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EXPERIMENT ON THE SLACK IN LIFELINES USED FOR ROOF WORK

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Falls are the most common type of accident on construction sites in Japan. Preventing falls from roofs necessitates the installation of scaffolds around houses, but this regulation failed to ease the difficulty experienced by construction workers as they erected scaffolds in a disaster area during the Great East Japan Earthquake. The challenge stemmed primarily from debris around the site. The threat to scaffold safety was unacceptable given that the time spent on scaffold installation and dismantling was longer than that typically spent on roof work. When installing scaffolds around a house was problematic, the construction workers used lifelines and safety belts when working on roofs. Nevertheless, the advantages of this approach are limited by the absence of specific criteria that regulate the use of these safety devices. When a worker falls from a roof, the fixed end of a lifeline usually holds up the worker, thereby preventing crashes to the ground. The problem is that the standards for measuring or evaluating the appropriate amount of slack in lifelines are unclear. We therefore examined existing criteria by testing a full-scale roof device and using parameters such as lifeline slack in the experiment. The torso load during a prevented fall is absorbed by the adopted lanyard and lifeline. The lanyard's hook hits roof eaves, thus increasing torso load. This result underscores the importance of providing a small lifeline slack.

Keywords: Work Accident, Fall, Safety Belt, Scaffold, Safety.

1 INTRODUCTION

In 2013, fall accidents in the construction industry in Japan (Japan Construction Occupational Safety and Health Association 2014) resulted in 160 worker fatalities. In these fatal accidents, falls from scaffolds were the most common hazard, accounting for the deaths of 34 people (21.3% of all fall accidents) as shown in Figure 1. Falls from roofs resulted in 27 fatalities (16.9%), thus ranking this accident as the second-most frequently occurring type. Falls due to pressing down on roof slates and plates caused 16 deaths (10%). The roof- and slate/plate-related fatalities amount to a total of 43 casualties (26.9%), indicating the alarming frequency with which roof-based accidents occur.

Preventing falls from roofs necessitates the installation of scaffolds around houses or buildings. Despite awareness of this regulation, however, construction workers experienced difficulties in erecting such structures in a disaster area during the Great East Japan Earthquake. The source of difficulty was debris scattered around the location. The threat to scaffold safety was unacceptable given that the time spent on scaffolds installation and dismantling was longer than that typically spent on roof work.

When installing scaffolds around a house was difficult, the construction workers used lifelines and safety belts as they worked on the roof. Nevertheless, this approach presents limited advantages given that no specific criteria for regulating the use of these safety devices have been established. A compounding problem is the absence of regulations regarding the amount of slack provided in lifelines. To address these issues, we examined the slack in lifelines used during roof work.

