



Fatal Fall Accidents in Small Building Construction Projects

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Abstract

Construction is one of the most dangerous industries in the United States accounting for over 21.7% of the occupational fatalities annually. Falls are the major cause of fatal construction accidents and, according to the Census of Occupational Fatalities and Injuries, majority of the fatal fall accidents happen in projects that are reported to cost under \$50,000. These small construction projects have unique circumstances because of the type of the contractors and short project durations. Comprehensive understanding of the root-causes, circumstances, and environment factors of these accidents is critical in developing preventative measures, standards, and targeted training programs. This paper provides a project level analysis of the fatal fall accidents in small building projects using Occupational Safety and Health Administration's accident reports between 1998 and 2007. The analysis includes categorization of accidents based on project size, type, and accident circumstances for each contractor type. The analysis identifies high risk activities for fall fatalities under different circumstances. This detailed project level information provides a valuable educational tool for construction programs as well as a guide to strategically target high risk areas through prevention, enforcement, and training.

Introduction

Construction is one of the largest and most dangerous industries in the United States. It accounts for over 4.5% of the gross domestic product, 8% of the active workforce, and over 21.7% of the occupational fatalities annually¹. Falls are the major cause of fatal construction accidents and, according to the Census of Occupational Fatalities and Injuries, majority of the fatal fall accidents happen in projects that are reported to cost under \$50,000². These small construction projects (project cost under \$50,000) have unique circumstances because of the type of the contractors and short project durations. These contractors typically have limited resources to complete their work and the opportunities for providing comprehensive training for the workers are very limited.

Historically, Fall, Struck-By, Electrocution, and Caught/In-Between accidents account for approximately 90% of all incidents in the construction industry¹. Fall accidents have the largest number in this list and from 2003-2007 they accounted for an average of 419 deaths per year which translates to 33.6% of all construction fatalities³. Several research efforts confirmed the seriousness of fatal fall accidents and pointed out specific areas to be studied further to devise preventative measures^{1,4,5}. Studies have tried to examine the effectiveness of fall prevention programs and many have concluded that there is little data to support the effectiveness of current programs and a more rigorous evaluation is necessary⁶. While fall prevention has been seen as less effective than fall protection, it is still necessary in many cases.

Recently, project level analysis of these incidents was proposed to offer a better understanding of the circumstances. This approach provides unique opportunities to target high risk areas, especially, for small companies and special trade contractors^{5,7}. Comprehensive understanding

of the root-causes, circumstances, and environment factors of these accidents is critical in developing preventative measures, standards, and targeted training programs.

This paper presents a project level analysis of the fatal fall accidents in small building projects using Occupational Safety and Health Administration’s accident reports between 1998 and 2007. The analysis includes categorization of accidents based on project size, type, and accident circumstances for each contractor type. The analysis identifies high risk activities for fall fatalities under different circumstances. This detailed project level information provides a valuable educational tool for construction programs as well as a guide to strategically target high risk areas through prevention, enforcement, and training.

Data Collection and Processing

This paper uses the OSHA accident investigation reports (based on OSHA-170 Forms) available at their website (www.osha.gov). The database includes accident investigations and fatalities reported to OSHA under every SIC number. The database was searched for “fatality only” incidents for Standard Industry Codes⁸ (SIC) 15, 16, and 17 that reflect building contractors, heavy/civil contractors, and special trade contractors respectively in June 2011. The search is filtered for incidents in a 10-year span from January 1, 1998 to December 31, 2007 resulting in 6379 fatality reports that contain SIC codes in the construction industry. While the reports go back to as early as 1990, between the years 1997 and 1998 the reporting method of fatalities was modified and more data became available after 1998.

As illustrated in Figure 1, the database search results showed that Falls had the highest percentage of fatal causes with 41%, followed by Struck by with 27%, caught-in/between with 10% and electrocution with 10%. This confirms the four major fatality causes identified by OSHA and the large proportion of fall fatalities in construction industry.

