Thesis for the Degree of Doctor of Philosophy

A Study on Automated Ribbon Bridge Installation Strategy and Control System Design

by

Van Trong Nguyen

Department of Mechanical System Engineering

The Graduate School

Pukyong National University

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A Study on Automated Ribbon Bridge Installation Strategy and Control System Design

부유식 교량 설치방법 및 제어시스템 구축에 관한 연구

by

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Advisor: Prof. Young-Bok Kim

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

In Department of Mechanical System Engineering,

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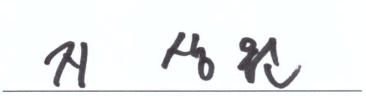

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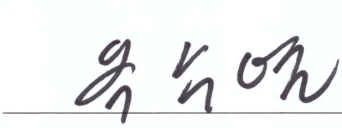

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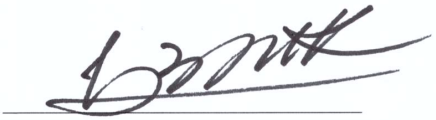

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Contents

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Abstract

Recently, Ribbon Floating Bridges are widely utilized in transportation, especially for emergency restoration in both military and civil fields thanks to their great advantages of ability to transport heavy combat vehicles, trucks, quick installation, and low environmental impacts. Since the installation and operation of the ribbon floating bridge are mainly carried by manual work, these jobs may contain high risks, particularly in dangerous situation and combat time. Therefore, it is critical to propose an installation strategy and self-operation automatically.

This dissertation aims to present a new approach for automated installation and operation of the ribbon floating bridge by proposing a mathematical modeling and designing a control system with different approaches.

The floating bridge system consists a series of interior and ram bays connected that can be considered as the multi-link manipulator. It is confirmed that there is no previous study related to this object although a lot of researchers paid attention to dynamic analysis. Be-

sides, the floating bridge systems normally work in continuous changing environment and are affected by various of uncertainties such as current flow, moving load, and other external disturbances that can lead to position displacement.

To successfully achieve the automatic installation and self-correction positional displacement of the ribbon floating bridge, the integrated propulsion systems are included and the yaw motion of every single bay is measured by the incremental encoder. The ribbon floating bridge is loaded in one riverside and then is rotated to the desired position across the river. In order to maintain the structure and operation of the bridge system, it is required to ensure the linearity of the whole bridge and keep its desired position. To completely perform these task, the followings are carried out:

• Firstly, the ribbon floating bridge system structure description and dynamic analysis are discussed and system modeling of the ribbon floating bridge consisting of five individual coupled floating units is given. In this system, there will be existences of two passive bays that do not have propulsion systems. The remaining three active bays are designed to integrate with three propulsion systems containing azimuth propellers, direct current motors and motor drivers. Besides, the yaw displacement between two continuous floating units is measured by the incremental encoder. The system modeling of the ribbon floating bridge describes the kinematics and kinetic of mechanical and electrical operation to obtain a dynamic system expressed by state equations.

• Secondly, a number of experimental studies is conducted in order to identify the dynamic characteristics of the floating unit. Be-