Static Loading Test Based Validating Current Gerber Hinge Status of Existing Steel Cantilever Through Truss Bridge

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Summary

When a structure was in insufficient condition, its material, and geometric properties, encompassing alters of boundaries' status and system connectivity could also be different to as-designed original condition. In this research, a static loading field test was carried-out on a bridge to evaluate its current status of hinges and bearings. The target bridge named Chousei Bridge for 77 in-service years is a steel cantilever through-truss bridge structured by suspended spans and cantilever spans connected via Gerber hinges. A series of sensors of strain and displacement were established to measure the response to the test loads. The bridge is then simulated as 3D finite element model with differentiating the hinges' condition considered as certain stiffness springs. Performing a comparison between the analytical results to the experimental results indicates that each hinge's current status is different to the others instead of the same stiffness parameter as original state.

Keywords: static loading test; steel; truss bridge; validation.

1. Introduction

Recently, the steel volume expended for new construction of bridges in Japan has been significantly decreased while a numerous quantity of steel bridges exceeding 50 years of life span in 20 years is realized [1]. A field static loading test using known-weight three-axle dump trucks was carried-out to evaluate the current performance of such a steel bridge, located in Nagaoka City, Japan. The measurement data used to construct a three-dimensional finite element model validated through comparisons axial forces and vertical displacement has supported a good understanding of actual boundary condition.

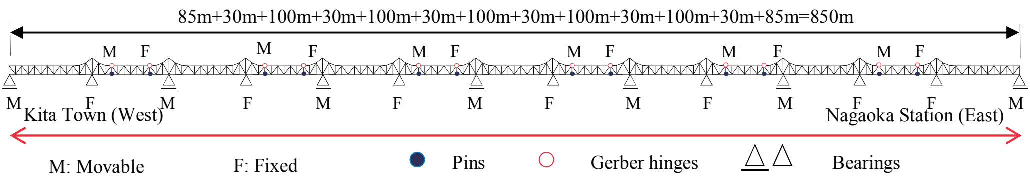

Fig.1: Elevation with condition of hinges and bearings

2. Bridge description and field static loading tests

The case study bridge, opened to the traffic in 1937 was originally designed as Gerber steel through cantilever truss bridge encompassing a series of anchored cantilever spans and suspended spans that linked to each other by Gerber hinges at upper level and pins at lower level (Fig.1). There were 100 strain gauges attached on 25 of upper and diagonal chords, 13 vertical displacement transducers for 13 spans utilized in the tests instrumented (Fig.2). Both trucks crawled over the bridge together, symmetrically to the bridge central line and stopped at pre-defined positions at mid-point of each span coinciding to its gravitational center point.

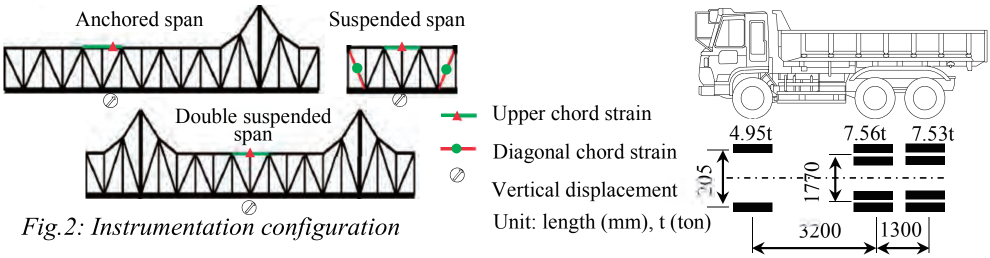

Fig.2: Instrumentation configuration

3. Validating current boundary condition of the bridge

A 3D linear elastic finite element (FE) model of the bridge superstructure is constructed utilizing an FE analysis software called DIANA [2]. Table 1 demonstrates the current condition of all bearings and Table 2 lists the stiffness parameters in three directions of the springs. The proposed model is confirmed through the axial force and vertical displacement comparisons between test and analytical results.

Table 1: Proposed bearing type changes

Bearing position	A1	P1	P2	P3	P4	P5	P6
Type change	M	F	M →F	F	M →F	F	M →F
Bearing position	P7	P8	P9	P10	P11	P12	A2
Type change	F	M →F	F	M →F	F	F	F
A: Abutment, P: Pier, M: Moving, F: Fixed							

Table 2: Proposed Gerber hinge stiffness

Span/Side	Left	Right
	Horizontal stiffness k_h(N/mm)	
2	$0,4x10^4$	$0,4x10^4$
4	$0,35x10^4$	$0,35x10^4$
6	$3x10^5$	$3x10^5$
8	$0,9x10^4$	$0,9x10^4$
10	0	$1x10^4$
12	$1,5x10^4$	0
All	Rotational stiffness k_r (Nmm/mm)	
	$2x10^4$	0
	Vertical stiffness k_v (N/mm)	
	$1,9x10^{10}$	$1,9x10^{10}$

4. Conclusion

In this study, the static field load tests on the in-service old steel multi-span cantilevered through truss highway bridge has been carried-out. A three-dimensional FE model of the whole bridge superstructure has also been constructed with some reasonable assumptions made to comprehend the response of the bridges to the real loads in the current boundary condition through the detailed comparisons between theoretical and practical results of axial forces and vertical displacement. The present stiffness parameters of Gerber hinges and changes of bearings with the fixing of five out of seven movable bearings have been validated based on the static load in the longitudinal direction. Based on the proposed finite element model of the bridge, further research into load rating of this aging bridge is necessary.

5. References

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