A Study of Numerical Simulations of Ship Motions While Underway Using a Coastal Wave Database

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The safety of maritime transportation should be ensured. However, the methods currently used to determine whether or not to cancel ship services are insufficient. A numerical simulation of ship motions was constructed using the coastal network wave database, NOWPHAS. A domestic ferry service, which navigates the Pacific Ocean, is set as the object of this study. Field observations of ship motions were implemented when typhoons approached Japan. The accuracy of ship motions obtained using 2 types of simulation methods is verified. Finally, this study reveals the factor that controls the accuracy of ship motions.

INTRODUCTION

More than 90% of global cargo is currently transported by sea. The safety of maritime transportation is a high priority at all times. Many studies have focused on the motions of moored ships due to long period waves in harbours facing the open seas (Shiraishi et al., 1996, 1999). Further, other studies have focused on ship motions when ships are entering a harbour or anchoring offshore (Sasa et al., 2005, 2006). While ships are underway, suitable navigation routes are selected following weather routing (James, 1957). However, the influence of ship motions is not considered in detail. Although there are many studies of ship motions in the ocean from the viewpoint of seaworthiness (Okusu, 1996), they mainly involve frequency domain analysis. Most domestic ferry lines do not have effective ways to determine whether to cancel service in stormy weather. The individuals responsible for canceling such services depend on their intuition and experience and sometimes fail to predict oceanographic conditions or ship motions. Any error in judgment has the potential of resulting in damage to cargo or casualty of the vessel. Few studies have involved comparisons of observed ship motions in a time series while the ships are underway in irregular waves. In Japan, the Nationwide Ocean Wave information network for Ports and Harbours (NOWPHAS) (Nagai et al., 1994) was established for the purpose of constructing safe harbours. This system is used to evaluate safety in port construction and operations from various aspects in the field of coastal engineering. It is also effective for the estimation of ship motions when underway. First of all, observing ship motions of domestic ferries in the Pacific Ocean has been carried out for 2 years, when typhoons approached Japan. Observation data would clearly demonstrate the characteristics of ship motions. The modeling of numerical simulations is carried out to verify observed ship motions with the coastal wave database. The simulated results show there are some parameters that influence the accuracy of reproduction. Finally, the cancellation of a domestic ferry service is determined with the use of a network coastal wave database.

CURRENT STATUS OF FERRY OPERATIONS

For navigation purposes, ship operators are always cognizant of changing oceanographic conditions. In particular, car ferries or RO/RO (Roll on/Roll off) ships must not load passengers and vehicle cargoes which are not acceptable under conditions of large amplitude ship motions. These vessels must operate in open seas without causing large motions or impulse forces. A study of cargo management by domestic ferries (Kobayashi et al., 2004) revealed that impact damage or collapse against vehicle cargoes sometimes occurs if pitch or roll motions are exceptionally large. The current procedures for cargo management are not sufficient under

<table>
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<tr>
<th>Topic</th>
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<tr>
<td>Criterion of ferry service</td>
<td>Ferry service can generally be provided until the significant wave height exceeds 4 m. However, the steps for cancellation must be very specific when typhoons are involved.</td>
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<tr>
<td>Situation of ship motions</td>
<td>Pitch motion is remarkable in head seas during navigation. As ferries enter a harbour, the roll and yaw motions increase in intensity near the breakwaters.</td>
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<tr>
<td>Damage of cargos</td>
<td>Cargo is sometimes damaged by the shock due to large ship motions.</td>
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Table 1 Present criteria of ship operations