EXPERIMENTAL STUDY ON FUNDAMENTAL PERFORMANCE OF SAFETY BELTS FOR FALL PREVENTION

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Many fatal accidents due to falling from heights have taken place at construction sites in Japan. The purpose of this study was to determine the fall prevention performances of different types of safety belts. Simply drop tests were carried out to measure the impact load and the posture of a human dummy using a Hybrid-Ⅲ pedestrian model and a sandbag. The probability of human injury and the magnitude of the impact force were examined by comparing the experimental results. The results point to the value of the harness-type safety belt. They also highlight the need to add a shock absorber device to absorb potential energy and prevent serious injuries.

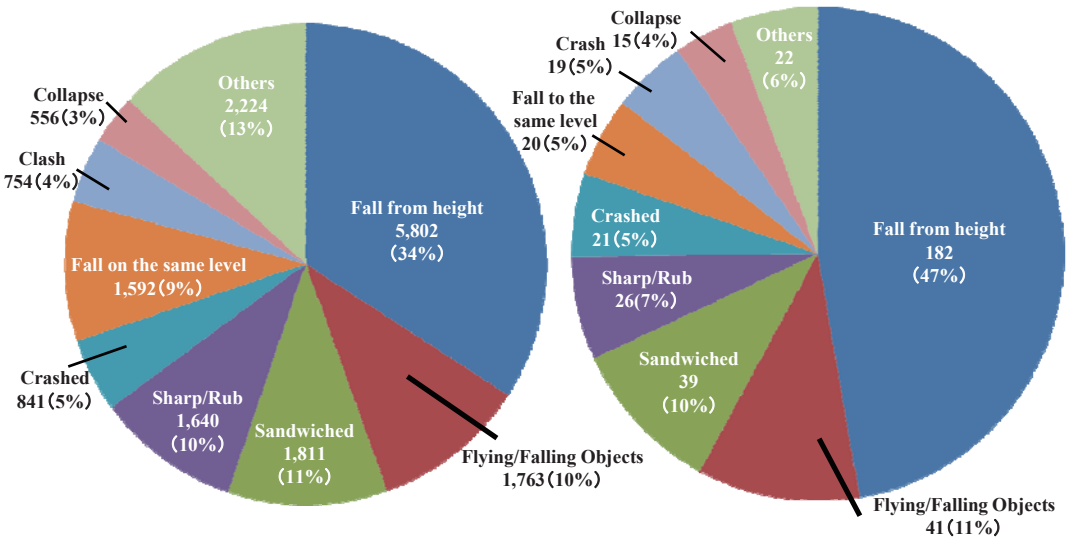
Introduction

In Japan, most fall prevention countermeasures aim to ensure the stability and upright posture of workers while working different types of work surfaces. These countermeasures are established in Japan in clause 1 of article 518 and 519 of the occupational safety and health regulation. Figure 1 shows an example of the principal countermeasures applied during repair work on a residential house.

Irrespective of these measures, many labor accidents due to falling has continued to take

Figure1. Fundamental safety measures following the housing works

Figure2. A disaster sites East Japan Earthquake



Total number of labor accidents in the construction industry in Japan

Labor accidents in the disaster site of East Japan Earthquake and Tsunami

Figure 3. Labor accidents in the construction industry in 2011

place in the construction industry, as shown in Figure 3 (Ministry of Labor Safety and Health Japan, 2012). In the disaster relief works following the East Japan Earthquake and the major tsunami happened in march 2011, there was a high rate of falling accidents. Figure 2 shows one of the repair or dismantle work sites in the Tohoku region damaged by the natural disaster. It is quite difficult to carry out the required countermeasures in such a construction site. Establishing fall prevention measures for such sites is one of the most urgent tasks (National Institute of Occupational safety and Health, 2011).

Clause 2 of article 518 and 519 of the occupational safety and health regulation refers to use of safety belts as a countermeasure. However, concrete methods are not established. A previous statistics analysis of fatal labor accidents at disaster construction sites revealed the following: (Yasumichi, 2011)

(1) Fall related accidents accounted for about one-third of all accidents.

(2) Nearly 90% of fatal accidents in building or housing construction were due to falls.

(3) A total of 75% of falls at sites were due to falls from roofs.

"The harness-type safety belt" is widely used throughout the world, but it is rarely employed in Japan (National Institute of Industrial safety, 1999). Instead, the waist-belt-type safety belt is used almost 100% of the time. The purpose of this study was to determine the fall prevention performance of these two types of safety belts..

Experimental Methods

This study focused on fall prevention measures used in roof repair works, as shown in Figure 4. Simply drop tests were carried using the two different types of safety belts, and the results were compared.

