II-367

HORIZONTAL AND UPLIFT FORCES DUE TO SEA WAVES IN THE FOUNDATION OF EMBEDDED STEEL CELLULAR STRUCTURES

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INTRODUCTION: Reliable prediction of horizontal and uplift forces in the foundation soil is required while designing embedded steel cellular structures. If these forces are excessively high, they, together with horizontal wave forces in sea water, likely to cause the overturning of the structures. In this paper, an approximate method is proposed for estimating the horizontal and uplift forces in the foundation soil analytically and the results are verified by experiments.

ANALYSIS METHOD: Figure 1 shows the analytical model of cellular structure considered for analysis. Firstly, the wave pressure on the cellular structure is computed by diffraction theory (Ref.1). Using these results, the pore pressure inside the foundation soil of the cellular structures is estimated by solving the Biot's consolidation equation (Ref.2). The uplift pressure on the bottom edge of the wave facing direction of the cellular structure is assumed to be equal to the pore pressure at that point. It is also assumed that this uplift pressure decreases linearly to zero along the width of the structure.

EXPERIMENTS: Experiments were performed in a wave tank using steel cellular structures of 80cm in diameter and 1m in height. The details of the wave tank and the experimental set-up are shown in Figure 2. The models were placed on a sand bed. Sinusoidal waves were generated at one end of the tank using piston-type wave generator. Wave pressures at different locations on the models and the pore pressures in the foundation soil were measured using pressure sensors. Experiments were conducted for three cases: embedded length = 0, 20cm and 40cm. Table 1 shows the

Table 1 Properties of the soil (sand) bed

Porosity	= 0.29
Degree of saturation	= 93.8%
Coefficient of permeability	= 0.01 cm/sec
Coefficient of volume compressiblity	= 0.001 kgf/cm^2

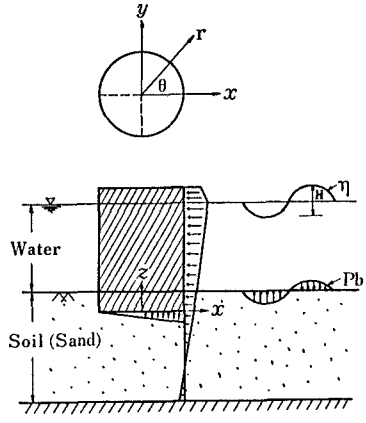

Fig.1 Schematic Diagram of Embedded Cellular Structure in Waves

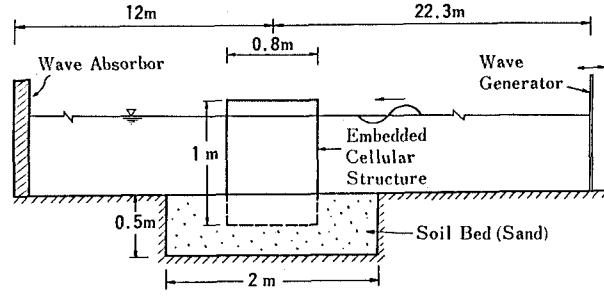

Fig.2 Details of the Experimental Set-up

properties of the foundation soil used in the experiments. Different input wave conditions were adopted by varying the wave heights and the wave periods.

RESULTS AND DISCUSSIONS: The pressures inside the soil layer are found to vary with the wave conditions and the soil properties. Figure 3 shows the values of maximum horizontal and uplift pressures. The values for the slightly-embedded structure and for the well-embedded structure are compared. In the figures, H is the wave height, T is the wave period and l is the embedded length of the model. The experimentally-obtained values are compared with the analytical results. The important findings are: (1) Experimetal results conform the validity of the method proposed in this paper for estimating the horizontal and uplift pressures in the foundation soil of embedded cellular structures. (2) Horizontal and uplift pressures are relatively small compared to the horizontal wave pressures in the sea water and may even take negative values depending on the soil properties and wave conditions. (3) As the depth from the soil surface increases, the horizontal and the uplift pressures generally become smaller. Figure 4 shows the effect of embedding on the value of uplift force on the structure. It is seen that by embedding the structure, the uplift pressure is reduced considerably.

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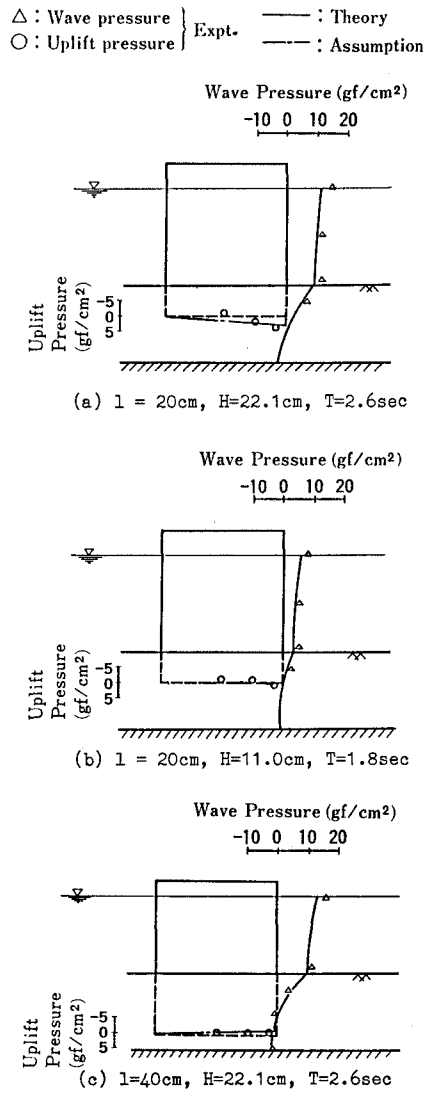

Fig.3 Wave and Uplift Pressures

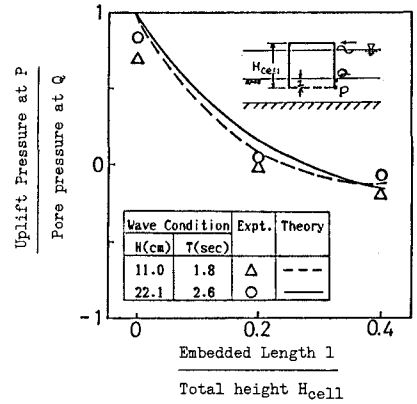

Fig.4 Relationship between Uplift Pressure & Embedded Length