Critical Incident Patterns of Residential Roofers

Evan Middlebrooks¹, Angelica Heard¹, Alea Singletary¹, Tonya Smith-Jackson¹, and Daniel Hindman²

¹Department of Industrial and Systems Engineering
North Carolina Agricultural and Technical State University

²Department of Sustainable Biomaterials
Virginia Tech

Abstract

There has been an increasing number of fatalities due to falls in roofing construction. Due to the smaller size of residential construction businesses, statistics on falls, especially non-fatal injuries, may be under-reported. Studies revealed relationships between demographic factors, experience levels, use of fall protection, and risk of falls in roofing. This study explored those relationships using a field experiment to test the degree to which fall arrest harnesses and anchorages facilitated or undermined performance of construction roofing tasks. In this study, we conducted a field experiment to test the degree to which fall arrest harnesses and anchorages facilitated or undermined performance of construction roofing tasks. The highest relative frequencies of critical incidents included having to adjust to the extreme postures while working (19%) and interference caused by the lanyard (32%). Participants conducted two roofing tasks while wearing fall arrest harnesses. Critical incidents were recorded and defined as any event demonstrating a hazard or problem with the task or harness. Participant feedback on the harness was also recorded. Harness redesign and work process design recommendations were provided.

Keywords
Construction, Safety, Critical Incidents Roofing, Ergonomics

1. Introduction

Roofing construction fatalities have become increasingly more prevalent in recent years. According to Occupational Safety and Health Administration (OSHA) more than one-third of fall deaths in residential construction are caused by falls from roofs. To some degree, the increases in fatalities have been due to an increasing number of falls. Several factors contribute to falls, including a lack of proper personal safety equipment and knowledge. This study evaluated the critical incidents that take place during roof work that could possibly lead to fatalities or injuries among construction workers. With the number of fall-related fatalities on residential construction sites occurring at a high rate, the critical incident technique serves as the prime mode of evaluation of potential factors that may contribute to occupational accidents. This approach involves an iterative method or system for compiling human subject observations that are significant and fulfill strategically outlined criteria (Flanagan, 1954). This allows for the deductive reasoning necessary to discover and introduce new findings as it pertains to the field of residential construction. A critical incident may consist of any quantifiable human act that explicitly invites researchers to form conclusions about the individual acting (Flanagan, 1954).

2. Study Purpose

The National Institute for Occupational Safety and Health (NIOSH) is responsible for conducting research and making recommendations for the prevention of work-related illnesses, injuries and fatalities (NIOSH, 2013). NIOSH has many different workplace safety and health topics and fall prevention is one of them. In April 2012 NIOSH and OSHA announced the launch of a construction fall prevention campaign (Spring, 2013). According to the U.S. Bureau of Labor Statistics, in 2010 there were more than 10,000 construction workers in the private
construction industry who were injured as a result of falling while working from heights on the job and another 255 workers were killed. The campaign’s goal is to prevent fatal falls from roofs, ladders, and scaffolds by encouraging construction contractors to: plan ahead to get the job done safely, provide the right equipment, and train everyone to use the equipment safely. A fall can occur during the simple acts of walking or climbing a ladder to change a light fixture or as a result of a complex series of events affecting a construction worker 80+ feet above ground. The highest frequency of fall-related fatalities was experience by the construction industry. Healthcare support, building cleaning and maintenance, transportation and material moving, and construction and extraction occupations are particularly at risk of fall injuries. Although many factors contribute to slips and falls while roofing the data collected has shown that the leading cause of critical incidents while roofing happen to be lanyard interference. The placement of the lanyard can cause discomfort to work so they are constantly readjusting it to their liking of comfort.

3. Method

A mixed methods approach was used to incorporate both qualitative and quantitative forms of data. This study is part of a larger study that will be completed in May of 2014. The critical incident approach was utilized to observe the behaviors and patterns among residential construction workers. A critical incident is any visually tangible activity exercised by the research subject or study participant (Flanagan, 1954). Critical incidents were observed and recorded with the use of video analysis and the think aloud protocol. K. Anders Ericsson and Herbert A. Simon were the cognitive psychologists who devised the protocol as a way to acquire more understanding of human thought processes (Gambier & Van Doorslaer, 2011). In regard to the residential roofing experiment, the initial research objective was to ascertain a more sophisticated level of understanding of contributing factors most associated with critical incidents and the relationship between these factors and major falls resulting in work-related injury.

3.1 Participants

Study participants were required to have previous work experience of at least 1 year in residential roofing construction. This criterion served to be ideal because it ensured that the participants were knowledgeable enough to complete each roofing task with sufficient instruction from the primary researcher. The minimum age requirement was 18 years. The maximum weight limit was 310 pounds or 140.61 kilograms (ISEA, 2014). The sample size of participants observed was 9. The mean age was 43.92 years (with a standard deviation of 9.42 years).

3.2 Apparatus

The roof structure used by study participants was a scaled world model. The scaled world model roof was designed to accurately reflect a realistic residential roof. The dimensions of the structure were 12 feet x 10 feet x 6 feet or 3.66 meters x 3.05 meters x 1.83 meters. Students in the American Society of Civil Engineers constructed the roof and made sure that safety was key. Researchers were responsible for applying tar paper and shingles at the base of the model shown in Figure 1.1 below. Tar paper and shingles needed to be applied halfway and one-quarter way up the test roof respectively to ensure participant position began at an elevation from the ground.
The questionnaires and critical incident recording sheet were simplistic in nature due to the type of information needed. The format’s simplicity also facilitated ease of replication. Questions about age, relevant work experience, and work-related injury were asked of each participant. The critical incident observation sheet consisted of four columns labeled for each task, tarpaper and shingle, critical incident codes (i.e. slip on roof, loss of personal protective equipment or PPE), frequency of each critical incident, and additional comments and observations. Along with the two incidents mentioned above, the behaviors or critical incidents monitored were as follows: fall from roof, slipping on roof, tool drop, nail drop, lanyard interference, negative body contact with tool (i.e. hitting hand with hammer), removal of PPE, harness adjustment, extreme postures (i.e. twisting, bending, leaning, reaching), and prompting the participant to speak out loud.

