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EXPERIMENTAL STUDY ON FALL PROTECTION DURING BRIDGE MAINTENANCE AND MANAGEMENT WORKS ON FRP INSPECTION PLATFORM

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Accidents from falls are a serious problem in the construction industry in Japan, where approximately 40% of fatal construction accidents are caused by falls. FRP inspection platforms are used for fall protection during bridge maintenance and management works. These structural elements are usually set on the side of an abutment for the inspection of the joint located between the abutment and a bridge girder. The hook of a safety belt is then fastened onto the guardrail of a platform when work is executed at a high location. Nevertheless, the degree of platform safety remains uncertain because of the properties of the FRP platform. In this study, therefore, the safety of a platform was experimentally confirmed through the use of 75- and 85-kg sandbags and a 100-kg human dummy. Results show that platform safety improved, as indicated by the sandbags remaining firmly attached to the hook latched onto a platform railing when they were dropped during the experiment.

Keywords: Bridge, Maintenance, Fall, FRP, Inspection platform, Construction accident.

1 INTRODUCTION

Frequent fall accidents are severe problems encountered in construction industries in Japan, where approximately 40% of fatal accidents are attributed to workers' falls (Figure 1). To reduce such hazards, the Japanese government amended the Occupational Safety and Health Regulations in 2009 (MHLW 2009). Despite these initiatives, however, mortality rates due to fall accidents remain high—a situation that motivated the use of FRP inspection platforms for fall protection during bridge maintenance and management works (Figure 2). An FRP inspection platform is usually set on the side of an abutment for the inspection of the joint located between the abutment and a bridge girder. The hook of a safety harness is then fastened onto the guardrail of a platform as work is executed at high places. Nevertheless, the degree of platform safety remains uncertain given the properties of the FRP platform.

To address this problem, the safety of a platform was experimentally confirmed through the use of 75- and 85-kg sandbags and a 100-kg human dummy. The sandbags were attached to a hook fastened onto the platform railing at a position identical to where a harness hook would typically be secured. This experimental method was executed in the same manner as that done for fall tests described in the Structural

Standards for Safety Harnesses of 2002 (MHLW 2002), under the Occupational Safety and Health Acts in Japan. The results show improvement in platform safety.

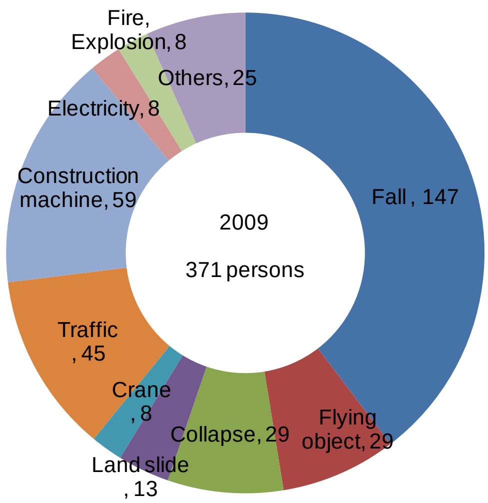


Figure 1. Fatal construction accidents in 2009.

Figure 2. FRP inspection platform.

2 EXPERIMENTAL METHOD

2.1 Test structures

Figures 3 through 5 show the test FRP platforms used in the experiments. These test structures were chosen on the basis of what a typical FRP platform would constitute:

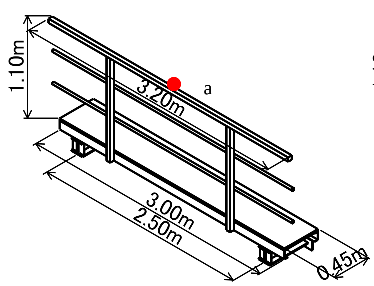


Figure 3. Test guardrail.

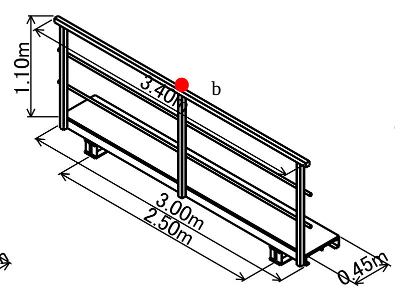


Figure 4. Test support.

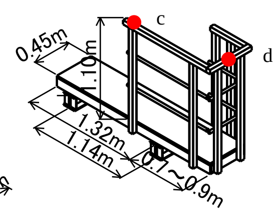


Figure 5. Projected parts used for testing.

Figure 3 shows the test structure used in examining guardrail strength. For the experiment, the hook of the safety harness was attached to Point a (Figure 3). Figure 4 shows the test structure used in investigating support strength. The hook of the safety harness was latched onto Point b (Figure 4). Figure 5 illustrates the test structure used to analyze the strength of projected components. The hook of the safety harness was fastened onto Points c and d (Figure 5).

