AN ANALYSIS OF FATAL EVENTS IN THE CONSTRUCTION INDUSTRY 2010

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This report is based upon OSHA-inspected fatal events in construction during calendar 2010. The data analyzed were provided by Dave Schmidt, Director, Office of Statistical Analysis, Occupational Safety and Health Administration. Thomas E. Cressler II, M.S., Senior Associate Director and John Wagner, M.S., Research Associate III conducted the study and prepared this report. This research was supported by contract No. J089F26523 with the United States Department of Labor, Occupational Safety and Health Administration. The authors thank Dr. John R. Moore for his critique and suggestions which added measurably to the report. The authors are solely responsible for all interpretations, conclusions and any errors found in the report.

Executive Summary

The Occupational Safety and Health Administration (OSHA) inspected 412 fatal construction incidents (excluding non-work related causes), involving 424 fatalities, in calendar year 2010. Seven of the 31 proximal causes classified in this report accounted for 231 (56.1 percent) of the fatal events investigated. They were: (1) "fall from/through roof": 54 events (13.1 percent); (2) "crushed/run-over of non-operator by operating construction equipment": 35 events (8.5 percent); (3) "fall from/with ladder": 33 events (8.0 percent); (4) "fall from/with structure": 30 events (7.3 percent); (5) "crushed/run-over/trapped of operator of construction equipment": 28 events (6.8 percent); (6) "electric shock by equipment contacting power source": 26 events (6.3 percent); and (7) "electric shock from equipment installation/tool use": 25 events (6.1 percent).

A comparison of the year-to-year ranks of the proximal causes during the 1991-2010 period shows that they are highly and significantly correlated, i.e., the individual ranks of the causes vary little from year-to-year.

Most of the fatal events involved a single victim, but 6 (1.5 percent) of the events were multi-fatality events which accounted for 18 (4.2 percent) of the fatalities.

Other findings included:

- Initiation. In 250 (60.7 percent) of the fatal events the victim was judged to be the primary initiator of the cause; in 125 events (30.3 percent) the victim was judged to be simply in the wrong place at the wrong time; in 16 events (3.9 percent) another employee was judged to be the primary initiator of the cause; 17 events (4.1 percent) could not be classified; and in 4 events (1.0 percent) the victim and another employee were judged to be primary initiator of the cause.

- Task. In 402 of the events (97.6 percent) the victim was judged to be performing work at the task site when injured; in 4 events (1.0 percent) the victim was going to or from work or not working when injured; and in 6 events (1.5 percent) no classification was possible.
- Timing. More fatal events happened on Thursday with 91 events (22.1 percent) occurring that day of the week, followed by Wednesday with 75 events (18.2 percent) and Monday with 73 events (17.7 percent) occurring on these days; and more fatal events happened between the 11 and 12 hours (11:00 am and 12:00 pm) with 48 events (11.6 percent) occurring during this time interval and the 13 and 14 hours (1:00 pm and 2:00 pm) with 48 events (11.6 percent) occurring during this time interval.

A special study examined the causes of fatalities occurring during highway/road construction, undertaken because of its unique exposure to external hazards, vehicular traffic, found that the leading cause of these 46 fatal events was “crushed/run-over by highway vehicle” accounting for 15 events (32.6 percent). The leading contributing cause of these 15 events was highway vehicles losing control and swerving into highway/road work sites, striking workers accounting for 4 events (26.7 percent).

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I. Introduction

This report focuses on the direct causes of fatal events in the construction industry which occurred in calendar year 2010. Seventeen earlier studies[1] by the Construction Industry Research and Policy Center (CIRPC) analyzed the causes of fatal events in this industry in 1991-1992, 1993-1994 and for each of the years 1995 through 2009.

II. Data

The data analyzed in this report, provided by OSHA from Form 170's, consist of narrative descriptions of the 412 fatal events inspected by OSHA which led to the 424 fatalities in construction during calendar year 2010. In this report, as in earlier reports, analysis includes all OSHA-inspected fatal construction events under both Federal and State jurisdiction. The Occupational Safety and Health Act of 1970 provides States with the option of administrating the Act themselves or accepting Federal administration of the Act. Twenty-nine States, District of Columbia, and the Virgin Islands chose administration under the Federal System, and the remaining twenty-one States and one Territory chose self-administration under State Plans[2].

As in the earlier studies, non-accidental fatalities on construction sites or contractor yards (such as deaths from non-work related heart attacks, strokes, seizures, etc.) and fatalities of construction workers killed off-site in traffic accidents were excluded from the analysis; in 1991-

[1] An Analysis of Fatal Events in the Construction Industry, 1991-1992 (1993), An Analysis of Fatal Events in the Construction Industry, 1993-1994 (1995), An Analysis of Fatal Events in the Construction Industry, 1995 (1996), An Analysis of Fatal Events in the Construction Industry, 1996 (1997), An Analysis of Fatal Events in the Construction Industry, 1997 (1999), An Analysis of Fatal Events in the Construction Industry, 1998 (2000), An Analysis of Fatal Events in the Construction Industry, 1999 (2001), An Analysis of Fatal Events in the Construction Industry, 2000 (2002), An Analysis of Fatal Events in the Construction Industry, 2001 (2003), An Analysis of Fatal Events in the Construction Industry, 2002 (2004), An Analysis of Fatal Events in the Construction Industry, 2003, (2005), An Analysis of Fatal Events in the Construction Industry, 2004 (2006), An Analysis of Fatal Events in the Construction Industry, 2005 (2007), An Analysis of Fatal Events in the Construction Industry, 2006 (2008), An Analysis of Fatal Events in the Construction Industry, 2007 (2009), An Analysis of Fatal Events in the Construction Industry, 2008 (2010) and An Analysis of Fatal Events in the Construction Industry, 2009 (2011). Construction Industry Research and Policy Center, University of Tennessee, Knoxville.

[2] States in the Federal System are: AL, AR, CO, CT, DE, DC, FL, GA, ID, IL, KS, LA, ME, MA, MS, MO, MT, NE, NH, NJ, NY, ND, OH, OK, PA, RI, SD, TX, VI, WV and WI. States and Territories under State Plans are: AK, AZ, CA, HI, IN, IA, KY, MD, MI, MN, NV, NM, NC, OR, PR, SC, TN, UT, VT, VA, WA and WY.

2009 these fatalities accounted for about 3.8 percent of OSHA-inspected fatal construction events but about 8.5 percent in 2010. Although the Occupational Safety and Health Act of 1970 requires employers to report fatalities to OSHA within eight hours of the occurrence of the event, all fatalities on construction sites are not inspected by OSHA; for example, OSHA does not inspect fatal construction events involving independent contractors with no employees. Therefore, the results reported here do not provide a year-to-year analysis of changes in the absolute number of fatal events or individuals killed on construction sites.

Each narrative record typically consists of a brief description of the event leading to the fatality. The narratives were analyzed and classified into one of 31 cause categories, using the collective judgment of the investigators. However, where the narrative description was omitted, inconclusive, or completely unclear; the event cause was coded "unknown cause or other".

CIRPC's review of over 1200 case files of fatal construction events occurring in 1997, 1998 and 1999 revealed that coded data for an event sometimes did not comport with corresponding narrative descriptions and the narrative descriptions were sometimes internally inconsistent. Later reviews of fatality files for other special studies lead us to believe these inconsistencies continue although at a lower rate. Consequently, the data analyzed in this report are restricted to the direct causes of the fatal events where the authors were able, in most cases, to classify the events with relative certainty according to 31 types of causes. Essentially the same causes as were used in CIRPC's previous fatality studies. For those who are interested, the original coded data from the files are included in Appendix C for the following classifications: (1) end-use of structure; (2) type of project; (3) victim by contractor type(s); (4) contract value of the construction project; and (5) construction operation associated with the fatality.

