Fatigue Damage of an Urban Expressway Steel Girder Bridge Constructed in 1964

FATIGUE DAMAGE OF AN URBAN EXPRESSWAY STEEL GIRDER BRIDGE CONSTRUCTED IN 1964

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Abstract

In Japan, infrastructure, including numerous highway and railway bridges, was intensively constructed during the rapid economic growth era from 1960' s to 1970' s. We are warned that those structures are now aged and may deteriorate in the near future. Since fatigue design had not been applied to highway bridges until 2002[1)], there is a high possibility that fatigue cracking will occur frequently in the future.

In this study, we try to grasp fatigue behavior and fatigue strength characteristics of the fatigue weak points in the actual bridge through fatigue tests of steel girders which had been used on an urban expressway for more than 40 years and removed in 2005. Before the fatigue tests, cracks inspection results are reported.

1. BRIDGE AND GIRDERS

The object of study is the Minato-machi Ramp Bridge, which was real urban expressway ramp girder bridge constructed in 1964, and removed in 2005. The bridge was a simply-supported composite main girder bridge. Girders have a web plate and a bottom flange with welded vertical stiffeners and gusset plates which connect cross frames and lateral bracings to main girders. Figs.1~3 shows the plan, elevation and cross section of the bridge. Test pieces were cut out from the red areas shown in Fig.1.

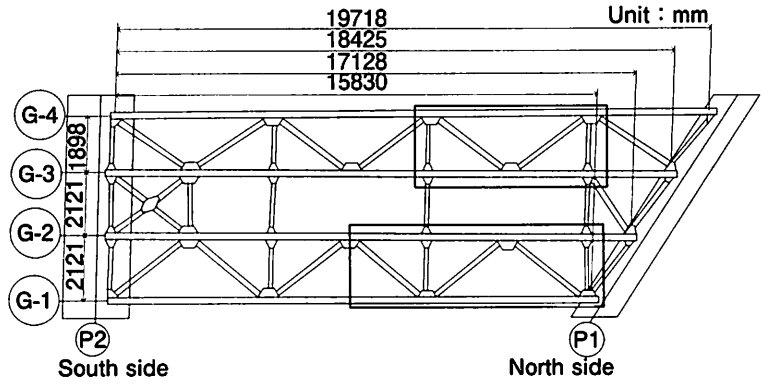

Fig. 1 Plan of Minato-machi Ramp Bridge

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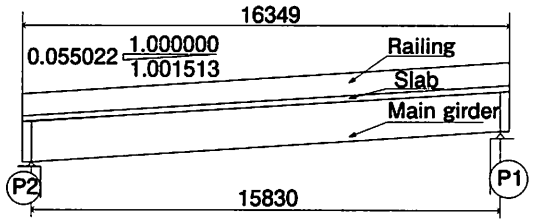

Fig. 2 Elevation of Minato-machi Ramp Bridge

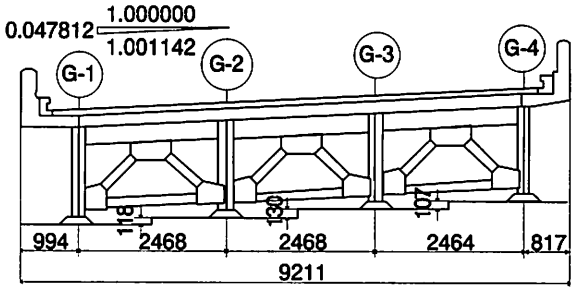

Fig. 3 Cross section of Minato-machi Ramp Bridge

2. CRACKS INSPECTION

2.1 Method

Before the fatigue tests, magnetic particle tests are conducted to detect the fatigue cracks which could have occurred under service loading. Toes of turn-round weldment are inspected in the welded joint which connects the gusset plate to the web of the main girder. The total number of inspected toes of turn-round weldment is 53 in 15 gusset plates. Fig.4 shows locations of gusset plates and inspected areas.