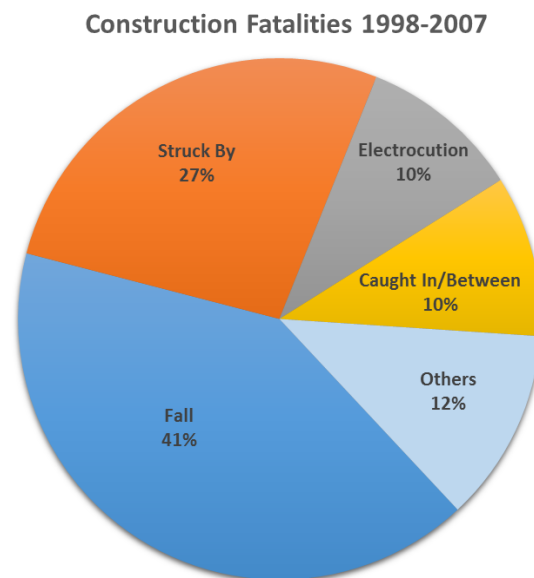


Figure 1. Fatality Cause Distribution of Construction Fatalities (1998-2007)

When the Fall fatalities were categorized by industry subsector, commercial building subsector lead the number of fall fatalities with 47% while residential building subsector (single and multi-unit) had the second most with 34%. Figure 2 shows the distribution of the Fall fatalities for the construction subsectors.

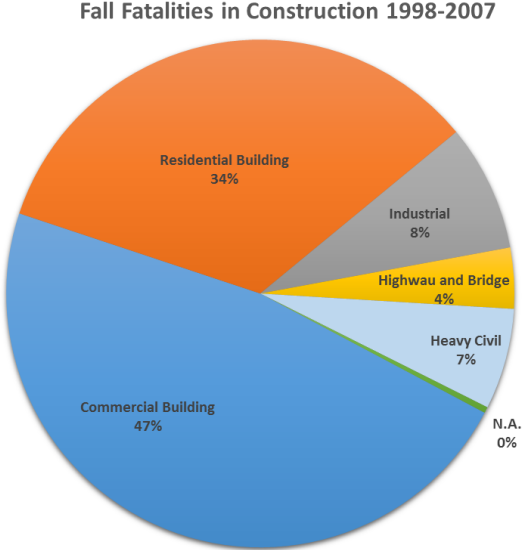


Figure 2. Fall Fatality Distribution of Construction Subsectors (1998-2007)

As shown in Figure 3, when the Fall fatalities were categorized for the project cost, under \$50k has the most fatalities with 599 (28%), followed by \$50k-250K with 402 (19%) fatalities and \$1M - \$5M with 330 (15%) fatalities.

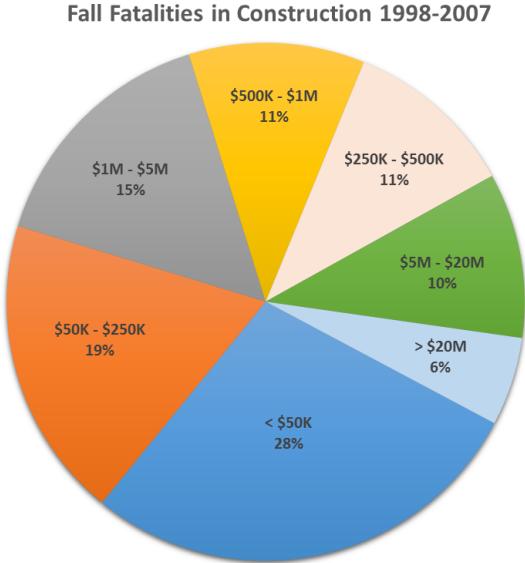


Figure 3. Fall Fatality Distribution of Construction Subsectors (1998-2007)

Fall Fatalities in Small Construction Projects

A total of 599 incidents accounted for the Fall fatalities in Commercial and Residential building projects with a cost of less than \$ 50,000 between 1998 and 2007. Although the accident reports did not specifically identify the root cause of these accidents, the report descriptions included additional information in most of the cases. However, it should be noted that in the majority of the cases, the descriptions were limited to a few words. The following categories were used to describe the cause of the Fall Fatalities: Lost Balance, Unguarded, Unsecured, Equipment Failure, Medical, Struck By, Collapse, Material failure, and Shock. The reports with limited information were noted as Limited Information. The distribution of the causes for each SIC code is presented in Table 1.