In classifying the events a rule of primacy was followed for multiple-cause fatalities the first cause in the chain of causes was recorded as the cause of the fatal event. Definitions of the causes are shown in Appendix A.

III. **Analysis of Fatal Events by Cause**

Table 1 shows the cause classification system, the number of times each cause represented a fatal event in 2010, the relative frequency of each cause and the number of victims killed.[3] It can be seen that "fall from/through roof" led all other causes in number of fatal events (54 or 13.1 percent of total events), followed by "crushed/run-over of non-operator of operating construction equipment" (35 or 8.5 percent). The third leading cause was "fall from/with ladder" (33 or 8.0 percent); the fourth leading cause was "fall from/with structure" (30 or 7.3 percent); the fifth leading cause was "crushed/run-over/trapped of operator of operating construction equipment" (28 or 6.8 percent); the sixth leading cause was "electric shock from equipment contacting power source" (26 or 6.3 percent); and the seventh leading cause was "electric shock from equipment installation/tool use" (25 or 6.1 percent). The number and relative frequencies of the remaining causes of the 412 fatal events analyzed may be read directly from Table 1. (Comparative and aggregated frequencies for earlier years are shown in Figures B1 through B4 in Appendix B.)

[3] Each event included at least one person killed and in several events additional workers were killed or injured.

Table 1. Construction Fatality Event Causes, 2010

Event Causes	Description	Number of Events and Victims: Events	Number of Events and Victims: Victims	Percent of Events
1.	asphyxiation/inhalation of toxic vapor	7	7	1.7
2.	caught in/struck by stationary equipment	3	3	0.7
3.	crushed from collapse of structure	14	15	3.4
4.	crushed/run-over of non-operator by operating construction equipment	35	35	8.5
5.	crushed/run-over/trapped of operator by operating construction equipment	28	28	6.8
6.	crushed/run-over by construction equipment during maintenance/modification	6	6	1.5
7.	crushed/run-over by highway vehicle/non-construction equipment	16	17	3.9
8.	drown, non-lethal fall	1	1	0.2
9.	electric shock by touching exposed wire	11	11	2.7
10.	electric shock by equipment contacting power source	26	26	6.3
		Event		Percent
	a. ladder	8		1.9
	b. scaffold	0		0.0
	c. crane/lifting equipment/boom/dump truck	11		2.7
	d. contact while handling materials such as gutters, iron rods, etc.	7		1.7
11.	electric shock from equipment installation/tool use	25	25	6.1
12.	electric shock, other	0	0	0.0
13.	elevator (struck/crushed by elevator or counter weights)	1	1	0.2
14.	fall from/with ladder: includes collapse/fall of ladder	33	33	8.0
15.	fall from/through roof	54	54	13.1
		Event		Percent
	a. fall off of roof	32		7.8
	b. fall through roof other than skylight	13		3.2
	c. fall through skylight or other opening	9		2.2
16.	fall from highway vehicle/construction equipment	2	2	0.5
17.	fall from/with scaffold	20	20	4.9
18.	fall from/with bucket (aerial lift/basket)	8	8	1.9
19.	fall from/with structure (other than roof)	30	30	7.3
		Event		Percent
	a. fall with collapse of structure	6		1.5
20.	fall from/with platform or catwalk	3	3	0.7
21.	fall through opening (other than roof)	2	2	0.5

Table 1. Construction Fatality Event Causes, 2010 (continued)

Event Causes	Description	Number of Events and Victims: Events	Number of Events and Victims: Victims	Percent of Events
22.	fall, other or unknown	2	2	0.5
23	fire/explosion/scalding	11	18	2.7
24.	hyperthermia/hypothermia	7	7	1.7
25.	hit, crushed, fall during lifting operations	23	23	5.6
26.	struck by falling object/projectile (including tip-over)	9	9	2.2
27.	crushed/suffocation from trench collapse	22	23	5.3
28.	crushed while unloading-loading equipment/material (except by crane)	6	7	1.5
29.	shock/burn from lightning	0	0	0.0
30.	crushed other	1	2	0.2
31.	unknown cause or other	6	6	1.5

		Event	Percent
a.	Other	3	0.0
Total		**412**	**424**	**100.0**

At the risk of misleading the reader by over generalizing, it may be informative to describe examples of frequently occurring specific situations leading to the 7 most frequent causes of fatal events as listed in Table 1.

Fall from/through Roof. An inattentive roofer or laborer without fall protection walks backward and off the roof or steps into a skylight opening or onto a covered skylight opening.

Crushed, Run-over, Non-operator. A laborer guiding trucks while backing up, a grade checker or a laborer performing site clean-up in proximity of excavating machinery is run-over after getting out of the line-of-sight of an operator/driver.

Fall from/with Ladder. Worker falls from or with a ladder because he/she over-reaches or fails to secure the ladder or missteps or slips or simply loses balance.

Fall from/with Structure. An ironworker without fall protection slips or loses balance while erecting steel frame and falls or a carpenter or an ironworker falls as a result of a collapsing structure or structural component.

Crushed/Run-over…Operator. Mobile construction equipment, such as a dozer or fork lift, goes over an embankment and rolls over or turns over when encountering uneven terrain, resulting in the crushing of the operator. (The operator may be crushed inside the equipment or crushed by the equipment while trying to escape.)

Electric shock by equipment contacting power source. A worker moves a ladder and the ladder contacts an overhead power line or an equipment operator positions a boom or raises a dump truck bed and contacts a power line.

Electric shock from equipment installation/tool use. An electrician working with live wires is electrocuted while replacing a light fixture or while trouble shooting a HVAC unit.

The number of victims killed by each cause is also shown in Table 1 where it can be seen that in most events only one worker was killed per event. There were 23 fatality causes where no event had multiple fatalities; only 6 fatality causes included events with multiple fatalities. "Crushed, other" was the fatality cause which had the most victims killed per event, i.e., 1 event

and 2 victims or 2.0 victims per event. The fatality cause, fire/explosion/scalding had the largest multiple loss of life, i.e., 11 events and 18 victims or 1.64 victims per event.

The data for construction fatalities in 2010 show that 6 of the fatal events, 1.5 percent of fatal events, involved multiple fatalities. The multiple-fatality events averaged 3.0 fatalities per event and accounted for an additional 12 fatalities, 2.8 percent and a total of 18 fatalities, 4.2 percent of the 424 individuals killed in 2010.

These results parallel those reported by the Bureau of Labor Statistics (BLS). During 1995-1999, 4 percent of all fatal work-related events involved multiple fatalities, and these multiple-fatality events accounted for 10 percent of the workers killed during the period. They averaged three fatalities per incident.[4] It should be noted that the BLS data included homicides, and they accounted for 19 percent of their multi-fatality incidents. There were no homicides in the 2010 OSHA data. Homicides have been excluded from the analysis in prior years.

Table 2 compares of the ranks of the causes in 2010 with the average rank of the causes of fatal events during the period 1991 - 2009. It can be seen that the overall rank pattern of the causes in 2010 is very similar to the rank pattern in 1991 – 2009. An overall statistical comparison of the correlation of the rank in 2010 with the average rank in 1991-2009 was calculated using a Spearman rank correlation procedure.[5] The correlation obtained was + 0.90, $p < 0.001$, indicating that the ranks of the causes in the two time periods are highly and positively correlated, i.e., did not change significantly between 1991 – 2009 and 2010[6].

[4] Drudi, Dino and Mark Zak," Work–Related Multi-Fatality Incidents," Monthly Labor Review, Vol. 127, No. 10, October 2004.
[5] Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences (New York: McGraw-Hill Book Co., Inc., 1956), p. 219.
[6]Five of the 719 fatal events in 2002 and 17 of 719 fatal events in 2001 had either no narrative or a narrative too incomplete to classify the cause of fatality. These records were coded as "unknown" cause; this was not done in prior years. They were omitted from the calculation of the Spearman Rank correlation in order to avoid data distortion.

