

# A Study of Difficulties of Entering and Departing Harbours Due to Wave-induced Ship Motions

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**It is very important to maintain safety when ships enter or depart harbours. In this study, ship motions are at first successfully observed in swells. It is shown that difficulties occur during berthing operations inside harbours as well as during entrances. Observed data are analyzed to learn these difficulties numerically. Numerical simulations of ship motions in swells during harbour entrance and departure are newly constructed at first. Their accuracy seems to be enough to compare to some cases of observed ship motions. Further, it is necessary to define the new evaluation parameters regarding the difficulty of the berthing operation; this is proposed and verified as the Difficulty of Berthing Function. The function can evaluate the operational difficulty quantitatively; this point should be considered part of harbour tranquility.**

## INTRODUCTION

When harbours are planned, the influence of external forces, such as waves and wind, is usually considered. Ships cannot moor in some harbours due to large amplitudes of motions on moored vessels. In the 1990s, many studies were conducted of this topic in the field of coastal engineering and port construction (Shiraishi et al., 1996). It is clear that long-period waves, about 60 s to 180 s, are the main cause of mooring difficulties. Long-period waves have been studied in detail from the viewpoint of the design of harbour facilities, such as breakwaters (Hiraishi et al., 1996), and a new system of mooring lines and fenders has been very effective in reducing the motions of moored ships. On the other hand, safety is very important as ships enter and depart harbours in severe seas. Safety while entering and departing harbours has been thoroughly studied, in many cases with the use of ship-handling simulators. However, the influence of winds and currents is usually considered. It is beyond the scope of this study to consider the overall safety of ships using harbours that face the open sea. Studies have been conducted on ship-handling as small fishing boats enter and depart harbours subject to winter storm waves (Kubo et al., 2000), and these have proposed a new concept involving the difficulty of entering a harbour in order to evaluate the safety of ship-handling in heavy waves. It then becomes necessary to understand the properties of ship motions as a ship enters and departs harbours subject to severe waves. It is important to study these problems in harbours facing the Pacific Ocean and for large ships. In this study, we carry out some hearing research about the difficulty of navigating ships near harbours during entrance and departure. Some important problems can be solved relative to navigating ships near a harbour entrance, particularly those

involving large ferries that navigate the Pacific Ocean. In 2002, ship motions in large ferries were repeatedly observed as they entered and departed harbours facing the Pacific Ocean during typhoon swells. Difficulty of navigation was also observed as the ferries approached and navigated the harbour. The berthing operation especially becomes very difficult near the quay wall because of the large roll motion, even if the ship is in a harbour. This is a very serious phenomenon for ships and harbours. Although it is very important to evaluate safety when entering or departing, the evaluation method is hardly established in this situation. It is necessary to construct new evaluation parameters in port planning. We study the numerical simulation model of ship motions during harbour entrance and departure. The accuracy of the simulation is compared with the observed data of ship motions. The total evaluation system of safety during harbour entrance and departure is proposed for port construction and operation.

## DIFFICULTY OF STEERING SHIPS SUBJECT TO SHIP MOTIONS WHILE ENTERING AND DEPARTING HARBOURS

Research is conducted for the BH Ferry Company to arrive at solutions to navigation problems at a harbour entrance. The following questions are asked of navigation officers of the BH Ferry Company:

1. Have you ever experienced navigational difficulties as a result of ship motions?
2. What kind of ship motions are related to navigation?
3. Which sea conditions cause navigation problems?
4. Where are the specific areas of the navigation problems?
5. What other operational problems have you experienced?

Table 1 gives a summary of the answers.

The answers in Table 1 make it clear that swells are the major danger to navigation in port. Ship motions caused by swells make navigation difficult. Ferry captains believe that waves make ship handling as well as ship mooring very difficult.

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