EFFECT ON BRIDGE RESPONSE INDUCED BY TRAFFIC VEHICLES AFTER MODIFICATION OF THE BRIDGE STRUCTURE

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1. Introduction

The Monoi Bridge, Chiba, Japan, was a multi simple-span steel plate girder bridge. It has been structurally modified by connecting their multi simple-spans to be continuous-spans. Furthermore the original metal bearings were replaced with the new rubber bearings. In order to investigate the bridge response induced by traffic vehicles after modification, the strains at lower flange of each girder are taken as the indicator because it is the most important parameter that influence the design, rating and capacity evaluation of bridge structure. The calibration test was performed to obtain the influence line for the strain at the midspan of each girder. It was carried out two times, before and after the modification process of the bridge. From the tests, the influence lines show that, after connecting of the span, the strains of each girder are decreased. In the other word, the moment induced by the traffic vehicle in the continuous-span is smaller than that of the simple-span bridge was.

2. The Monoi Bridge

The Monoi Bridge is a steel plate girder bridge. Before the modification, it consisted of 28 simple-spans, each 29.5 to 34.656 m length. The bridge carries 3-lane roadway. The 200 mm reinforced concrete slab with a 75 mm thick asphalt is carried directly by 5 main girders and 4 longitudinal stringers as shown in Fig. 1. The secondary members, such as, floor beam, sway and lateral bracing are also assembled in the bridge structure.

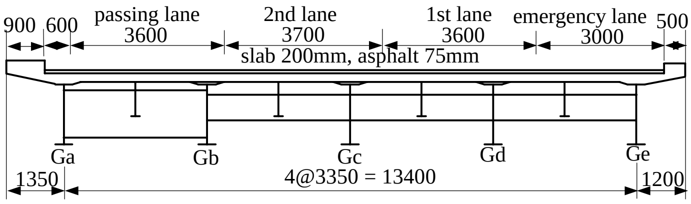

Fig.1 General section of the Monoi Bridge

Recently the improvement and replacement of some parts of the bridge structure has been performed to strengthen the bridge. The original simple-span steel plate girders have been connected by using high strength bolts and gusset plates and they become continuous girders. However there is no change for reinforce concrete deck it is still has an expansion join at abutment. The metal bridge bearings of the original structure were replaced by the new rubber bearings. Fig. 2 shows the bridge structures that were strengthened by several methods.

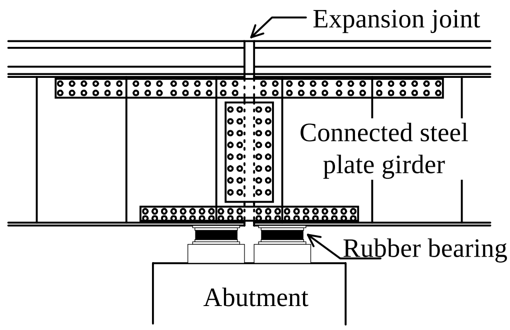

Fig.2 Improved bridge structure

3. Calibration Test

The purpose of calibration test is to obtain the influence line for the strain of each girder at midspan. The concept of Weight-in-motion was applied. Strain gauges were placed on the bottom flange of each girder at midspan. At each girder, strain gauges were also attached on the stiffeners at midspan and a quarter of span. These gauges on stiffeners were used only to provide the velocity of the calibration truck.

The test used a 3-axle known weight truck running pass the bridge with the restriction that there is no any other traffic vehicle on the target span together with the calibration truck. During the calibration truck is passing on the target span, the signal from each gauge is converted from analog to digital at frequency 500 Hz and recorded in a computer. Then the recorded data is passed to some digital signal processing and now the data is ready to be used to calculate the influence line. Fig. 3 shows the plot of the recorded strain data of a girder.

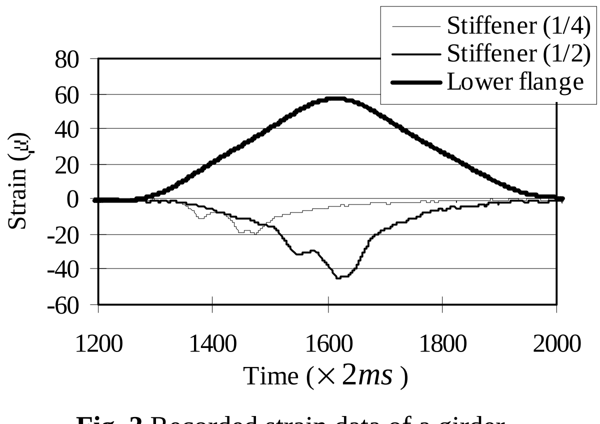

Fig. 3 Recorded strain data of a girder

The test was performed on both the simple-span (before connected) and continuous-span (after the bridge girders have been connected). The target span of the test is between abutment P26 and P27. The test was divided in three cases, i.e., the calibration truck run on 1^{st} lane, 2^{nd} lane and passing lane. They are referred to case 1, 2 and 3 respectively.

Keyword: Steel plate girder bridge, Bridge response, Bridge strengthening, Influence line

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4. FEM Analysis

A commercial finite element program, so called ABAQUS, was selected to analyze the Monoi Bridge model. The Monoi Bridge FEM model was created as a complex three dimension model. The model used shell element to model steel plate members and two-node beam in space element to model bracing members. Eight-node continuum element was used to model the concrete slab. The results of FEM analysis show that the response of the bridge also can be predicted by applying finite element method.

