NUMERICAL ANALYSIS ON NATURAL VIBRATION CHARACTERISTICS OF 5-SPAN CONTINUOUS PC RIGID-FRAME BOX GIRDER BRIDGE

Muroran Institute of Technology	○ Student member	Thanh Vu Minh
Muroran Institute of Technology	Member	Masato Komuro
Muroran Institute of Technology	Fellow	Norimitsu Kishi
Koken Engineering Co. Ltd.	Fellow	Ryoji Kawase

1. INTRODUCTION

In order to use the bridges for long period, operation and management for these continuously are very important. Inspection of the natural vibration frequency and modes for bridges may be one way to evaluate these structural health. From this point of view, many researches on field vibration test and numerical analysis for bridges have been conducted (Bayraktar et al., 2010; Zhang et al., 2013).

In this paper, in order to investigate the natural vibration characteristics of an actual five-span continuous PC rigid-frame box girder bridge, which has not been opened yet, field vibration test was carried out (Vu et al., 2019). And also finite element numerical analysis was performed to investigate the applicability of the method compared with the field test results.

2. BRIDGE DESCRIPTION

The Obirashike-river bridge is of a five-span continuous PC rigid-frame box girder bridge, located in the east part of Hokkaido, Japan. Description of the bridge is summarized in Table 1. Photo 1 shows a bird's eye view of the bridge.

3. OVERVIEW OF EXPERIMENT

A total of 34 high-sensitive servo-type vibration meters were placed on both sides of the slab to accurately evaluate the natural vibration frequencies and modes of the bridge as shown in Figure 1. The acceleration response of the bridge was monitored after passing a weight control vehicle by means of a wireless LAN system. The measured data were recorded in a sampling time of the data was set to 5 ms (200 Hz) while the bridge was closed to other traffic.

Table 1 Description of Obirashike-river Bridge.

Design	Five-span continuous PC rigid-frame box girder
Total length	392 m (40+88+136+88+40 m)
Width	10.51 m
Girder height	3.5 - 7.5 m
Completion	2015
Longitudinal gradient	0.31 %

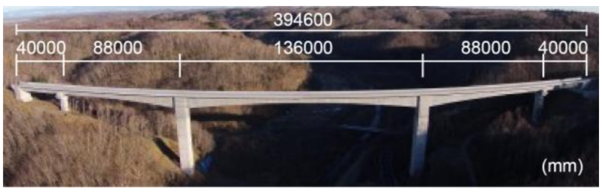

Photo 1 View of Obirashike-river bridge.

4. FINITE ELEMENT ANALYSIS

To verify the experimental results, natural vibration analysis was carried out by using ABAQUS code. For modeling of the bridge in this study, the following assumptions were made: (1) The bridge was simply modeled by changing the approximation curve to a straight line; (2) all materials were elastic and homogenous; (3) fixed supports were assumed as boundary conditions for all piers and abutments; and (4) a longitudinal gradient was ignored because it was trivial.

Figure 2 shows the finite element analysis model of the Obirashike-river bridge. The model was a combination of the slab, box girder, abutments, and piers with their properties according to construction drawing. The connection of the bridge and two piers (P1 and P4), the bridge and two abutments (A1 and A2) were modeled as the tied constraint of two contact surfaces at box girder of the bridge with piers and abutments, respectively, because the exciting force on the bridge was relatively small. The model was created by using solid elements with a total of 148,582 nodes and 257,133 elements. The material properties of the bridge were assumed to be as follows: the modulus of elasticity, Poisson's ratio, and the density was 32.5 GPa, 0.2, and 25 kN/m^3, respectively.

Figure 3 shows an example of the typical natural vibration mode obtained from the numerical analysis.

5. COMPARISON OF THE EXPERIMENTAL AND ANALYTICAL RESULTS

Figure 4 shows a comparison between vibration modes obtained from the tests and the FE analysis in this study.

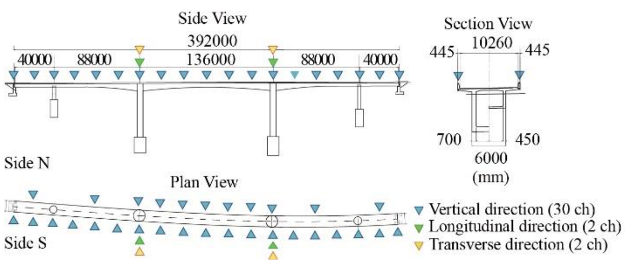

Fig. 1 Location of measuring points.

Keywords: PC box girder bridge, natural vibration characteristic, vibration test, finite element analysis
Contact Address: 27-1 Mizumoto, Muroran, Hokkaido, Japan, 050-8585, TEL/FAX 0143-46-5232

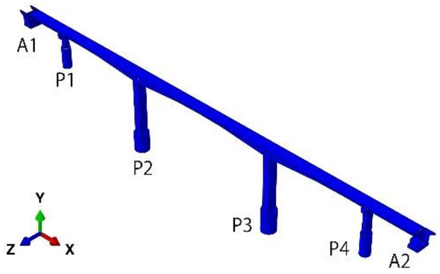

Fig. 2 Finite element model.

