論文題名 Study on Remote Monitoring System of Dynamic Behavior and Environment of Highway Bridges in Coastal Area

長崎大学大学院生産科学研究科　　Jawaid Bashir Ahmad

Structures, including bridges, buildings, dams, pipelines and offshore structures are complex engineered systems that ensure society's economic and industrial prosperity. These infrastructures begin to deteriorate once they are built and used. Maintaining all types of structures in safe and reliable conditions for daily use is a topic that has received considerable attention in the literature of civil engineering in recent years.

Developing remote monitoring system for dynamic behavior and environment of highway bridges in coastal area is essential to maintain their effective management. Especially, to identify the level of structural deterioration by changes of dynamic characteristics such as natural frequency, modal damping and mode shapes. In addition, dynamic characteristics estimation method has been used for remote monitoring of the bridge. Subsequently, ambient vibration measurements of existing bridges were conducted to verify efficiency of the method. Furthermore, environmental effects, such as characteristics of ambient vibration, the annual change of frequency of the object bridge versus temperatures were evaluated.

The first part of the thesis contains the introduction and the determination of bridge modeling and dynamic analysis of example bridges.

The second part addresses the use of available ambient vibration sources which significantly reduces the cost of testing. Besides, this part includes the application of advanced realization theories for estimation of bridge dynamic characteristics using ambient vibration with high-quality experimental measurements. This was verified by the measurement and experiment on the existing real bridge. A steel arch bridge situated in Nagasaki Prefecture has been selected as the object bridge. Multipoint ambient vibration measurement was executed on the bridge considering different bridge environment (ambient vibration conditions) such as strong windy condition with random moving vehicles (Case1), strong windy condition without moving vehicles (Case 2) and weak wind condition without moving vehicles (Case 3).

The third part contains the application of ambient vibration for long term continuous monitoring system of the existing bridges for estimation of dynamic characteristics under varying environmental conditions. In addition this part addressed the changes in frequency versus the temperature variation.

And the last part contains the conclusion and remarks. Findings of the study can be summarized as that stable and continuous estimation of dynamic characteristics were possible for stationary ambient vibration. In case of non-stationary ambient vibration, some lacks or changes of frequency have caused in lower modes due to vehicles influence.

This dissertation is composed of 8 chapters.

Chapter 1 has been focused on background of the study followed by the review of previous works and finally objectives and outline of the dissertation.

Chapter 2 presents modeling and dynamic analysis of the example bridges by the finite element method and state space representation of equation of motion and at the end the dynamic analysis results for examples bridges have been performed.

Chapter 3 describes dynamic characteristics estimation method of bridges by realization theories. In the chapter, the dynamic characteristics estimation by time series analysis is discussed by realization theories.

Chapter 4 describes the ambient vibration measurement using the theories and measurement system for the existing steel arch bridge. Multipoint ambient vibration measurement was executed on the bridge for different ambient vibration conditions.

Chapter 5 describes the results of multipoint ambient vibration measurement of the object steel arch bridge. The estimated frequency for the different ambient vibration cases are indicated respectively. As for the lower vibration mode, we found that strong windy condition has better accuracy in frequency estimation and induces higher vibration modes, where moving vehicle effects accuracy of the frequency estimation results.

Chapter 6 deals with the verification of the effect of wind velocity on frequency estimation accuracy by remote monitoring for Kashiragajima bridge. The chapter ends with measurement results, such as relation between velocity of the wind and vibration characteristic estimation.

Chapter 7 discusses long term monitoring of natural frequencies of existing steel arch bridge by theoretical tools of remote monitoring system. Measurement apparatus were installed on the object bridge for automated measurement, and natural frequencies were observed by remote monitoring system. Consequently, yearly change of natural frequency revealed to be change with the change of temperature.

Chapter 8 includes concluding and remarks of the dissertation.