Occupational Injuries and Fatalities in the Roofing Contracting Industry

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Abstract: The purpose of this paper is twofold: (1) to determine jobs/tasks associated with current injury, illness, and fatality trends in the roofing industry; and (2) to identify current safety practices associated with the prevention of these illnesses, injuries, and fatalities. In order to achieve the project objectives, a survey was designed and sent to Michigan roofing contractors. To design an adequate survey, the research team first collected background information using U.S. Bureau of Labor Statistics online database, published research, and contractor interviews. Of the 48 roofing companies asked to participate, 24 completed the survey. The survey results indicated that hand and finger injuries due to cutting operations and back injuries due to the manual handling of heavy and bulky materials to be the most frequent roofing contracting task/injury combination. Falls from elevations as well as on the same level typically occurred when carrying heavy and bulky materials such as bundles of shingles on slippery and inclined walking/working surfaces. These findings from this study may assist safety professionals in the construction industry in making effective changes for improving safety and productivity.

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Introduction

The construction industry is a major contributor to the United States economy, employing over 6 million workers representing 5% of the total United States workforce (BLS 2002d). However, a significant number of nonfatal injuries occur in the construction industry. The latest statistical information from the Department of Labor indicates that the construction industry accounts for 8.9% of the total recordable injury cases in the United States (503,500 injures) (BLS 2002a). These injuries are not only detrimental to workers but are costly as well. National Institute for Occupational Safety and Health (NIOSH) reported that 15% of all workers' compensation costs are spent on construction injuries (NIOSH 2002). Considering that construction only accounts for 5% of the workforce, this is a serious overrepresentation.

Safety and health assurances within the construction industry are complex due to various factors. The continuous changing of the work environment in addition to the composition of work crews and the work to be carried out on a construction site often exposes workers to unforeseen and unfamiliar hazards (Helander 1991). Besides these changing hazards, other factors such as the multiplicity of operations being carried out and the proximity at which various crews operate, help make construction workers prone to risky situations (NIOSH 2002). Because these factors cannot be avoided at most times, alleviating safety risks in construction becomes a difficult venture.

One of the most hazardous sectors within the construction industry is the roofing industry (OSHA 2002). Choi et al. (2003) found that the insurance premiums in the roofing companies have been significantly increased, while workers' compensation costs are on the rise as well. Fig. 1 shows the total recordable injuries from 1992 to 2000 for general, construction, and roofing sectors in the United States (BLS 2002d,a,b,c,e). Construction, which is a subgroup of general industry, contributes a high rate of injuries per 100 full time workers. The rate represents the number of injuries incurred per 100 full time employees in the period of 1 year. Again, roofing, which is a subgroup of the construction industry, is also responsible for high rate of injuries per 100 full time workers.

Fatalities also pose a significant problem in the construction industry. The BLS statistics for the year 2000 show the construction industry having 1,154 fatal injuries. This made up 21% of all fatalities in the United States and again demonstrated that the number of fatal work injuries occurring in the construction industry was the highest out of any industry (BLS 2002b). Roofers are

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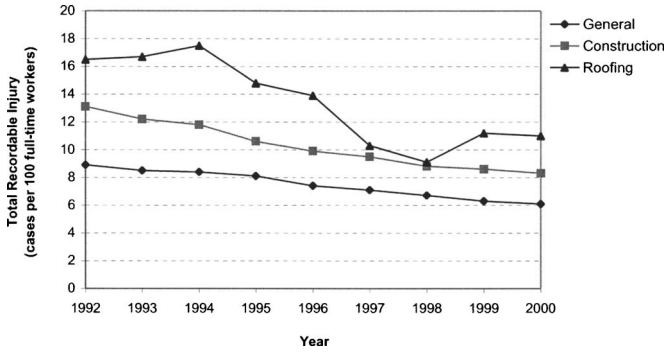

Fig. 1. Total recordable injuries from 1992 to 2000 for general, construction, and roofing sectors in United States (Bureau of Labor Statistics)

about six times higher at risk for fatal occupational injuries than the average worker, with falls being fatal events in 75% of cases (Ruser 1995).

Additionally, falls from roofs are a serious cause of nonfatal injuries in the construction industry. The injuries caused by falls from roofs are typically extremely severe, requiring long periods of treatment and recovery, and resulting in substantial medical costs (Gillen et al. 1997). Johnson et al. (1998) conducted a fall protection analysis for workers on residential roofs and found that fall protection plans were not prepared as required, and positive safety measures such as guardrails and personal fall arrest systems were not used. They listed the reasons, including the extreme competitiveness of the home building and roofing industries, unsafe worker behavior, design difficulties, conventional construction practices, and a lack of knowledge.

