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Characteristics of low-frequency motions of ships moored inside ports and harbors on the basis of field observations

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Abstract

In order to understand characteristics of low-frequency motions of ships moored inside ports and harbors, analysis on actual cargo handling logbook of stevedoring services company, including events of interruption of cargo handling, and countermeasure for ship mooring problems are investigated by field observations at two ports and numerical simulation on moored ship motions. First model port concerns with interruption of cargo handling due to the low-frequency motions. Second model port relates to a resonant effect of long-period waves or harbor oscillations, and its countermeasure by mooring system. From the investigation, it is confirmed that the low-frequency motions of ships are induced by a resonance between surge motions and long-period waves or harbor oscillations and an asymmetry in the mooring system, and affect safe ship mooring and operation efficiency of cargo handling in ports and harbors significantly.

Keywords: Moored ship; Low-frequency motions; Long-period waves; Harbor oscillation; Seiche; Port; Harbor; Fender; Mooring rope; Mooring system

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1. Introduction

Recently harbor tranquility has been evaluated by not only wave height at berth but also wave period, and moreover, ship motions moored at the berth directly [1,2]. It is necessary for port and harbor authorities to achieve and offer more effective and intelligent transport system to customers such as shipping and transportation companies. On the other hand, it has been reported in various ports and harbors that large and low-frequency motions of ships moored inside them are induced by asymmetrical mooring system on fenders and mooring lines as subharmonic motions, and by a resonant effect between surge motions and long-period waves such as seiche, harbor oscillations and bounded long-period waves during calm weather condition [3,4]. In each case, interruption of cargo handling occurs and the operation efficiency is disturbed, thus the port becomes to be ineffective and/or unsafe port. All ports and harbors need to avoid to be recognized as unsafe port.

Many studies on the long-period waves have been done [5,6]. However, any effective countermeasures against the low-frequency motions of ships moored inside ports and harbors have not been proposed and the mechanism have not been found out in details and clearly. The issue is only solved by seamanship of pilots and harbor masters on site practically.

In this paper, analysis on actual cargo handling logbook of a stevedoring services company, which include events of interruption of cargo handling, and several types of ship mooring problems at two ports are demonstrated, and characteristics of the low-frequency motions are investigated by field observation and numerical simulation on moored ship motions.

2. Effect for annual harbor tranquility

2.1. Outline

Effect of low-frequency motions of ships for annual harbor tranquility and situations on interruptions of cargo handling is investigated by using actual cargo handling logbook of a stevedoring services company at a harbor facing to the Pacific Ocean. Evaluation method on operation efficiency of cargo handling based on moored ship motions is applied, instead of the ordinary method by wave height. From the investigation, it is confirmed that effect of long-period waves should be considered for reproduction of the large and low-frequency motions at the interruptions, and influences the operation efficiency remarkably.

2.2. Operation efficiency based on moored ship motions during swells

2.2.1. Calculation conditions for moored ship

(1) Model harbor and jetty
Fig. 1 shows a model port; Port-1, which is a typical reclaimed harbor. A target jetty is located at slip entrance of No. 3 pier as shown in Fig. 2. The water depth is 10 m.

(2) Ship dimensions and mooring arrangement
Since the jetty is a public berth, various ships in sizes and kinds use the jetty. Considering the cargo handling logbook of the wharf usage, two target ships, 696 GT and 15,000 DWT general cargo ships, are determined as the minimum and the