PERMANENT FALL-ARREST SYSTEM FOR LOW-RISE RESIDENTIALS DURING SERVICE LIFE

Seyed Kasra Modares, University of Toronto, Canada
Supervised by Prof. Brenda McCabe, University of Toronto, Canada

Abstract: Falls are the reason behind one out of every five Canadian lives lost to injury-related causes every year. One of the sources of fall accidents, which is often neglected, is falling off the roof of a low-rise building after the construction is over and the structure has entered its service life. Peaked roof houses in particular pose a great falling hazard during maintenance operations due to their sloped surfaces. During the construction of such buildings, this problem is solved by using a fall-arrest system consisting of a quick-mount bracket to which a lifeline is attached, and the worker is tied to it with the lanyard connected to his/her harness. While this solves the problem during the building stage, the system is temporary and is dismantled and removed after the construction is over. The proposed solution is a fall-arrest system integrated into the structure that would be a permanent feature of the house. The design uses a galvanized steel anchor system, placed on the midspan of the peak line of the sloped roof. In order to protect it from strong winds and for aesthetic reasons, it features two hinges on its bases, thus allowing it to be bent down when not in use. The system will provide an anchor point to be used with a human fall-arrest system, while providing fall protection for ladders which might be used to access the roof. As such, it would eradicate the potential hazards from ladder slip & fall, and falling from the sloped roof.

1 INTRODUCTION

1.1 Falling Hazards during Service Life of Low-Rise Residential Buildings

Every year, construction accidents and incidents take the lives of hundreds of workers in Canada. In 2008, those working in construction had the highest rate of work-related injury in the country, with the number of reported injuries totaling 24.5 out of every 1000 employees in the industry (Employment and Social Development Canada 2014). In the same year, out of the 15,064 Canadians who lost their lives due to injury-related causes 18% (the third highest after suicides and road accidents) were due to falls (Statistics Canada 2014). Taking the province of British Columbia as a sample case, 9% of all short and long term disabilities and fatalities in the construction industry were due to falls from heights (Work Safe BC 2012). Accidents cause human costs such as dismemberment and death, while also incurring economic costs on not only employers but also insurance companies and the government, hurting the whole economy as a result.

One of the sources of fall accidents, and one which is often neglected, is falling off the roof of a low-rise building after the construction is over and the structure has entered its service life. Of the 13,320,615 private dwellings in Canada in 2011, 7,329,150 were low-rise (Canadian Census Analyzer 2014); these structures can be further subdivided into those having flat or peaked roofs. Due to their sloped surfaces, peaked roof houses in particular pose a great falling hazard during maintenance operations, such as cleaning the chimney or shoveling off the snow during the winter season. In addition, a ladder might need to be used to access the roof, which poses another falling hazard as the ladder might slip.

2 MITIGATING THE PROBLEM

2.1 Permanent Fall-Arrest System

During the construction of sloped roof low-rise residential buildings, this problem is solved by using a fall-arrest system. The system is constructed using a combination of a quick-mount bracket, a shingler's platform and an edge protection bracket (Figure 1 in Appendix A). A vertical lifeline is attached to the quick-mount bracket, and the worker is then tied to the lifeline with the lanyard connected to his/her harness. The edge protection and the shingler's platform provide additional support for the worker while he/she is laying the tiles on the roof. While this solves the problem during the building stage, the system is temporary and is dismantled and removed after the construction is over. As a result, the building does not have a fall-arrest system that could be used over its service life for maintenance or other activities.

The proposed solution to this problem is a fall-arrest system integrated into the structure that would be a permanent feature of the house. This device will not only provide an anchor point to be used with a human fall-arrest system, but will also provide fall protection for ladders which might be used to access the roof of the building. As such, the device would eradicate the potential falling from height hazards associated with low-rise residential buildings during their service life, namely ladder slip & fall, and falling from the sloped roof.

2.2 The Design: Double-Hinged Anchor System

The design is a permanent fixed anchor fall arrest system that could be incorporated into the design of new peaked roof low-rise residential buildings and provide fall protection for workers, handymen, and homeowners undertaking maintenance work on the roof or for ladders used to access the roof. It must be noted that the design may also be used for existing structures subject to the approval of a Professional Engineer; however this topic and the lateral load resistance capacities necessary for an existing building roof to support the device are beyond the scope of this report and as such have not been included.