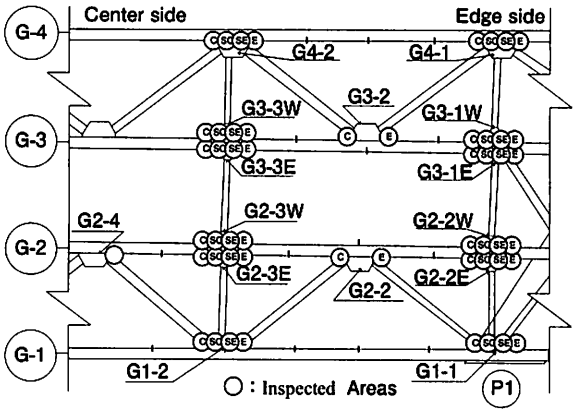

Fig. 4 Locations of gusset plates and inspected areas

At first, to confirm the shape and length of paint cracks, the paint cracks are inspected. Next, the paint is removed by hammer. Finally, we tried to detect the fatigue cracks by magnetic particle test.

2.1 Paint cracks inspection

Table.1 shows the result of the paint cracks inspection. Red and yellow areas show paint crack occurrence areas. There were 18 paint crack occurrence areas in the 53 inspected areas.

Paint cracks in the red areas are along the toes of turn-round weldment which are fatigue weak points. Paint cracks in the yellow areas are not along the toes of turn-round weldment.

In the 5 blue areas we could not judge the shape and length of the paint crack because of burning and deterioration.

Table 1. Result of paint cracks inspection

Gusset Plate	Inspected Area	Paint Crack Length(mm)	Note	Gusset Plate	Inspected Area	Paint Crack Length(mm)	Note
G1-1	C	12,7,7		G3-1E	C	33	
	SC	0			SC	0	
	E		Burned		E	0	
	SE		Deterioration		SE	0	
G1-2	C	83,65		G3-1W	C	0	
	SC	0			SC	0	
	E		Burned		E	0	
	SE	0			SE	3	
G2-1E	C	0		G3-2	C	13	
	SC	0			E	27	
	E	0		G3-3E	C	0	
	SE	0			SC	0	
G2-1W	C	5			E	0	
	SC	0			SE	0	
	E	0		G3-3W	C	0	
	SE	0			SC	17	
G2-2	C	13			E	0	
	E	12,9			SE	0	
G2-3E	C	23		G4-1	C	23	
	SC	0			SC	12	
	E	6			E		Deterioration
	SE	0			SE		Burned
G2-3W	C	0		G4-2	C	20,18	
	SC	0			SC	0	
	E	0			E	17,9	
	SE	0			SE	27	
G2-4		35,32					

2.3 Magnetic particle test

Fig.5 shows the result of magnetic particle tests. MT signs that may indicate fatigue cracks were observed at 2 weldments among the 18 turn-round weldments with paint cracks. Several paint cracks were observed at the G1-2-C gusset plate.

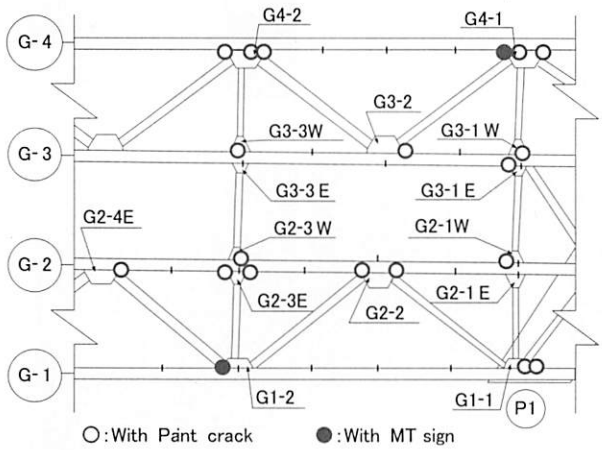

Fig. 5 Results of magnetic particle test

A MT sign of 8mm length was observed under a 83mm paint crack at the G1-2-C gusset plate. A MT sign of 4mm length was observed under a 23mm paint crack at the G4-1-C gusset plate. Photos.1～4 shows paint cracks and MT signs in the G1-2-C and G4-1-C gusset plates.

