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FALL-FROM-VEHICLE INJURIES IN THE CONSTRUCTION INDUSTRY

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Data analyzed by the National Institute for Occupational Safety and Health, Division of Safety Research show that falls from vehicles accounted for more than 35% of the fall-related injuries in the heavy construction industry during the period 1980 through 1987. Improvements in access systems on many trucks and other heavy equipment used in construction could help to reduce these injuries.

INTRODUCTION

Construction workers are exposed to a variety of hazardous conditions. Overall injury incidence rates per 100 full-time workers (FTW) indicate that in 1987 the national average for the private sector was 8.0. For the construction industry, the incidence rate was 14.5 (BLS, 1989), more than 1.8 times the national average. In addition, the national average for lost workday rate (a measure of injury severity) for the private sector was 67.3 days per 100 FTW. For construction, the lost workday rate was 134.9 days (BLS, 1989), slightly more than twice the national average.

The construction industry is separated into three main sectors. These have been assigned a Standard Industrial Classification (SIC) code depending on the major types of construction activities normally conducted by the employer. The three sectors are:

<u>SIC 1500</u>: Residential (single-family houses, apartment buildings, hotels, motels, etc.) and non-residential (commercial, industrial, recreational, etc.) building contractors,

<u>SIC 1600</u>: Heavy construction contractors (highways, streets, bridges, tunnels, sewers, water lines, power lines, etc.), and

<u>SIC 1700</u>: Special trade contractors (plumbing, heating, painting, papering, electrical, carpentry, etc.).

A complete description of these SIC codes is provided in the Standard Industrial Classification Manual (Office of Management and Budget, 1972).

In an effort to direct resources toward the types of cases where the greatest benefits could be derived, the National Institute for Occupational Safety and Health (NIOSH) has assessed injury and fatality data and identified the prevention of falls to be a major priority. NIOSH has conducted and sponsored a number of investigations to develop a better understanding of falls from elevations in the construction industry. These have included point-of-erection activities (Western Institute for Safety and Health, 1981), the roofing industry (Parsons et al., 1986), subjective judgement of slipperiness of painted structural steel (University of Oklahoma, 1988), investigations conducted by NIOSH, Division of Safety Research on occupational fatalities caused by falls from elevations as part of the Fatal Accident Circumstances and Epidemiology (FACE) project, and activities related to fatal falls from scaffolds (Bobick et al., 1990).

A review of the relevant literature (Long, 1983; Hurst and Khalil, 1984; Stanevich, 1986) suggested that a problem of falls from vehicles was related to the access systems of heavy equipment used in SIC 1600 activities. Vehicle access systems provide operators a means of entering and exiting the cab, or other workers a means of performing maintenance activities. Because of the intended purpose, these workers are exposed to a fall-from-elevation hazard when using the access system.

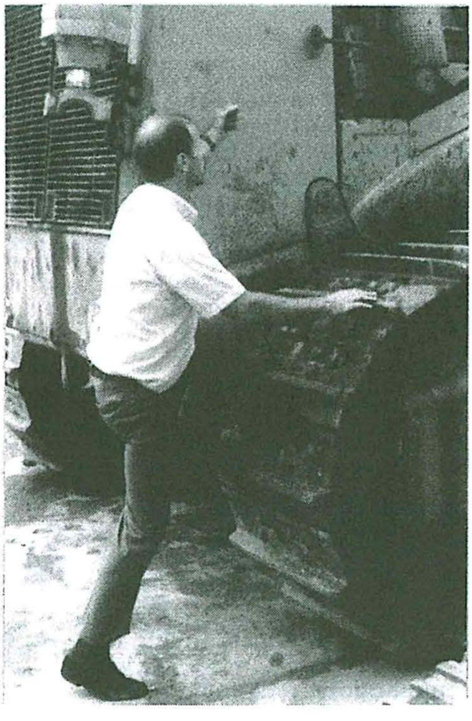

Figure 1. Typical posture needed to ascend large dozer.

