International Journal of Offshore and Polar Engineering
Vol. 12, No. 1, March 2002 (ISSN 1053-5381)

A Theoretical Approach to the Slamming Impact Pressure Acting on the VLFS

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ABSTRACT

The matched asymptotic expansion technique is applied to a theoretical analysis of the slamming impact acting on the VLFS. The theory demonstrates that the memory effect plays an important role in the evaluation of the relative wave elevation under the bottom exposure. It also shows that the zero-draft approximation can be applicable to the estimation of the slamming impact. Comparisons between the numerical results of the present theory and the experimental results show that the theoretical value of impact pressure is in good agreement with the experimental values.

INTRODUCTION

A conceptual design of the VLFS (Very Large Floating Structure) has been taking place in Japan. According to the initial plan of this project, the VLFS has a thin plate configuration of very large horizontal scale. Therefore the motion of the VLFS has a different nature from that of a ship-like floating structure. Several reliable numerical works on the calculation of motion of the VLFS have been completed recently, and it was found that the elastic motion of the VLFS seems like a propagation of water waves beneath a thin elastic-plate. Hence only a limited area of the bottom near the edge can be exposed, even in high seas. This fact implies that the matched asymptotic expansion technique is applicable to the estimation of slamming of the VLFS. In this technique, the exposed region is considered as an inner region that will be called the slamming inner region.

The zero-draft approximation is widely applied to the estimation of motions of the VLFS, (e.g., Ohmatsu, 1997). Since this approximation does not satisfy the body boundary condition at the edge, the flow around the edge must be investigated when we apply this approximation to the slamming theory. In the case of 2-dimensional flow, Bessho and Komatsu (1974, 1976) showed that the horizontal velocity at the edge has a logarithmic singularity. This result implies that the flow around the edge is singular, and an inner problem that will be called the edge inner problem (or the edge inner region) is considered.

We have 2 inner regions to be considered in this paper, and it seems to be complicated. When a slamming impact causes a structural damage, the scale of exposure is much larger than the scale of draft. This fact suggests that the scale of the edge inner region can be assumed to be much smaller than the scale of the slamming inner region. Then these 2 inner regions can be treated separately, and the zero-draft approximation can be applicable to the slamming inner region. Finally we can construct a simple linear solution, which is smoothly connected to the ordinary impact theory.

A slamming theory that deals the slamming inner region and the impact theory is discussed below, as are some numerical results. Although the edge inner region has no direct relation to the present slamming theory, it is discussed in Appendix A to justify the zero-draft approximation.

Received September 1, 2001; revised manuscript received by the editors December 12, 2001. The original version (prior to the final revised manuscript) was presented at the 11th International Offshore and Polar Engineering Conference (ISOPE-2001), Stavanger, Norway, June 17–22, 2001.
KEY WORDS: VLFS (Very Large Floating Structure), slamming, impact pressure, matched asymptotic expansion method.

SLAMMING OF VLFS

The elastic motion of the VLFS in waves seems like waves traveling in the VLFS, whose length is of the same order as the wavelength of incident waves. Thus, while the slamming occurs only in the limited region along the edge of the VLFS, the scale of the exposure area is much larger than the draft of the VLFS. Employing these facts, a simple slamming theory can be composed.

Relative Wave Elevation in Slamming Inner Region

Suppose a rectangular body floating in the infinitely deep water as a simple 2-dimensional model of the VLFS. The edge is located at the $x = 0$, and the body is floating in the domain $x \leq 0$. Fig. 1 shows the coordinate system. It is assumed that the amplitude of incident waves a is very small and of the same order as the draft of the VLFS d:

$$\frac{a}{\lambda} \ll 1, \qquad \frac{a}{d} = O(1), \tag{1}$$

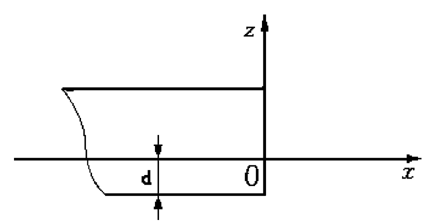

Fig. 1 Coordinate system