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# COUNTERMEASURE FOR INSTALLATION OF SAFETY ROPES ON RESIDENTIAL ROOFS

YASUMICHI HINO, KATSUTOSHI OHDO, and HIROKI TAKAHASHI

*Construction Safety Research Group,*
*National Institute of Occupational Safety and Health, Tokyo, Japan*

Numerous fall accidents have occurred in the construction industry worldwide. General countermeasures for fall prevention include the use of temporary scaffolds with guardrails, but these structures cannot always be installed along side construction objects because of obstacles, such as trees and air conditioning units. In such construction sites, the effective use of other safety measures, including safety ropes and harnesses, are needed. Another urgent security issue is the prevention of falls from ladders. This study focuses on a safety countermeasure applied during preparation works for residential roof repair, such as ascent or descent on portable ladders, ground-to-roof set up of safety ropes (lifelines), and rope removal upon conclusion of repair work. On the basis of experiments on a full-scale residential roof and a human dummy, an effective countermeasure that features the use of ladders, ropes, and safety retracting lifelines with shock absorbers was developed.

*Keywords*: Fall accidents, Ladder, Retracting lifeline, Shock absorber, Roof repair works, Construction sites.

## 1 INTRODUCTION

Since the East Japan Earthquake in March 2011, significant attention has been directed toward the prevention of fatal accidents caused by falls from heights (Hino et al. 2013), such as residential roofs, during disaster repair works. Convenient safety countermeasures are particularly needed for short-duration works, such as decontamination or roof tile removal.

Motivated by these problems, this study formulated a new safety countermeasure for such residential roof works. This measure focuses primarily on the use of (1) a portable ladder (JSA 2013), (2) a retracting lifeline with a shock-absorber (NIIS 1999), and (3) four nylon ropes. Under these measures, a worker can safely install a lifeline connected to a safety harness attached onto a roof. To validate the effectiveness of the developed measure, experiments were carried out using a full-scale residential roof structure and a human dummy generally called the “hybrid-3 pedestrian” in the automobile industry.

Experimental results show that the proposed measure is very effective in preventing falls from ladders and slips from ridges. The assembly and disassembly methods used are also discussed in this paper.

## 2 STATISTICS

Figure 1 shows grouped results on the causes of fatal labor accidents in the Japanese construction industry in 2014 (JCOSHA 2014). About 40% of the fatal labor accidents were due to fall from heights. Figure 2 shows grouped results on the sites where fatal fall accidents have occurred in the recent 5 years. The total number of fatal fall accidents during this period was 793, with 60.2% occurring during building or housing works. The accidents with the highest frequency are falls from temporary scaffolds, according for about 20% of the total. Roof-related accidents account for about 30%, the sum of the number of falls from roofs, slate roofs, and ladders.

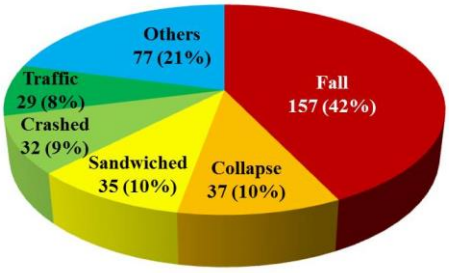


Figure 1. Fatal labor accidents in the construction industry in Japan (2014).

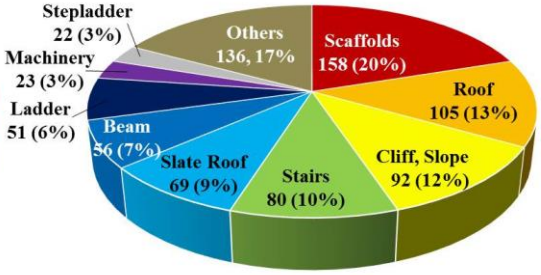


Figure 2. Fatal fall labor accidents in the Japanese construction industry in recent 5 years.

## 3 PROPOSED COUNTERMEASURE

The proposed safety method is intended for residential roof work sites for which temporary scaffolds with guardrails cannot be installed alongside roof edges. This countermeasure minimizes the possibility of falls from eaves, and enables a smooth descent to the ground because of the use of a full-body harness, a retracting lifeline with a shock absorber, and lifelines attached onto the roof (Figure 3).

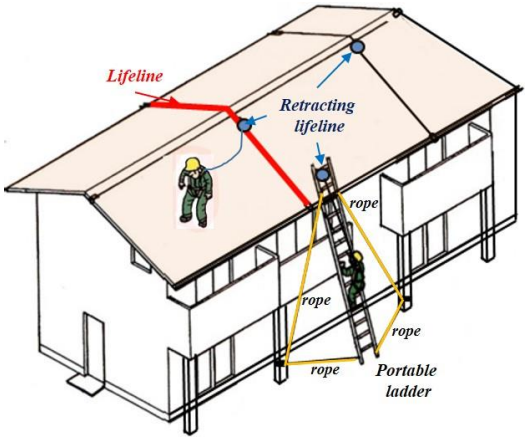


Figure 3. One of the countermeasures for residential roof work sites when temporary scaffolds with guardrails cannot be installed alongside roof edges.

