

AN ANALYSIS OF FATAL EVENTS IN THE CONSTRUCTION INDUSTRY 2009

**Prepared for: Office of Statistical Analysis
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This report is based upon OSHA-inspected fatal events in construction during calendar 2009. 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 II 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 470 fatal construction incidents (excluding non-work related causes), involving 478 fatalities, in calendar year 2009. Seven of the 30 proximal causes classified in this report accounted for 244 (51.9 percent) of the fatal events investigated. They were: (1) “fall from/through roof”: 55 events (11.7 percent); (2) “fall from/with structure”: 37 events (7.9 percent); (3) “fall from/with ladder”: 33 events (7.0 percent); (4) “electric shock from equipment installation/tool use”: 32 events (6.8 percent); (5) “fall from/with scaffold”: 30 events (6.4 percent); (6) “crushed/run-over of non-operator of construction equipment”: 29 events (6.2 percent); and (7) “crushed/run-over/trapped of operator of construction equipment”: 28 events (6.0 percent).

A comparison of the year-to-year ranks of the proximal causes during the 1991-2009 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 (1.3 percent) of the events were multi-fatality events which accounted for 14 (3.0 percent) of the fatalities.

Other findings included:

- **Initiation.** In 270 (57.4 percent) of the fatal events the victim was judged to be the primary initiator of the cause; in 150 events (31.9 percent) the victim was judged to be simply in the wrong place at the wrong time; in 30 events (6.4 percent) another employee was judged to be the primary initiator of the cause; 17 events (3.6 percent) could not be classified; and in 3 events (0.6 percent) the victim and another employee were judged to be primary initiator of the cause.

- Task. In 456 of the events (97.0 percent) the victim was judged to be performing work at the task site when injured; in 8 events (1.7 percent) the victim was going to or from work or not working when injured; and in 6 events (1.3 percent) no classification was possible.
- Timing. More fatal events happened on Tuesday with 106 events (22.6 percent) occurring that day of the week, followed by Monday and Wednesday, each with 82 events (17.4 percent) occurring on these days; and more fatal events happened between the 14 and 15 hours (2:00 pm and 3:00 pm) with 62 events (13.2 percent) occurring during this time interval, followed by 13 and 14 hours (1:00 pm and 2:00 pm) with 59 events (12.6 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 57 fatal events was “crushed/run-over by highway vehicle” accounting for 20 events (35.1 percent). The leading contributing cause of these 20 events was highway vehicles losing control and swerving into highway/road work sites, striking workers accounting for 8 of the 20 events (40.0 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 2009. Sixteen earlier studies¹ 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 2008.

II. Data

The data analyzed in this report, provided by OSHA from Form 170's, consist of narrative descriptions of the 470 fatal events inspected by OSHA which led to the 478 fatalities in construction during calendar year 2009. 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 Plans².

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) and An Analysis of Fatal Events in the Construction Industry, 2008 (2010). 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.

2008 these fatalities accounted for about 3.6 percent of OSHA-inspected fatal construction events but about 6.0 percent in 2009. 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 2009, 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 (55 or 11.7 percent of total fatal events), followed by “fall from/with structure (other than roof)” (37 or 7.9 percent). The third leading cause was “fall from/with ladder” (33 or 7.0 percent); the fourth leading cause was “electric shock from equipment installation/tool use” (32 or 6.8 percent); the fifth leading cause was “fall from/with scaffold” (30 or 6.4 percent); the sixth leading cause was “crushed/run-over of non-operator by operating construction equipment” (29 or 6.2 percent); and the seventh leading cause was “crushed/run-over/ trapped of operator of construction equipment” (28 or 6.0 percent). The number and relative frequencies of the remaining causes of the 470 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, 2009