The Spearman rank-order correlation between 2009 and 2010 causes was calculated and found to be + 0.87, $p < .001$, indicating also that the pattern changed very little between 2009 and 2010.

The correlation result is not surprising given that the general composition of construction output, and therefore the mix of construction operations required to produce the output, was probably very similar during the time periods examined. This interpretation implies that the rank of a cause is a function of the magnitude of exposure to the cause and/or the inherent danger associated with the cause.

While the rank order of fatality causes has not changed significantly it should be noted that falls are relatively more important. Falls, as a whole, now represent 36.3 percent of construction fatal events, whereas for the 1991-2009 period they represented 33.7 percent of construction fatal events.

Table 2. Comparison of Ranks of Causes of Fatal Events in 1991 - 2009 with 2010

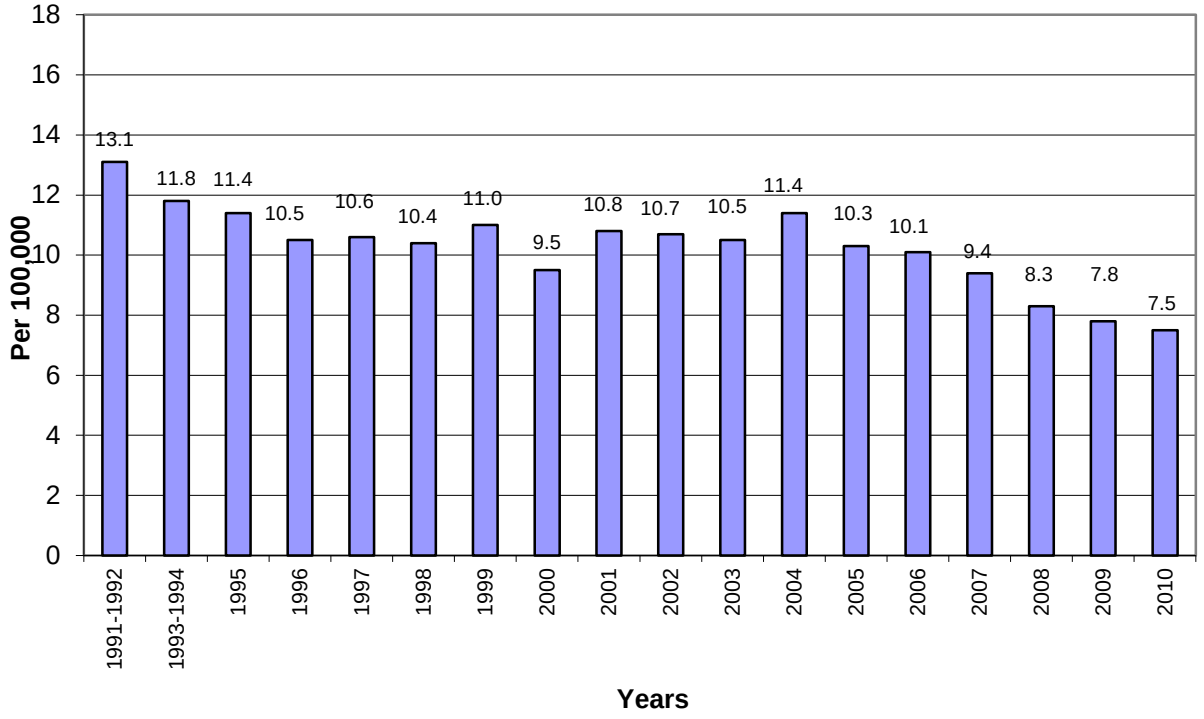
Event	1991 - 2009 Average			2010		
	Number	Percent	Rank	Number	Percent	Rank
1. asphyxiation/inhalation of toxic vapor	8.2	1.3	22	7	1.7	18
2. caught in/struck by stationary equipment	5.8	0.9	23	3	0.7	22
3. crushed from collapse of structure	26.4	4.1	11	14	3.4	12
4. crushed/run-over of non-operator by operating construction equipment	50.0	7.7	3	35	8.5	2
5. crushed/run-over/trapped of operator by operating construction equipment	35.0	5.4	5	28	6.8	5
6. crushed/run-over by construction equipment during maintenance/modification	13.6	2.1	19	6	1.5	20
7. crushed/run-over by highway vehicle	25.2	3.9	12	16	3.9	11
8. drown, non-lethal fall	5.6	0.9	24	1	0.2	27
9. electric shock by touching exposed wire	20.8	3.2	14	11	2.7	13
10. electric shock by equipment contacting power source	40.9	6.3	4	26	6.3	6
11. electric shock from equipment installation/tool use	33.5	5.2	6	25	6.1	7
12. electric shock, other	3.7	0.6	28	0	0.0	29
13. elevator (struck/crushed by elevator or counter weights)	2.7	0.4	29	1	0.2	27
14. fall from/with ladder: includes collapse/fall of ladder	28.2	4.4	10	33	8.0	3
15. fall from/through roof	75.8	11.7	1	54	13.1	1
16. fall from highway vehicle/construction equipment	4.9	0.8	27	2	0.5	25
17. fall from/with scaffold	23.9	3.7	13	20	4.9	10
18. fall from/with bucket (aerial lift/basket)	14.3	2.2	17	8	1.9	16
19. fall from/with structure (other than roof)	55.6	8.6	2	30	7.3	4

Table 2. Comparison of Ranks of Causes of Fatal Events in 1991 - 2009 with 2010 (continued)

Event	1991 - 2009 Average			2010		
	Number	Percent	Rank	Number	Percent	Rank
20. fall from/with platform or catwalk	15.0	2.3	16	3	0.7	22
21. fall through opening (other than roof)	17.5	2.7	15	2	0.5	25
22. fall, other or unknown	5.3	0.8	25	2	0.5	25
23. fire/explosion/scalding	12.7	2.0	20	11	2.7	13
24. hyperthermia/hypothermia	4.9	0.8	26	7	1.7	18
25. hit, crushed, fall during lifting operations	33.2	5.1	7	23	5.6	8
26. struck by falling object/projectile (including tip-over)	28.4	4.4	9	9	2.2	15
27. crushed/suffocation from trench collapse	28.9	4.5	8	22	5.3	9
28. crushed while unloading-loading equipment/material (except by crane)	12.4	1.9	21	6	1.5	20
29. shock/burn from lightning, other	14.1	2.2	18	7	1.7	18
Total	**646.5**	**100.0**		**412**	**100.0**	

The number of OSHA-inspected fatal construction events has varied over the years since 1991 as has employment in construction establishments.[7] The trend of these fatal events per 100,000 construction establishment employees is shown in Figure 1.

Figure 1. Fatal Events per 100,000 Construction Establishment Employees, 1991-2010



The trend shows a marked reduction in the number of fatal events per 100,000 construction establishment employees.

IV. Analysis by Victim's Situation

Fatal events were analyzed to determine the role of the 'victim' in each event. The analysis classified the role of the victim by four general categories: (1) victim(s) was (were) the

[7] Bureau of Labor Statistics, National Employment, Hours, and Earnings, CES, Table B-1 http://www.bls.gov/data/

primary, immediate contributor to the event; (2) person(s) other than victim(s) was (were) the primary, immediate contributor to the event; (3) no individual directly contributed to the event, i.e., the victim(s) was at the wrong place at the wrong time; and (4) unknown.

The first category includes, for example, most falls, crushed/run-over of operators, electrocutions other than those occurring during lifting operations, asphyxiations and hypothermia. The second category includes, for example, most crushed/run-over of nonoperators, lifting operations, loading/unloading of equipment/materials, struck by highway vehicles, fall from/with aerial lift, and electrocutions from crane boom/tackle contacting overhead power lines. The third category includes, for example, most structure and trench collapses, struck by projectile/falling objects, and lightning.

