



Fatal Work-Related Falls from Roofs

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Each year over 500 U.S. workers are killed in falls and approximately 20% of these falls are from roofs. This study examines death certificate data from the National Institute for Occupational Safety and Health National Traumatic Occupational Fatalities database and found 288 fatal falls from roofs in 1984-86, 138 (48%) of which were matched with reports of Occupational Safety and Health Administration investigations. Workers in the construction industry suffered 232 of the 288 fatal falls (80%). Workers in roofing trades (SIC 1761, 104 deaths) and structural steel erection (SIC 1791, 27 deaths) had the greatest frequency of injury. Poorly marked or unguarded roof openings were associated with 42 deaths. There were 24 fatal falls through skylights, and 27 fatal falls through other roof structures or materials unable to support a worker's weight. Of the 24 fatal falls through skylights, sufficient details were available to determine that 12 of the 24 involved falls through plastic or fiberglass skylights. Standards for strength requirements for skylights are advisable. Data sources used for this study lacked details concerning use of personal protective equipment such as safety belts and lanyards. However, the study provides general information on falls from roofs that may be useful in planning preventive measures.

INTRODUCTION

Falls are the fourth leading cause of death in the workplace in the United States, after motor-vehicle crashes, machinery incidents, and homicides (Baker, O'Neill, Ginsburg, &

Li, 1992). In England, falls account for one half of fatal work accidents (Liv, 1981) and 11% of all work-related deaths are in roofers (Health and Safety Executive, 1984). In the U.S. construction industry, falls are the leading cause of work-related death (Bell & Stout, 1990). Roofers have been identified as having increased injury rates compared to the rest of the construction industry (Parsons, Pizatella, & Collins, 1986; Personick, 1990). Falls are responsible for 9% of workers compensation claims in roofers, and loose materials on roofs such as shingles or plywood were reported to be particularly hazardous in regard to potential falls (Parsons et al., 1986).

A study of 55 fatal falls from roofs investigated by the Occupational Safety and Health Administration (OSHA) reported that 27 falls (49%) were from the roof edge or the edge of

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roofing materials being worked on, 17 (31%) were through nonsupportive materials such as tarpaper or insulation, 9 (16%) were through roof openings, and 2 (4%) were from other situations (Cloe, 1979). Environmental conditions such as high wind or rain causing the worker to slip and fall were involved in 6 (11%) of the 55 cases.

There is no epidemiologic information in the literature listing rates of fatal work-related falls from various sites. The present study was done to examine the extent of fatal falls from roofs, the factors involved in the falls, and to identify hazardous conditions that might be the focus for prevention efforts.

METHODS

Death certificate information concerning workers who died in fatal falls was obtained by searching the National Institute for Occupational Safety and Health (NIOSH) National Traumatic Occupational Fatalities (NTOF) database. The database has been described before (Bell et al., 1990) and consists of all U.S. death certificates in 1980 and after, in which the "Injury at Work" box was marked "Yes," in which the external cause of death was an injury according to the International Classification of Diseases, Ninth Revision (ICD-9) E800-E999 (World Health Organization, 1977), and the victim was 16 years of age or older. NTOF data files contain the written description of cause and manner of death as recorded by the certifier on the death certificate. NTOF files for 1984-86 were searched for deaths from falls as defined by an underlying cause of death ICD-9 E880-E886 or E888. A computer search was done of the death certificate injury description for all deaths from falls mentioning "roof," "skylight," "parapet," "deck," "rooftop," "cover," "dome," "plastic," and "insulation." These records were then manually reviewed to select those whose description identified the fatal fall as having been from a roof.

A computer printout of all 4,756 OSHA fatality investigations in 47 U.S. states for 1984-1986 was obtained from OSHA Management Data Systems; this list was fur-

ther compiled and reviewed (Suruda & Agnew, 1989). California, Michigan, and Washington state investigation data were not included in the Federal OSHA database due to format incompatibility. All OSHA fatality investigations of falls mentioning roofs were matched to the NTOF records identified above by location, date of death, worker age, and site of fall.