While the exact causes leading to fall incidents are rarely found in the literature, fatality investigation reports or worker compensation descriptions indicate the most commonly mentioned initial reasons for falls were slips, trips, and loss of balance (Hsiao and Simeonov 2001). Walking/working on inclined and slippery surfaces (e.g., steep roofs) demands intensive controls to maintain a posture and avoid balance disturbance. Balance control on roofs is important not only for standing or walking, but also for other activities. Handling heavy and bulky materials as well as operating equipment on confined surfaces makes the control of balance challenging. Temporary work environments, more specifically the incomplete support surfaces on roofs, require workers' careful attention.

Therefore, the primary goal of this study is to identify specific tasks that are frequently associated with injuries, illnesses, and fatalities in roofing construction. The purpose of this paper is twofold:

1. to determine jobs/tasks associated with current injury, illness, and fatality trends in the roofing industry; and
2. to identify current safety practices associated with the prevention of these injuries, illnesses, and fatalities.

Scope of Roofing Industry

The roofing industry is typically a specialty contracting work within the construction industry. Operations falling under this specialty industry include roofing, siding, and sheet metal work. In the United States, there are approximately 25,000 firms that can be classified under the roofing industry. A total of approximately 300,000 workers are employed by these firms, with 200,000 workers directly involved in the application of the roofs (OSHA 2002). Tasks involved in roofing work include roof construction, repair, renovation, and maintenance (Hsiao and Simeonov 2001).

The two major areas included in the roofing industry are commercial roofing and residential roofing. Commercial roofing involves low-pitched roofs, ranging from a slope of 0.32 cm per 30.48 cm (0.6°) to 5.08 cm per 30.48 cm (10°). Since their slopes are low, commercial roofs are often considered flat roofs. The three classifications of low-sloped systems are built-up roofing, modified bitumen roofing, and single ply systems. Residential roofs on the other hand, will commonly vary from a slope of 5.72 cm per 30.48 cm (11°) to slopes greater than 30.48 cm per 30.48 cm (45°). Roofs with slopes of this dimension are classified as steep roofs. The majority of steep sloped roofing projects are residential projects. Residential roofing accounts for one-third of the total annual market for the United States roofing industry and about 80% of roofing contractors perform only residential work (OSHA 2002).

Bureau of Labor Statistics Data

Using the United States government's Bureau of Labor Statistics (BLS) safety and health statistics, injury, illness, and fatality data were collected from 1999 to 2000 (BLS 2002d, a,b,c,e). Statistics related to the roofing contracting work were collected and compared to relevant data from the construction industry as a whole. Statistical information provided by the BLS fall under two main categories: nonfatal occupational illnesses and injuries and occupational fatalities. The five primary sets of statistics collected were: (1) events or exposures of injuries and illnesses; (2) natures of injuries and illnesses; (3) sources of injuries and illnesses; (4) parts of body affected in injuries and illnesses; and (5) fatalities. Each specific set will be further discussed in following subsections. The statistics were collected from the BLS online database for each individual year from 1999 to 2000 (BLS 2002d,a,b,c,e). The various data sets were complied over the 2 year span for a current cumulative review, and represented in graphical format.

Event or Exposure Leading to Injuries and Illnesses

The first statistical category reviewed was the number of occupational injuries involving days away from work by event or exposure leading to injury. The BLS defines event or exposure as "the manner in which the injury or illness was produced or inflicted" (BLS 2002c). The types of events and exposures have been divided into ten main categories: (1) contact with objects; (2) caught in or crushed; (3) fall to lower level; (4) fall on same level; (5) slips or trips without fall; (6) overexertion; (7) repetitive motion; (8) exposure to harmful substance; (9) transportation accidents; and (10) all other events. When computing this data, falls to a lower level and falls on the same level were combined and simply termed "falls." This was done in an attempt to simplify the data set. For roofing contractors, falls were found to be the primary event or exposure, accounting for 26% of all cases (i.e., 2,760 cases of 10,539 cases). The category of falls, 20% were caused by falls to a lower level and 6% by falls on the same level. Contact with objects was the next most frequent event or exposure, accounting for 24% of all the cases. The next largest category was overexertion at 19%, mainly caused by lifting.

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Nature of Injuries and Illnesses

The second statistical category reviewed was the number of nonfatal occupational injuries involving days away from work by nature of injury or illness. Nature of injury or illness is defined as "the principal physical characteristic of a disabling condition" (BLS 2002c). The BLS has broken the various natures into eight major categories: (1) sprains and strains; (2) fractures; (3) cuts and punctures; (4) bruises; (5) heat burns; (6) multiple traumatic injuries; (7) back pain; and (8) all other natures. The most prevalent type of roofing contracting injuries and illnesses were sprains and strains. They accounted for 36% of the total cases (i.e., 3,900 cases of 10,719 cases). Strains are the result of overstretched or torn muscles, and sprains are the results of torn ligaments. Strains and sprains will frequently cause swelling and intense pain. Other significant natures were cuts and punctures with 14% of the total cases and fractures with 11%.