It should be understood that these classifications do not indicate fault or preventability of the fatality. For example, while falls are generally classified as "victim was the primary contributor to the event", many fall fatalities would have been prevented with compliance with OSHA's fall protection standards. Similarly, trench collapses classified as "being in the wrong place at the wrong time" are preventable with compliance with OSHA's trenching standard.

Although the classifications were often subjective due to a lack of precise information or conflicting information, following are the results for the 412 events: (1) victim primary initiator of event: 250 events (60.7 percent); (2) victim and another employee primary initiator: 4 events (1.0 percent); (3) person other than victim primary initiator: 16 events (3.9 percent); (4) wrong place at wrong time: 125 events (30.3 percent); and (5) unknown: 17 events (4.1 percent).

An additional classification of the 412 fatal events was also analyzed to estimate the distribution of events by work status of the victim. As with the previously discussed classification of who initiated the event, the work status classifications were also subjective.

Nevertheless, it may be useful in understanding, in a general sense, the situations in which construction fatalities occur. It was found that: (1) 402 (97.6 percent) of the fatal events involved workers performing work at their task site; (2) 4 (1.0 percent) of the events involved workers going to or from work or not working; and (3) 6 (1.5 percent) of the events could not be classified.

The first category includes, for example, many roofing fatalities, fatalities resulting from structure and trench collapses, events involving crushed/run-over of operators, electrocutions while installing electrical equipment, workers caught in stationary equipment, workers falling from/with aerial lifts and scaffolds and workers climbing/relocating on structures.

V. Analysis of Fatal Events by Day of Week and Time

The fatality data reported on OSHA Form 170 includes the date and time of day of most fatal events. Table 3 shows the distribution of fatal events by day of the week. Contrary to the popular conception that most fatalities occur on Mondays and Fridays, it can be seen that Thursday had the largest number of events, 91, followed by Wednesday with 75 events and Monday with 73 events. The number of Tuesday and Friday fatal events is the same for each, 68. Note, however, that without knowing the total number of construction hours worked each day, it is not possible to be certain that any one day is more or less hazardous than another.

Table 3. Distribution of Fatal Construction Events by Day of Week, 2010

Day	Number of Events	Percent
Monday	73	17.7
Tuesday	68	16.5
Wednesday	75	18.2
Thursday	91	22.1
Friday	68	16.5
Saturday	22	5.3
Sunday	15	3.6
Total	**412**	**100.0**

Table 4 shows the distribution of fatal events by hour (military) of the day. It can be seen that the 11-12 hour period and the 13-14 hour period contained the most fatal events, 48 each. As pointed out previously, without knowing the total hours worked in construction each hour, it is not possible to calculate hourly event rates. However, it may be reasonably assumed that the total construction hours worked each hour during the 8-12 hour period and the 13-17 hour period are approximately equal. If so, the results showing that 156 of the fatal events occurred in the 8-12 hour period and a nearly equal number, 147, occurred in the 13-17 hour period are not surprising. Almost three-fourths (73.5 percent) of the fatal events occurred during these eight hours.

Table 4. Distribution of Fatal Construction Events by Hour, 2010

Hour	Number of Events	Percent
0–1	4	1.0
1–2	3	0.7
2–3	2	0.5
3–4	1	0.2
4–5	1	0.2
5–6	1	0.2
6–7	5	1.2
7–8	13	3.2
8–9	25	6.1
9–10	37	9.0
10–11	46	11.2
11–12	48	11.6
12–13	38	9.2
13–14	48	11.6
14–15	30	7.3
15–16	32	7.8
16–17	37	9.0
17–18	15	3.6
18–19	8	1.9
19–20	5	1.2
20–21	6	1.5
21–22	2	0.5
22–23	2	0.5
23–24	3	0.7
Total	**412**	**100.0**

VI. Highway/Road Construction Fatalities

One might think that highway/road construction would be relatively safe, since most work activity at these sites occurs at or near ground level. Falls from elevations, the leading direct cause of construction fatalities, would have a low potential. However, in 2010, 48 workers were killed in 46 events while working on highway/road projects. On-site operating construction equipment was involved in 21 fatal events (45.6 percent).

Table 5 ranks the direct causes of the fatal events by their frequency. The table shows that the leading causes were "crushed/run-over by highway vehicle" (15 events or 32.6 percent), followed by "crushed/run-over of nonoperator by operating construction equipment" (13 events or 28.3 percent), and "crushed/run-over of operator by operating construction equipment" (8 events or 17.4 percent). Other event causes are shown in Table 5.

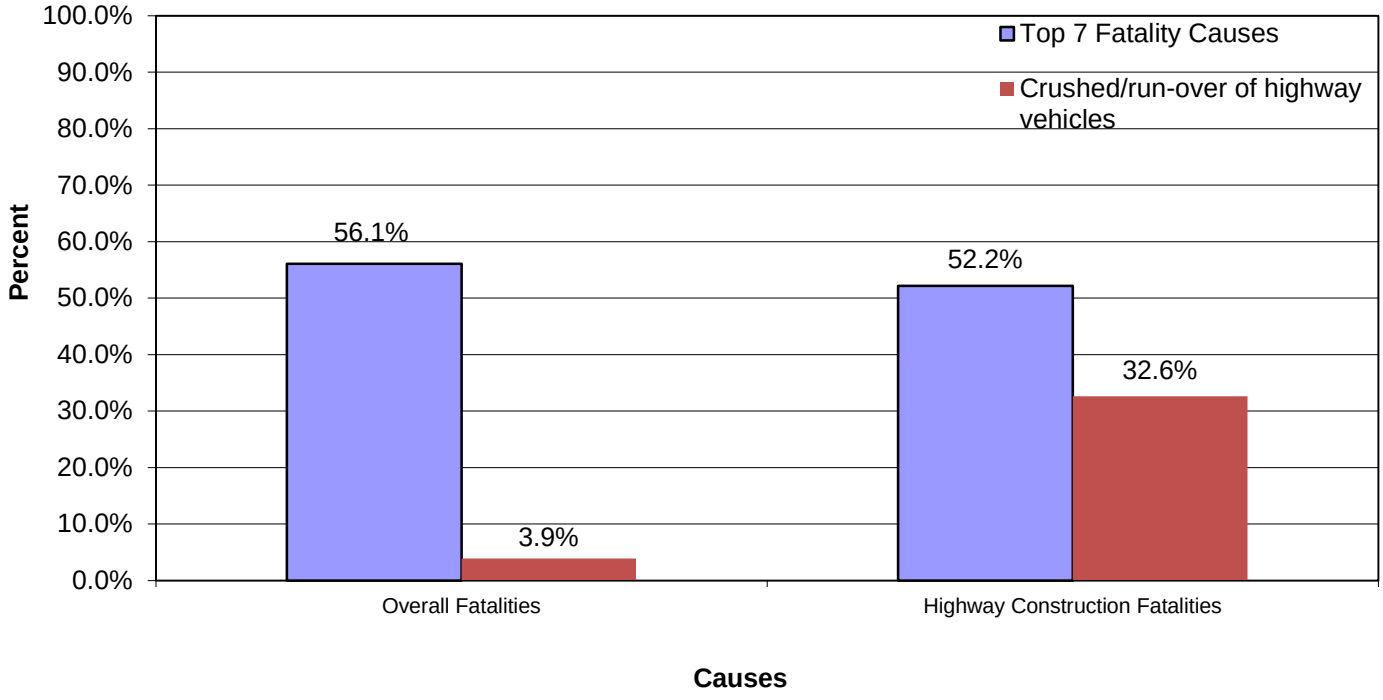
Table 5. Frequency of Fatality Causes in Highway/Road Construction, 2010