2.2 Experimental conditions

Table 1 lists the experimental conditions; 26 fall tests were performed. Nine test structures, that is, “Guardrails I, II, III,” “Supports I, II, III,” and “Projected Parts I, II, III,” were assembled and used (Table 1).

Table 1. Experimental conditions.

No.	Specimen	Fall object	Loading method
1	Guardrail I	Static, 75kg	Point a
2		Dynamic fall, 75kg	Point a Fall from height of platform, Space between guardrail and fall object, 0.4m
3	Guardrail II	Static, 75kg	Point a
4		Static, 100kg	Point a
5		Dynamic fall, 75kg	Point a Fall from height of platform, Space between guardrail and fall object, 0.4m
6	Guardrail III	Static, 75kg	Point a
7		Static, 100kg	Point a
8		Dynamic fall, 75kg	Point a Fall from height of guardrail, Space between guardrail and fall object, 0.4m
9	Support I	Static, 75kg	Point b
10		Static, 100kg	Point b
11		Dynamic fall, 75kg	Point b Fall from height of platform, Space between guardrail and fall object, 0.4m
12	Support II	Static, 75kg	Point b
13		Static, 100kg	Point b
14		Dynamic fall, 75kg	Point b Fall from height of platform, Space between guardrail and fall object, 0.4m
15	Projected I	Static, 75kg	Point c
16		Static, 100kg	Point c
17		Dynamic fall, 75kg	Point c Fall from height of guardrail, Space between guardrail and fall object, 0.4m
18	Projected II	Static, 75kg	Point c
19		Static, 100kg	Point c
20		Dynamic fall, 75kg	Point c Fall from height of guardrail, Space between guardrail and fall object, 0.4m
21	Support III	Static, 85kg	Point b
22		Static, 100kg	Point b
23		Dynamic fall, 85kg	Point b Fall from height of guardrail, Space between guardrail and fall object, 0.5m
24	Projected III	Static, 85kg	Point d
25		Static, 100kg	Point d
26		Dynamic fall, 85kg	Point d Fall from height of guardrail, Space between guardrail and fall object, 0.5m

Static tests were first performed on each test structure. The sandbags weighing 75 and 85 kg were fastened onto Points a, b, c, or d using the hook of the safety harness and a 1.7 m lanyard. These test fall objects were slowly lowered by a crane, as shown in Figures 6 and 7. The heavier of the two sandbags was subsequently used, after which the 100-kg human dummy was lowered in the same manner as the sandbags (Figure 8).

Next, dynamic fall tests were performed on each test structure. The 75-kg sandbag was dropped and then the 85-kg sandbag was dropped from a position identical to where a harness hook was placed (Figure 9). The experimental method accords with the fall test described in the Structural Standards for Safety Harnesses (SSSH) of 2002. In the dynamic fall tests, the impact load acting on the lanyard was measured by the load cell. The sampling frequency for measuring the impact load was set to 1000 Hz.

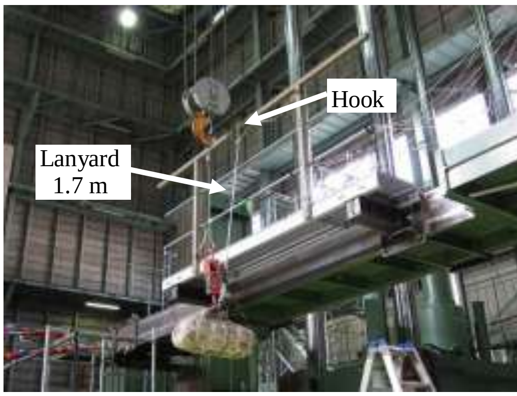


Figure 6. Sandbag, 75 kg.

Figure 7. Sandbag, 85 kg.

Figure 8. Human dummy, 100 kg.

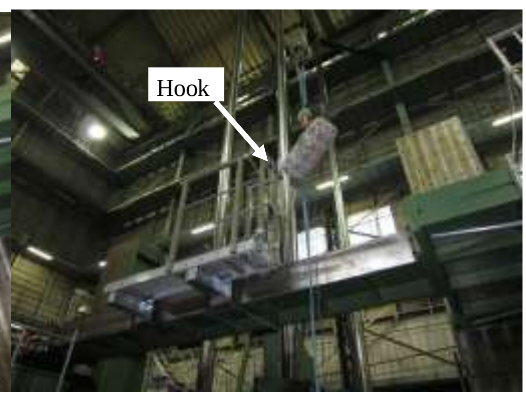


Figure 9. Dynamic fall tests, No. 26.