Source of Injuries and Illnesses

The third statistical data reviewed were the number of nonfatal occupational injuries involving days away from work by source of injury or illness. Source of injury or illness is "the object, substance, exposure, or bodily motion that directly produce(s) or inflict(s) the disabling condition" (BLS 2002c). The sources of injuries and illnesses were divided into nine major categories: (1) chemical and chemical products; (2) containers; (3) machinery; (4) parts and materials; (5) worker motion or position; (6) floor, walkways, or ground surfaces; (7) handtools; (8) vehicles; and (9) all other sources. The largest source of injuries and illness for roofing contractors was parts and materials, accounting for 27% of all cases (i.e., 2,919 of 10,791 cases). The categories floors, walkways, or ground surfaces and worker motion or position were the next two largest categories, at 24 and 12%, respectively.

Parts of Body Affected by Injures and Illnesses

The next set of statistical data reviewed was the number of nonfatal occupational injuries involving days away from work by parts of the body affected by injury and illness. These major areas are the head, neck, trunk, upper extremities, lower extremities, body systems, multiple body parts, and all other body parts. These categories are then further subdivided into more specific areas. For instance, the major category upper extremities are further divided into the subcategories: wrist, hand, finger, and other parts of upper extremities.

For roofing contractors, it was found that 30% (i.e., 3,300 of 10,815 cases) of injuries and illnesses were to the trunk. The upper and lower extremities were also found to be significant injury areas, accounting for 24 and 26%, respectively. When further divided into the subcategories, it appeared that the back was the most prevalent area of injury and illness, accounting for 21% of the total cases (i.e., 2,273 of 10,815 cases). The fingers (9%), knees (7%), and feet/toes (7%) were also found to be specific areas of frequent injury and illness. Overall, the primary parts of the body affected are the feet, knees, fingers, and back.

Fatalities

The construction industry reported the largest number of fatal work injuries of any industry and accounted for nearly one-fifth of the fatality total in 2000 (BLS 2002e). Falls were the most frequent fatal event in construction from 1999 to 2000, accounting for 32% of all cases. Transportation incidents (26%), contact with objects (21%) and exposure to harmful substances (15%) were all also significant fatal events and exposures.

Construction specialty trade contractors such as roofers, carpenters, pipe fitters, and electricians all face a high risk of falls while working on roofs, ladders, and scaffolds. But the entire construction industry confronts a high risk of fatal injuries from its varying work environment. At a construction site, the environment, the work to be done, and the composition of the crews change continuously, which exposes the worker to unforeseen and unaccustomed hazards (Helander 1991). In addition, construction workers are frequently changing projects and employers, thus constantly changing the norms for safety. In the roofing industry, the fatalities due to falling are overwhelming. Falls were the most frequent fatal event in roofing construction, accounting for 75% of all cases. This margin is so wide that the next most significant event of fatalities was exposure to harmful substances or environments and transportation incidents, which accounted for 12 and 10%, respectively.

While the exact triggering factors leading to fall incidents are rarely found in the literature, fatality investigation reports, or worker compensation descriptions, the most commonly mentioned initial reasons for falls were slips, trips, and loss of balance (Hsiao and Simeonov 2001). Workers either slipped while walking, lost their balance while on the roofing surface, or lost their balance when surface materials slipped, for example roofing shingles lying on the roof slipped (Parsons et al. 1986). Stepping on loose materials on pitched roofs, resulting in slips off the roof edge (Suruda et al. 1995), steep roofs causing slip or imbalance (Parsons and Pizatella 1985), and inadequate worker's perceptions of the strength and load-bearing capacity of skylight elements (Bobick et al. 1994) were also reported as common incidents.

Methodology

The BLS data and analysis are insightful, yet lack detailed information in many areas. In particular, the potential risk factors causing unforeseen injuries and illnesses need to be identified, since specific tasks that are linked to these risk factors could provide further knowledge of how to mitigate the injuries and illnesses. In order to obtain additional data, a one page survey (included as the Appendix) was designed for roofing contractors. The purpose of the survey was to identify specific tasks that are frequently involved with injuries, illnesses, or fatalities in the roofing industry. Due to the wide variety of tasks, equipment, and procedures involved in roofing, it is difficult to develop and administer a comprehensive survey. Therefore, the survey was designed to study the most significant hazards and case types, as identified by the BLS statistics. Of the four injury and illness data sets collected, parts of the body is the most specific and the most easily identifiable description.