Description	Frequency	Percent
Crushed/run-over by highway vehicle	15	32.6
Crushed/run-over of non-operator by operating construction equipment	13	28.3
Crushed/run-over of operator by operating construction equipment	8	17.4
Electric shock by equipment contacting power source	3	6.5
Crushed/run-over by construction equipment during main/mod.	2	4.4
Fall from highway vehicle/construction equipment	1	2.2
Fall, other or unknown	1	2.2
Hit/crushed/fall during lifting operation	1	2.2
Hyperthermia/Hypothermia	1	2.2
Crushed from collapse of structure	1	2.2
Total	**46**	**100.0**

Figure 2 compares the top 7 fatality causes with "crushed/run-over by highway vehicle" for highway/road construction. The top 7 fatality causes (identified in Table 1) had 231 events (56.1 percent) of the total 412 events compared with only 16 events (3.9 percent) for "crushed/run-over by highway vehicle." For highway/road construction fatal events, the top 7

fatality causes (shown in Table 5) had 43 events (93.5 percent) and "crushed/run-over by highway vehicle" had 15 events (32.6 percent) of the 46 fatal events. It should be noted that the top 7 fatal event causes which accounted for over 56.1 percent of the total events also accounted for 52.2 percent of the highway/road work construction fatal events. However, the "crushed/run-over by highway vehicle" cause increased significantly from less than 4 percent overall to over 32 percent for highway/road construction.

Figure 2. Highway Construction Fatality Cause Comparison, 2010



Since traffic on many or most highway/road varies by time of day, and most construction on highway/road occurs during the day, one might expect that most "crushed/run-over by highway vehicles" fatalities would occur during morning and afternoon commuting periods when traffic loads peak. Table 6 shows fatal events caused by victim being struck/run-over by highway vehicles by time of day (1- 24 hours). For the previous four years, 2006 through 2009, a

majority, ranging from 50 percent to 80 percent, of the construction fatalities caused by "crushed/run-over by highway vehicle" have occurred from mid-morning through late-afternoon. This year 47 percent of the fatalities occurred during these hours and 40 percent of the fatalities, double the previous three years, occurred between late night and early morning.

It is not possible to calculate fatality rates for these time-of-day periods without knowing the hours worked in each period, however, as mentioned earlier the morning and evening commuting periods would seem to be the times when these events are most likely to occur. With shifting road work practices, road work done at night to avoid traffic congestion, the historical and expected periods of fatal events may be changing. More information about conditions which contribute to fatalities in highway/roadway construction would seem to be an area worthy of further investigation.

Table 6. Construction Fatalities Caused by "Crushed/Run-Over by Highway Vehicle" by Time of Day, 2010

Time	Frequency	Percent
Early Morning: 24:00 - 5:00	3	20.0
Dawn: 5:00 - 8:00	0	0.0
Mid-Morning: 8:00 - 11:00	3	20.0
Mid-Day: 11:00 - 14:00	3	20.0
Late-Afternoon: 14:00 - 17:00	1	6.7
Evening: 17:00 - 20:00	2	13.3
Late Night: 20:00 - 24:00	3	20.0
Total	**15**	**100.0**

Since “crushed/run-over by highway vehicle” was the leading direct cause of fatal events occurring in highway/road construction, it may be helpful in protecting workers engaged in highway/road construction by looking for specific situations in which these fatalities occurred. The often brief summaries of highway construction fatalities in IMIS provided little or no information on speed limits, pavement conditions, visibility, protective barriers, work zone markings or potential impairments of vehicle operators involved in the fatalities. However, it was still possible to identify six sub-categories of “crushed/run-over by highway vehicle”. Table 7 shows these sub-categories and their frequency.

This table shows that the largest numbers of fatal events occurred when highway vehicles lost control and swerved into work zones striking workers, or a highway vehicle struck a flagger signaling traffic at the beginning of a marked work zone. Each sub-category accounted for 4 (26.7 percent) of the fatal events. These sub-categories were followed by the situations where a worker installing signs or traffic signals in an unprotected work zone was struck by a highway vehicle or a highway vehicle struck a worker paving an unprotected work zone. Each sub-category accounted for 2 (13.3 percent) of the fatal events. A highway vehicle entered an inadequately marked and protected work zone fatally injuring one worker (6.7 percent) and a highway vehicle struck a shadow vehicle protecting workers, crushing one worker (6.7 percent). One of the event descriptions (6.7 percent) was inadequate for classification, indicating only that the worker had been run-over by a highway vehicle.

Table 7. Frequency of Sub-Categories of "Crushed/Run-Over by Highway Vehicle", 2010

Sub-Category	Frequency	Percent
1. highway vehicle lost control and entered (by swerving or inadvertently entering) well-identified work zone, striking victim	4	26.7
2. highway vehicle struck victim installing signs or traffic signals in unprotected work zone	2	13.3
3. highway vehicle struck victim (flagger) signaling traffic at beginning of marked work zone.	4	26.7
4. highway vehicle struck victim working (paving) in unprotected work zone	2	13.3
5. highway vehicle struck victim who walked into traffic zone	0	0.0
6. highway vehicle struck shadow vehicle protecting moving vehicle from which victim was performing work, crushing victim	1	6.7
7. highway vehicle struck victim by entering inadequately marked and protected work zone	1	6.7
8. unknown	1	6.7
Total	**15**	**100.0**

APPENDIX A

Definitions of Fatality Causes

1. asphyxiation/inhalation of toxic vapor: lack of oxygen and/or inhalation of toxic gas, (excluding asphyxiation resulting from fire/explosion)

2. caught in/struck by stationary equipment: body or clothing caught pulling worker into equipment

3. collapse of structure: building or other structure falling on worker, not including falling ladder, scaffold, aerial lift/ basket, platform, with a structure, trench collapse, or wall (earthen) collapse

4. crushed/run-over of non-operator by operating construction equipment: non-operator run-over or crushed between equipment and ground or another object by an operator controlled piece of construction equipment

5. crushed/run-over/trapped of operator by operating construction equipment: includes rollover and catching of body in equipment or between equipment and ground or other object while operating the equipment[*]

6. crushed/run-over by construction equipment during maintenance/ modification: includes equipment/parts falling on worker while assembling or disassembling equipment

7. crushed/run-over by highway vehicle: any run-over by non-construction equipment, including trains

8. drown, non-lethal fall: non-lethal falls into water and flooding of container, trenches, etc.

9. electrocution by touching exposed wire/source: body part contacting the wire/source except when installing equipment or using a tool

10. electrocution by equipment contacting wire

    a. ladder
    b. scaffold
    c. crane/lifting equipment/boom/dump truck
    d. other: contact while handling materials, e.g. gutters, iron rods, painting equipment, etc.

11. electrocution from equipment installation/tool use: includes failure to de-energize equipment, inappropriate energizing, contacting energized part with tool or body, and inadequately grounded tools or exposed tool wires

12. electric shock, other and unknown cause

13. elevator (struck/crushed by elevator or counter-weights)

14. fall from/with ladder: includes collapse/fall of ladder

[*]Includes fatalities resulting from asphyxiation/fire/explosion/drowning of trapped operators.

15. fall from roof; fall through roof: skylight or other opening

    a. fall off of roof
    b. fall through roof other than skylight
    c. fall through skylight or other opening

16. fall from vehicle (vehicle/construction equipment): falls from vehicle or equipment while in motion or at rest.