Criteria for designing access systems for earth-moving machinery are contained in International Standard ISO 2867-1976 and in recommendations in the Society of Automotive Engineers document J185. The ISO Standard (ISO, 1976) recommends that the maximum height of the first step should not exceed 700 mm (27.56 in) and the preferred height of the first step should be 400 mm (15.75 in). Visits by NIOSH researchers to highway construction sites have found many vehicles with the first step ranging from 800 mm (31.5 in) to 914 mm (36.0 in). Figure 1 shows a typical posture required to climb onto a larger dozer. Several researchers have indicated first-step heights as extreme as 1,016 mm (40 in) (Long, 1983) to 1,143 mm (45 in) (Hurst and Khalil, 1984).

Injuries resulting from workers falling during ingress and egress activities are frequent and are generally considered to be a normal part of the construction work environment. Injuries that have occurred during mounting and dismounting machinery account for approximately 26% (Stanevich, 1986) to 28% (Construction Safety Association of Ontario, 1982) of the lost-time injuries involving heavy equipment operations.

In addition to excessive height of the first step, other recognized problems (Hurst and Khalil, 1984) that can contribute to worker injuries are: hidden steps that do not permit visual contact by the worker; lack of or mislocation of handrails; unstable handhold (worker uses the door or steering wheel) that can cause a shift in the center of gravity and a corresponding loss of balance; and, poor tread conditions that can reduce the coefficient of friction of the stepping surface, thus increasing the possibility of slipping.

This particular study examines the trends over an 8-year period for injuries related to falls from vehicles in SIC 1600 and compares them with the other two construction sectors.

METHOD

The Supplementary Data System (SDS) is a database maintained by the Bureau of Labor Statistics (BLS, 1982). It consists of workers' compensation records from states that voluntarily participate. Each state codes its cases according to a uniform format. The format was designed and intended to record factual information, not subjective interpretations. The most recent available data are for calendar year 1987.

Year-to-year trends in the fall-from-vehicle injuries were examined by eliminating states that did not participate in all 8 years. During the period 1980 to 1987, there were 19 states that consistently provided records each year. These states were: Alaska, Arizona, California, Colorado, Hawaii, Iowa, Indiana, Kentucky, Maryland, Michigan, Missouri, Mississippi, Nebraska, New Mexico, Ohio, Oregon, Tennessee, Washington, and Wisconsin.

The records for the states reporting claims were searched for each of the years 1980 through 1987. The initial search strategy was to select all cases in the construction industry (i.e., SIC codes 1500, 1600, and 1700) for each year. Cases selected were from "current case" files, which means the claim was received or coded by the state agency during the year.

Cases in the SDS records have been coded to indicate, among other descriptors, the type of event most directly leading to an injury. The following is a listing of the accident types: struck against, struck by, fall from elevation, fall on same level, caught in/under/between, rubbed or abraded, bodily reaction, overexertion, contact with electrical energy, contact with temperature extremes, contact with radiation/caustics/toxic/noxious substances, motor vehicle accidents, transportation accidents other than motor vehicle, exposure to noise, and explosions.

From the set of construction claim records, those cases coded as falls from elevations were identified. The eight fall-from-elevation sub-categories include: (a) fall from elevation, unspecified, (b) falls from scaffolds, walkways, platforms, etc., (c) falls from ladders, (d) falls from piled materials, (e) falls from vehicles, (f) falls on stairs, (g) falls into shafts, excavations, floor openings, etc., and (h) fall to lower level, not elsewhere classified. Since categories (a) and (h) are both unspecified, they were combined into one generic category and labeled as "falls from one level to another."

RESULTS

The SDS data for the 19 states reporting claims during the period 1980 through 1987 contain 1,266,226 compensation claims filed by U.S. construction workers for all types of work-related injuries and illnesses. A total of 177,785 (14.0%) of these claims were filed by construction workers for injuries caused by falling from elevated work surfaces. The fall-from-elevation injuries were distributed among the following sub-categories: falls from one level to another (32%), falls from ladders (27%), falls from scaffolds (17%), falls from vehicles (12%), falls into shafts (6%), falls on stairs (6%), and falls from piled materials (0.3%).