Table 1. Fatal Fall Causes in Small Building Construction Projects (1998-2007)

SIC	FALL CAUSE										TOTAL
	Limited Info	Lost Balance	Unguarded	Unsecured	Equipment Failure	Medical	Struck By	Collapse	Material Failure	Shock	
1761	70(12%)	66(11%)	59(10%)	19(3%)	11(2%)	4(1%)	2(0%)	3(1%)	2(0%)	-	236(39%)
1521	13(2%)	16(3%)	9(2%)	6(1%)	2(0%)	3(1%)	-	-	1(0%)	-	50(8%)
1799	10(2%)	11(2%)	6(1%)	4(1%)	6(1%)	1(0%)	3(1%)	1(0%)	-	1(0%)	43(7%)
1721	12(2%)	11(2%)	5(1%)	10(2%)	2(0%)	1(0%)	-	-	1(0%)	-	42(7%)
1751	13(2%)	10(2%)	7(1%)	7(1%)	1(0%)	1(0%)	-	1(0%)	-	-	40(7%)
1731	8(1%)	6(1%)	2(0%)	6(1%)	4(1%)	1(0%)	-	-	-	-	27(5%)
1741	8(1%)	9(2%)	2(0%)	-	5(1%)	-	1(0%)	1(0%)	-	-	26(4%)
1711	5(1%)	3(1%)	6(1%)	6(1%)	2(0%)	-	1(0%)	-	-	-	23(4%)
1542	9(2%)	4(1%)	6(1%)	-	3(1%)	-	-	-	-	-	22(4%)
1795	4(1%)	2(0%)	5(1%)	2(0%)	-	1(0%)	1(0%)	1(0%)	-	-	16(3%)
1791	2(0%)	6(1%)	3(1%)	4(1%)	-	-	-	-	-	-	15(3%)
1742	3(1%)	6(1%)	1(0%)	1(0%)	1(0%)	1(0%)	-	-	-	-	13(2%)
1522	5(1%)	3(1%)	1(0%)	1(0%)	1(0%)	-	-	1(0%)	-	-	12(2%)
1541	2(0%)	2(0%)	4(1%)	2(0%)	2(0%)	-	-	-	-	-	12(2%)
1796	2(0%)	3(1%)	1(0%)	1(0%)	-	-	-	-	-	-	7(1%)
1531	-	2(0%)	1(0%)	1(0%)	-	-	-	-	-	-	4(1%)
1793	-	-	1(0%)	1(0%)	-	-	-	-	-	-	2(0%)
1611	-	1(0%)	-	-	1(0%)	-	-	-	-	-	2(0%)
1794	-	-	1(0%)	-	-	-	-	-	-	-	1(0%)
1622	-	1(0%)	-	-	-	-	-	-	-	-	1(0%)
1623	-	-	-	-	1(0%)	-	-	-	-	-	1(0%)
1752	-	-	1(0%)	-	-	-	-	-	-	-	1(0%)
1743	-	1(0%)	-	-	-	-	-	-	-	-	1(0%)
1771	1(0%)	-	-	-	-	-	-	-	-	-	1(0%)
1781	-	-	1(0%)	-	-	-	-	-	-	-	1(0%)
TOTAL	167(28%)	163(27%)	122(20%)	71(12%)	42(7%)	13(2%)	8(1%)	8(1%)	4(1%)	1(0%)	599(100%)

