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Ice and Earthquake Loads on a Structure in the Okhotsk Sea

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ABSTRACT

The Okhotsk Sea region is known to be earthquake susceptible, but the manner in which we consider a simultaneous loading of earthquake and ice in the design of a marine structure in the region has not been fully understood. This study tackles the task of how to consider the simultaneous loading in the design load determination. A method using finite element modeling and the Monte Carlo simulation is proposed, and it seems to be successful. The method proposed here does not give a general conclusion, but it offers a general procedure with which to evaluate the simultaneous loading in the design.

INTRODUCTION

The basic research project named "Study on Ice Load Acting on Marine Structures," organized by Japan Ocean Industries Association (JOIA), started in FY1993. After some site generic studies, the main target area has been clearly set as the Okhotsk Sea region since FY 1998. Because this region is known to be earthquake susceptible, studies on earthquake loading on a structure in ice-covered waters have been undertaken as one of the most important tasks in the project.

The existing guidelines, such as CSA (1992) or API (1995), do say that a special consideration of simultaneous loading is needed when one determines design loads for a structure in ice-covered waters. For instance, the CSA guideline states, "The effect of sea ice coverage on the response of the structure to an earthquake should be given special consideration." But it does not say anything more than that. Since the frequency or probability of earthquake loadings should be greater in the Okhotsk Sea region than in regions where the existing guidelines apply, it was then decided that the authors would tackle the task of the manner in which simultaneous loading should be considered in the design load determination for a structure in ice-covered waters.

The authors recognized that the joint probability of occurrence of both loadings should be established before starting studies on the earthquake loadings in ice-covered waters. But the authors also realized that it would take considerable time to do this. Thus the steering committee of the JOIA project decided to start studies to clarify what would happen in the event that:

1. An earthquake loading occurs when a structure is surrounded by a stable, uniform ice cover (hereafter, an earthquake load under a stable ice-cover condition).
2. An earthquake loading occurs when a uniform ice cover is interacting with a structure (hereafter, an earthquake load under a drifting ice-cover condition).

The effort to establish the joint probability of occurrence has been continued while the above-mentioned studies are progressing. However, the authors realized that it would be difficult to establish the joint probability of occurrence because of too few data on both loadings in the region in question. Thus the authors decided to take an alternative way, that is: To clarify a magnification of design earthquake load caused by sea ice coverage under both stable and drifting conditions. The words "a magnification of design earthquake load" mean the manner in which the earthquake load under an open-water condition is magnified by sea ice coverage. For the stable ice-cover condition, the magnification of design earthquake load can be deduced from the studies on the development of hydrodynamic pressures during an earthquake. Both the theoretical and experimental studies on this issue have already been reported, and they will be mentioned briefly in this paper. On the other hand, the magnification of design earthquake load under the drifting ice-cover condition was not directly obtainable. First we calculated a total load on a structure, which is tentatively to be designed, by the finite element method, simulating the situation

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