Table 1 provides fall-from-vehicle injury data for the years 1980 through 1987. The first column lists the total number of fall-from-vehicle injuries that occurred in the entire construction industry. The next three columns provide information for SIC sectors 1500, 1600, and 1700, respectively. The data presented are the total number of fall-from-vehicle injuries reported for that SIC sector in that particular year. The value in parentheses is the percentage that the fall-from-vehicle cases represents of the total number of falls that occurred in that particular SIC sector for that specific year.

The last row of Table 1 provides a total for the 8 years analyzed. The number in parentheses in this last row is the 8-year mean for that SIC sector. As shown, falls from vehicles account for 35.1% of all SIC 1600 fall-related injuries over the period 1980 through 1987. As a comparison, falls from vehicles account for 6.1% and 9.0% of SIC 1500 and SIC 1700 fall-related injuries, respectively.

Even though the total number of falls from vehicles for SIC 1700 was higher than SIC 1600 in six of the eight years analyzed, the percent of falls from vehicles for the heavy construction sector (SIC 1600) far exceeded the corresponding percentages for the specialty trade sector (SIC 1700). The percentages that falls from vehicles represented in heavy construction were three to five times greater than those for the specialty trade construction.

At this point, information on the type and size of the equipment would be very useful. Unfortunately, these data are unavailable through the SDS database. Some limited insight into equipment type can be gained by looking at the occupations involved with fall-from-vehicle injuries. Certain types of equipment operators can be identified. Table 2 supplies a breakdown of these occupations for SIC 1600 during 1987.

Table 1. Falls from vehicles in construction by SIC sector and corresponding percent of total falls for that SIC sector, 1980 through 1987 (19 states reporting data).

Year	Total Vehicle Falls, Constrn	**SIC 1500** Veh Falls & (% of Total Falls occr'g in SIC 1500)	**SIC 1600** Veh Falls & (% of Total) Falls occr'g in SIC 1600)	**SIC 1700** Veh Falls & (% of Total) Falls occr'g in SIC 1700)
1980	3,330	497 (6.6%)	1,451(35.1%)	1,382(10.6%)
1981	2,380	339 (5.8%)	985 (30.3%)	1,056 (9.7%)
1982	2,290	323 (6.3%)	1,009(33.0%)	958 (9.2%)
1983	2,538	378 (6.4%)	1,049(34.3%)	1,111 (9.5%)
1984	2,923	432 (6.1%)	1,168(38.5%)	1,323 (9.2%)
1985	2,687	383 (5.8%)	1,025(36.4%)	1,279 (8.9%)
1986	2,526	373 (5.5%)	970 (36.2%)	1,183 (7.7%)
1987	2,139	338 (6.1%)	840 (38.3%)	961 (7.6%)
Total and (Avg)	20,813	3,063 (6.1%)	8,497(35.1%)	9,253 (9.0%)

By analyzing the occupations employed in SIC 1600 who were involved in a fall-from-vehicle incident, we can estimate that 23% of the injuries involved heavy trucks, and at least 6% of the injuries involved graders, bulldozers, or scrapers. In addition, a total of 10.6% are involved in operating other types of equipment (miscellaneous material mover, excavating machinery, and other heavy equipment). The SDS records do not provide any additional information (e.g., size, year, model, etc.) about the vehicles.

Another important aspect, which cannot be addressed through the SDS database, is the activity of the worker prior to the injury-producing event. Even though a worker may have been involved in a fall from a vehicle, there is no definite indication that the worker's activity involved the use of the access system. The worker may have been positioned on the machine doing maintenance or filling fluids or even handling supplies. Additional detailed information is sorely needed to provide sufficient insight into the factors associated with fall-from-vehicle injuries.

A total of 51 separate occupation categories were involved in the 840 fall-from-vehicle incidents occurring in 1987. Despite the wide diversity of occupations, five categories accounted for nearly 70% of the injured workers. The first 13 categories had at least 1% in each entry; these 13 accounted for 88.5% of the total. The remaining 38 occupations accounted for 11.5% of the injured workers.

Table 2. Listing of the leading SIC 1600 occupations involved with a fall-from-vehicle incident during 1987.