Lost balance was defined as losing one's footing or balance during their work and could be attributed through human error. Unguarded was defined as a specific area, mainly openings or wholes that was not properly guarded per OSHA rules and regulations. Unsecured was defined as an area or environment not being properly sectioned off from the work area or edges that were not secured. Equipment failure was a machine failure during normal operation. This could be related to poor maintenance, pushing the machine past its limit, or using the wrong equipment for the task. Medical category contained any fatality resulting from a medical condition that helped cause the fall but would not have killed the individual without the fall. Struck by described incidents in which the employee was hit by an object that caused them to fall. Collapse was defined as a complete failure of a structure or platform and the individuals fall because the surface they are working on is no longer there. Material failure was defined as a tool or non-mechanical object failure causing the individual to fall. Shock was described as exposure to electrical shock causing the individual to fall, but would not have killed him on his own.

As shown in Table 1, 167 (28%) incidents did not have any information related to the fall cause. Lost Balance included 163 (27%) followed by Unguarded with 122 (20%), Unsecured with 71 (12%), and Equipment Failure with 42 (7%) accounting for the majority of the Fall fatalities. SIC 1761 (Roofing, Siding, and Sheet Metal Work) had the highest fatalities for the preceding five factors (Lost Balance 66(11%), Unguarded 59(10%), Unsecured 19(3%), and Equipment Failure 11(2%)). SIC 1521 (General Contractors-Single-Family Houses) and SIC 1799 (Special Trade Contractors, Not Elsewhere Classified) codes followed SIC 1761.

The accident reports also included Fall Height information which is the elevation at which the fall occurred and almost always how far the individual fell. In this paper, Fall Height was determined through a combination of what the fall height was noted in the accident description, what was identified in the Fall Height category, and what was identified in the Fall Distance Category. When there was a conflict the accident description was used.

The data showed that Fall Fatalities occurred as high as 190 ft and as low as only 1 ft. 12 (2%) of the fatalities were labeled as unknown where the report gave no information regarding the height of the fall. The most reported fall heights were 20 ft with 49 (8%), 10 ft with 45 (8%), 15 ft with 39 (7%) and 30 ft with 34 (6%). 86% of all the fall fatalities happened at heights of 30 ft or less and 256 (43%) of those fatalities happened with the range of 11 to 20 ft. The largest fatality numbers were for SIC 1761 with 19 (3%) fatalities with a fall height at 20 and 25ft. Increasing fatality numbers were observed from 1 to 10 ft followed by an even distribution between 10 to 20 ft. The fatality numbers decreases for heights over 20 ft with the exception of 25 and 30 ft.

Tables 2 and 3 show the distribution of Fall Causes and Fall Height for the SIC Codes 1761 and 1521. Loss of balance appears to be the leading cause of the fatal falls for both SIC 1761 and 1521. However, the Unguarded and Unsecured categories present a larger problem for SIC 1761 while the distribution of the fall heights are significantly different for SIC 1521.

Table 2. Distribution of Fatal Fall Causes and Fall Height – SIC 1761 (1998-2007)

