Evaluation bridge by impact hammering method

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1. Introduction

Determination of predominant frequency is essentail for evaluating the vibration characteristics of bridges. For the determination of predominant frequency, there are different excitation methods including ambient vibration, impact hammering and test vehicle running. Among these methods, the impact hammering method is generally used for short span bridges and has an advantage of quick experimental setup.

In this paper, the dynamic responses of a bridge due to impact generated by hammer are studied to check the stability of this method. The responses of bridge structure are analyzed with a number of impacts at particular impact point as well as giving hammer impacts at different locations of bridge.

2. Description of bridge

The study area is Yoshida Bridge which is located at Nishiyama, Kikuma Town of Imabari City. The overall dimensions of this bridge are 17.20 m in length, 15.72 m wide in south end and 11.98 m wide in north end. It is composed of 14 precast, prestressed box–girders. The span length of this Bridge is 16.54 m with skew angle of 60°. The cross section view of this bridge is shown in Figure 1.

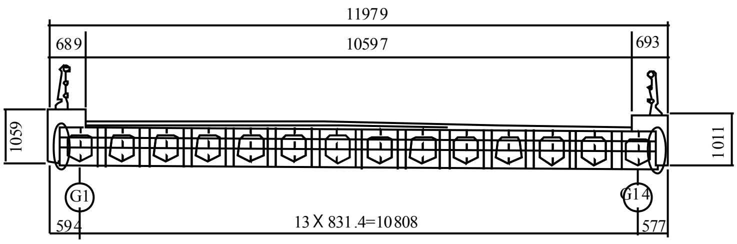

Figure 1: Cross- sectional view of Yoshida Bridge (Note: All dimensions are in mm)

3. Impact tests

The vibration measurement system is essentially composed of central data acquisition system GEODAS-12-USB-24ch to which six velocimeter CR4.5-2S are connected. These sensors are placed on each quarter span of the bridge as shown in Figure 2 schematically. One sensor is placed on the ground which is 8.6 m apart from south end of bridge. The grid lines along the longitudinal direction are drawn at the interval of 2.65 m. Similarly, the grid lines along the transverse direction of bridge are drawn at the interval of 4.13 m parallel to skew line. The impact locations are the intersection of these grid lines (A1, A2, A3……..E3, E4, E5) as shown in Figure 2. Wooden hammer with 2.55 Kg weight is used as the impact excitation source. The sampling frequency is set to 200 Hz and measurements are taken by giving impacts at the interval of 20 seconds for one minute duration. The velocity time histories obtained from each impact are subsequently transformed into frequency domain by using Fast Fourier Transformation. Then predominant frequency is by

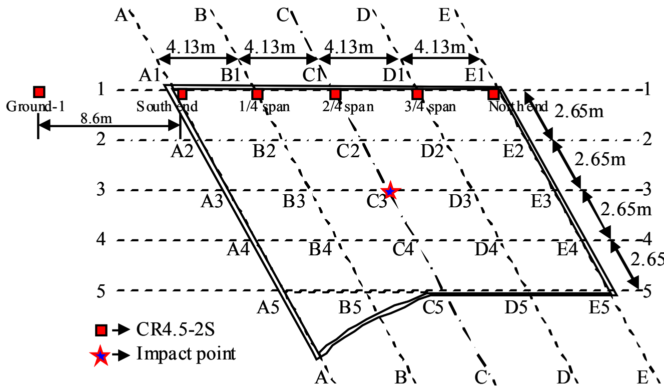

Figure 2: Plan view of Yoshida Bridge with sensors configuration and impact locations

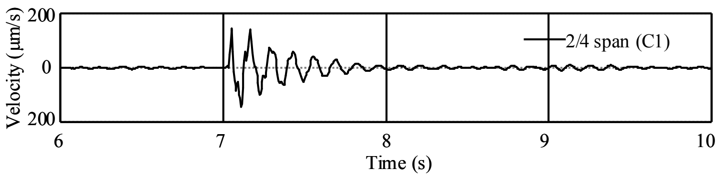

Figure 3: Velocity time history of free vibration of point C1 (2/4 span) due to impact at point C3 in Yoshida

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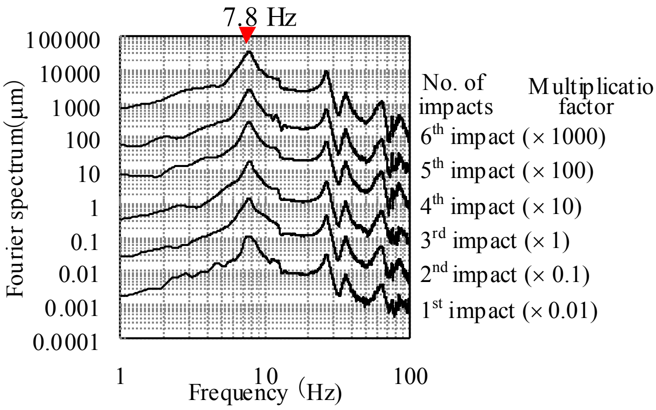