17. fall from/with scaffold: includes collapse/fall of scaffold

18. fall from/with bucket (aerial lift/basket): includes collapse/fall of bucket

19. fall from/with structure (other than roof): fall through opening in the side or through the floor (not opening in the floor) and with the structure in a collapse

    a. fall with collapse of structure

20. fall from/with platform or catwalk (attached to structure: includes collapse/fall of platform)

21. fall through opening (other than roof): falls through stairwells, equipment openings, or other openings in a floor

22. fall, other or unknown

23. fire/explosion/scalding, excluding electrical burns/explosions

24. heat/hypothermia

25. lifting operations: failure of equipment, inappropriate lifting, and all loading and unloading by crane operations except electrocution. (Includes objects falling and striking victim during lifting operation)

26. struck by falling object/projectile (including tip-over): does not include collapse of structure, trench, earthen wall, or lifting operations

27. trench collapse: includes earthen wall

28. unloading-loading equipment/material (except by crane): includes slipping and tipping over of construction equipment/material while loading and unloading

29. lightning

30. crushed

31. unknown cause or other

    a. other

APPENDIX B

Figure B1. Comparison of Construction Fatality Events, 1995-2009 with 2010

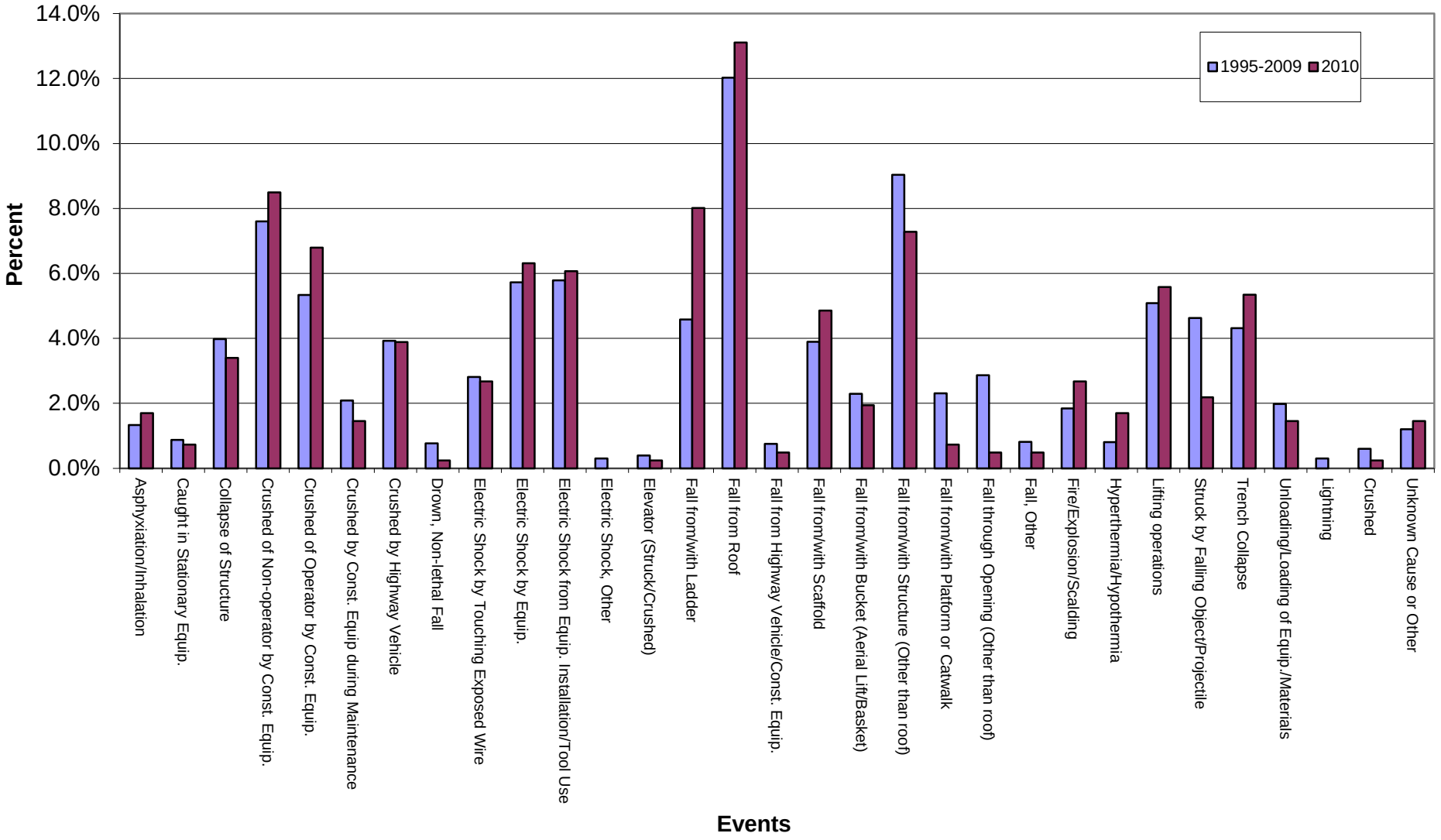


Figure B2. Comparison of Construction Fatality Events, 2010

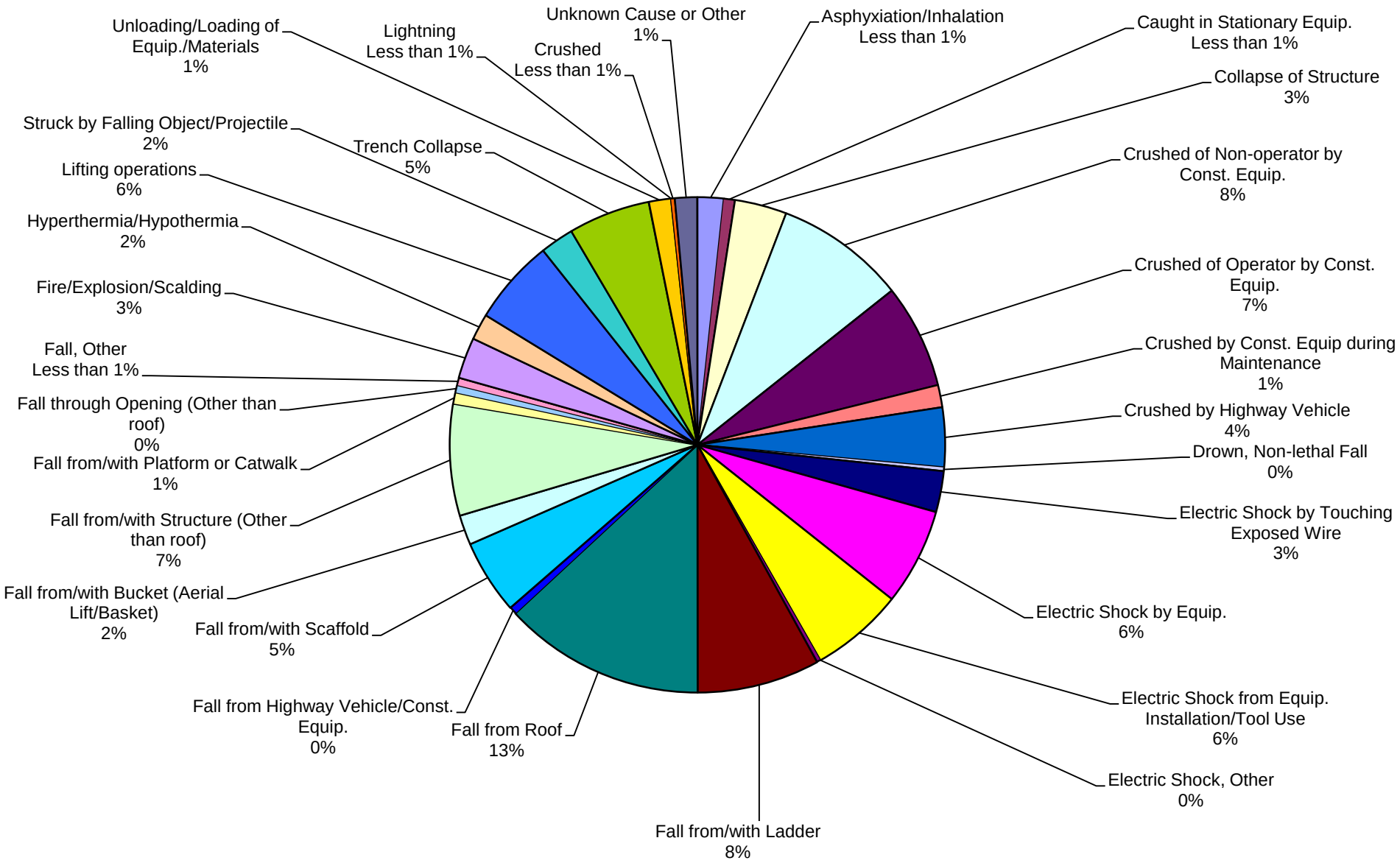


Figure B3. Comparison of Construction Fatality Events, 1995-2009

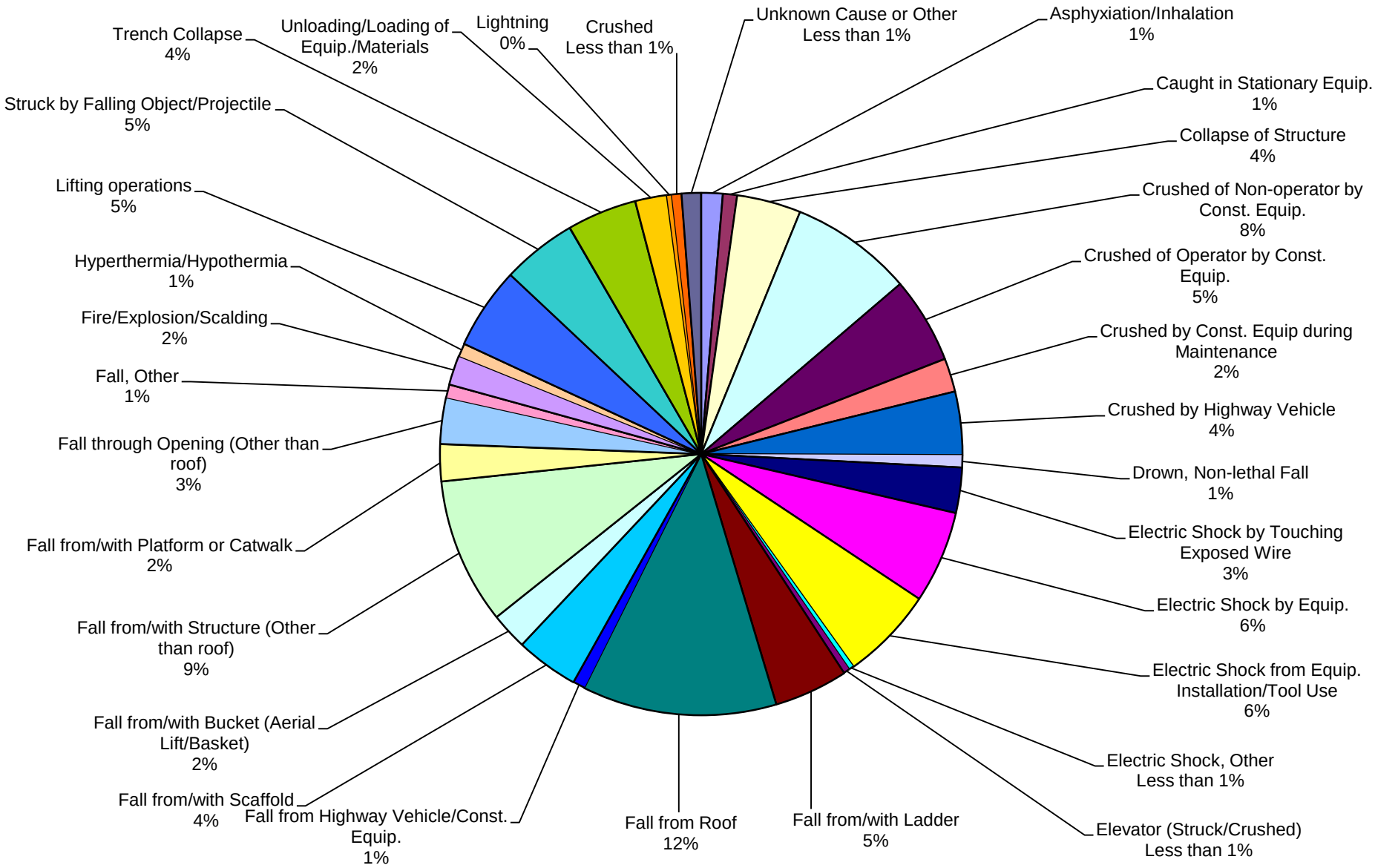
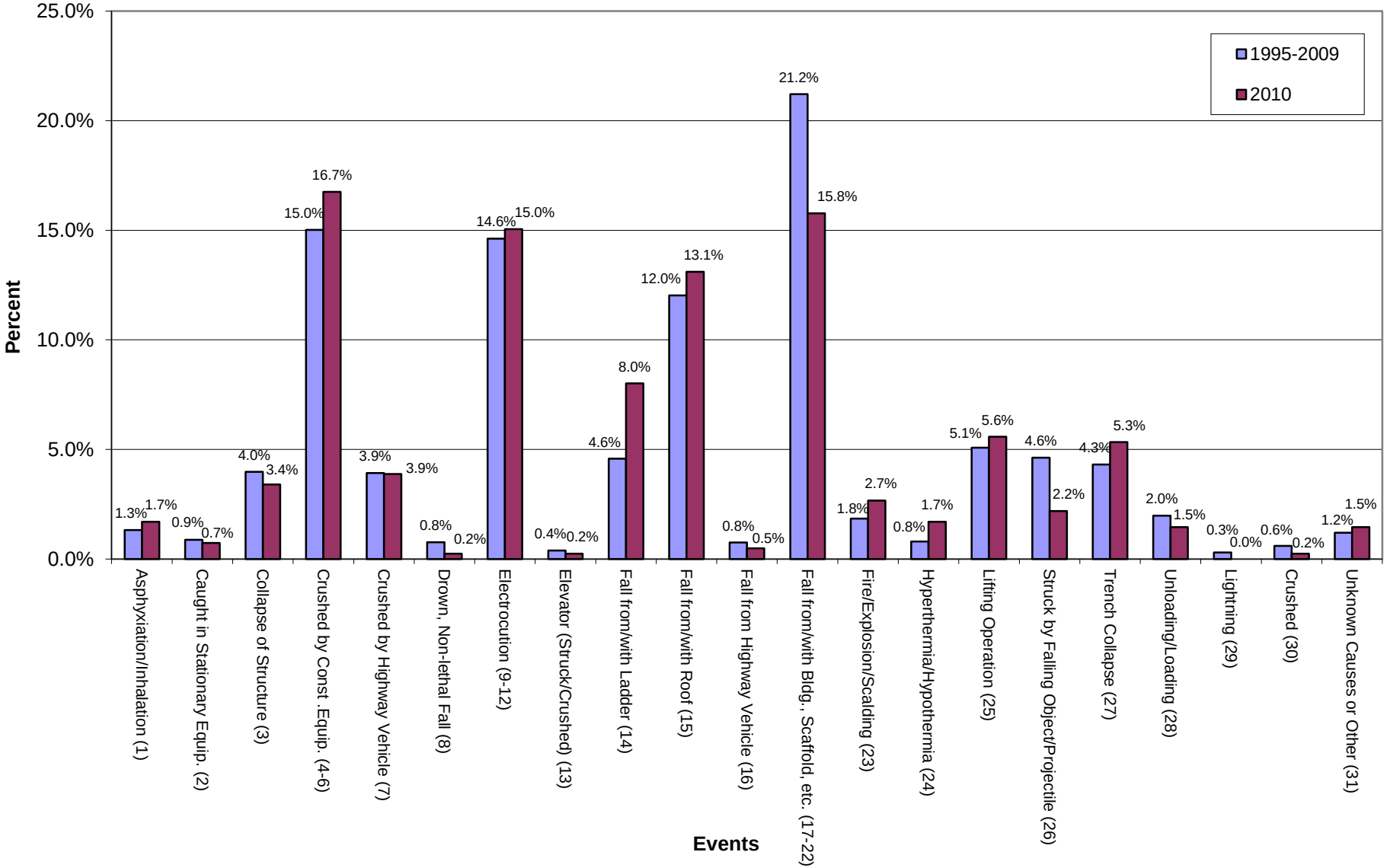