Fall Height	Fall Cause (SIC 1761)										TOTAL
	Limited Info	Lost balance	Unguarded	Unsecured	Equipment failure	Medical	Struck by	Collapse	Material failure	Shock	
1	-	1(0%)	-	-	-	-	-	-	-	-	1(0%)
2	-	1(0%)	-	-	-	-	-	-	-	-	1(0%)
5	-	1(0%)	-	-	-	-	-	-	-	-	1(0%)
7	3(1%)	-	-	-	1(0%)	-	-	-	-	-	4(2%)
8	4(2%)	5(2%)	1(0%)	-	-	-	-	-	1(0%)	-	11(5%)
9	2(1%)	2(1%)	1(0%)	1(0%)	-	-	-	-	-	-	6(3%)
10	4(2%)	3(1%)	2(1%)	3(1%)	1(0%)	-	-	1(0%)	-	-	14(6%)
11	2(1%)	2(1%)	-	-	-	-	-	-	-	-	4(2%)
12	2(1%)	1(0%)	5(2%)	1(0%)	1(0%)	-	-	-	-	-	10(4%)
13	3(1%)	-	1(0%)	-	1(0%)	-	-	-	-	-	5(2%)
14	2(1%)	2(1%)	2(1%)	1(0%)	-	-	-	-	-	-	7(3%)
15	8(4%)	2(1%)	3(1%)	-	-	1(0%)	-	-	-	-	14(2%)
16	2(1%)	4(2%)	2(1%)	1(0%)	1(0%)	1(0%)	-	-	-	-	11(5%)
17	1(0%)	2(1%)	1(0%)	2(1%)	1(0%)	1(0%)	-	1(0%)	-	-	9(4%)
18	5(2%)	4(2%)	2(1%)	-	1(0%)	-	-	-	-	-	12(5%)
19	2(1%)	-	3(1%)	-	-	-	1(0%)	-	-	-	6(3%)
20	5(2%)	6(3%)	4(2%)	1(0%)	2(1%)	-	-	1(0%)	-	-	19(8%)
21	1(0%)	3(1%)	3(1%)	-	1(0%)	-	-	-	1(0%)	-	9(4%)
22	4(2%)	4(2%)	-	1(0%)	-	-	-	-	-	-	9(4%)
23	3(1%)	2(1%)	1(0%)	-	-	-	-	-	-	-	6(3%)
24	1(0%)	-	-	-	1(0%)	-	-	-	-	-	2(1%)
25	3(1%)	8(4%)	6(3%)	-	-	1(0%)	1(0%)	-	-	-	19(8%)
26	4(2%)	2(1%)	2(1%)	1(0%)	-	-	-	-	-	-	9(4%)
27	-	-	5(2%)	1(0%)	-	-	-	-	-	-	6(3%)
28	-	-	2(1%)	-	-	-	-	-	-	-	2(1%)
30	1(0%)	5(2%)	3(1%)	3(1%)	-	-	-	-	-	-	12(5%)
31	-	-	1(0%)	-	-	-	-	-	-	-	1(0%)
32	-	-	1(0%)	-	-	-	-	-	-	-	1(0%)
33	-	-	2(1%)	-	-	-	-	-	-	-	2(1%)
34	-	-	1(0%)	-	-	-	-	-	-	-	1(0%)
35	3(1%)	1(0%)	-	-	-	-	-	-	-	-	4(2%)
38	1(0%)	-	-	-	-	-	-	-	-	-	1(0%)
40	3(1%)	1(0%)	1(0%)	1(0%)	-	-	-	-	-	-	6(3%)
41	-	-	1(0%)	-	-	-	-	-	-	-	1(0%)
45	-	-	1(0%)	-	-	-	-	-	-	-	1(0%)
60	-	1(0%)	-	-	-	-	-	-	-	-	1(0%)
63	1(0%)	-	-	-	-	-	-	-	-	-	1(0%)
65	-	-	-	1(0%)	-	-	-	-	-	-	1(0%)
70	-	2(1%)	-	-	-	-	-	-	-	-	2(1%)
92	-	-	1(0%)	-	-	-	-	-	-	-	1(0%)
120	-	1(0%)	-	-	-	-	-	-	-	-	1(0%)
unknown	-	-	1(0%)	1(0%)	-	-	-	-	-	-	2(1%)
TOTAL	70(30%)	66(28%)	59(25%)	19(8%)	11(5%)	4(2%)	2(1%)	3(1%)	2(1%)	-	236(100%)

Table 3. Distribution of Fatal Fall Causes and Fall Height – SIC 1521 (1998-2007)