Data were collected from the BLS online database and previously published resources to determine what type of injuries, illnesses, and fatalities were the most prevalent in roofing construction. Using this information, an initial survey instrument was designed. Primarily, the questions focused on parts of the body frequently injured in roofing contracting. Several questions were drafted for each of the body parts frequently involved in lost-workday cases. The majority of these questions were phrased so that a body part was identified, and the contractor could identify tasks that were associated with injuries and illnesses to that par-

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ticular body part. The survey also contained questions about other significant hazards such as machinery and hand tools. This preliminary survey instrument was administered in person to four local contractors. Based upon the response of these contractors, the survey instrument was further refined. The focus of the survey was narrowed, and repetitious material was eliminated. Several roofing contractors in Michigan were contacted via telephone to elicit their participation in completing the survey. The roofing contractors who participated in the survey were identified and selected from the National Roofing Contractors Association webpage directory. Approximately 48 roofing contractors were asked to complete the survey.

Survey Results and Discussion

Of the 48 roofing companies asked to participate, 24 completed the survey. This represents a response rate of 50%. The size of the participating companies greatly varied, with some employing as few as 0 workers (self-owned) and others as many as 95. The participating roofing contractors worked in residential and commercial roofing, siding, and sheet metal installation. The participants were primarily from Michigan. There were four types of questions included in the survey. The first type of questions required participants to record a written response. The second type asked them to rank choices from a given list from most frequent to least frequent, the third type asked for participants to allot percentages among selections in a given list so as to designate order of importance, and the last type of question asked the participants to select one or all the pertinent choices from a given list (see the Appendix for the survey used).

The first section of the survey was designed to collect background information on the various companies. Participants were asked to record the number of workers employed within their firms. Special attention was paid to the number of workers who work out on the projects. Recorded numbers were then grouped into ranges for easy analysis. Thirteen percent of respondents (3 of 24) were owned by sole proprietors, with employers having no employees working under them. Fifty-four percent (13 of 24) employed 1–10 employees, while 13% employed 11–20 employees. Eight percent (2 of 24) employed 21–40 employees, and 13% had over 40 workers employed. Looking at the gender distribution of the companies surveyed, the percentage of male employees had a wide margin over female employees. Only 16% of the firms reported having women employees, and of these, the women population represented less than 25% of the total number of workers.

The companies were asked whether or not safety programs were maintained at their companies. Only 28% of the companies reported having established safety programs. Exiting programs included written policies, toolbox talks, videotapes, and monthly safety meetings. Some responses from the remaining 72% of participants responded with statements regarding OSHA fall protection and roofing contractors association guidelines. Those responses were not counted as safety programs since these procedures are supposed to be kept as a standard. The owners of the companies were in charge of the majority of these safety programs. In some cases a vice-president or manager was in charge of the safety program. The findings from this study indicate that a strong correlation exists between size of company and maintaining the safety program. Larger roofing companies are generally better organized from a safety standpoint.

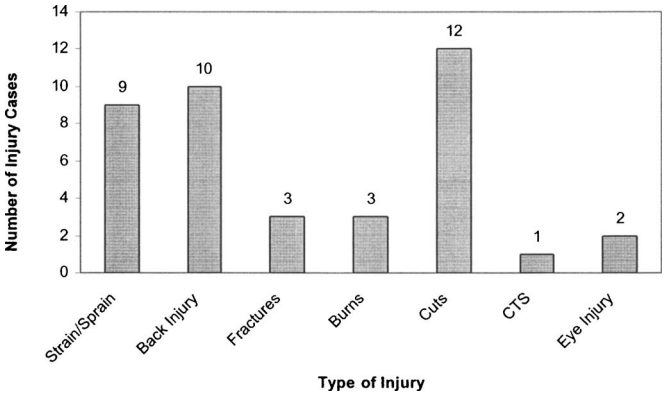

Fig. 2. Common types of injuries and illnesses—survey results

Injuries and Illnesses

A large portion of the injury and illness section of the survey was based on BLS information so that the information collected from the BLS could be more closely examined and could be applied to the specific companies. Questions focused on types of injuries sustained, causes of the injuries, and the parts of the body affected by the injury. A few of the questions were concerned with the employees and some of the questions dealt specifically with the issue of falls. Fifty-five percent of respondents (12 of 22) reported having injuries within the last year. The numbers ranged from a minimum of 1 injury to a maximum of 23 injuries. Forty-five percent (10 of 22) firms had incidents of zero. Injuries seemed to be more prevalent among the bigger firms.

Companies were asked to pick from a list as well as to list common injuries that occur on their work sites. Companies could also list other injuries that were not included selections in the given list. Choices included sprains/strains, back injuries, fractures, burns, cuts, and carpal tunnel syndrome (CTS). Other types of injuries that were specified included injuries to the eye. Cuts made up the majority of the selected injuries totaling 30% (12 of 40 total cases) of the listed types of injuries. Back injuries followed with 25%, and sprains and strains made up 23% of the selected injuries. The other types of injuries included fractures (7%), burns (7%), eye injuries (5%), and CTS (3%) (see Fig. 2).