Event Causes	Description	Number of Events and Victims		Percent of Events
		Events	Victims	
1.	asphyxiation/inhalation of toxic vapor	2	2	0.4
2.	caught in/struck by stationary equipment	2	2	0.4
3.	crushed from collapse of structure	20	20	4.3
4.	crushed/run-over of non-operator by operating construction equipment	29	29	6.2
5.	crushed/run-over/trapped of operator by operating construction equipment	28	29	6.0
6.	crushed/run-over by construction equipment during maintenance/modification	11	11	2.3
7.	crushed/run-over by highway vehicle/non-construction equipment	27	29	5.7
8.	drown, non-lethal fall	4	4	0.9
9.	electric shock by touching exposed wire	11	11	2.3
10.	electric shock by equipment contacting power source	16	16	3.4
		<u>Event</u>	<u>Percent</u>	
a.	ladder	2	0.4	
b.	scaffold	1	0.2	
c.	crane/lifting equipment/boom/dump truck	7	1.5	
d.	contact while handling materials such as gutters, iron rods, etc.	6	1.3	
11.	electric shock from equipment installation/tool use	32	32	6.8
12.	electric shock, other	3	3	0.6
13.	elevator (struck/crushed by elevator or counter weights)	0	0	0.0
14.	fall from/with ladder: includes collapse/fall of ladder	33	33	7.0
15.	fall from/through roof	55	55	11.7
		<u>Event</u>	<u>Percent</u>	
a.	fall off of roof	35	7.4	
b.	fall through roof other than skylight	8	1.7	
c.	fall through skylight or other opening	12	2.6	
16.	fall from highway vehicle/construction equipment	4	4	0.9
17.	fall from/with scaffold	30	32	6.4
18.	fall from/with bucket (aerial lift/basket)	15	15	3.2
19.	fall from/with structure (other than roof)	37	38	7.9
		<u>Event</u>	<u>Percent</u>	
a.	fall with collapse of structure	9	1.9	
20.	fall from/with platform or catwalk	5	5	1.1
21.	fall through opening (other than roof)	12	12	2.6

Table 1. Construction Fatality Event Causes, 2009 (continued)

Event Causes	Description	Number of Events and Victims		Percent of Events
		Events	Victims	
22.	fall, other or unknown	2	2	0.4
23.	fire/explosion/scalding	4	6	0.9
24.	hyperthermia/hypothermia	9	9	1.9
25.	hit, crushed, fall during lifting operations	24	24	5.1
26.	struck by falling object/projectile (including tip-over)	24	24	5.1
27.	crushed/suffocation from trench collapse	17	17	3.6
28.	crushed while unloading-loading equipment/material (except by crane)	5	5	1.1
29.	shock/burn from lightning	1	1	0.2
30.	crushed other	2	2	0.4
31.	unknown cause or other	6	6	1.3
		<u>Event</u>	<u>Percent</u>	
a.	Other	0	0.0	
Total		470	478	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.

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.

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

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.

Fall from/with scaffold. A worker moving on a scaffold missteps or steps on a loose plank and falls from the scaffold. Workers also fall from scaffolds during entry/exit and fall from/with scaffolds during assembly/disassemble.

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.

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.)

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 24 fatality causes where no event had multiple fatalities; only 5 fatality causes included events with multiple fatalities.

“Fire/explosion/scalding” was the fatality cause which had the most victims killed per event, i.e., 4 events and 6 victims or 1.5 victims per event.

The data for construction fatalities in 2009 show that 6 of the fatal events, 1.3 percent of fatal events, involved multiple fatalities. The multiple-fatality events averaged 2.3 fatalities per event and accounted for an additional 8 fatalities, 1.7 percent and a total of 14 fatalities, 2.9 percent of the 478 individuals killed in 2009.

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 was one homicide in the 2009 OSHA data. The homicide has been excluded from the analysis as in prior years.

Table 2 compares of the ranks of the causes in 2009 with the average rank of the causes of fatal events during the period 1991 - 2008. It can be seen that the overall rank pattern of the causes in 2009 is very similar to the rank pattern in 1991 – 2008. An overall statistical comparison of the correlation of the rank in 2009 with the average rank in 1991-2008 was calculated using a Spearman rank correlation procedure.⁵ The correlation obtained was + 0.89, $p < 0.001$, 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 – 2008 and 2009⁶. The Spearman rank-order correlation between 2008 and 2009 causes was calculated and found to be + 0.92, $p < .001$, indicating also that the pattern changed very little between 2008 and 2009.

