating structure (figure 1), consists of a floating structure made of MDF wood. This model is 13kg and in the form a rectangular cube, 130cm long, 40cm wide and 5cm high.

Figure 1) Overview of the wavemaker flume, 20m long, 1m outside to outside wide and 1m high.

The floating structure has a 2.5 cm natural draught (figure 2). The structure, under its own weight, was positioned in 3 and 4cm draught depth.

Figure 2) the laboratory model of VLFs under its own weight with 2.5cm draught depth. The structure is made of MDF wood in the form of a hollow rectangular cube. The internal area of this model provides the necessary buoyancy force for usage in higher draught depths.

After calibration 6 sine waves and 3 jonswap spectrums, γ =3/3 and heights=3cm,5cm,6cm, were shown at the model. The movements of the floating plates is measured using acoustic sensors and water surface fluctuations are measured by impedance sensor which are located both behind and in front of the plates (figures 3 and 4).

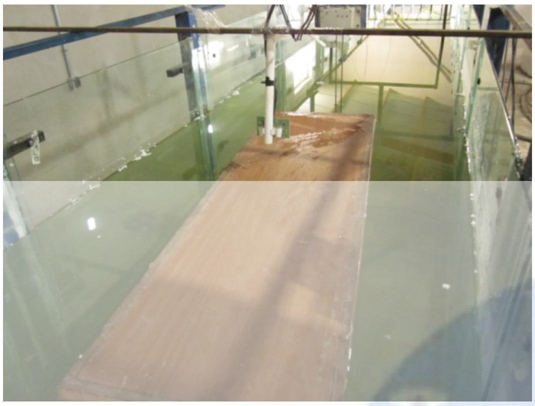

Figure 3) A display of the vertical movements of the floating structure model in the flume of Sciences Center Laboratory. This sensor records the movements of the model's center under in response to waves. The sensor itself is immobile.

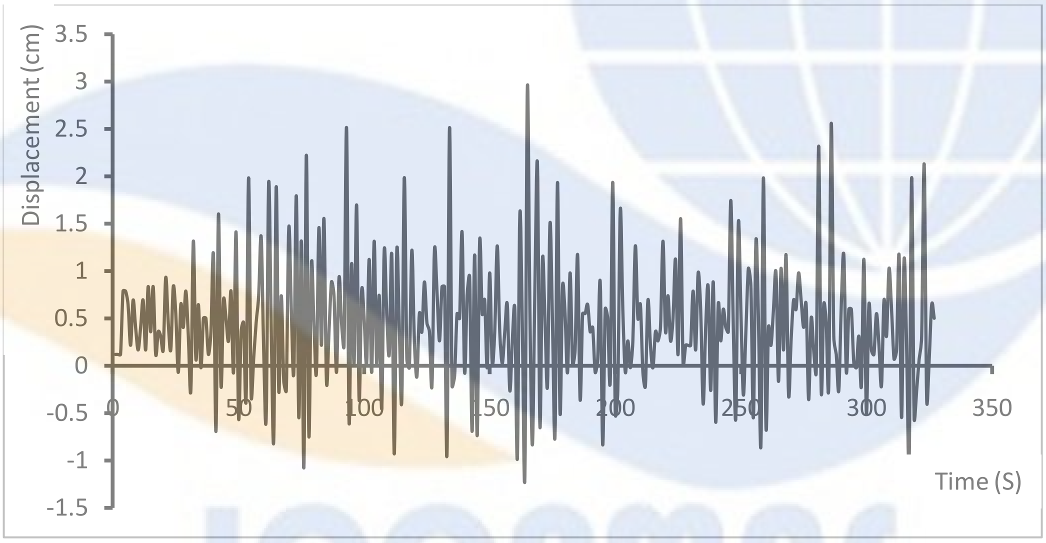

Figure 4) Diagram of vertical movements of the floating structure in cm under Jonswap wave spectrum, Hs= 3cm, X= 150cm, d=3cm. The diagram was drawn using the input of the acoustic sensor. The sensor records 3 inputs each 3 seconds.

A Review of the matched Eigenfunction Expansions method (MMEE)

In this method considering the restriction of the chosen plate (figure 5) there types of potential functions are selected. Then by applying the moment conditions of zero shearing and cutting and the adaptive conditions of pressure and speed at both ends of the plate, introduction of new a internal coefficient and solving the equation 4N+8 using the simultaneous equations system, the unknown coefficients of the potential function were calculated and based on the results the transfer coefficient can be easily obtained.