Table 1. Fatal labor accidents in disaster relief work (1985 to 2005)

Fatal labor related accidents	Number	Building or housing works		Civil engineering works	
		Number	Rate	Number	Rate
Total	356	61	100%	292	100%
Falls (from roof)	106	53 (46)	87% (75%)	50	17%
Construction machinery	91	1	2%	90	31%
Landslides	49	0	0%	49	17%
Collapse	18	1	2%	17	6%
Flying/falling Objects	16	1	2%	15	5%
Traffic	27	2	3%	25	9%
Crane	14	0	0%	14	5%
Drowning	12	0	0%	12	4%
Electrification	6	2	3%	4	1%
Other	17	1	2%	16	5%

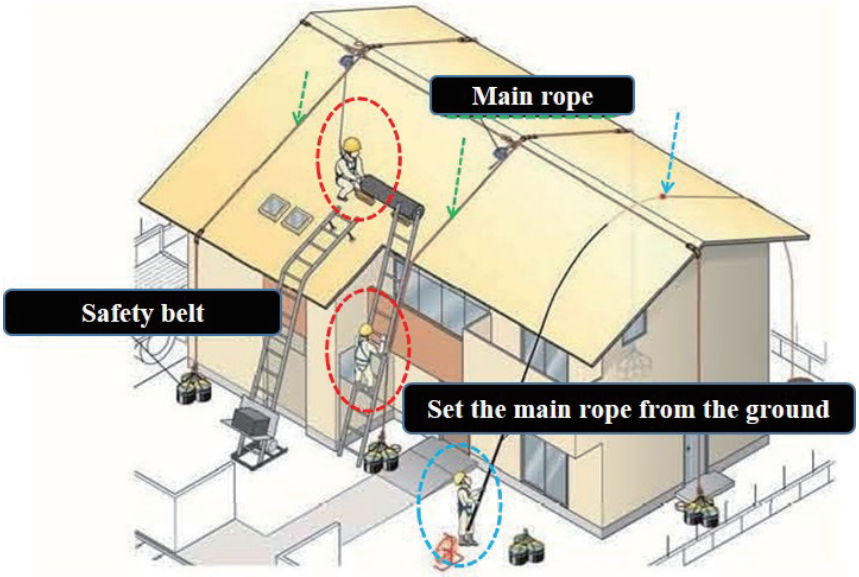


Figure 4. An example of a repair sites

Figure 5 shows the experimental parameters and conditions used in each test. The hook of the safety belts was fixed to the assumed main rope located on the surface of the roof at height of about 1m lower from the gravity. Two types of falling bodies, a sandbag or a Hybrid-Ⅲ pedestrian human dummy, were dropped from the assumed eave of the roof using separating devices. The weight of each falling body was 75kg. The ropes of the safety belts used in this experiment were all made with nylon and new. They were 1700mm long and did not have any additional functions, such as shock absorber device. The impact loads acting on the rope were measured with load cell. A high speed camera was also used in the experiments to realize basic characteristics of human dummy posture while falling.

