Experimental Results of Ship-to-Ship Stabilized Mooring System for Mobile Harbor

Tae-Gweon JEONG*, Yun-Sok LEE**, Chao Chen***, † Se-Won KIM

*† Department of Navigation Sciences, *Korea Maritime University, Busan 606-791, Korea*
** Sea Training Center, *Korea Maritime University, Busan 606-791, Korea*
*** Marine Simulation Center, *Korea Maritime University, Busan 606-791, Korea*

ABSTRACT : *A new concept of ocean transport system, called mobile harbor, was introduced as a feasibility study in Korea in 2009. Target of the mobile harbor is a short distance transport of containers with or without cargo handling cranes. Although the mobile harbor project has a lot of topics to deal with, this paper is to focus on only ship-to-ship stabilized mooring, which plays a key role in cargo handling. The ship-to-ship stabilized mooring system was developed and installed on board a barge of LOA 32m and breadth 12m. The dockside tests as sea test were carried out so as to ascertain ascertained whether the systems can work well to control the barge's motion. The results of dockside test showed that the heave motion of the barge's motion can be reduced by more than 45%.*

KEY WORDS : *mobile harbor, mother ship, mobile harbor ship, ship-to-ship stabilized mooring system, positioning winch, embedment drag anchor*

1. Introduction

A new concept of ocean transport system, called mobile harbor, was introduced as a feasibility study in Korea in 2009. Target of the mobile harbor is a short distance transport of containers with or without cargo handling cranes. Many study groups for the mobile harbor carried out their own fields and frequently had group discussions about them (Jang, 2009: Kim, 2009; Lee, 2009; Myung, 2009; Park, 2009; Shin,2009). That is, they investigated a series of conceptual designs and operational feasibility of the mobile harbor, such as the size of mobile harbor and mother ship, design, working sea state, cargo handling speed, motion analysis for floating structure, actuator analysis, mooring and berthing method, control system for mobile harbor ship, mooring line and cargo handling crane, proper location for mobile harbor service, etc.

The ship-to-ship SMS is one of important parts of mobile harbor project and consists of the optimum SMS and specialized equipment involved in it. For the optimum SMS, mooring method is that one side of the MH ship is securely moored alongside a mother ship by mooring lines and Yokohama fenders between them and the other moored at the sea bottom by fore and aft suction pile anchors. Positioning winch systems, which are originally modified from conventional auto-tension ones, are developed together with control system in this study. The winch systems are to measure and control the motion variation of the MH ship by suppressing the surge and sway motion, especially, the heave motion.

Sea tests are planned to be two stages; the first is carried out dockside and the other alongside the mother ship. This study is to deal with dockside tests as the first stage of the sea tests, which are to find out the difference of the motion of the MH ship between without the control of the positioning winch systems and with it. After all it will be ascertained whether the winch systems can work well to control these motions or not.

2. The Conceptual Design and Mooring of Mobile Harbor

One of the conceptual designs of mobile harbor here was suggested as shown in Fig. 1. The design is intended for the optimum SMS. Firstly the mother ship of 10,000 TEU class will be anchored with four (4) suction pile anchors and the MH ship moored with two (2) suction pile anchors and two (2) bollards of the mother ship..

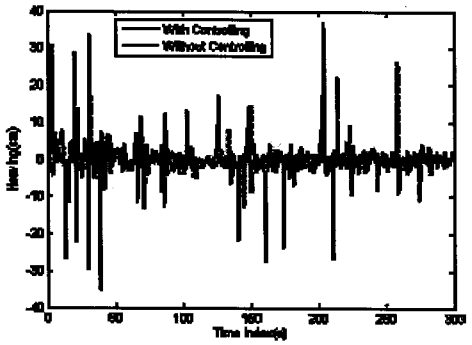
* Representing author, tgjeong@hhu.ac.kr (051) 410-4246
† Corresponding author, hanhanghae@civil.kyushu-u.ac.jp 011)241-5625
** lys@hhu.ac.kr
*** cc20202@163.com

3. Dockside tests on the ship-to-ship SMS

The rotary movement of yaw, pitch and roll and the translational movement of surge, sway and heave were determined by analyzing positions obtained from the DGPS receivers. This study is to compare six (6) DOF motions controlled with those uncontrolled and to ascertain whether the SMS developed will be available for the mobile harbor.

Only five (5) results among dockside tests were described. All six DOF motions were analyzed, but due to limited paper space only heave motions were shown here. And it also is because the heave motions of the barge were focused on due to the importance of controlling the vertical motion.

The following shows an example of Dockside test No.1.



<Fig.1> Comparison of heave motions 'controlled' and 'uncontrolled' on condition of average height 0.15m and max height 0.28m

☐ Time and date of test: 10:30-11:00 Dec. 18, 2009

☐ Height and period of sea wave: average height and period of sea wave during the test are 0.15m and 8.76s respectively and the maximum height and period 0.28m and 4.14s respectively.

☐ Direction and speed of wind: the wind speed was 2~10 m/s and direction 260~350° during the test.

☐ Heave motion: Fig. 1 shows the heave motions 'controlled' and 'uncontrolled'. In the figure blue line indicates 'controlled motion' and red dash line represents 'uncontrolled motion'. As shown as in Fig. 1 the controlled heave motion is significantly less than the uncontrolled motion.

4. Conclusions

This study suggested one of the conceptual designs of mobile harbor and developed the ship-to-ship SMS and carried out dockside tests to validate the conceptual mobile harbor. As a result, the following are concluded.

- To keep ship-to-ship stabilized mooring, we suggested that the mother ship be moored with four-point suction pile anchors and wire ropes and also the MH ship be moored with two-point suction pile anchors and wire ropes outwards and with wire ropes and Yokohama fenders towards the mother ship.
- To control translational motion, especially heave motion, the ship-to-ship SMS, called positioning winch system, was developed.
- The dockside tests were carried out to check the motion of a barge of 400 CBM alongside the wharf, Korea Maritime University. The barge was moored with four (4) positioning winch systems, 4 DPS sensors, wave meter, and anemometer.
- The heave motion of the barge decreased by more than 45% during dockside tests.

Acknowledgements

This research was part of the results of the project called "the Development of Ship-to-Ship Stabilized Mooring System and Equipment concerned" supported by a grant from "the Development Program of Original Technologies for Mobile Harbor" funded by the Ministry of Education, Science and Technology.

References

(1) Jang T.S. (2009): Simultaneous nonparametric identification of nonlinear roll damping and restoring moment of a mobile harbor, 2009 Mobile Harbor R&D Workshop, KAIST.

(2) Kim K.S. (2009): The Development of Zero Moment Crane Stabilized Control System, 2009 Mobile Harbor R&D Workshop, KAIST

(3) Kim S.H. (2009): The Conceptual Design of Mobile Harbor Floaters, 2009 Mobile Harbor R&D Workshop, KAIST.

(4) Lee J.M.(2009): The Development of High-speed Cargo Handling System for Mobile Harbor and Stabilization of Floating Objects, 2009 Mobile Harbor R&D Workshop, KAIST.