Fall Height	Fall Cause (SIC 1521)										TOTAL
	Limited Info	Lost balance	Unguarded	Unsecured	Equipment failure	Medical	Struck by	Collapse	Material failure	Shock	
2	-	1(2%)	-	-	-	-	-	-	-	-	1(2%)
5	-	1(2%)	-	-	-	-	-	-	-	-	1(2%)
6	-	1(2%)	-	-	-	-	-	-	-	-	1(2%)
8	-	1(2%)	1(2%)	-	-	-	-	-	1(2%)	-	3(6%)
9	3(6%)	-	1(2%)	-	-	1(2%)	-	-	-	-	5(10%)
10	2(4%)	4(8%)	-	1(2%)	1(2%)	-	-	-	-	-	8(16%)
11	2(4%)	-	2(4%)	-	-	-	-	-	-	-	4(8%)
12	-	-	1(2%)	1(2%)	-	-	-	-	-	-	2(4%)
13	-	-	-	1(2%)	-	-	-	-	-	-	1(0%)
14	-	2(4%)	-	-	-	-	-	-	-	-	2(4%)
15	1(2%)	-	2(4%)	1(2%)	-	-	-	-	-	-	4(8%)
16	-	1(2%)	-	-	-	-	-	-	-	-	1(2%)
17	-	-	-	-	-	1(2%)	-	-	-	-	1(2%)
18	-	1(2%)	2(4%)	-	-	-	-	-	-	-	3(6%)
20	-	1(2%)	-	1(2%)	-	-	-	-	-	-	2(4%)
22	1(2%)	-	-	-	-	-	-	-	-	-	1(2%)
25	-	1(2%)	-	-	-	-	-	-	-	-	1(2%)
26	1(2%)	-	-	-	-	-	-	-	-	-	1(2%)
27	-	1(2%)	-	-	1(2%)	-	-	-	-	-	2(4%)
30	2(0%)	-	-	-	-	-	-	-	-	-	2(0%)
50	-	1(2%)	-	-	-	-	-	-	-	-	1(0%)
unknown	1(2%)	-	-	1(2%)	-	1(2%)	-	-	-	-	3(6%)
TOTAL	13(26%)	16(32%)	9(18%)	6(12%)	2(4%)	3(6%)	-	-	1(2%)	-	50(100%)

The location of the fall can also be observed from the accident descriptions and keywords. The locations categories were defined as Roof, Ladder, Platform/Scaffold, Opening, Structure, Bucket, Vehicle, and Other. Roof was defined as an individual fall from the roof structure itself. Ladder was defined as the individual falling from either the process of getting on/off the ladder or while climbing/descending on the ladder. Platform/Scaffold was defined as the individual falling from a scaffold or job built surface including mechanical platforms. Opening was defined as the individual falling through a purposely-created hole in the floor or roof (stairwell, skylight, elevator shaft). Structure was defined as falling from any beam, joist, or column. Bucket is defined as falls from mechanical buckets. Vehicle was defined as any other vehicle not previous defined.

The analysis showed that Roof location had the most fatalities overall with 193 (32%), followed by Ladder with 130 (22%), Platform/Scaffold with 101 (17%) and Opening with 98 (16%). SIC 1761 had the most fatalities with 236 (39%) followed by SIC 1521 with 50 (8%). In each of the top 4 fall causes, SIC 1761 had the most fatalities (Roof 126 (21%), Opening with 44 (7%),

Ladder with 41(7%), and Platform/Scaffold with 20(3%)). SIC 1761 accounted for over 65% of all roof fatalities and approximately 45% of all opening fatalities. Tables 4 presents the distribution of fatality cause and fall location for SIC 1761 and SIC 1521.