Figure B4. Comparison of Construction Fatal Events, 1995-2009 and 2010



APPENDIX C

Table C1. Construction Fatal Events by End-Use Type, 2010

End Use Type	Description	Number of Events	Percent
1	Single Family or Duplex	85	20.6
2	Multi-family	23	5.6
3	Commercial	92	22.3
4	Manufacturing	14	3.4
5	Refinery	5	1.2
6	Powerplant	6	1.5
7	Sewer or Water Plant	20	4.8
8	Other Building	47	11.4
9	Highway/Road Work	48	11.6
10	Bridge	12	2.9
11	Tower, Tank, Storage Elevator	13	3.2
12	Shoreline, Dam, Reservoir	3	0.7
13	Pipeline	8	1.9
14	Excavation, Landfill	6	1.5
15	Powerline, Transmission Line	12	2.9
16	Other Heavy Construction	10	2.4
17	Contractors Yard	3	0.7
18	Unknown	5	1.2
	Total	**412**	**100.0**

Table C2. Construction Fatal Events by Type of Project, 2010

Project Type	Description	Number of Events	Percent
1	New, Addition and Alteration	268	65.0
2	Maintenance, Repair and Demolition	122	29.6
3	Other	17	4.1
4	Missing	5	1.2
Total		**412**	**100.0**

Table C3. Construction Fatal Events by Four-Digit SIC, 2010

Description	SIC	Number of Events	Percent
General Contractors - Single Family Houses	1521	15	3.6
General Contractors - Residential Buildings Other than Single Family	1522	5	1.2
General Contractors - Industrial Building and Warehouses	1541	7	1.7
General Contractors - Non-residential Buildings, other than Industrial and Warehouse	1542	18	4.4
Highway and Street Construction, Except Elevated Highways	1611	39	9.5
Bridge, Tunnel, and Elevated Highway Construction	1622	7	1.7
Water, Sewer, Pipeline, and Communications and Power Line Construction	1623	34	8.2
Heavy Construction, Not Elsewhere Classified	1629	20	4.8
Plumbing, Heating and Air-Conditioning	1711	31	7.5
Painting and Paper Hanging	1721	21	5.1
Electrical Work	1731	37	9.0
Masonry, Stone Setting, and Other Stone Work	1741	14	3.4
Plastering, Drywall, Acoustical, and Insulation Work	1742	3	0.7
Terrazzo, Tile, Marble, and Mosaic Work	1743	1	0.2
Carpentry Work	1751	10	2.4
Roofing, Siding, and Sheet Metal Work	1761	51	12.4
Concrete Work	1771	16	3.9
Water Well Drilling	1781	3	0.7
Structural Steel Erection	1791	19	4.6
Glass and Glazing Work	1793	1	0.2
Excavation Work	1794	19	4.6
Wrecking and Demolition Work	1795	10	2.4
Installation or Erection of Building Equipment, Not Elsewhere Classified	1796	6	1.5
Special Trade Contractors, Not Elsewhere Classified	1799	25	6.1
Total		**412**	**100.0**

Table C4. Construction Fatal Events by Project Value, 2010

Project Value Code	Cost	Number of Events	Percent
1	Under $50,000	157	38.1
2	$50,000-$250,000	63	15.3
3	$250,000-$500,000	55	13.4
4	$500,000-$1,000,000	34	8.2
5	$1,000,000-$5,000,000	53	12.9
6	$5,000,000-$20,000,000	27	6.6
7	$20,000,000 and over	18	4.4
8	Unknown	5	1.2
	Total	**412**	**100.0**

Table C5. Construction Fatalities by Construction Operation, 2010

Code	Description	Number of Fatalities	Percent of Fatalities
01	Backfilling and compacting	14	3.4
02	Bituminous concrete placement	1	0.2
03	Construction of playing fields, tennis courts	1	0.2
04	Cutting concrete pavement	1	0.2
05	Demolition	21	5.1
06	Dredging	0	0.0
07	Elevator, escalator installation	1	0.2
08	Emplacing reinforcing steel	3	0.7
09	Erecting structural steel	8	1.9
10	Erection of coffer dams, caissons	0	0.0
11	Excavation	20	4.8
12	Exterior masonry	14	3.4
13	Exterior cladding	1	0.2
14	Exterior carpentry	14	3.4
15	Exterior painting	19	4.6
16	Fencing, installing lights, signs, etc.	7	1.7
17	Fireproofing	0	0.0
18	Forming	5	1.2
19	Forming for Piers or Pylons	0	0.0
20	Installing interior walls, ceilings, doors	2	0.5
21	Installing metal siding	7	1.7
22	Installing windows and doors, glazing	0	0.0
23	Installing culverts and incidental drainage	3	0.7
24	Installing equipment (HVAC and other)	26	6.3
25	Installing plumbing, lighting fixtures	12	2.9
26	Installing underground plumbing conduit	5	1.2
27	Interior Tile Work (ceramic, vinyl, acoustic)	1	0.2
28	Interior masonry	1	0.2
29	Interior plumbing, ducting, electrical work	11	2.7
30	Interior carpentry	4	1.0
31	Interior painting and decorating	2	0.5
32	Landscaping	3	0.7
34	Paving	16	3.9
35	Pile driving	4	1.0
37	Placing bridge girders and beams	3	0.7
38	Plastering	3	0.7
39	Pouring or installing floor decks	1	0.2
40	Pouring concrete floor at grade	4	1.0
41	Pouring concrete for piers and pylons	3	0.7
42	Pouring concrete foundations and walls	6	1.5

Table C5. Construction Fatalities by Construction Operation, 2010 (continued)

Code	Description	Number of Fatalities	Percent of Fatalities
43	Roofing	44	10.7
44	Seawall construction, riprap placement	1	0.2
45	Site clearing and grubbing	7	1.7
46	Site grading and rock removal	9	2.2
47	Stripping and curing concrete	0	0.0
48	Surveying	3	0.7
49	Swimming pool construction	2	0.5
50	Temporary work (buildings, facilities)	12	2.9
51	Traffic protection	9	2.2
52	Trenching, installing pipe	15	3.6
53	Waterproofing	3	0.7
54	Steel Erection of Solid Web-Connecting	1	0.2
56	Steel Erection, Solid Web-Welding	1	0.2
57	Steel Erection, Solid Web – Plumbing up	1	0.2
59	Steel Erection, Solid Web - Hoisting	1	0.2
60	Steel Erection of Open Web Steel Joist - Connecting	1	0.2
62	Steel Erection of Open Web Steel Joists-Welding	1	0.2
65	Steel Erection of Open Web Steel Joists-Hoisting	1	0.2
66	Installation of Decking-Initial Laying Deck (Including Layout & Safety)	2	0.5
67	Installation of Decking-Final Attachment Deck (Welding/Shear Studs/Etc)	0	0.0
70	Other Activities-Installing Ornamental and Architectural Steel	4	1.0
71	Other Activities-Post Decking Detail Work	3	0.7
00	Unknown/Missing	44	10.7
	Total	**412**	**100.0**