	Occupation	Frequency	Percent	Cumulative Percent
1.	Construction Laborer	222	26.4	26.4
2.	Heavy Truck Driver	193	23.0	49.4
3.	Operating Engineer	76	9.0	58.4
4.	Grader, Dozer, Scraper Opr	52	6.2	64.6
5.	Construction Trades	41	4.9	69.5
6.	Misc. Material Mover	32	3.8	73.3
7.	Excavating Machinery Opr	31	3.7	77.0
8.	Heavy Equipment Opr	26	3.1	80.1
9.	Construction Supervisor	22	2.6	82.7
10.	Laborers, not construction	18	2.1	84.8
11.	Welders and Cutters	13	1.5	86.3
12.	Machinery Maintenance	9	1.1	87.4
13.	Carpenters	9	1.1	88.5

DISCUSSION

Infrastructure problems

The interstate highway system has been in use since the 1950s. Because of the aging of the highway infrastructure and the necessity for an efficient roadway network, an increase in activity is anticipated toward rehabilitation and maintenance of these highways during the next decade. Along with this increase in construction activity, an increase in occupational injuries and fatalities can be expected.

Statistics cited in a recent editorial (Wicker, 1990) indicate that the annual national spending to maintain the existing highways and bring them up to minimum standards will have to double from $13 billion to $26 billion. In addition, a total of $50 billion will be needed to repair or replace 240,000 bridges that are considered unsafe (Wicker, 1990). Consequently, the number of workers and pieces of equipment employed in the heavy construction sector (SIC 1600) are likely to increase in response to the demands of these needed repair and rehabilitation activities.

In addition, a major problem in the U.S. that has to be addressed concerns the upgrading of antiquated water supply and sewer systems. Routine sewer overflows are a problem right now for more than 1,100 U.S. cities according to an article in the Engineering News-Record (ENR), a popular construction engineering trade journal. The estimated total costs nationwide will be more than $100 billion during the next decade (ENR, 1990). As of 1989, only 328 of the 1,100 cities had submitted control plans to the Environmental Protection Agency for review and approval (ENR, 1990).

A review of ENR for the period of April 1990 to November 1990 indicates that more than 80 projects are being initiated in the U.S. that relate to SIC 1600 activities, i.e., highways, bridges, pipe lines, power plants, railways, flood control, hazardous waste cleanup, tunnels, and so forth. A conservative estimate from this limited review indicates that more than $120 billion will be spent in the next 10 years for these 80 projects.

Considering the anticipated future activity in this sector of construction, it is expected that occupational injuries and fatalities will continue to occur as a result of this work.

Surveillance limitations

If that hypothesis is accepted, then the capability of analyzing the injury data in a more detailed fashion will be a necessity. The current SDS data does not permit such detailed analyses. An example of a more useful record system is the one maintained by the Mine Safety and Health Administration (MSHA), U.S. Department of Labor. It includes the worker's activity at the time of injury. One of the activities that is specifically recorded is "getting on or off equipment." Similar to SDS, MSHA collects information on the machine involved with the incident, but MSHA data goes beyond SDS by asking for the machine manufacturer and the machine model number. Thus, the size of the equipment and the type or configuration of the access system can be determined.

Similarly, information is unavailable regarding when the injuries are occurring. Are they happening at the first step, or while the operator is climbing upward, or even while the operator moves from the ladder into the cab? Are the injuries occurring more often because the workers are jumping off at the bottom, or because an awkward posture is required due to a partially hidden step at the beginning of the dismount? Answers to these types of questions are needed to determine the factors associated with fall-from-vehicle injuries.

CONCLUSIONS

Workers falling from vehicles is fairly common in the construction industry, accounting for about one out of every eight fall injuries. In heavy construction (SIC 1600), the situation is considerably worse, where more than 35% of the fall injuries are workers falling from vehicles. One aspect of the heavy equipment which may contribute to the workers being injured is the access system. There appears to be a need for improving the access system on construction vehicles to make them more ergonomically functional. This may be accomplished if employers, who have experienced difficulties with access systems, request assistance from vehicle manufacturers and distributors, and from experienced researchers and consultants to help address the problems.

In addition, the SDS database cannot supply sufficient detail to provide enough insight into the fall-from-vehicle incidents that are occurring in the construction industry. An injury surveillance tool is needed that will collect detailed information to help identify problems associated with mounting and dismounting mobile construction equipment.

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