To explain the function of the proposed design, the basic features of a fall-arrest system must first be explained. According to sections 26.5, 26.6 & 26.7 of the Construction Safety Regulations outlined in the OHSA (O.Reg.213/91), a fall-arrest system shall consist of an assembly of components, namely a full body harness, a lanyard equipped with a shock absorber or similar device, an adequate lifeline, a rope grab and locking snap hooks (Figure 2 in Appendix A). The lifeline must be attached to an appropriate independent fixed support (Construction Safety Association of Ontario 2007).

In the case of existing low-rise residential buildings in service, there is no suitable anchor point required in the building code, and thus no possibility of having an integrated fall-arrest system. The proposed design uses a galvanized steel double-hinged anchor system similar in shape to dock cleats used to tie-off boats and yachts, and it would be placed on the midspan of the peak line of the sloped roof. Due to the nature, shape, and central location of the cleat, lifelines may be connected to it from either side of the roof. (See Figure 3 in Appendix A). Once the lifeline is attached to the cleat, a worker can safely tie-off him/herself or the ladder. According to the aforementioned regulations, the anchor point must be capable of supporting at least 6 kilonewtons (1350 pounds) of static force without exceeding the allowable unit stress for each material used, and must be installed according to the local building code.

The construction regulation (O. Reg. 213/91) requires that before workers use any fall-arrest system, the employer must develop written rescue procedures (Construction Safety Association of Ontario 2007). Since the nature of the rescue procedure differs from location to location and is specific to the local conditions and capabilities available, this report will not propose a specific rescue plan. However, the Washington State Department of Labor and Industries lists a number of general recommendations including a possible self-rescue operation, and is thus suggested by this report in Appendix B as a potential reference on the topic.

2.3 Constructability and Aesthetics

One potential disadvantage of such a permanent anchoring feature on the top of the roof is the diminished aesthetics of the building. To counter this, the design features two hinges on its bases, thus allowing it to be bent down when not in use and therefore not visible as an extrusion on top of the structure. A further benefit of this system is that the cleat will be less exposed to harsh weather conditions such as strong winds, helping increase the durability and life-time of the system.

In terms of the design's practicability, it has been mentioned in the previous sections that during construction a similar fall-arrest system exists to protect the worker working on the roof. It is therefore reasonable to assume that the top section of the roof has the lateral load resistance capacity required to support the cleat and act as a fixed support anchorage for the fall-arrest system. Therefore the only point that must be considered in terms of additional engineering work is to integrate the proposed anchoring system and its hinges into the design of the top edge of the roof from the beginning.

2.4 Changes to the Building Code

The main reason why falls are not a major issue for high-rise buildings during service life is the fact that the building code mandates the provision of a fall-arrest system on the roof to be used for all maintenance purposes. In order for this design to have its intended effect and truly minimize the number of falling accidents, this article suggests a regulatory change to the building code to require all new buildings and all re-shingling projects to install anchors. A fixed anchor point for fall-arrest systems would thus be necessary for all low-rise residential buildings and homeowners must tie off their ladders when they re-shingle the roof, clean the gutters, hang Christmas lights, shovel snow, paint the trim, etc.

3 FINAL REMARKS

The proposed design, permanent cleat-shaped anchorage system with hinges, is a simple device which is easy to install and use, and is a simple cost-effective way to solve an often neglected but nevertheless dangerous problem. In low-rise residential buildings, a fixed anchorage point is available to be used with fall-arrest systems but is removed after the construction is over. This design simply provides a permanent anchor point to be used during the service life of the building, while no additional design or calculation is required in terms of the other aspects of the fall-arrest system such as the length of the lifeline, type of lanyard needed, free fall and fall stopping distance, and the usage methods practiced during the construction of the house. Despite the small scale of the design, it could potentially save hundreds of workers or even civilians such as the homeowners themselves every single year. In other words, it is a simple solution to a neglected but life-threatening hazard.