3.3 Procedure
Each participant observation took place outdoors and off campus at a university-affiliated location. Three cameras were used to help document the critical incidents in a manner that was conducive to data coding technique used. Informed consent documents detailing the study objective, participant rights, and data confidentiality were administered per human subjects ethics. Research observations, questionnaires, and interviews were administered in written and verbal forms. The recordings were kept secure in a limited access laboratory and served as the main source from which critical incidents were extracted for data collection purposes. The primary and secondary camera angles were strategically placed in fixed, stable positions. One stationary position was located at the base of the roofing structure. The other stationary position was located on an original, elevated platform above the roofing structure to allow for aerial viewing. The tertiary camera angle was provided from the perspective of the lead researcher who wore a hardhat with a small camera attached at the top. The three camera angles served to be equally important as witnessing the events of a critical incident from all necessary angles were crucial for evaluation and analysis.

The procedure encompassed primary data collection through the means of questionnaires regarding such factors as demographics and residential roofing construction experience. For continuity purposes and to gauge familiarity and harness compatibility, each task (donning, tarpaper, shingles, and doffing), was individually timed. Following the step of recording participant height and weight measurements, participants were asked to don the harness while the lead researcher recorded how long it took to complete donning (time) by using a stopwatch and the process of donning the harness itself visually by using the mobile or what was referred to as the floating camera angle of the lead researcher. There were two different types of harnesses and two different types of anchorages used and alternated. The participants were briefed on the tarpaper task expectations. Participants were then asked to put on all Personal Protective Equipment (PPE). This included wearing a hard hat, gloves, knee pads, and goggles (if so desired). Participants were instructed to apply tarpaper to the test roof using a hammer and tarpaper nails in a manner based on previous on-the-job experience. After completing the tarpaper task, participant feedback regarding the fall arrest harness and anchor was collected with the use of hand-written responses and audio recorders. Participants were then asked to apply two rows of shingles over the tarpaper in a manner that is most familiar to him or her. Shingle task completion was timed and recorded as well. The post-task interview involved a number of ordinal questions regarding the experiences with and attitudes toward the fall arrest system (Middlebrooks, Heard, Singletary, Smith-Jackson, 2013).

3.4 Data Analysis
Critical incident coding procedures involved a two-tiered monitoring scheme. Two different researchers reviewed participant video files. The video observations served to record critical incidents with more accuracy and greater magnification. Time associated with each critical incident was notated. SAS 9.2 System was utilized to produce the mean and standard deviations of tasks. Critical incidents (CIs) were identified by video analysis. Raw frequencies are reported and illustrated in Table 1.
4. Results

The SAS analysis package was used to analyze quantitative data. Frequencies from the qualitative video coding were entered into the SAS data set along with questionnaire responses in the form of ratings and quantized nominal values. The interview section specifically asks each participant their age, years of experience, and any previous accidents or critical incidents that might have occurred.

Given the small data set and the limited degrees of freedom, no correlations were found between age and critical incidents. However, some interesting trends were identified. The age range of the participants was between 27 and 63 years old (M= 43.92; SD = 9.42). Roofing experience ranged from two to 30 years. For the following critical incidents, a trend indicated that the higher the age and years of experience, the higher the frequency of the following critical incidents: removing PPE, use of extreme postures, and struck by objects. The total number of frequencies was 57 out of a total of 224. Just like in anything the more time devoted to something, the more knowledge is learned. Frequency of the critical incidences are correlated to experience.

The roofers should still be comfortable in order to better adjust to the transition of implementing these safety rules. With the raw frequencies of each critical incident recorded the lanyard interference was the largest critical incident. The lanyard interference led to discomfort, leaving the participants to move in extreme postures. And then slipping as the least frequent critical incident at barely 2%. This is shown in Figure 2.
5. Discussion and Conclusions

This information is apart of the preliminary data based on 9 participants. Data will continue to be collected. In 2009, roofing construction worker attitudes were studied in depth. Workers expressed the reasons for reluctance towards fall arrest systems. Among these reasons were time-consumption, interruptive equipment readjustment, discomfort, lack of administration, and peer pressure (Sa, 2009). The representative sample of participants shared positive sentiments towards the implementation of fall arrest systems in residential roofing. From there this study helped highlight the different areas where the roofers were least safe.

In the future, various location placements of the lanyard on the harness will need to be examined. Participants were able to learn to appreciate safety precautions. Employer incentives and assistance for proper safety practices is a link between the worker and the harness saving a life. (Smith-Jackson, Hindman, Shields, Thomas, Gallagher, Koch, 2011). With construction and residential roofing occurring outside, employers may want to add or snacks to go with smaller breaks as incentives. Attendance to mandatory courses and/or training showing how to properly work various harnesses, lanyards and personal protective equipment, will also have an impact on the actual use of the information.

Acknowledgments

This research was funded by the National Institute for Occupational Safety and Health (NIOSH) under the auspices of the Center for Innovation in Construction Safety and Health headquartered at Virginia Tech. The authors wish to express gratitude to Dr. Marcia Williams, director of the NC A&T Louis Stokes Alliance for Minority Participation (LSAMP) and to Dr. Dan Hindman (Virginia Tech). We are also grateful to Dr. Taher, Dr. Hamoush, and NC A&T State University’s American Society of Civil Engineers.

References