One of the most important considerations is the safe implementation of countermeasures on the roof. To this end, this paper details the installation and disassembly method required (Figure 3). As previously stated, the safety measure primarily involves the use of a portable ladder, a retracting lifeline with a shock absorber, and four nylon ropes (Figure 4). Such equipment enables a worker to securely set up a lifeline connected to a safety harness on the roof. The retracting lifeline with the shock absorber is connected to the upper end of the two ladder columns. The upper sides and bents of the ladder columns secured onto a rigid structure such as steel columns with the four nylon ropes.

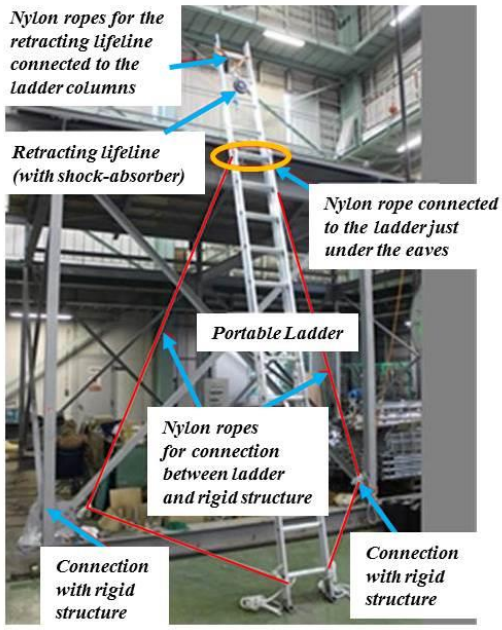


Figure 4. Image of the proposed countermeasures as implemented.

## 4 EXPERIMENTAL METHOD AND RESULTS

To confirm the effectiveness of the proposed measure, experiments were conducted on a full-scale residential roof and the "hybrid-3 pedestrian" (Figure 5). The loss of balance of a worker near a ridge was simulated. Eave height and roof angle were set up at 4 m and about 22 degrees, respectively. A teflon sheet was placed on the roof surface to realistically replicate slippery conditions; that is, the setup must not result in unrealistic high-speed sliding from the ridge. The proposed system would be evaluated as sufficiently safe if the human dummy did not crash to the ground under the adopted experimental conditions.

In addition, the retracting lifeline with the shock absorber was connected to two ladder columns with nylon ropes, and the strap of the retracting lifeline was passed outside of the ladder columns in order to prevent rung fractures due to the impact loads. Figure 6 shows images of the situation of loss of balance with the human dummy, for which falls were prevented by the retracting lifeline attached onto the upper end of the

ladder. The results show that the human dummy was completely protected by the proposed system and did not crash to the ground.

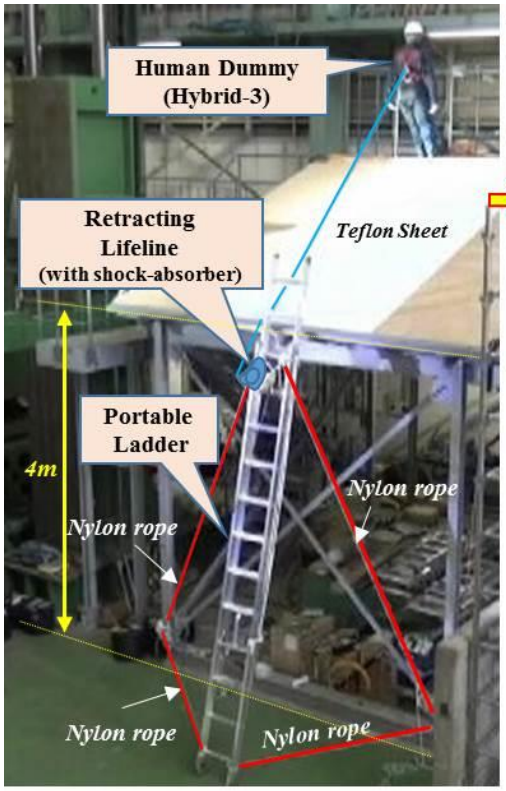


Figure 5. Experimental method.

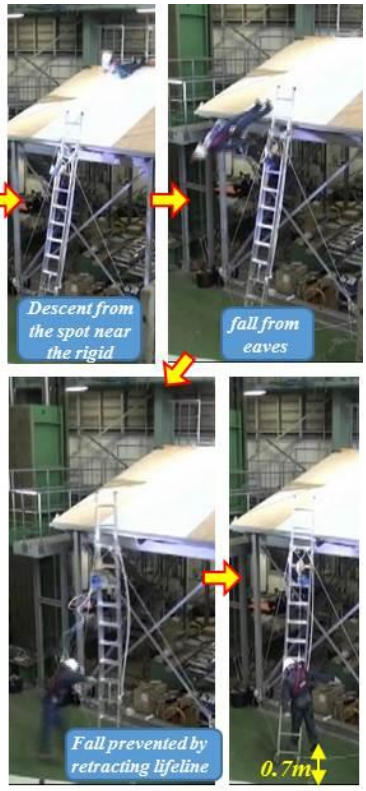


Figure 6. Experimental results.

## 5 CONCLUSION

In this research, a new safety countermeasure for residential roof works was proposed. The developed method was shown to be an excellent safety measure, effectively preventing not only falls from ladders, but also slipping from the ridges.

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