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FUNDAMENTAL STUDY ON DYNAMIC PROPERTY OF DEPLOYABLE EMERGENCY BRIDGE USING SCISSORS MECHANISM

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Summary

This paper presents a new type of emergency bridge, called Mobile Bridge, which can be quickly constructed in case of damage after a natural disaster. The concept of the bridge is based on the application of a scissors mechanism, which enables its rapid deployment. In the case of deployable structures as well as the static analysis of different configurations of expansion, it is important to investigate the dynamic behavior of the system. The high compliance and flexibility of the scissors-type bridge may influence the comfort and safety of users in case of heavy dynamic loads such as human-induced impacts, wind gusts, or earthquakes. Up to now, the authors have constructed several types of the experimental Mobile Bridges. The presented research reviews fundamental numerical and experimental results for the Mobile Bridge 4.0. Experimental testing included strain and acceleration measurements in free and forced loading conditions. From these results, it was possible to estimate basic mechanical characteristics, including the static and dynamic properties, of the bridge. The conducted research allows for better and safer design of the structure of the Mobile Bridge.

Keywords: deployable Bridge; scissors-type bridge; emergency bridge; dynamic property; natural frequency; acceleration measurement

1. Introduction

In recent years, the world has seen several types of natural disasters that have caused many critical situations in the lives of people by damage of an infrastructure. It is important to rebuild damaged traffic routes immediately in such serious situations in order to facilitate quick relief and restoration activities.

a) b)

Figure 1: Vibration modes after installation in vertical direction. a) 4.6 Hz in the 1st mode, b) 14.4 Hz in the 2nd mode.

Therefore the authors have proposed a rapidly and easily constructible emergency bridge using a deployable system, called Mobile Bridge™ (MB). It is based on the concept of the Multi-Folding Micro-structures (MFM) theory [1-2]. The original structural form of the MB, in its patent, is similar to a scissor system for its structural form. The design concept of the MB enables the reduction of construction time on site by deploying the structural frame directly over a damaged bridge or road. Up to now several types of the experimental MBs were constructed based on the our patents. The presented research reviewed numerical and experimental results for the full-scaled Mobile Bridge version 4.0 (Herein called MB4.0). The current model, the MB4.0, was the length of approximately 20 m and the height of 2 m. Main structural members of the bridge were made of extruded aluminum alloy, while the frame of the hydraulic deployment system was constructed of SS400 steel. Experimental testing included strain and acceleration measurements in free and forced loading conditions. In the case of deployable structures, as well as the static analysis of different configurations, it is important to investigate the dynamic behavior of the system. The high compliance and flexibility of the scissors-type bridge may influence the comfort and safety of users in case of heavy dynamic loads such as human-induced impacts, wind gusts, or earthquakes.

2. Mechanical property based on numerical simulation and experimental testing

The fundamental mechanics of the MB including its static and dynamic properties are discussed following numerical simulation and experimental testing using the MB4.0. Due to the page limitation, we would like to show the eigenvalue analysis and vibration modes. The preliminary results of the eigenvalue analysis of the MB4.0 in fully deployed and after construction was presented in **Fig. 6** and **Fig. 7**, respectively. When the bridge is fully deployed, the eigenvalues for the 1st mode in the vertical and horizontal direction are 1.5 Hz and 8.0 Hz, respectively, and in the 2nd mode, 2.0 Hz and 5.6 Hz. These results indicated that the vibrations in horizontal direction were larger than in vertical direction after construction. Therefore, special attention has to be paid to in-plane vibrations when the full-scaled MB is installed on site.

3. Conclusion

This paper reviewed a story of the research development of the MB and presented numerical and experimental results based on the MB4.0. The eigenvalue analysis revealed the basic vibration modes of the MB4.0 and indicated that major vibration of the scissoring bridge was dependent on its boundary conditions. Thus, it is more susceptible to vibration in the horizontal direction than in the vertical direction after installation. Besides, we found the logarithmic decrement of the MB4.0 from the experimental testing. The conducted research allows for better and safer design of the MB. Further details of the experimental testing and numerical analysis will be presented at the conference.

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