Displacement Measurements in Steel Girder Bridge Using Video Camera

Tokyo City University	General student member	○Chanoknunt SANGSOBHON
Tokyo City University	General member	Hidehiko SEKIYA
Tokyo City University	General member	Masayuki TAI
Tokyo City University	General member	Shogo MORICHIKA
Shutoko Technology Center	General member	Mizuki HAYAMA
Metropolitan Expressway	Non-member	Masanobu NAGAI

1. Introduction

Bridge structure is the important infrastructure that provides a safe and efficient means of transportation for people, goods, and services. Due to the frequent use of bridges, they are subjected to cyclical loads on a daily basis which can result in fatigue damage. This type of damage is considered to be one of the major causes of bridge failure. Proper maintenance is necessary to prevent bridge failure. Applying a proper monitoring system is significant since fatigue damage is often difficult to detect with naked eye[1)]

Since fatigue occurs when a material undergoes cyclic loading[2)] ,measuring the displacement response that lead to high strain which is caused by cyclic loading is one way to determine the fatigue environment. Various methods can be used to measure bridge displacement response, including contact displacement gauges and MEMS sensors. Video cameras are an option for collecting field data since they can be easily set. Thus, in this study, the displacement responses were measured using a 4K video camera.

2. Material and Method

2.1 Bridge description

The test bridge consists of a single span with five main girders and a reinforced concrete (RC) deck plate with three traffic lanes. It is located in Tokyo and is managed by the Metropolitan Expressway Company, Limited. Figure 1 depicts the experimental setup. A 4K video camera, contact displacement gauges and strain gauge were installed in an in-service steel girder bridge.

2.2 Video camera specification and contact displacement gauge specification

A 4K video camera was used in this experiment. It recorded video data at a resolution was 3840 × 2160 pixels and 60Mbps, XAVC QFHD 29.97 p. frame rate. The videos were recorded in long profile format throughout the recording period. In this experiment, the contact displacement gauge model CDP-25, which operate at a sampling frequency of 100 Hz was used. The capacity range of this device is from 0 to 25 mm. The nonlinearity is 0.1% RO and it has a sensitivity is 500 $\times 10^{-6}$ strain/mm.

2.3 Field measurement

The field measurements were performed under the in-service bridge without traffic control. A 4K video camera was placed beneath the bridge, and three contact displacement gauges and strain gauges were installed to measure the responses of the test bridge under live loads. The camera was positioned between girder 2 and girder 3, while the contact displacement

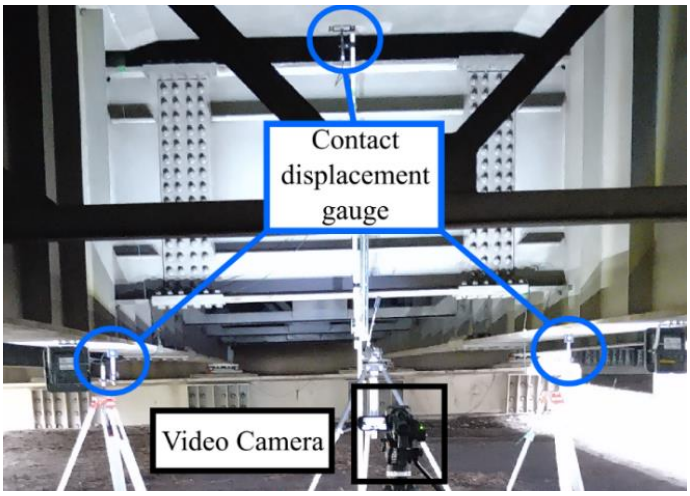

Figure 1

Keywords: Displacement measurement, Image sensing, Fatigue

Contact: 〒158-8557 Tokyo-to Setagaya-ku Tamazutsumi 1-28-1 Tokyo City University Tel: 03-5707-0104

gauges were attached under girder 2, girder 3, and under the bridge slab between girder 2 and girder 3. The space between the lower flange and ground is about 1.0-1.3m. Although the camera was capable of recording responses at three different points, only the response at G3 was considered for this study.