Figure 4: Reproducibility of Fourier spectra of point C1 (2/4 span) of Yoshida Bridge due to impacts at C3

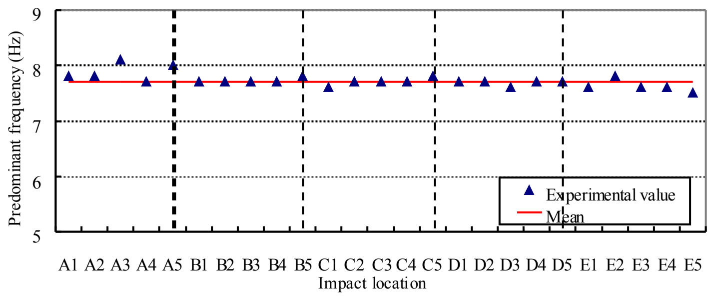

Figure 5: Predominant frequency of Yoshida Bridge due to impact at different locations

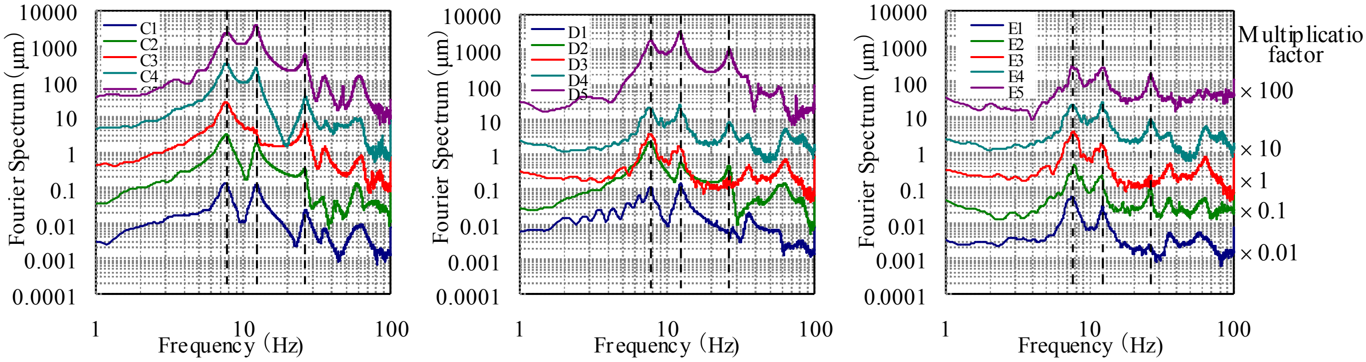

Figure 6: Fourier spectra of point C1 (2/4 span) due to impacts along CC, DD and EE grid lines

peak picking method.

4. Results

The velocity time history due to impact at point C3 is shown in Figure 3. Six impacts are given at the interval of 20 seconds at the mid point (C3). The Fourier spectra due to these impacts are illustrated in Figure 4. The amplitude of Fourier spectra are multiplied by multiplication factor assign in right side of graph in order to align graph in vertical axis. The average predominant frequency of Yoshida Bridge due to six impacts at the mid point is found to be 7.8 Hz with standard deviation of 0.06 Hz and coefficient of variation (c.o.v) is found to be 0.8 %. This small variation in predominant frequency indicates that frequencies extracted from impact hammer test are reliable and stable.

The impacts are also given at points from A1 to E5. Fourier spectra due to impacts along grid lines CC, DD and EE are shown in Figure 6. The Figure 6 is the Fourier spectra obtained from sensor located at the point C1 (2/4 span). The shapes of Fourier spectra due to impacts at different location are similar but some difference can be seen in higher frequency of vibration. In the Fourier spectra due to impact at mid point (C3), there is no clear peak around 12.3 Hz whereas there is clear peak around 12.3 Hz if impacts points are other than C3. Figure 5 shows the predominant frequency of bridge due to impact at different points. The mean predominant frequency due to impacts at various locations is found to be 7.7 Hz with the standard deviation of 0.13 Hz and coefficient of variation (c.o.v) is found to be 1.6 %. These observations indicate that first predominant frequency of bridge is independent of impact location.

5. Conclusions

The first predominant frequency due to impact hammer excitation is statistically reliable with approximately 2% of coefficient of variation (c.o.v) and independent of impact location. In the most cases, respective peaks at higher frequencies appear at same respective frequencies although impacted points are different.

6. Acknowledgement

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