Options included in the source of injury section included overexertion, motion/position, slip/trip, tools/machinery, and chemicals. Participants again were able to specify other types of sources that were not included in the given list and these included objects affecting the eyes of the worker and worker's carelessness. Because answers like worker's carelessness were not specific enough for our study, they were not included in the graphing of our survey results. The most prevalent source of injury was motion/position totaling 31% (31 of 100 total cases) of the selected sources. Slips/trips accounted for 22% of the selected injuries and tools/machinery accounted for 22% as well. Other sources included overexertion (17%), chemicals (4%), and objects in worker's eye (4%) (see Fig. 3).

The survey also contained a section in which participants were asked to rank the frequency at which certain parts of the body were affected with injury and illness. Seven parts of the body were listed: (1) knees; (2) hands/fingers; (3) back; (4) shoulders; (5) eyes; (6) foot/ankle; and (7) head/neck. These were all areas of the body that the BLS database indicated were frequently involved with lost workday cases in roofing. The participants were asked to rank the relative frequency on a scale of 1–7, with 1 being the most frequent. Hand/fingers injuries had the highest

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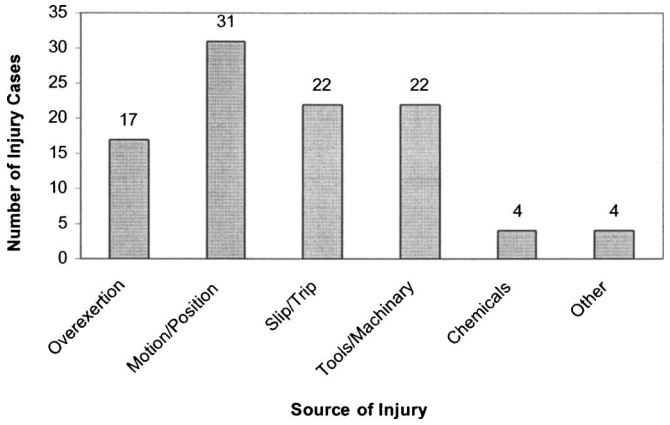

Fig. 3. Common sources of injuries and illnesses—survey results

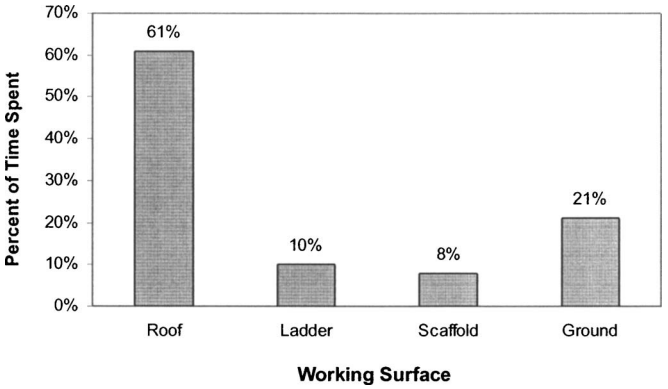

Fig. 5. Percentages of time spent on different working surfaces—survey results

ranking with a mean response value of 1.4, while back injuries and illnesses had the second highest ranking with a mean response value of 1.7. Shoulder and knee had the third and fourth highest ranking with a mean value of 3.8 and 3.9, respectively. The other three parts of the body were assessed rankings of 4.3 (eyes), 4.6 (foot/ankle), and 4.8 (hand/neck).

The section concerning falls asked participants to rate the amount of falls that occurred from the same level or to a lower level. The recorded percentages were averaged. Falls to a lower level averaged 54%, and falls on the same level averaged 46% of all the falls. This response was surprising since workers in the roofing industry commonly work at elevated heights above ground level. A closer study of the survey results revealed, however, that the majority (80%) of all the companies that allotted a higher percentage to falls from the same level, worked primarily on low sloped roofs. This information suggests a possible link between working on steep-sloped roofs and fall injuries. Percentages were also recorded for the events leading to the falls. These events included tripping, slipping, being struck by an object, and obstruction of view. Participants were also given the opportunity to provide additional events and then allot a percentage to that event. Alternative events that were specified included lifting/moving, stepping off roof and improper set up of equipment. Averages derived from the respondents (24 companies) showed that slipping was the most leading event to falls (59%). Tripping averaged 25%, being struck by objects (5%), and obstruction of view (2%) (see Fig. 4).