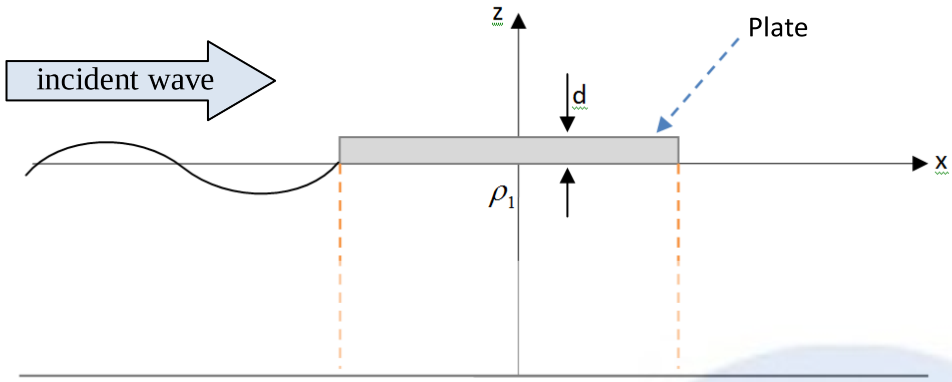

Figure 5) The restricted floating plate under the influence of surface wave impact

Conclusion

A sine wave with 1.8m length, 6cm height, draught depths of 3 and 4cm and a 1.5 distance from the brace to the structure was shown at the structure. Results indicated that the increase of the draught depth significantly decreases structure's movements (figure 6). In the next stage a sine wave with a draught depth of 3cm, 6cm height, lengths of 2 and 2.2m, and a 1.5 distance from the brace to the structure was shown at the structure. This time the results indicated that any movement in the structure causes a significant increase of the wave length (figure 7).

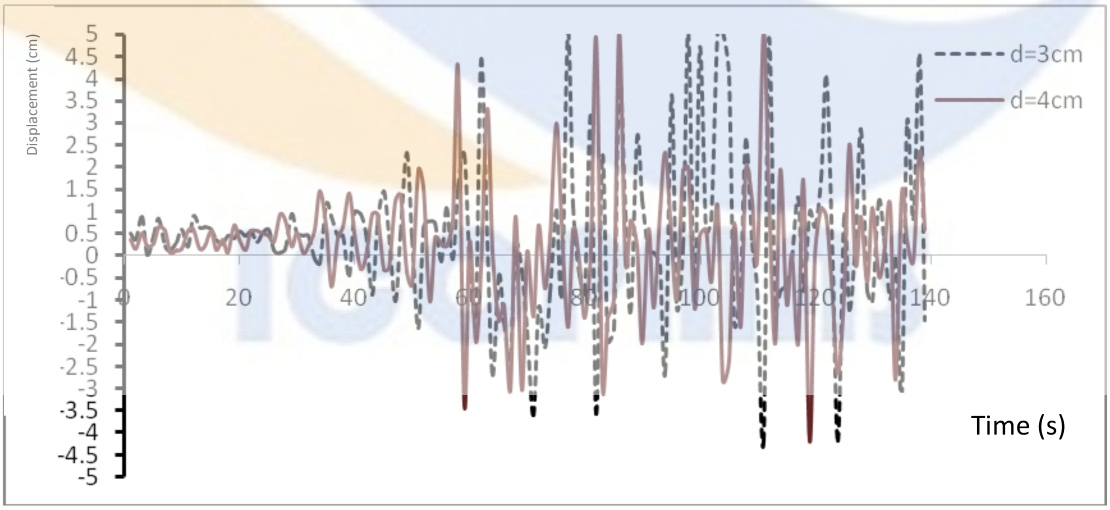

Figure 6) The sine wave with L=1.8, H=6cm, X=1.5m and draught depth = 3 & 4cm. as indicated in the shape the structure's movement is significantly decreased by increasing the depth of the draught.

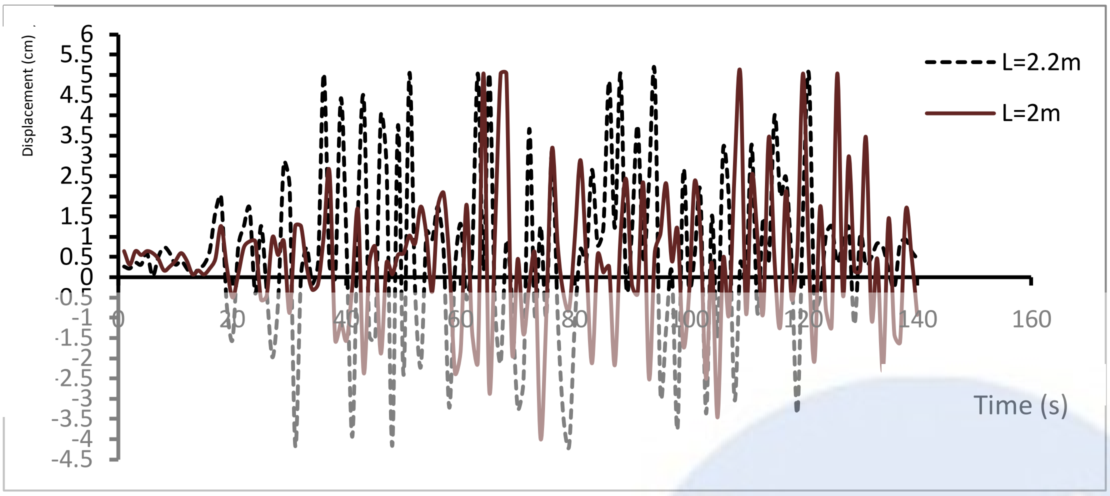

Figure 7) The sine wave with d=3cm, H=6cm, X=1.5m and wave length = 2 & 2.2m. as indicated in the shape the structure's movement is significantly increased by increasing the wave length.