Bureau of the Census' County Business Patterns (CBP; Department of Commerce, 1984-1986) was used as the denominator for calculating rates based on the Standard Industrial Classification (SIC; Office of Management and Budget, 1987) of the establishment employing the victim. CBP employment data exclude several worker populations (e.g., government workers, self-employed workers, and administrative workers) that are included in death certificate data. Selection of any other employment data source would have resulted in similar differences between worker populations covered by employment and fatality counts. CBP was chosen for calculating rates because it provides a national estimate of employment for detailed industries and because of its use in prior publications based on NTOF data (Bell et al., 1990; Jenkins, Layne, & Kisner, 1992). Since NTOF includes worker groups that are excluded by CBP, slightly different rates would result if more complete employment data by SIC were available.

Falls from roofs were categorized with respect to the location of the fall as either perimeter falls or falls through the roof. The latter category was further subdivided into falls through skylights, falls through roof openings, and falls through fragile materials such as insulation. Falls through skylight openings or other roof openings were counted as falls through a roof. Only falls through skylights in place (glass, fiberglass, or plastic) were counted as falls through skylights.

RESULTS

There were 1,695 fatal work-related falls in the 3 year period and 288 of these (17%) were from roofs (Table 1). There were no multiple-victim incidents involving falls from roofs. Only 1 of the 288 victims was a female. The

TABLE 1
FATAL WORK-RELATED FALLS AND FALLS FROM ROOFS IN THE UNITED STATES 1984-1986
IDENTIFIED FROM DEATH CERTIFICATES AND FROM OCCUPATIONAL SAFETY AND HEALTH
ADMINISTRATION INVESTIGATIONS

	1984	1985	1986	Total
All Falls	566	626	503	1,695
Falls from roofs	97	106	85	288

average victim's age was 38.7 years, with a range of 17 to 82.

Construction workers sustained 232 (80%) of the 288 fatal roof falls (Table 2). SIC 17, special trade contractors, accounted for the largest number of construction deaths, 172. Within SIC 17, roofing and structural steel erection had the highest fatality rates (Table 3).

OSHA investigation reports were matched with 138 (48%) of the 288 death certificates. Thirty-nine death certificates were from the three states for which we had no OSHA data (CA, MI & WA). OSHA investigated a greater proportion of the deaths in the construction industry (83%) than in other industries (78%). OSHA investigations provided more details concerning the incident (e.g., location victim fell from, and size of victim's employer) than did death certificates.

The location of the fatal roof falls is shown in Table 4. Of the 288 fatal falls, 70 (24%) were from the roof perimeter or edge of the roof work area and 93 (32%) were through a roof structure, and in 125 deaths (43%) there was insufficient information to determine the roof area of the fatal fall. For those cases in which both OSHA and death certificate information were available (138 deaths, Figure 1), falls from the roof perimeter (65, 47%) and through the roof structure (64, 46%) each accounted for almost half of the deaths.

The height of the fatal fall was known for 148 (51%) of 288 cases (51%) and is shown in Figure 2. The mean height of the fatal falls was 34.75 ± 23.9 feet, with a range of 9 to 175 feet.

Falls From the Roof Perimeter

The level of detail in the reports varied considerably and did not provide much information on falls from the roof perimeter other than to attest to the lack of perimeter protection, such as a toe board, rail, or a net. Eleven reports mentioned that a roof hoist was involved in the fatality. In one death, the worker fell while reaching for materials on a hoist. In 10 other cases a hoist came loose, catapulting the worker from the roof edge or pulling him off as he attempted to hold back the falling hoist. Ten deaths involved loose materials on pitched roofs in which the worker stepped on the material and slid off the roof edge skateboard-style, and there were two reports in which the worker slipped on hot tar.

Falls Through the Roof Structure

Unguarded roof openings were involved in 42 of the 93 deaths in which the worker fell through the roof. In 27 of the 93 cases, a worker fell through the roof structure. Rotten roofs,

TABLE 2
FATAL FALLS FROM ROOFS BY INDUSTRY IN TH U.S., 1984-1986. IDENTIFIED FROM DEATH CERTIFICATES
AND FROM OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION INVESTIGATIONS

Industry	Number of Falls
Agricultural	5
Construction	232
Manufacturing	14
Transportation and Utilities	3
Trade	4
Services	25
Other Industries	5
Total	288

TABLE 3
RISK OF FATAL FALLS FROM ROOFS IN THE U.S. CONSTRUCTION INDUSTRY 1984-1986. IDENTIFIED
FROM DEATH CERTIFICATES AND FROM OSHA INVESTIGATIONS