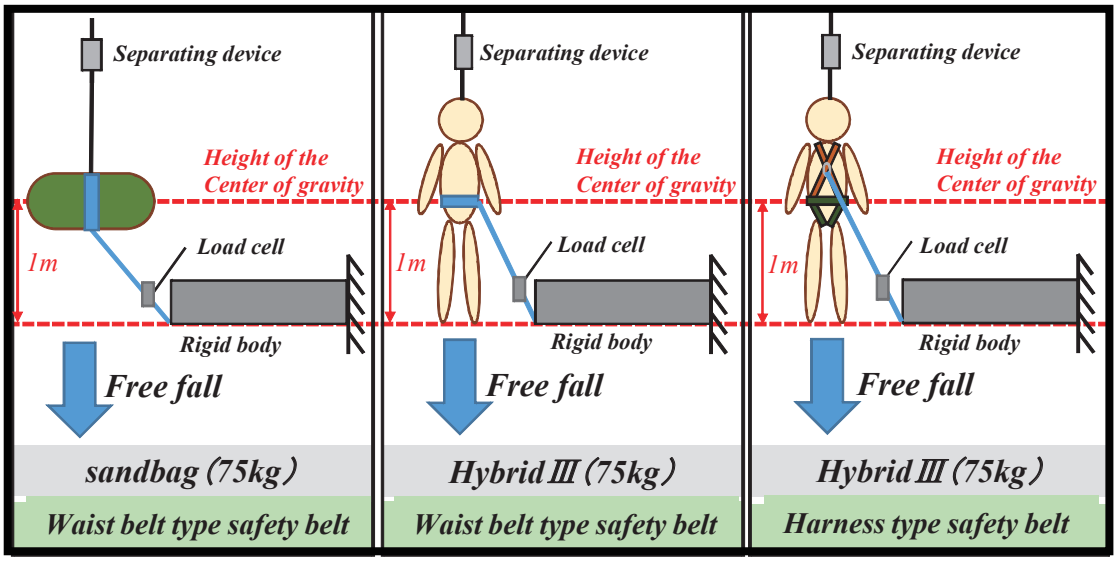


Figure 5. Experimental parameters and conditions

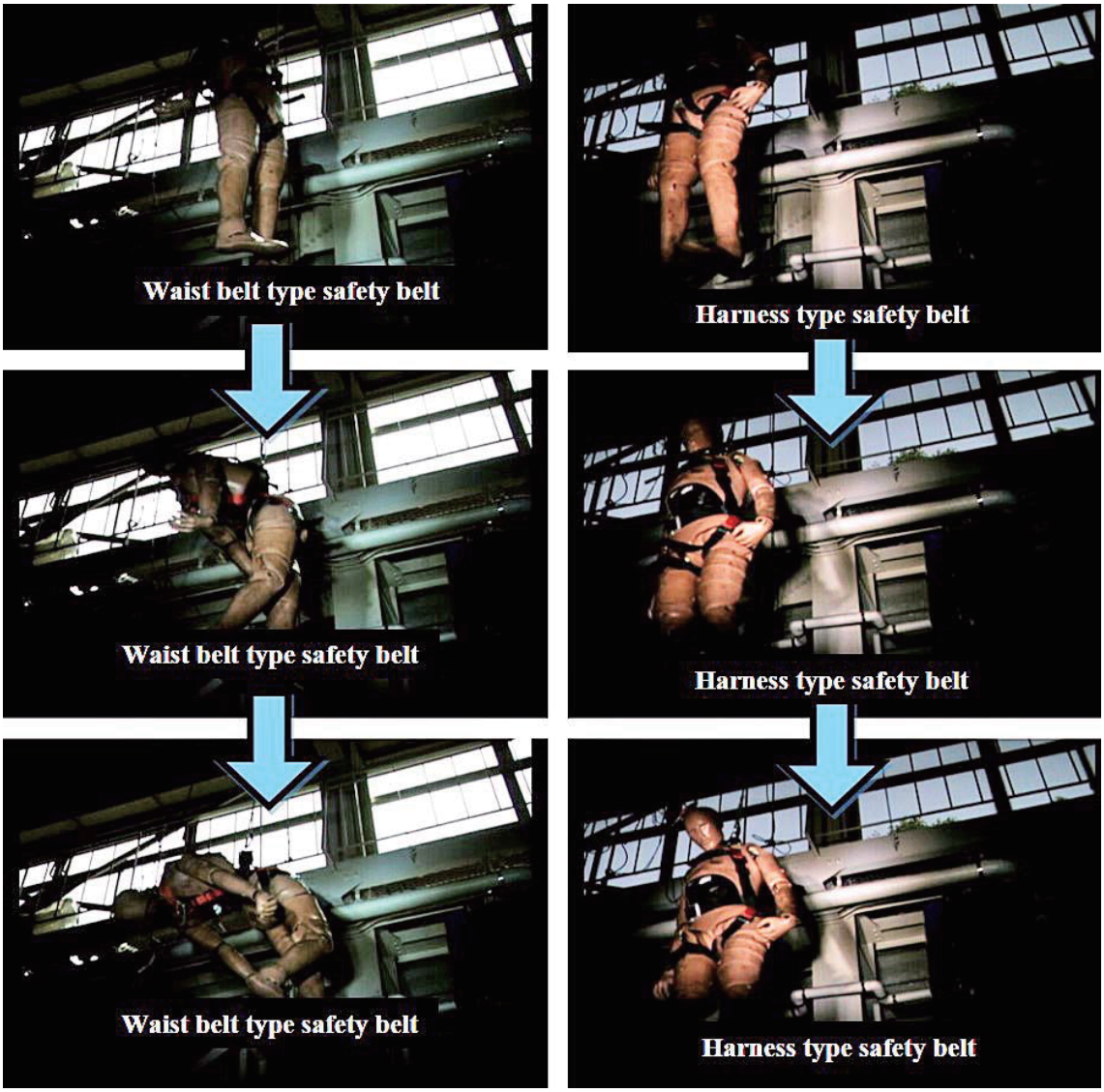
Experimental Results

Photo.1 shows the posture of the Hybrid-Ⅲ pedestrian human dummy while falling. In the experiment using a waist-belt- type safety belt, the neck or waist parts of the Hybrid Ⅲ pedestrian model was bent considerably during the falling. From the results of the posture shown in Photo.1, spinal cord injury at the neck or waist may occur if worker used a waist-belt-type in the same falling situation. In contrast, very little bending of the human dummy occurred in the experiment with the harness-type safety belt. Instead, the head part of the human dummy remained upright, and the leg part remained down side.