4 APPENDICES

4.1 Appendix A

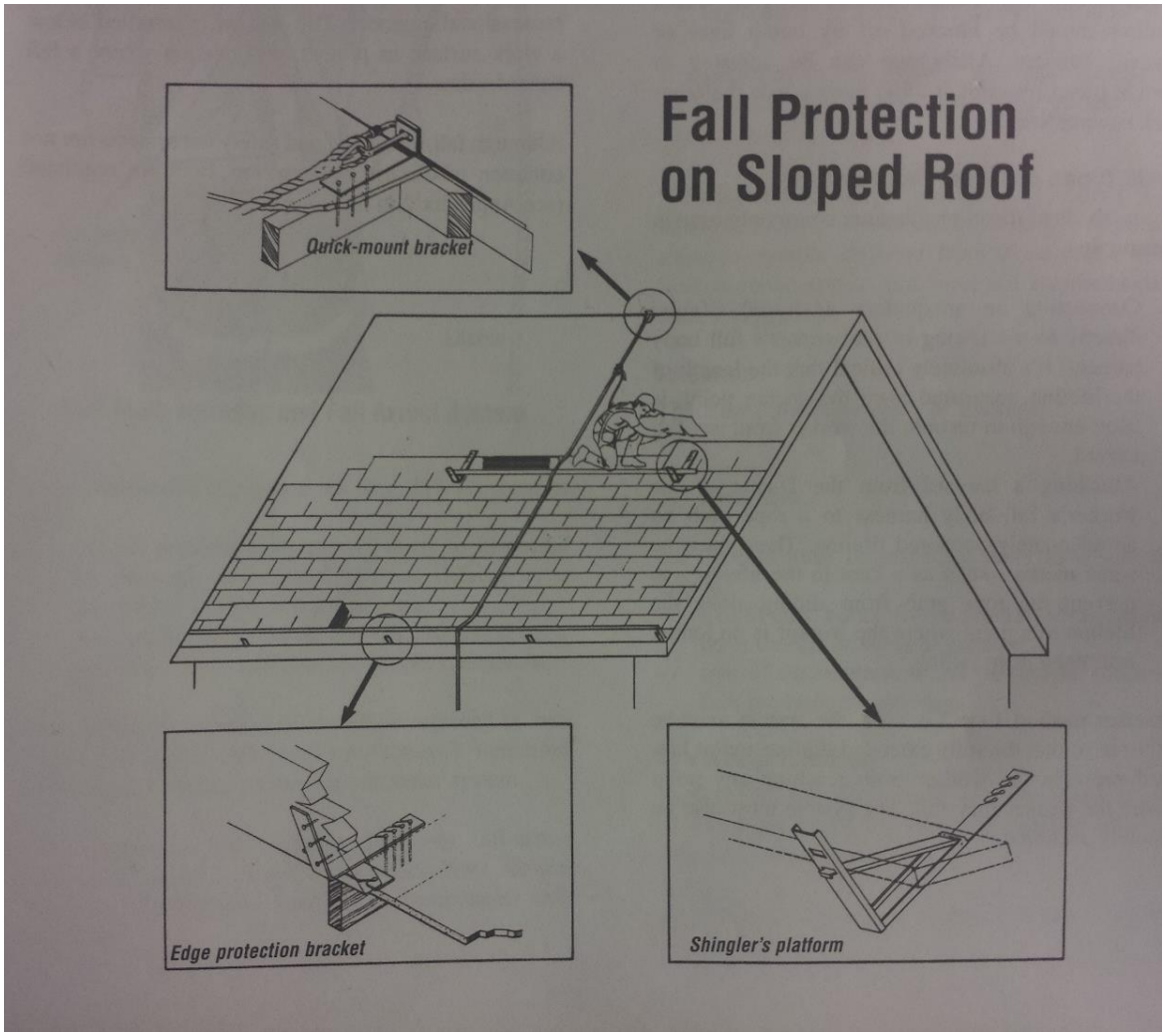

Figure 1: Temporary Fall-Arrest System Used During the Construction of a Low-Rise Residential (Construction Safety Association of Ontario, 2007)