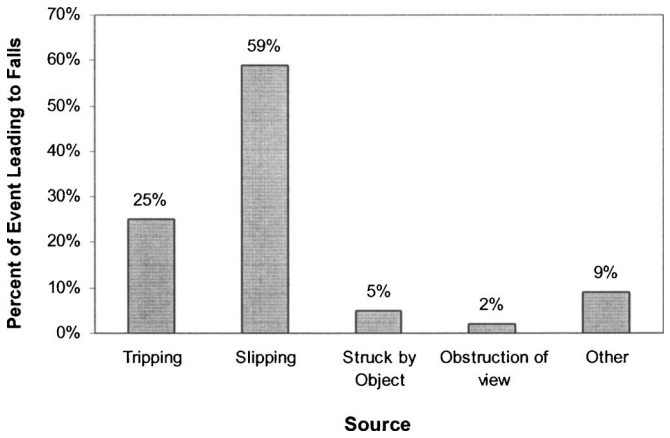

Fig. 4. Percentage of fall injuries by sources leading to falls—survey results

Walking/Working Surfaces

This section of the survey was designed to examine various characteristics of the walking/working surface that a roofer will commonly walk/work on. Factors included information about the type and condition of the surface. Questions also focused on height and pitch information.

The participants were asked to assign veritable percentages to different types of surfaces and instrumentation that a roofer will commonly walk/work on in order to assess time distribution on the different types of surfaces and tasks. These surfaces included roof, ladder, scaffold, and ground. Averages derived from the respondents (24 companies) showed that the majority of time is spent on roofs (61%). Twenty-one percent of the time is spent working at ground level. Ten percent of the time is allotted for work performed on ladders and 8% of the time is allotted for work performed on scaffolds (see Fig. 5). Participants were also asked to list various surface conditions on which workers are susceptible to walking/working. Responses included asphalt shingles, oriented strand board (OSB) decking, asphalt aggregate and ceramic granules, rigid insulation, and nailed surfaces.

The participants were also asked to record common heights at which workers operate. Forty-four percent of respondents (10 of 23) work on heights from 3.05 m (10 ft) to 3.66 m (12 ft). Twenty-two percent of the companies recorded working on heights from 6.40 m (21 ft) to 9.14 m (30 ft) and one company worked on heights of more than 9.14 m (30 ft). Six percent of the companies recorded working on heights of less than 3.05 m (10 ft).

Since roofers usually walk/work on inclined surfaces, the participating companies were asked to list the most common pitch on which they perform their various tasks. They were also asked to give percentages of time spent on different ranges of pitch (rise over run). These ranges included pitches less than 5.08 cm per 30.48 cm (10°), from 5.08 cm per 30.48 cm (10°) to 15.24 cm per 30.48 cm (26°), from 15.24 cm per 30.48 cm (26°) to 30.48 cm per 30.48 cm (45°), and pitches greater than 30.48 cm per 30.48 cm (45°). In recording common pitches, 38% recorded pitches were in the range of 5.08 cm per 30.48 cm (10°) to 15.24 cm per 30.48 cm (26°). Twenty-two percent of the companies recorded

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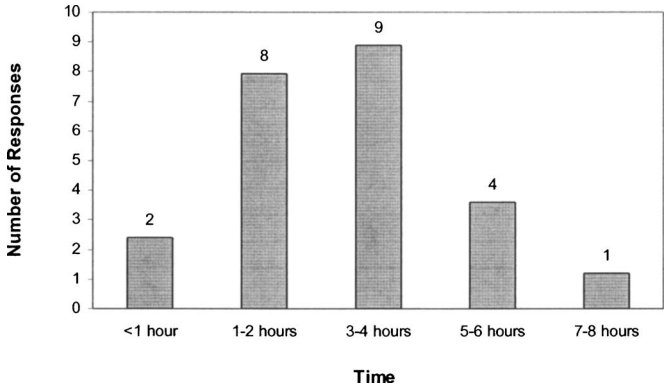

Fig. 6. Time spent on manual lifting/carrying—survey results

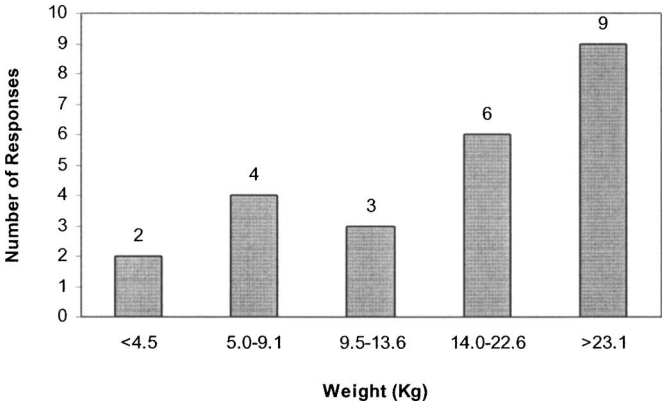

Fig. 8. Weight of load lifted/carried—survey results

that they commonly work on pitches less than 5.08 cm per 30.48 cm (10°), and 11% recorded pitches ranging from 15.24 cm per 30.48 cm (26°) to 30.48 cm per 30.48 cm (45°).

