EVALUATION OF SMALL BRIDGE DYNAMIC CHARACTERISTICS BY IMPACT VIBRATION TEST AND THE THREE-DIMENSIONAL FEM ANALYSIS

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1. INTRODUTION

For the appropriate maintenance of the existing bridge, establishment of the technique of an economical, effective healthy degree evaluation is demanded. There is the inspection of structural rigidity that used vibration properties for something typical as the guideline which estimates healthy degree. In this paper, the authors found the characteristic frequency of the existing portable bridge by a shock vibration examination using the small FWD. In addition, the authors reproduced a superstructure of the object bridge by three-dimensional FEM model and the vibration analysis which changed the support condition is performed. The authors examined a vibration characteristic evaluation of the object bridge by comparing the result of the three-dimensional FEM analysis with the impact vibration test.

2. THE OBJECT BRIDGE

Object bridge is the simply supported composite girder bridge. It's lengths is 20.0m, and total width of the bridge is 6,300mm. Girder height is 800mm.Tickness of RC slab is 160mm, and one of concrete pavement is 50mm. Figure 1 shows the cross section of the object bridge.

3. RESULTS OF THE FWD EXAMINATION

In this study, the authors executed the impact vibration test with portable FWD. We let weight of 25kgf drop from 1.0m height onto RC slab of the object bridge. It is dropping the weight on six points in 1/2 points and 1/4 points of each girder span. We measured the acceleration of 9 points, in 1/2 points, 1/4 points and 3/4 points of each girder span as shown in Figure 2. Each accelerometer sampled the reply acceleration data per 0.0001 seconds. We calculated a fourier amplitude spectrum and a phase difference spectrum by an FFT

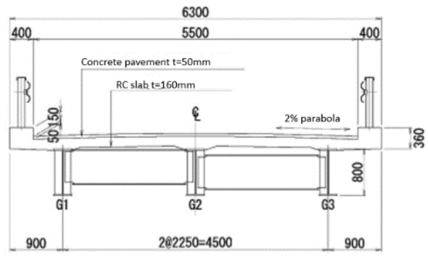

Fig. 1. A cross section of the object bridge

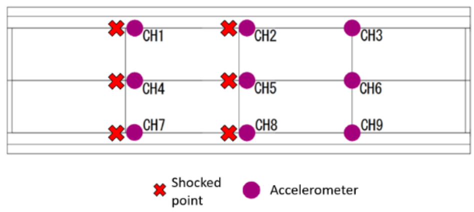

Fig. 2. The positioning of impact vibration test

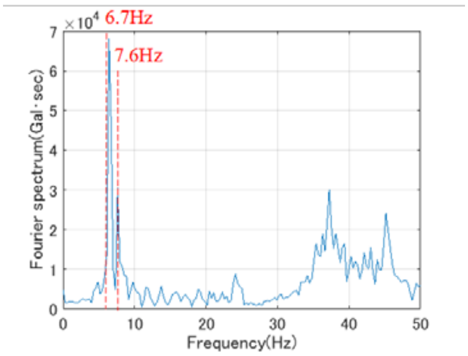

Fig. 3. An instance of fourier amplitude spectrum

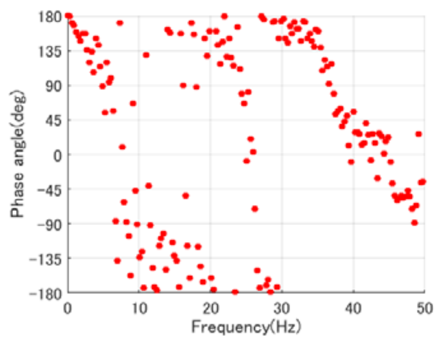

Fig. 4.An instance of phase difference spectrum

method from 16384 sequence acceleration data and looked for excellence frequency. Figure 3 shows the fourier amplitude spectrum (obtained from the acceleration wave at that point when dropping 1/2 point of G3 girder span.) Figure 4 does a one of the phase difference spectrum of same point. The excellence frequency of 6.7Hz was seen in the amplitude spectrum of all accelerometer placement positions when a 1/2 point of each girder length was shocked. Excellence frequency was also seen in 7.6Hz by acceleration waves on G1 and G3 girders mainly. The authors considered 6.7Hz is the frequency which indicates the first bending vibration mode, and 7.6Hz is the frequency which indicates the first torsion vibration mode.

4. **RESULTS OF** THE NATURAL VIBRATION

The authors made a superstructure model of the object bridge using three-dimensional FEM analysis tool. The authors used shell element for main girders and cross beams, and solid element for slabs. The total number of nodes of the FEM model is 13,482.and the total number of elements is 9016. Each Young's modulus of RC and steel are Ec=23500N/mm^2, and Es=205,000N/mm^2. Table 2 shows the analysis result that changed support pattern into 4 patterns.

5. CONCLUSION

The authors measured an acceleration waves pattern by the impact vibration test using the portable FWD. We calculated a fourier amplitude spectrum and a phase difference spectrum by a FFT method and found the excellent frequency of the object bridge. In addition, the authors tried identification of the basic vibration mode. The natural frequency of bending and torsion mode of a certain pattern of supports reaches the excellent frequency of the test.

For the further studies, we will try to insert some spring models to consider the degree of restraint of each supports.

Table 1. Measured excellent frequency by the impact vibration test

Measurement point	Excellence frequency(Hz)	Estimated vibration mode shape
1/2, 1/4 points of span	6.7	The bending mode
1/4 point of span	7.6	The torsion mode

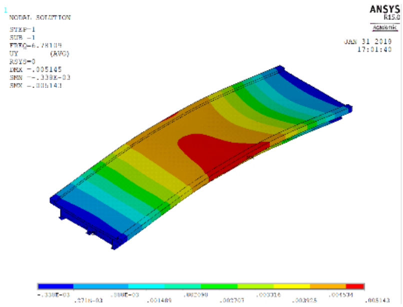

Fig. 5. The bending mode shape of analysis model

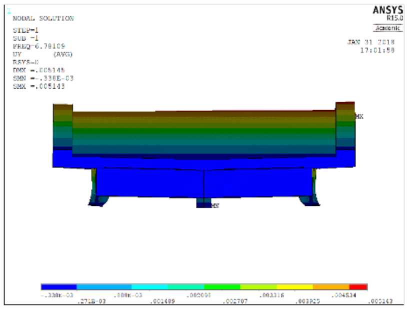

Fig. 6. A cross section of the bending mode shape of analysis model

Table 2. Results of the natural vibration analysis (Hz)

Pattern	Support pattern			Natural frequency	
	G1	G2	G3	The bending mode shape	The Torsion mode shape
①	pin-pin	pin-pin	pin-pin	—	8.3
②	pin-pin	pin-roller	pin-pin	6.8	7.1
③	pin-roller	pin-pin	pin-roller	—	6.2
④	pin-roller	pin-roller	pin-roller	4.5	6.2