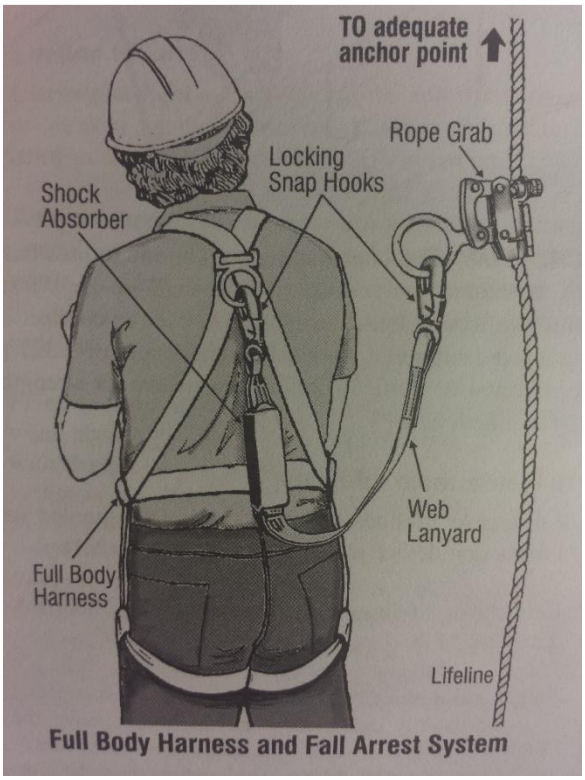

Figure 2: An Example Fall-Arrest System with all Necessary Components (Construction Safety Association of Ontario, 2007)

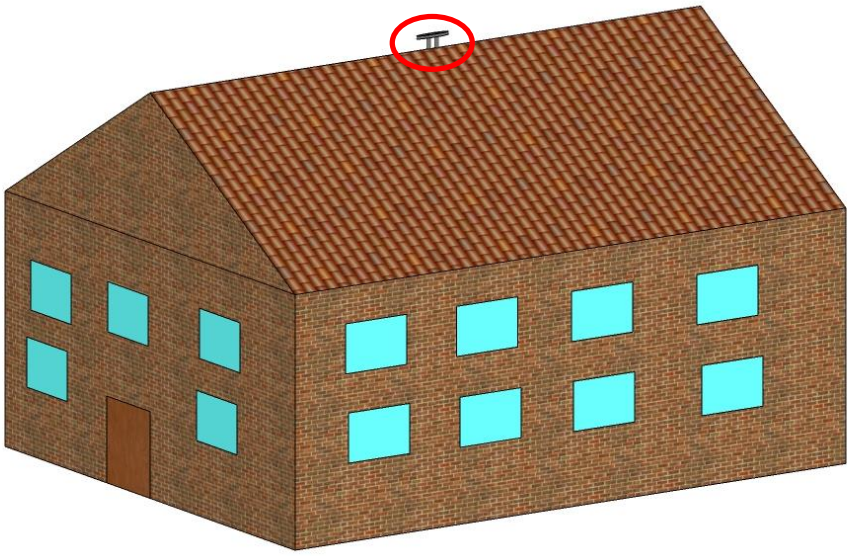

Figure 3: The Proposed Design, Showing the Cleat on the Midspan of the Top of the House

4.2 Appendix B

The type of rescue procedure to be followed after the fall-arrest system has been activated depends on the local conditions and capabilities and resources available. The July 2011 issue of the Occupational Health & Safety Journal (available http://ohsonline.com/Articles/2011/07/01/The-Most-Overlooked-Aspect-of-Fall-Protection.aspx) suggests that the following items are examples of what your rescue plan should include:

- Type of rescue system
- Location of rescue anchorages
- Equipment needed
- Attachment to fallen worker's harness
- Required training
- Specific actions to achieve successful rescue

Furthermore, the Washington State Department of Labor and Industries has published a reference document titled *Fall Protection: Responding to Emergencies*, whereby it provides suggested methods and guidelines for both self-rescue and also aided-rescue in the event of a falling accident. The document is available online at http://www.lni.wa.gov/wisha/publications/FallProtectionEmergencies.pdf

5 REFERENCES

Canadian Census Analyzer. 2011. *Census Profiles Files.* Retrieved April 17, 2014 from the World Wide Web: http://dc1.chass.utoronto.ca.myaccess.library.utoronto.ca/cgi-bin/census/2011/displayCensus.cgi?year=2011&geo=prov

Construction Safety Association of Ontario. 2007. *Basics of Fall Protection*, CSAO, Ontario, Canada.

Employment and Social Development Canada. 2014. *Work-Related Injuries.* Retrieved April 12, 2014 from the World Wide Web: http://www4.hrsdc.gc.ca/.3ndic.1t.4r@-eng.jsp?iid=20#M_3

Statistics Canada. 2011. *Injuries in Canada: Insights from the Canadian Health Survey.* Retrieved April 12, 2014 from the World Wide Web: http://www.statcan.gc.ca/pub/82-624-x/2011001/article/11506-eng.htm

Work Safe BC. (2012). *Work Safe BC 2012 Statistics.* Retrieved April 12, 2014 from the World Wide Web: http://www.worksafebc.com/publications/reports/statistics_reports/assets/pdf/stats2012.pdf