Construction trade	Employment* (1984-1986) average	Fatal falls from roofs (3 years)	Average annual rate per 100,000 workers
SIC 15 (Building Construction)	1,093,891	57	1.74
SIC 16 (Heavy Construction)	598,219	3	0.17
SIC 17 (Special Trade Contractors)	2,561,369	172	2.24
All Construction	4,436,655	232	1.74
SIC 1761 (Roofing)	192,574	104	18.00
SIC 1791 (Structural steel Erection)	57,336	27	15.69

County Business Patterns, private sector employment only. This excludes self-employed, government, agricultural production, and managerial workers who are included in the fatality count

roofs made of thin materials such as 5/16" asbestos cement panels, or partly completed roofs with areas of exposed insulation or other material not capable of supporting a worker's weight, were involved in these deaths.

There were 24 fatal falls through skylights. Sufficient information was available to determine that 12 of these were plastic or fiberglass skylights. Thicknesses of skylight materials were reported in only two cases; one was 0.063" plexiglass, the other 0.125" plastic. In two separate incidents, a worker sat on a plastic skylight during a break period and the skylight collapsed. One of the fiberglass skylights mentioned in a report was on a corrugated metal roof and had been painted over with the same color paint as the roof. The skylight was unmarked and unguard-

ed so that it was difficult for the worker to detect the skylight.

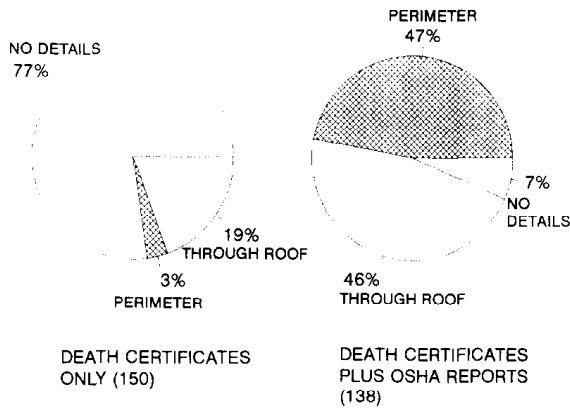
Other Factors

Information on the availability and use of personal protective equipment was available for only a few cases. One report, concerning a worker who slid off a pitched roof while applying tar, stated that the worker had worn cowboy boots that had leather soles. No other report mentioned footwear. There was only one report that specifically mentioned that a worker was wearing a safety belt at the time of the fatal fall and further, that the lanyard had not been attached to a tie point. There was failure of support platforms in two separate cases in which toe boards cracked, allowing a roofer

TABLE 4
LOCATION OF FATAL WORK-RELATED FALLS FROM ROOFS, 1984-1986
IDENTIFIED FROM DEATH CERTIFICATES AND FROM OSHA INVESTIGATIONS

Location of falls		
Roof perimeter, edge, or parapet		70 (24%)
Through the roof structure or openings		93 (32%)
Roof openings)	42	
Roof Structure	27	
Skylights	24	
No details on roof area of fall		125 (43%)
Total		288 (100%)

FIGURE 1
SITE OF FATAL FALLS FROM ROOFS, BASED ON
INFORMATION AVAILABLE



was laid out on a roof, collapsed while a worker was standing on it, causing a fatal fall. No reports mentioned the use of nets.