5. Results and Discussions

From the calibration test, the influence lines for strain of bottom flange at midspan for each girder was obtained for all cases. The influence line of each girder of case 1 (1st lane) is plotted in Fig. 4 and 5 for simple and continuous span respectively. It can be seen obviously that the magnitudes of the influence lines of the continuous girders are smaller than those of the simple-span girders. It can be said that the bridge girders after having been connected has the smaller moment induced by the same load comparing with the original girders.

The results of the case 2 and 3 are also in the same trend as case 1. Table 1 compares the magnitude of the influence lines of each girder between the simple-span and continuous-span for all cases. Consider the maximum magnitude among each girder in each case, it can be found that the maximum magnitude strain decrease 10.6, 6.1 and 15.4 % in case 1, 2 and 3 respectively after the modification. From these results it can be confidently said that the bridge can be subjected to traffic load higher than the original structure.

The result from FEM analysis is shown in Fig. 6. Fig. 6 shows the influence lines of each girder of case 1 for simple-span. It can be seen that the result from FEM is very close to the result from calibration test. This verifies that the response of the bridge can be predicted by applying finite element analysis method.

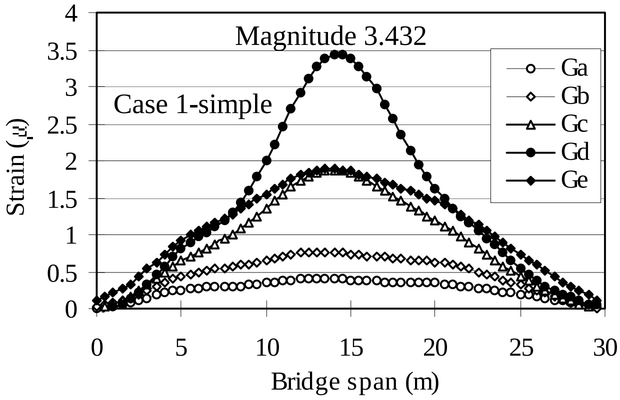

Fig. 4 Influence line for original structure (simple-span)

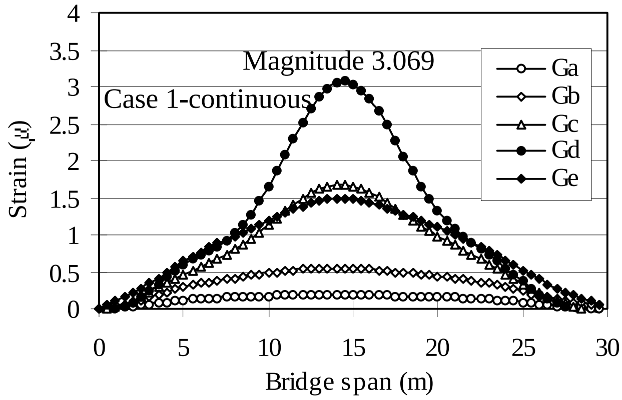

Fig. 5 Influence line for improved structure (continuous-span)

6. Conclusions

As the result from the calibration test, the Monoi Bridge, after having been modified, has higher loading capacity than the original structure. This indicates that connecting of bridge girders and changing of the bridge bearing, is an effective method to strengthen the steel plate girder bridge.

Table 1 Comparing of magnitude of influence line between original and connected girder.

	Case 1 (lane 1)			Case 2 (lane 2)			Case 3 (lane 3)		
	Simple	Cont.	%diff.	Simple	Cont.	%diff.	Simple	Cont.	%diff.
Ga	0.405	0.200	50.5	1.013	0.832	17.8	2.981	2.522	15.4
Gb	0.765	0.552	27.9	1.728	1.601	7.3	2.534	2.211	12.7
Gc	1.870	1.674	10.5	2.449	2.301	6.1	1.178	0.975	17.2
Gd	3.432	3.069	10.6	1.186	0.983	17.1	0.437	0.227	48.0
Ge	1.889	1.484	21.4	0.698	0.476	31.8	0.211	-	-

The FEM model of Monoi Bridge can predict well the response of the real bridge. However the model must be the complex three-dimensional model. There is not only the primary members are included in the model but also the secondary members, such as stringers, floor beam, bracing should be included in the model. There are several cases that the field is not convenience to carry out for any restriction. For example, it costs a large amount of budget or the traffic is very difficult to perform the test. In these cases, FEM analysis is especially important to predict the response of the bridge.

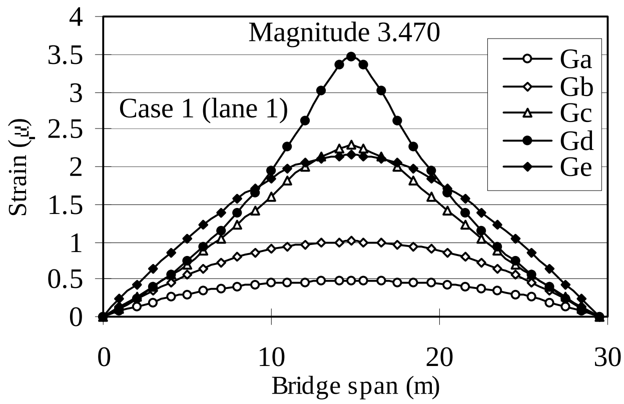

Fig. 6 Influence line for original structure obtained for FEM model (simple-span)

7. References

Fred Moses (1979), Weigh-in-motion system using instrumented bridges, Transportation Engineering Journal.