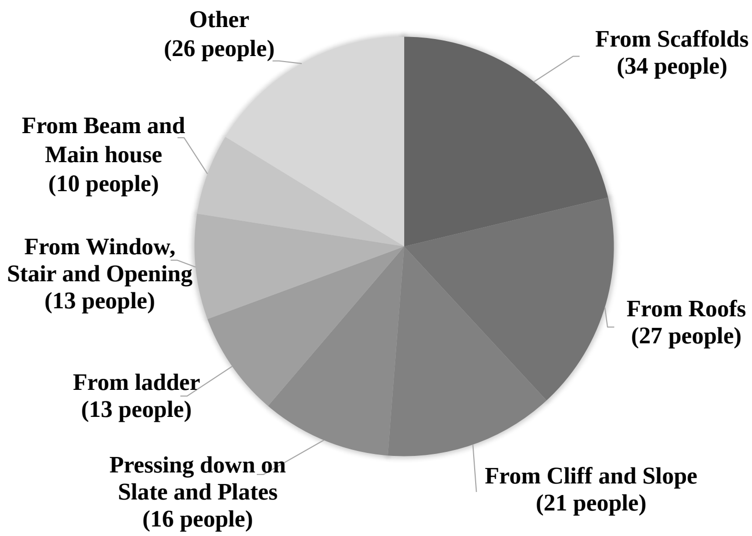


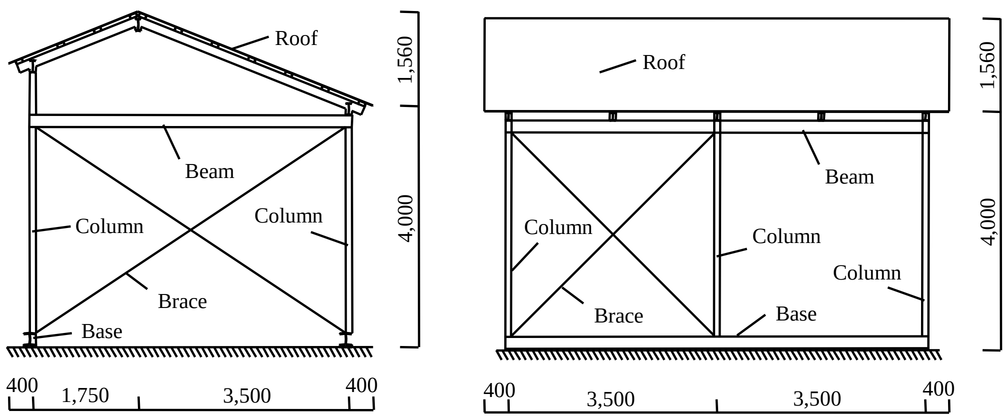
Figure 1. Fall accidents in Japan's construction industry, 2013.

2 TEST OVERVIEW

A roof device was used for testing as shown in Figure 2. The roof on which the experiment was conducted is made of wood, is of a gable-style framework, and is inclined at 21.8 degrees (4/10). These features constitute the roof design of a generic house. The distance from the ground to the roof eaves is 4,000 mm.

A torso equipped with a Japanese-standard safety belt was used in the test to simulate falls. The torso's weight is 833 N. The test setup is illustrated in Figure 3 and 4, and the location of the torso is shown in Figure 5. In a scenario wherein a worker falls from the eaves, the torso was set on the eaves' surface. The center of the torso was positioned 300 mm horizontal to the eaves and at a 1,000-mm distance from the roof's edge. A crane was used to place a separation device on top of the torso; the device was intended to function as a release mechanism for when the falls were simulated. A full harness was strapped onto the torso to prevent crashes to the ground as the torso fell. Additional devices used were a three-strand, nylon lifeline with a diameter of 12 mm and a three-strand, nylon lanyard with a diameter 11 mm and a length of 1,700 mm (including the hook). These ropes were attached to the roof as shown in Figure 3 and 4, with the fixed end of the lifeline connected to the eaves by a hook. Load cells were placed in three locations on the roof (Figure 3) to measure torso load, the load exerted at the junctions of the lanyard and lifeline, and the hook load. Slack in the lifeline was set in three configurations: no slack, 500-mm slack, and 1,000-mm slack. Slack was applied near the fixed end of the lifeline.

During the test, the torso was separated from the crane by the separation device and allowed to fall freely. In the first test, we applied no slack in the lifeline, and the lanyard was equipped with a shock absorber. On the basis of the results, we refrained from attaching a shock absorber to the lanyard for the tests under the 500 mm and 1,000 mm slack conditions.



a) Elevation at the narrow side. b) Elevation the long side.

Figure 2. Roof device for the test.