Lifting and Carrying Methods

This section concerning lifting/carrying was important to the study in determining information about common loads carried and load handling techniques when working on roofs. Relevant issues included time spent on lifting/carrying per day, number of repetitions performed per day, distances traveled while handling loads, weight of the loads carried, and method of carrying the common loads.

Responses from the survey determined that the most favorable accumulated time designated to manual lifting/carrying per day was within the range of 3–4 h. Thirty-seven percent of the respondents (9 of 24) chose this range as the most common (see Fig. 6). Other choices and response rates included 1–2 h (33%), 5–6 h (15%), 7–8 h (5%), and less than 1 h (10%), respectively.

Fifty-two percent of the respondents (11 of 21) selected a range of 3.35 m (11 ft)–9.14 m (30 ft) as the most common distance traveled for a manual carry (see Fig. 7). Other choices and responses included a range of 9.45 m (31 ft)–15.24 m (50 ft) (19%), less than 3.05 m (10 ft) (19%), and more than 15.54 m (51 ft) (10%), respectively.

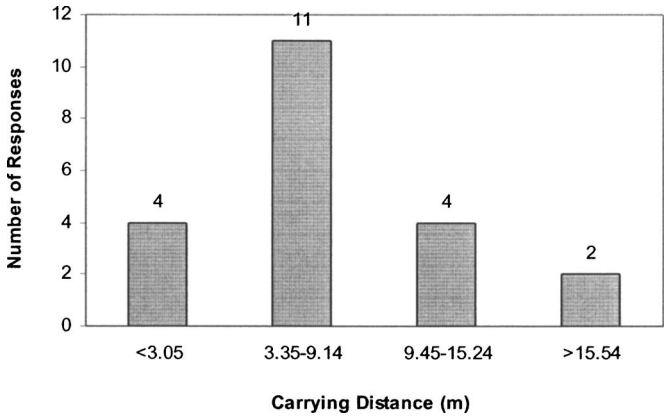

Fig. 7. Distance traveled for manual carry—survey results

The approximate weight of the most common types of load was designated to weigh more than 23.1 kg (51 lb) (see Fig. 8). Thirty-eight percent of the respondents (9 of 24) agreed on that choice. Other choices and response rates included 14.0 kg (31 lb)–22.6 kg (50 lb) (25%), 5.0 kg (11 lb)–9.1 kg (20 lb) (17%), 9.5 kg (21 lb)–13.6 kg (30 lb) (12%), and less than 4.5 kg (10 lb) (8%), respectively.

On-Site Interviews

Six different roofing sites were visited. Residential building projects, as well as roof repair jobs, were observed. A total of 20 roofers participated in the onsite interviews. The roofers were mostly asked questions pertaining to specific manual material handling methods and procedures. The projects varied in size and in detail. Pitches (vertical to horizontal slopes) of the observed roof projects ranged from 10.16 cm per 30.48 cm (18°) to 20.32 cm per 30.48 cm (34°).

Methods for lifting and carrying remained consistent from one work site to the next. When the worker was carrying a load down an inclined roof, the most common observed carrying method was two hands at the waist level. When the worker was carrying up the roof, the common observed carrying method was one or two hands above shoulder level. Because of the heavy weight of the materials (e.g., bundles of shingles) being handled workers tended to lean forward when they walked up an inclined roof and to lean back when carrying objects down the sloped roof. This manual material-handling task has a high potential risk of back injury. For example, the weight (i.e., 33 kg) of a bundle of shingles is significantly greater than the maximum recommended weight (i.e., 23 kg) for lifting at the standard lifting under optimal conditions in NIOSH 1991 lifting guideline (Waters et al. 1993). While carrying loads up or down the inclined surfaces, workers never walked straight up the slope, but rather walked in a diagonal path. The exception was in cases when the worker was walking in a valley or on top of a ridge. Roofers explained that walking diagonally, rather than straight up or down an incline, made it easier for them to perform their tasks.

During the hot summer months, roofers said that they usually had to start before the sun rises so that certain tasks (e.g., felting

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and shingling) were not done during the middle of the day. Roofers also stated that extra heat of 10°C is typically generated while working on the roof with black asphalt shingles and felt when the sun is out. The elevated temperature will cause the body to work hard to cool the internal organs. This additional workload will further decease the lifting capacity. In order to compensate for the lost time in the afternoon, roofers worked in the evenings and early mornings. In some cities, there are ordinances that do not allow construction work to begin before 7 a.m. In these cases, workers get as much done without the use of loud machinery, such as measuring, site cleanup, and making preparations for the following workday.