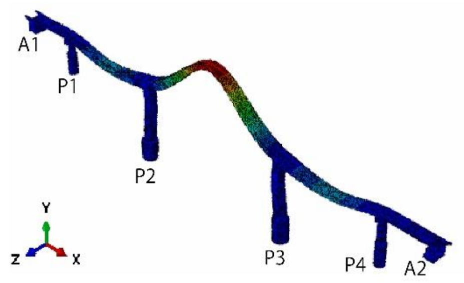

Fig. 3 An example of the natural vibration mode.
(1st vertical vibration mode, f_a = 1.471)

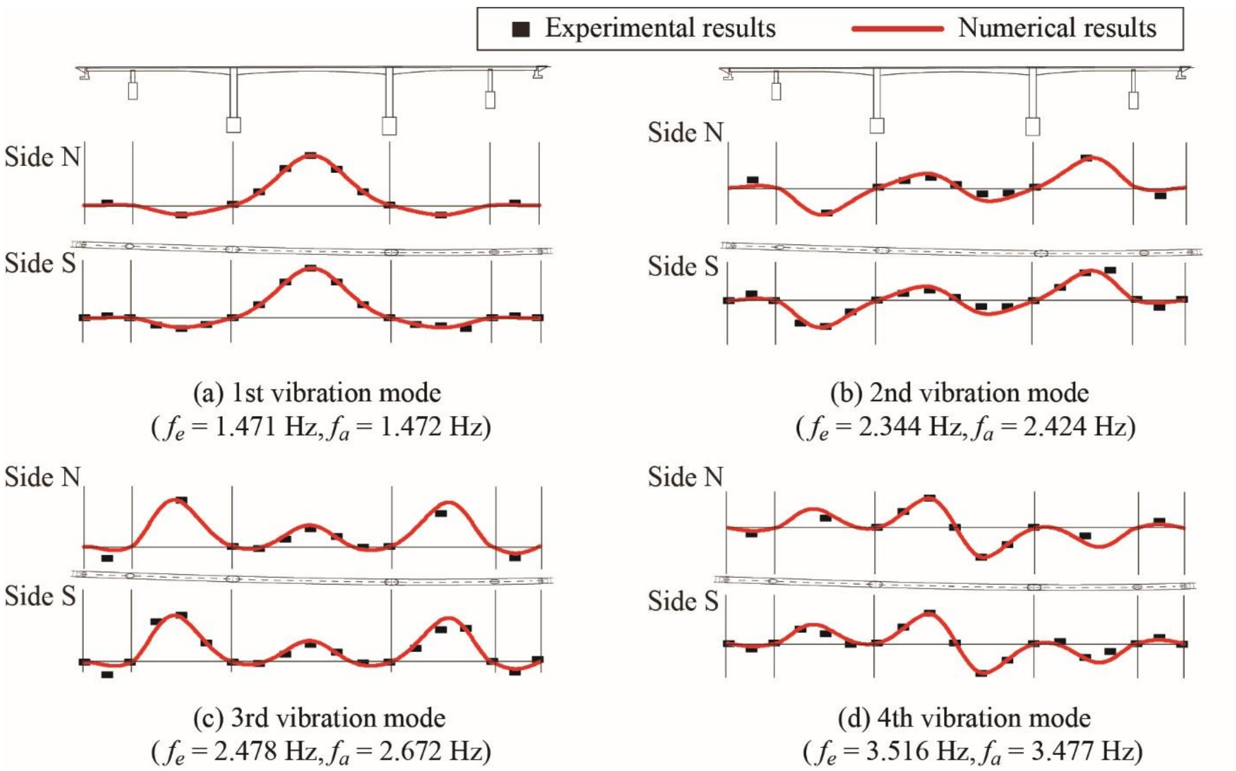

Fig. 4 Comparison of the mode shapes between the numerical and the experimental results.

All vibration modes were specified using time histories of the acceleration measured along the bridge. All modes are normalized with respect to the maximum amplitude at the side S of the bridge.
According to Figure 4, it was confirmed that: (1) all mode shapes were almost similar in both sides of the slab of the bridge, and (2) all mode shapes show the locations of experimental results were on or near the numerical results with slight distances.
Therefore, it was observed that the natural vibration frequencies and modes obtained from the ambient vibration are almost similar to the results by applying the FE analysis based on the undamaged bridge.

6. CONCLUSION

The results obtained of this study were as follow:

1) The natural vibration frequencies and modes from the ambient vibration test were almost similar to the numerical analysis results;
2) The natural vibration frequencies and modes of the undamaged bridge before the start of the operation were verified.

ACKNOWLEDGEMENTS

Regarding the vibration test of the bridge, we received the assistance of the Kushiro Branch of Hokkaido Regional Development Bureau. We express our deep appreciation for the cooperation.

REFERENCES

Bayraktar, A., Altunişik, A. C., Birinci, F., Sevim, B., and Türker, T.: Finite-element analysis and vibration testing of a two-span masonry arch bridge, Journal of Performance of Constructed Facilities, ASCE, 24-1, 2010, pp. 46-52.

Zhang, J., Prader, J., Grimmelsman, K. A., Moon, F, Aktan, A. E., and Shama, A.: Experimental vibration analysis for structural identification of a long-span suspension bridge, Journal of Engineering Mechanics, ASCE, 139-6, 2013, pp. 748-759.

Vu, M. T., Komuro, M., Kishi, N., and Kawase, R.: Field vibration tests on natural vibration characteristics of 5-span continuous PC rigid-frame box girder bridge, Proceeding of Hokkaido Chapter of the JSCE, Vol.75, A-49 (CR-ROM), 2019.