There are no MT signs in the inspected areas that have no paint cracks, or that have paint cracks in places other than along the toes of turn-round weldment which are fatigue weak points.

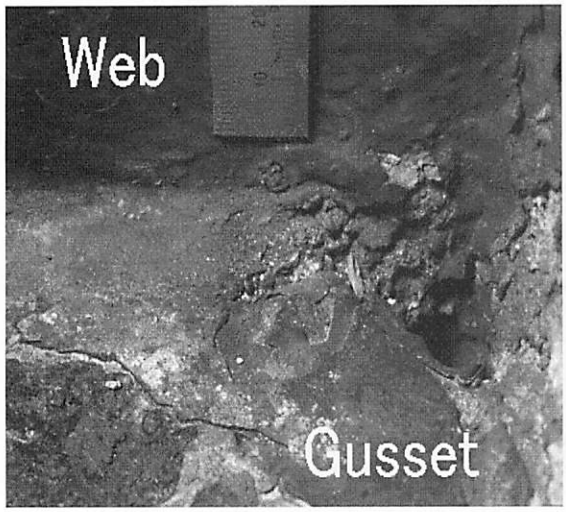

Photo. 1 Deterioration of paint

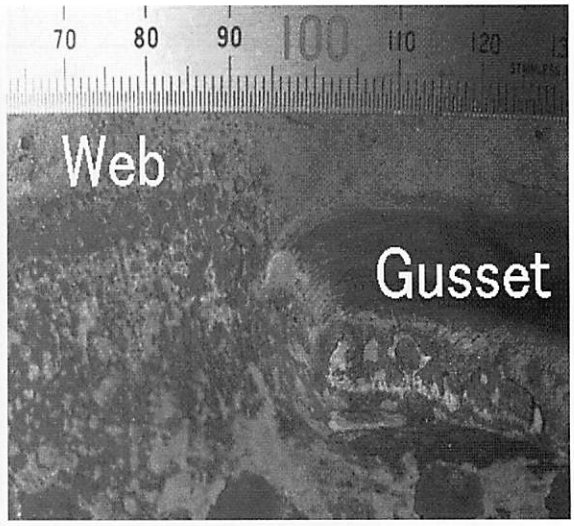

Photo. 2 Paint burned

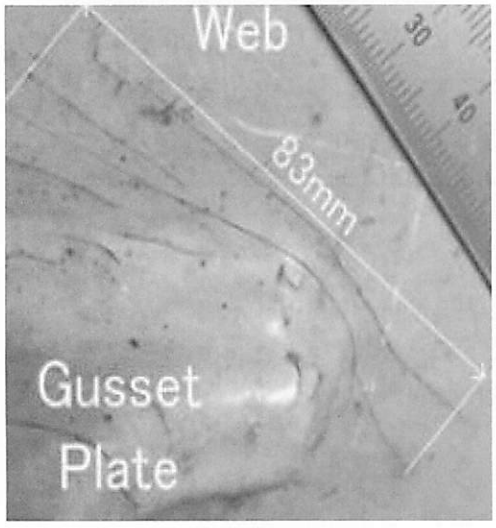

Photo. 3 Paint cracks on G1-2-C

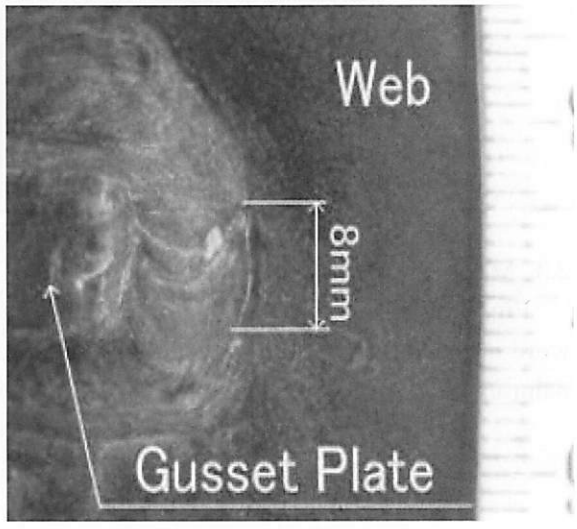

Photo. 4 MT sign on G1-2-C

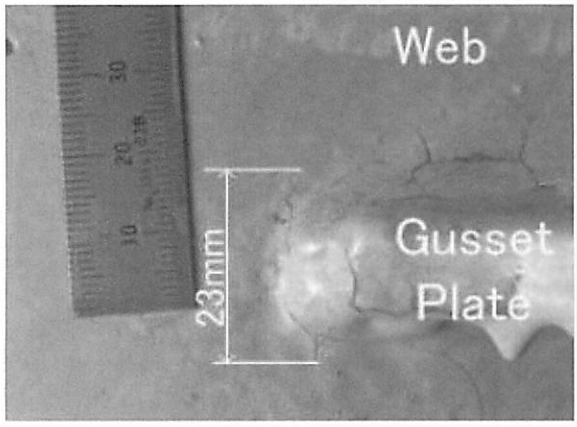

Photo. 5 Paint crack on G4-1-C

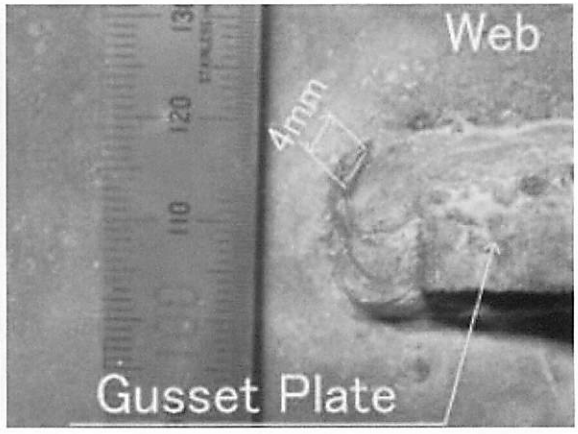

Photo. 6 MT sign on G4-1-C

3. FATIGUE TEST

Fatigue behavior and a fatigue characteristic of fatigue weak point are declared by the fatigue test using repetition bending load of specimens. We mainly used the magnetic particle test for crack detection during fatigue test. For detection of fatigue cracks, we tried to leave a beach mark in a fatigue fracture by reducing the load range to half. Also, we conducted repairs and reinforcements such as stop halls or splices for cracks occured and progressed, and confirmed the result.

4. CONCLUSIONS

Fatigue cracks were inspected before fatigue test. The principal results obtained through this study are as follows.

1) MT signs that may indicate fatigue cracks were observed at 2 weldments from among 18 turn-round weldments with paint cracks.
2) A MT sign of 8mm length was observed under a 83mm paint crack at the G1-2-C gusset plate. A MT sign of 4mm length was observed under a 23mm paint crack at the G4-1-C gusset plate.
3) There are no MT signs in the inspected areas which have no paint cracks, or that have paint cracks in places other than along the toes of turn-round weldment which are fatigue weak points.

We are currently conducting static loading tests and fatigue tests.

It would be possible to predict accurately the location and time of fatigue cracking in numerous steel bridges constructed in 1960's by grasping fatigue behaviour of urban expressway steel girders constructed in 1964. Furthermore, this would result in improving the safety and maintenance efficiency of existing bridges, and would provide effective information on revising the fatigue design specifications for new bridges.

REFERENCES

1) Japan Road Association, "Specifications for Highway Bridges", 2002 (in Japanese)
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