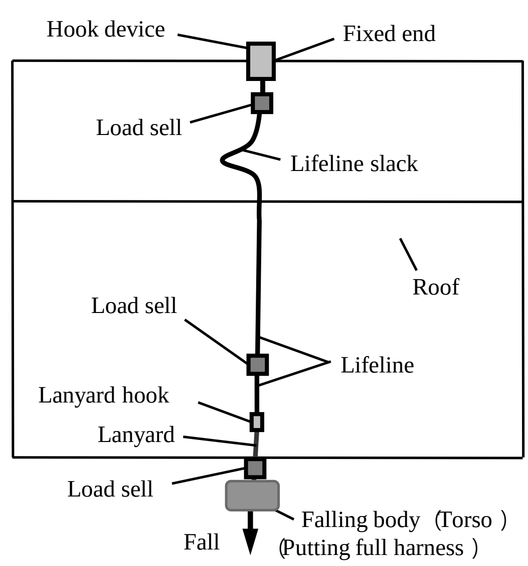
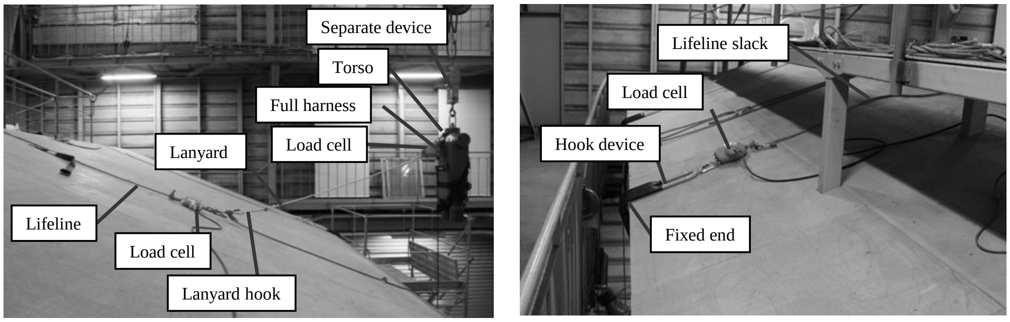


Figure 3. Test setup (roof plan).



a) Near torso. b) Near fixed end.

Figure 4. Test setup.

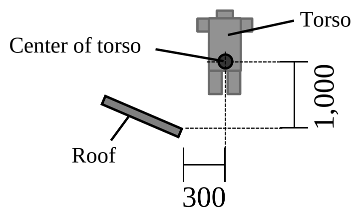


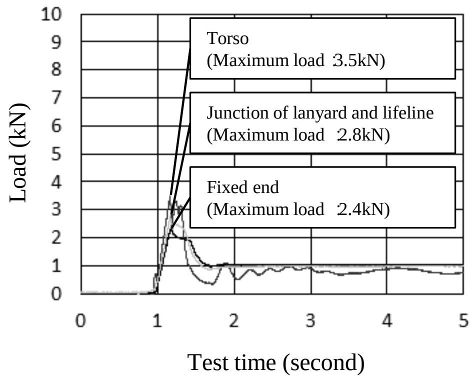
Figure 5. Torso setup (elevation of eaves).

3 RESULTS AND DISCUSSION

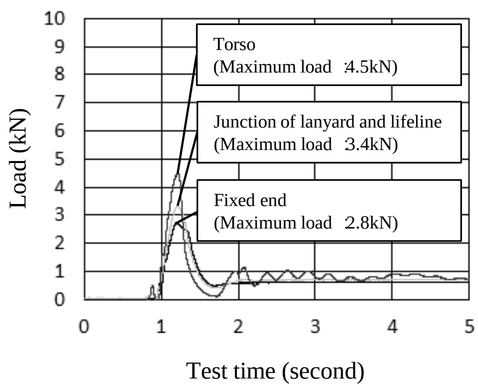
The test results are shown in Figure 6, and the condition of the torso after the tests is illustrated in Figure 7. In Figure 6, the vertical axis represents the load, and the horizontal axis represents the test duration. Under the no-slack condition, the torso's maximum load is 3.5 kN. The shock absorber fails to work because it functions at loads greater than 4.0 kN. The findings derived from the no-slack condition are therefore identical to those of experiments in which no shock absorber is used.

The longer the lifeline, the larger the torso's load, because the distance travelled during a fall is also long, as shown Figure 6. The torso's maximum load in the 1,000-mm slack condition is 8.1 kN – a value 1.8 and 2.3 times higher than those generated under the 500-mm and no-slack conditions, respectively. The torso's load during the prevented fall is transmitted through the lanyard and through the lifeline via its fixed end. As the lanyard and lifeline are elongated, the greater the shocks absorbed. In the 1,000-mm slack condition, the lanyard hook is hit and caught at the eaves as shown in Figure 7c. In this instance, the hook functions in a similar manner as a fixed end. The lanyard absorbs shocks, but the lifeline does not. The results indicate that under these conditions, the torso's maximum load increases.