In the laboratory is calculated from the wave height ratio to the radiated wave height. Therefore by the laboratory transmission coefficient was resulted and then the transmission coefficient with changing the wave length and period was calculated again using the MMEE method was numerically calculated. The result indicated that the numerical and laboratory transmission coefficients were a match and the results were confirmed (figures 8 and 9).

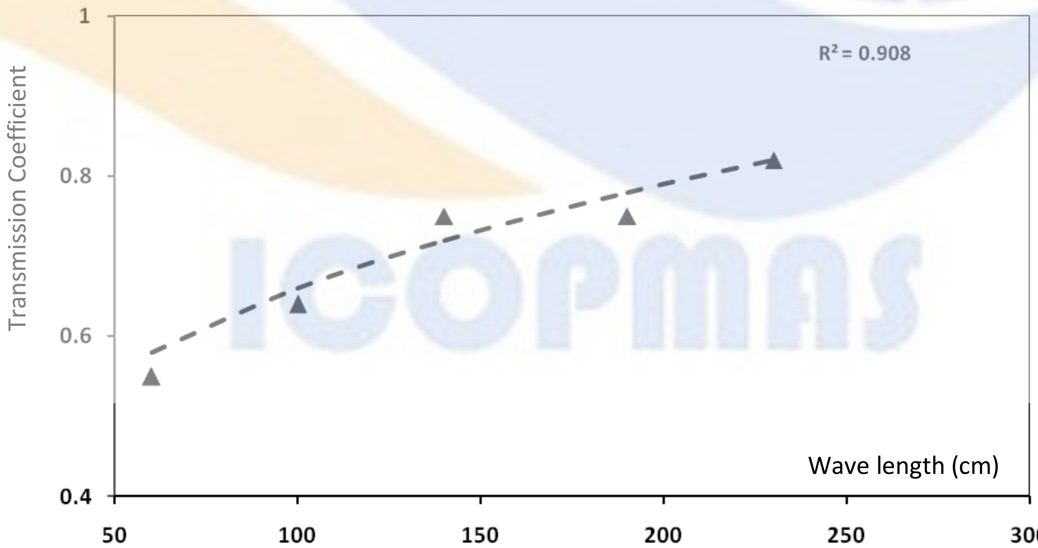

Figure 8) the comparative diagram of the laboratory transmission coefficient and the diagram of the MMEE numerical method

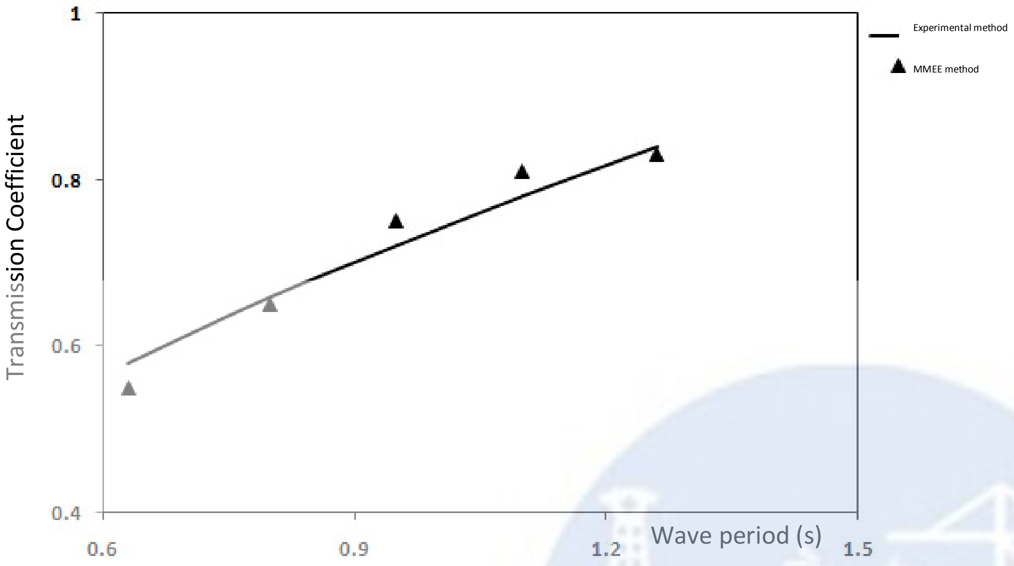

Figure 9) the comparative diagram of the laboratory transmission coefficient and the diagram of the MMEE numerical method

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