3 EXPERIMENTAL RESULTS

In tests 2, 11, and 17, the test structures were broken by the impact loads of the fall tests, and the test fall objects fell to the ground. After these tests, the broken plates of the members in the tests 2, 11, and 17 were made thicker to strengthen the platform. Table 2 and Figure 10 show the improved members. The thickness of each member was changed to 2 or 1.5 times, depending on the failure mode, as shown in Table 2. In the next tests after improvement—tests 5, 14, and 20—the sandbag did not fall, and the effects of the improvement were confirmed.

The methods used for tests 23 and 26 were the same as those used for the fall test described in Structural Standards for Safety Harnesses (Figure 11).

Table 2. Experimental results.

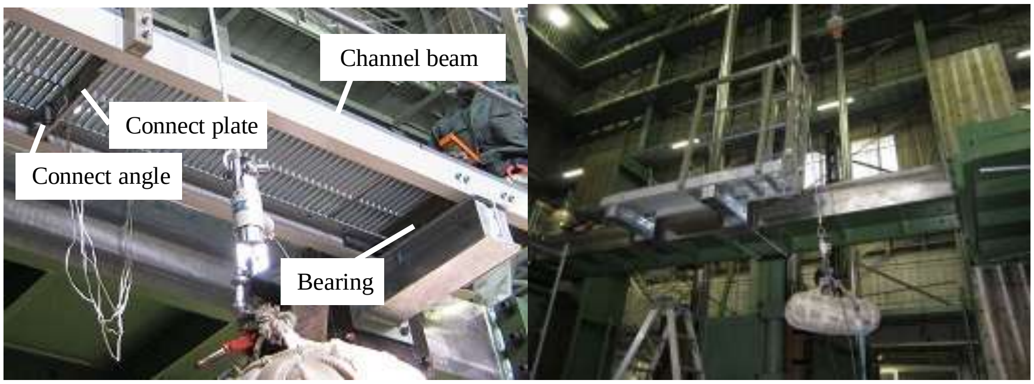
No.	Specimen	Fell to ground or not	Improvement of members
1	Guardrail I	Did not fall	Initial model
2		Fell to ground	
3	Guardrail II	Did not fall	Cconnect angle 6mm --> 12.7mm
4		Did not fall	Connect plate 6mm --> 9.4 mm
5		Did not fall	etc.
6	Guardrail III	Did not fall	〃
7		Did not fall	
8		Did not fall	
9	Support I	Did not fall	Initial model
10		Did not fall	
11		Fell to ground	
12	Support II	Did not fall	Cconnect angle 6mm --> 12.7mm
13		Did not fall	Connect plate 6mm --> 9.4 mm
14		Did not fall	etc.
15	Projected I	Did not fall	Initial model
16		Did not fall	
17		Fell to ground	
18	Projected II	Did not fall	Channel bam Normal --> Strengthen Cconnect angle 6mm --> 12.7mm
19		Did not fall	Connect plate 6mm --> 9.4 mm
20		Did not fall	Basement, bearing with 2mm plate etc.
21	Support III	Did not fall	〃
22		Did not fall	
23		Did not fall	
24	Projected III	Did not fall	〃
25		Did not fall	
26		Did not fall	

Failure modes

Figure 12 shows the result of the measurement of the impact load acting on the lanyard when the sandbag was dropped in test 26. In this test, the impact load used was the maximum throughout all the drops. The structural standards require that the impact load acting on the lanyard be less than 8 kN; the maximum impact load for test 26 was less than 8 kN (Figure 12). We can therefore conclude that the safety of the FRP platform improved under the capacity required by the structural standards.

4 CONCLUDING REMARKS

(1) The safety of the FRP platform improved in that the 85-kg sandbag did not fall to the ground as it was dropped from the railing. This weight is a requirement specified in Japan's Structural Standards for Safety Harnesses of 2002.



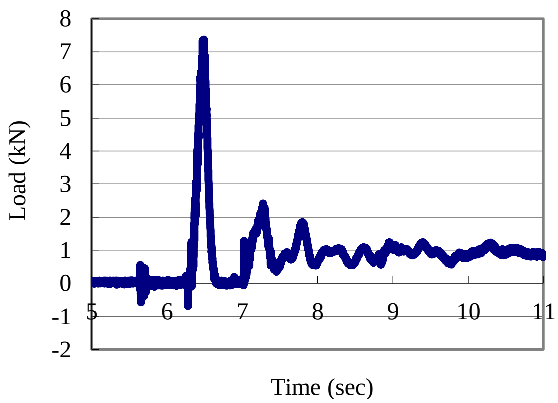


Figure 12. Impact load acting on lanyard, No. 26.

(2) Japan's Structural Standards for Safety Harnesses also requires that the impact load on a lanyard be less than 8 kN; the maximum impact load used throughout all the tests was less than 8 kN.

(3) The safety of the FRP platform improved under the capacity required by the Structural Standards for Safety Harnesses.

Acknowledgment

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MHLW, *Structural Standards for Safety Harnesses of 2002*, Ministry of Health, Labour, and Welfare, Japan 2002.