2.4 Displacement measurement method

The video was first extracted into images series. The movement of the pixel of the target part would be considered as displacement. The region of interest (ROI) was created over the target part of every image to detect the movement. MATLAB's edge detection[3] was used to trace the shape of the target part. Then the interesting part could be detected. The overall procedure is shown in Figure 2. The coordinate of the center of the detected target would be used to calculate for the displacement responses. The coordinate of the target object of the image when no load was applied is considered as Img_1, while those which subsequent to time step are considered as Img_i, where i is the order of images from 1 to n, where n is the total number of images in time series. The displacement response time step i can be given by

$$Disp_i = Img_1 - Img_i \tag{1}$$

To verify the accuracy of the bridge displacement response measured in pixel units, a fundamental experiment was conducted to determine the scale factor for converting the unit from pixels to millimeters. This was achieved by establishing the relationship between the distance from the video camera to the contact displacement gauge and the size of one pixel. By determining this relationship, the pixel size for various distances could be calculated. The video camera used in the experiment had a fixed recording resolution of 3840 × 2160 pixels. However, the size of objects captured by the camera can vary depending on the distance between the camera and the objects. Therefore, the size of a pixel is dependent on the distance between the camera and the target objects.

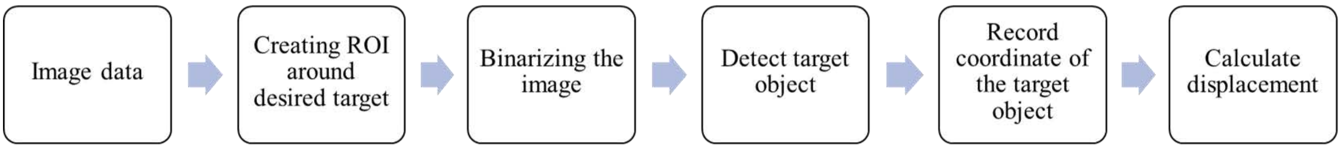

Figure 2

3. Displacement response measured using image sensing

The example of the displacement response measured from video data is shown in Figure 3. The result is shown in the same unit as the contact displacement gauges. The trend of displacement response obtained from image sensing followed approximately the displacement response obtained from the contact displacement gauges.

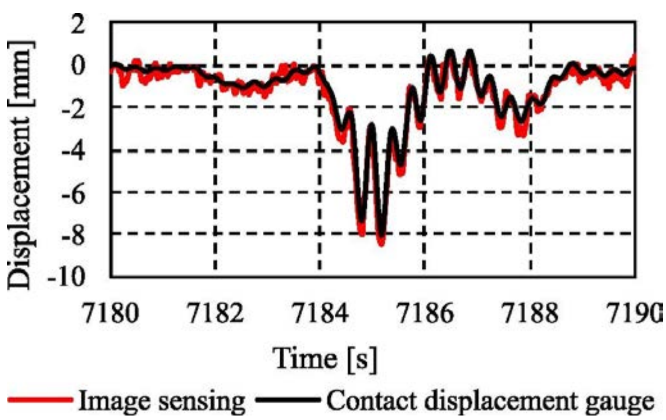

Figure 3 Displacement of G3

4. Discussion, Conclusion and Future work

This study observed the in-service steel girder bridge using the 4K video camera and compiled it with an image processing technique. The bridge displacement response was obtained. The trend of displacement response obtained from image sensing followed approximately the displacement response obtained from the contact displacement gauges. In future work, the displacement responses will be used for evaluating the fatigue environment.

5. References

1) Fisher, J. W., Roy, S.: Fatigue Damage in Steel Bridge and Extending Their Life, *Advanced Steel Construction*, 11(3), 250-268, 2015.
2) Shan, Y., Liao, K.: Environmental fatigue behavior and life prediction of unidirectional glass-carbon/epoxy hybrid composites, *International Journal of Fatigue*, 24. 847-859, 2002.
3) Image Processing Toolbox User's Guide. Mathwork Inc.; Available online: https://www.mathworks.com/help/pdf_doc/images/images_ug.pdf.