Additionally, the interviewees were asked questions pertaining to specific foot injuries and the occurrence of foot pain. Although the paper survey with office manager and vice-president were not very useful in gathering information on foot injuries/pain, the job-site interviews with roofers proved very helpful. According to the roofers, the greater the slope, the more ankle and foot pain they felt. When asked if these aches and pains were worse at the beginning of their careers or currently, they stated that it was worse when they started. They also mentioned that over time they had learned how to shift their body weight from one side to the other to give each side a rest while they were up on the roof. The roofers said that the best way to relieve the pain was to rest and ice the sore area when they got off work. They also mentioned that another way of relieving the pain was through drinking alcohol.

Concluding Remarks

The BLS data are useful in identifying general areas that warrant further investigation. The current data from the BLS indicated that the roofing industry is the most problematic because of the occurrence of an extensive number of injuries/illnesses and fatalities in recent years as well as the injury rate at which those injuries/illnesses and fatalities occur. The majority of these injuries are due to falls and overexertion and a considerable amount are due to workers being struck by objects. Strains and sprains are the most prevalent types of injury resulting in the back being the part of the body mainly affected. The walking/working surface along with parts and materials have been identified as the major source of the injuries.

The survey discussed in this paper identified specific tasks that may be associated with an elevated risk of specific types of occupational injuries, illnesses, and fatalities. For instance, tasks such as slippery and inclined surfaces, and the manual handling of heavy and bulky materials have been associated with back injuries. Falls from elevations as well as on the same level typically occurred when carrying heavy and bulky materials on slippery and inclined walking/working surfaces. Additionally, the survey identified hand/finger injuries as a frequent occurrence in the roofing contracting sector, which is consistent with the BLS data. However, the survey results indicated that hand/finger injuries in the roofing contracting sector ranked first among body part injuries as opposed to the sixth place ranking suggested by the BLS data. Furthermore, cuts and puncture injuries ranked first among the nature of injuries as opposed to the third place ranking suggested by the BLS data. These findings need to be studied in further detail before it can be concluded that hand/finger injuries may be a more frequent occurrence in Michigan than other parts of the country.

The findings from this study may provide valuable background information for a further scientific investigation (e.g., laboratory simulation/experiments) that should be made in order to better understating roof-work-related risk of falls. For example, research can be performed to assess the relationships between certain individual characteristics (e.g., ethnics, age, smoking, alcohol consumption, inactivity, and sleep disorders) and occupational accidents due to falls from roofs (e.g., steep roofs). Additional research can be performed to address the possible effects on loss of balance of other environmental factors commonly encountered in roof construction (e.g., slope, elevation, temperature, humidity, and wind).

Finally, construction-roofing companies need to pay particular attention to the tasks identified in this paper to reduce the risk of injury and illness to their workers. Failure to do so may result in higher worker turnover, higher lost work time, lower worker morale, increased workers' compensation claims, and decreased profitability. Safe work practices associated with these tasks need to be established and documented so the construction industry can benefit as a whole.

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Appendix. Survey Instrument

Background

- What are the primary types of work that your company does?
- If you were to experience lost time due to injury, to what Standard Industrial Classification (SIC) would you report?
- How many employees do you employ? Gender: Male _____% Female _____%
- What kinds of safety programs do you maintain?
- Who oversees the safety program? Occupational Nurse Physician Other:
- How many steps (rank) away from the president/ CEO is the overseer?

Injuries and Illnesses

- Estimate how many non-fatal injuries your company had last year? How many did you report?
- What are the most common types of injury or illness in your line of work?
- How do these injuries or illnesses typically happen?
- Please rank these parts of the body as to the frequency at which injuries and illnesses occur to them:

  (1-most frequent, 7-least frequent) ____Knee Injuries ____Finger/Hand ____Back ____Shoulder
  ____Eye ____Foot/Ankle ____Head/Neck
- What are the most common types of falls that result in injury? Same level _____% Fall to lower level _____%
- When falls occur, what percent of time is covered by: Tripping ____% Slipping _____% Struck by an object ____% Obstruction of View _____% Other (Please list): _____%
- Briefly describe the **most** common instance that has resulted in an employee falling and injuring him/herself. _____

Work Surface/Condition

- What types of surface conditions (in % of time) are the workers commonly walking on? Roof _____ % Ladder _____% Scaffold _____% Ground _____% Other (Please list): _____%
- When working in *elevation*, what is the most common height in feet? The most common pitch?
- What percent of work time is spent on the following ranges of pitch? < 10°_____% 10° to 26° _____% 26° to 45°_____% > 45°_____%

Lifting/Carrying

Circle the one appropriate value in each row for your company.

Accumulated time for manual lifting/carrying during a day per employee	< 1 hr	1-2 hrs	3-4 hrs	5-6 hrs	7-8 hrs
Total distance traveled for each manual carry	< 10 ft	11-30 ft	31-50 ft	51-70 ft	> 70 ft
Approximate weight of the load the individual lifts/carries manually	< 10 lbs	11-20 lbs	21-30 lbs	31-50 lbs	> 51 lbs

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