Table 4. Distribution of Fatal Fall Causes and Fall Location – SIC 1761 and 1521 (1998-2007)

Fatality Cause (SIC 761 and 1521)												
SIC	Fall Location	Limited Info	Lost Balance	Unguarded	Unsecured	Equipment Failure	Medical	Struck By	Collapse	Material Failure	Shock	Total
1761	Roof	50(21%)	48(20%)	17(7%)	4(2%)	2(1%)	1(0%)	-	3(1%)	1(0%)	-	126(53%)
	Opening	-	2(1%)	40(17%)	1(0%)	-	-	-	-	1(0%)	-	44(19%)
	Ladder	12(5%)	14(2%)	-	12(5%)	2(1%)	1(0%)	-	-	-	-	41(17%)
	Platform/Scaffold	6(3%)	2(1%)	1(0%)	2(1%)	5(2%)	2(1%)	2(1%)	-	-	-	20(8%)
	Structure	1(0%)	-	1(0%)	-	1(0%)	-	-	-	-	-	3(1%)
	Vehicle	-	-	-	-	1(0%)	-	-	-	-	-	1(0%)
	Bucket	1(0%)	-	-	-	-	-	-	-	-	-	1(0%)
	Other	-	-	-	-	-	-	-	-	-	-	-
	TOTAL	70(30%)	66(28%)	59(25%)	19(8%)	11(5%)	4(2%)	2(1%)	3(1%)	2(1%)		236(39%)
1521	Ladder	4(8%)	6(12%)	-	4(8%)	-	1(2%)	-	-	-	-	15(30%)
	Roof	5(10%)	4(8%)	3(6%)	-	-	1(2%)	-	-	-	-	13(26%)
	Platform/Scaffold	1(2%)	3(6%)	2(4%)	-	1(2%)	1(2%)	-	-	1(2%)	-	9(18%)
	Structure	2(4%)	3(6%)	-	-	1(2%)	-	-	-	-	-	6(12%)
	Opening	-	-	4(8%)	1(2%)	-	-	-	-	-	-	5(10%)
	Vehicle	-	-	-	1(2%)	-	-	-	-	-	-	1(2%)
	Other	1(2%)	-	-	-	-	-	-	-	-	-	1(2%)
	Bucket	-	-	-	-	-	-	-	-	-	-	-
	TOTAL	13(26%)	16(32%)	9(18%)	6(12%)	2(4%)	3(6%)	-	-	1(2%)	-	50(8%)

In Table 4, SIC 1761 account for significantly higher numbers in Lost Balance/Roof Location and Unguarded/Opening Location. Ladder and Platform/Scaffold locations show a relatively uniform distribution of fall cause for SIC 1761 and 1521. In the aggregated data, SIC 1721 (Painting and Paper Hanging) showed the highest number of Ladder fall fatalities accounting for 50% of the ladder incidents.

Summary and Conclusions

Construction is one of the most dangerous industries in the United States. Construction involves a project-based dynamic work environment which requires the participation of a large number of small companies. Fall accidents account for the highest number of fatalities in construction

where the majority occurs in small construction projects under \$50,000 in size. Identification of circumstances and causes of these accidents are critical for intervention and prevention efforts. Project level analysis of fall fatalities offer a more insightful view to help develop a variety of solutions including training, program development, and risk management.

Small construction projects under \$50K accounted for 31% of all fatalities and 28% of fatal falls in the database. Commercial and residential building subsectors show a disproportionately high number of fall fatalities. Commercial projects represented 35% of all fatalities and 47% of fatal falls while residential represented 27% of all fatalities and 34% of fatal falls. The major risk areas for commercial and residential projects were identified as fall from roof, fall from ladder, fall from platform/scaffold, and fall from opening. The percentage of fatal falls also showed an increase in small building projects (Under \$50K) compared to the overall numbers.

In the small construction projects, the average fall height for commercial projects was 19.88 ft. and residential projects was 17.44 ft. Residential projects accounted 76% of their fatal roof falls from less than two stories. Commercial projects accounted 88% of their fatal roof fall from less than 2 stories. This illustrates that a vast majority of fall fatalities are happening at heights under 30ft. However, the data includes fatal descriptions from 1 to 190 ft.

Project level analysis approach provides a better understanding of construction fatalities and offer more insightful information to develop intervention and prevention of high risk activities and work areas. The ability to provide detailed information has a direct impact on the construction industry while offering an educational tool to demonstrate the work environment in a more realistic manner.

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