Figure 6 shows the time histories of the impact force acting on the safety rope of each type of safety belts. The impact force on the harness-type was similar to the impact force on the sandbag. The duration was also similar. In contrast, the impact force on the waist-belt-type safety belt was smallest in all the experiments. Thus, the duration is longer than other type experiments.

From these results, the harness-type safety belt cannot be expected to reduce the impact force and energy during falls. However, the risk of serious head injury could be expected to be relatively low, because the falling posture was quite stable when the human dummy wore the harness-type. In addition, excessive bending of the waist would be low. With the waist-belt-type safety belt, the risks of serious head injury and body part injuries due to excessive bending would be very high, because the falling posture might be a handstand posture and he worker's head may crash directly into some construction equipment or the rigid grand surface.

Figure 7 shows labor accident statistics data on the main parts injured in victims of fatal falls during 30 years in Japan. This figure shows that head injuries account for most of the damage during falls. Therefore, it is important to reduce the risk of head injury for prevention of fatal accidents and physical impediments.



(a) Using a waist-belt-type safety belt (b) Using a harness-type belt

Photo 1. Postures of the human dummy during the drop tests

Summary

The results raise concerns that serious head injury and body part injury may occur due to excessive bending during falls when the waist-belt-type safety belt is worn. In contrast, the risk of serious head injury appears to be relatively low with the harness-type belt because the falling posture was quite stable in the tests with human dummy. However, the harness-type safety belt cannot be expected to reduce the impact force and energy during falls. Therefore, the harness-type safety belt with an added shock absorber device to absorb potential energy is strongly recommended for prevention of serious injuries and physical impediment.

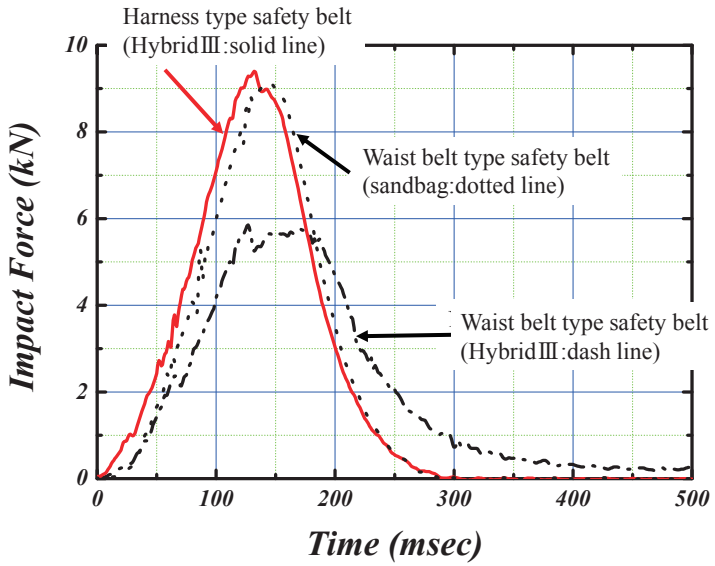


Figure 6. Impact force on the lanyard due to fall

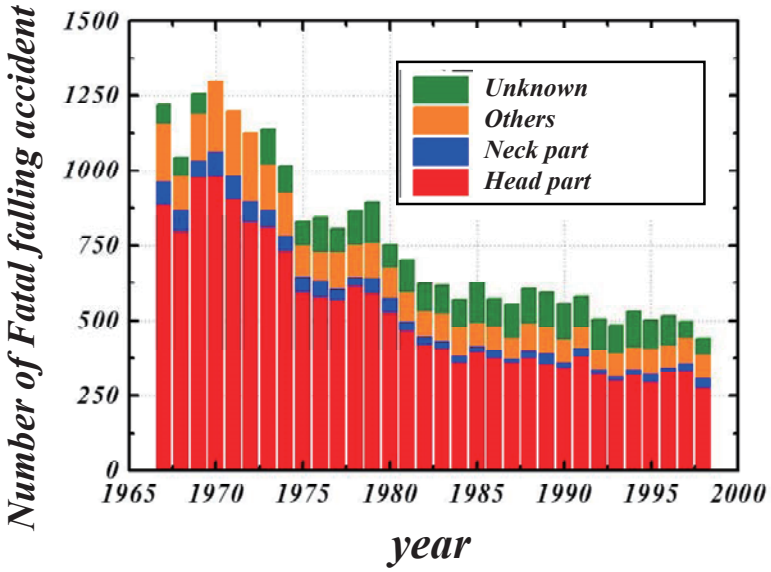


Figure 7. Number of fatal falls divided into main injury region

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