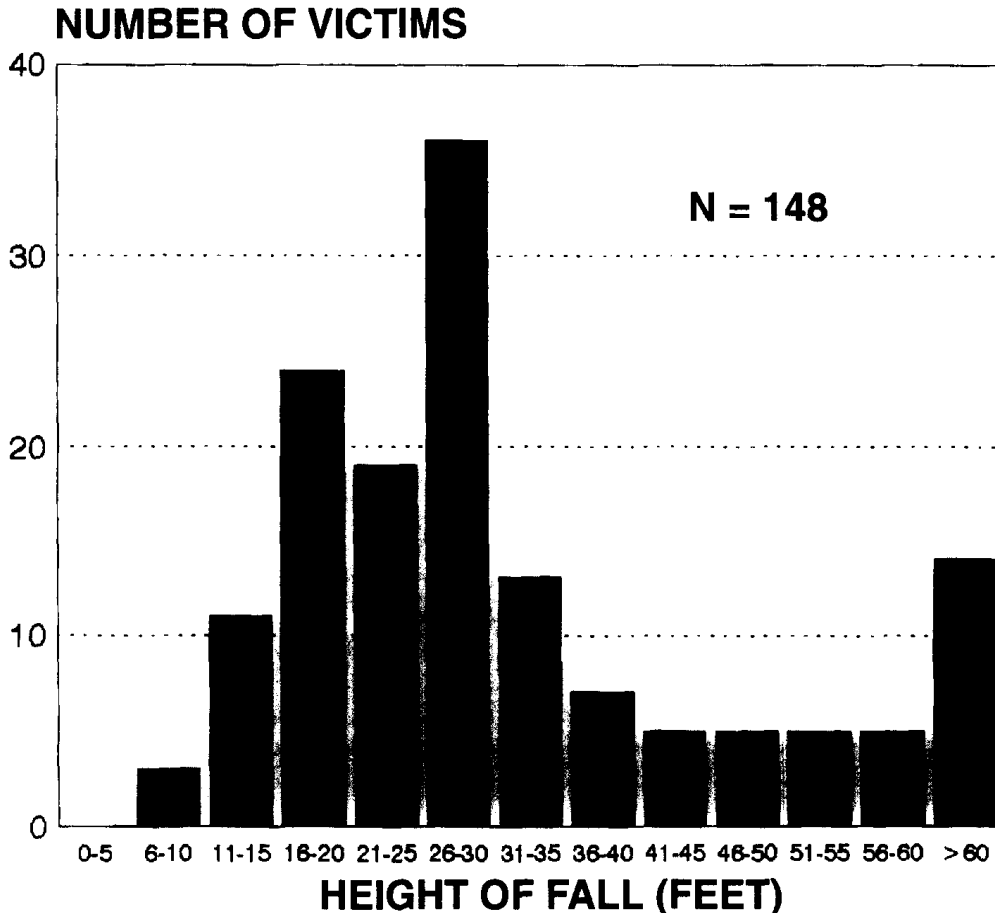
Additional information was available from the 138 OSHA reports, including: citations for safety violations were issued in 112 of 138 deaths (81%); small business establishments with fewer than 11 employees accounted for 35 (27%) of the 138 deaths; a collective bargaining agreement with a union was in force in 45 (33%) of the 138 deaths investigated by OSHA.

DISCUSSION

Falls from roofs are an important cause of fatal work injury, with 288 deaths identified in 1984-86 from death certificates in NTOF. The actual number is probably greater, since death certificate data identify only 85% of fatal work

to fall from the roof. In a third case, a job-built ladder (also known as a chicken ladder), which

FIGURE 2
HEIGHT OF FATAL FALL FROM ROOFS, FOR CASES WHERE HEIGHT WAS KNOWN



injuries (Stout & Bell, 1991). In addition, some of the death certificates in the NTOF database lacked sufficient details to determine the location of a fatal fall, and deaths from California, Michigan, and Washington state were missing from the OSHA database and these could not be matched to death certificates in NTOF. For these reasons the 288 cases probably represent a minimum number of fatal roof falls in 1984–86.

Of the 288 deaths, most involved construction activities. Within the construction industry, 74% of fatal falls from roofs occurred in the special trades sector (SIC 17). Fatality rates were highest in roofing (SIC 176) and steel erecting (SIC 179) (Table 3). There were a few deaths in service industries such as building cleaning and maintenance services (SIC 7349).

Approximately one-third of the deaths for which the height of fall was known were from heights of 30 feet or less, suggesting that roof work on relatively low buildings (3 stories or less) requires adequate fall protection. OSHA has a standard that pertains specifically to fall protection for work on low-pitched roofs exceeding 16 feet in height (29 CFR 1926.500 g). Fourteen victims died from falls of less than 16 feet (see Figure 2), suggesting a need for adequate fall protection at elevations of less than 16 feet. For these fourteen victims, adequate fall protection below 16 feet was lacking. Safety practices for work on roofs in the UK are covered in detail by the Health and Safety Executive (1979). In the U.S., OSHA has several specific regulations regarding roof perimeters, skylights, and roof openings:

1. Railings or screens guarding all skylights and other openings in roofs must be installed before roofing work begins and must remain in place until construction is complete, in accordance with 29 CFR 1910.23 and 1926.500.
2. Wearing of appropriate personal protective equipment is the responsibility of the employer (29 CFR 1926.28).
3. Conventional protective devices such as guardrails or safety belts/harnesses with lanyards (29 CFR 1926.104) may not always be practical. When this is the case, employers must provide alternative forms of protection against falls, such as fixed covers, catch

platforms, or safety nets as described in 29 CFR 1926.105. Nets are especially useful because they provide passive protection for workers—that is, the protection does not depend on workers recognition and response to the hazard. In construction operations, netting can be installed when the roof openings are made and left in place until all construction activities are complete, or until more permanent guards are installed.

4. Unprotected sides and edges of roofs can be protected by the use of a motion-stopping-safety system, warning line system, or a safety monitoring system as described in 29 CFR 1926.500. Also, training shall be provided to all employees engaged in roofing work so that they are able to recognize and deal with the hazards of falling associated with working near a roof perimeter. The employees shall also be trained in the safety procedures to be followed in order to prevent such falls, in accordance with 29 CFR 1926.500(g).

Providing fall protection on pitched roofs is made easier by the use of an anchor or tie point. Building codes do not require this, but their use has been suggested (Deroide & Archer, 1983). Anchoring devices spaced along a pitched roof allow for secure mounting of toe boards and scaffolds and also provide attachment points for PPE such as safety belts and lanyards.

The role of environmental factors such as wind, rain, and slippery surfaces underfoot was largely undetermined, given the limited information available. The role of human factors and work experience also could not be assessed because few factors related to the fatal fall were mentioned on death certificates and OSHA reports. Prather, Crisera, and Fidell (1975) reported that apprentice roofers have twice the injury rates of experienced roofers. The length of time on the job of the workers fatally injured in the present study is unknown. Attitudes of supervisors concerning safe work practices may play an important role. A survey of high- and low-accident roofing companies in California reported that most roofers saw the foreman as the key person responsible for job safety. However, the workers believed there was a conflict between productivity and safety, that is, safe work habits resulted in a slower work pace (Prather et al., 1975).

Fragile Roof Areas and Skylights

Roof openings, skylights, and rotten roofs were involved in a substantial number of deaths, 93 (Table 4). Fragile roof materials such as 5/16" asbestos cement roofing, uncovered insulation, or loose plywood sheeting covering roof openings are an important hazard on roofs. In England, falls through fragile roof materials exceeded those from roof edges as a cause of injury, though the number of fatal injuries was not reported (Health & Safety Executive, 1979).

Skylights were involved in 24 deaths, and 12 of these were known to be plastic or fiberglass. The National Institute for Occupational Safety and Health (NIOSH), in response to investigations of eight fatal falls through skylights, issued an alert recommending the installation of railings or screens on skylights and skylight openings (NIOSH, 1990). There are no strength requirements for plastic or fiberglass skylights related to the ability of the skylight to support a worker who might sit, stand, or fall on the skylight. Standards for strength requirements may be warranted to protect roofing and maintenance workers in the vicinity of the skylight. Skylights could be strengthened by increasing the thickness, changing the material composition, or by incorporating metal mesh into the skylight structure.

Manufacturers or purchasers of skylights should affix decals to each skylight, warning individuals against sitting or stepping on these units. Manufacturers should also consider modifying the design of skylights to strengthen them sufficiently to support the weight of a worker who steps, sits, or falls on one. If such changes would adversely affect the smoke-venting capacity of the skylight, a dome-shaped protective grillwork over the skylight should be considered (NIOSH, 1990).

SUMMARY

This study combined two data sources to furnish a descriptive analysis of fatal falls from roofs. We found 96 deaths per year for 1984-1986. When details were known, approximately one half of fatal falls were through the roof structure or into a roof open-

ing, and the remainder were from the roof perimeter. Although this analysis lacks detail for key factors such as the availability of PPE by workers on roofs, it provides epidemiologic information concerning the number of fatal injuries, the roof area where fatal falls occurred, and some limited information on the circumstance of injury. We hope that the information in this study will be of use to those responsible for worker safety on roofs.

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