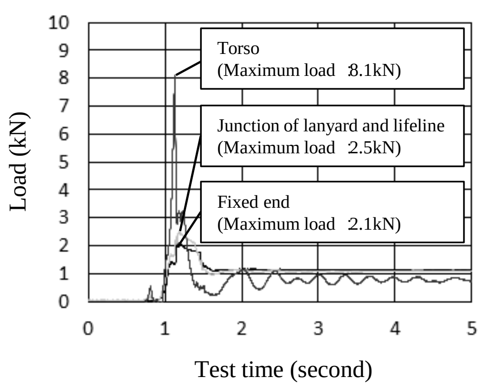
The maximum load exerted at the junction of the lanyard and the hook's maximum load under the 1,000 mm slack condition are smaller than those exerted under the no-slack and 500 mm slack conditions. The load exerted on the eaves is larger, and the lifeline's load is smaller because the lanyard hook functions similar to a fixed end.



a) No slack.

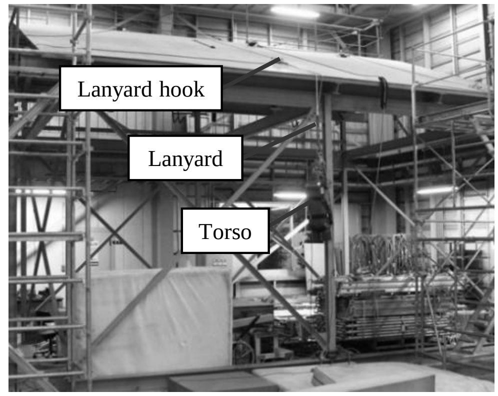


b) 500-mm slack.

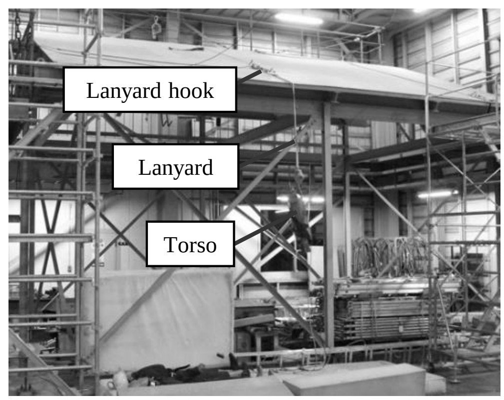


c) 1,000-mm slack

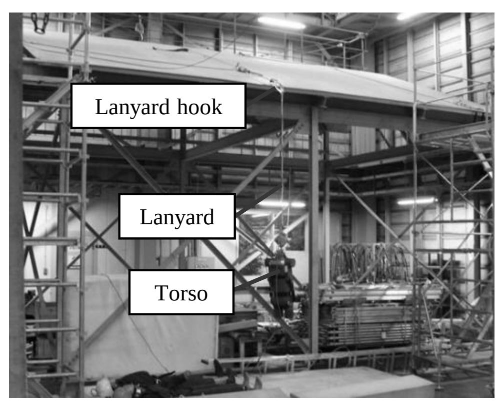
Figure 6. Torso condition after test.



a) No slack.



b) 500-mm slack.



c) 1,000-mm slack

Figure 7. Relationship between load and test duration.

4 CONCLUSIONS

1. A torso's load during a prevented fall is absorbed by the combined use of a lanyard and a lifeline.
2. When a lanyard's hook hits roof eaves, the torso load increases.
3. An important safety requirement is to provide a small amount of slack in lifelines.
4. A lanyard's hook should be connected to a roof in such a way that prevents a worker from falling.

Reference

Working Standard Manual on Safety Devices for Fall Prevention–Setting Scaffolds for Roof Work is Difficult, Japan Construction Occupational Safety and Health Association, Tokyo, Japan. In Japanese, 2014.