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 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 have become relatively more important. Falls, as a whole, now represent 41.2 percent of construction fatalities, whereas for the 1991-2008 period they represented 37.1 percent of construction fatalities.

Table 2. Comparison of Ranks of Causes of Fatal Events in 1991 - 2008 with 2009

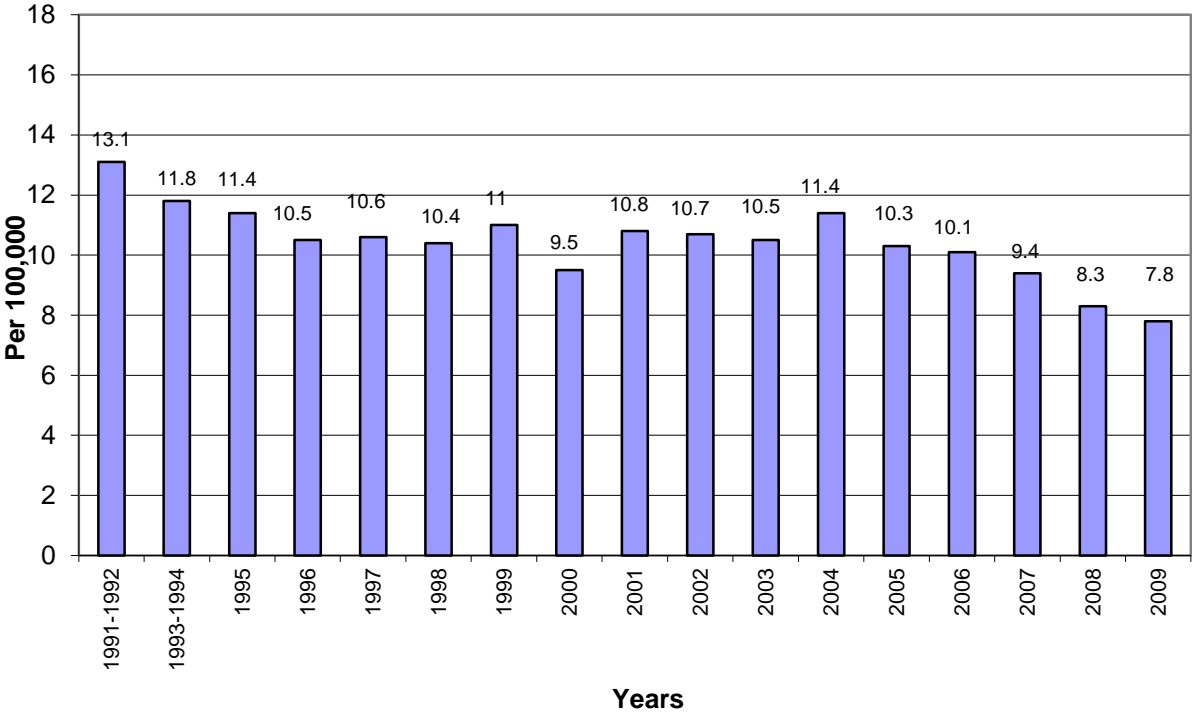
<u>Event</u>	<u>1991 - 2008 Average</u>			<u>2009</u>		
	<u>Number</u>	<u>Percent</u>	<u>Rank</u>	<u>Number</u>	<u>Percent</u>	<u>Rank</u>
1. asphyxiation/inhalation of toxic vapor	8.6	1.3	22	2	0.4	27
2. caught in/struck by stationary equipment	6.0	0.9	23	2	0.4	27
3. crushed from collapse of structure	26.7	4.1	11	20	4.3	11
4. crushed/run-over of non-operator by operating construction equipment	51.2	7.8	3	29	6.2	6
5. crushed/run-over/trapped of operator by operating construction equipment	35.4	5.4	5	28	6.0	7
6. crushed/run-over by construction equipment during maintenance/modification	13.8	2.1	19	11	2.3	16
7. crushed/run-over by highway vehicle	25.1	3.8	12	27	5.7	8
8. drown, non-lethal fall	5.7	0.9	24	4	0.9	23
9. electric shock by touching exposed wire	21.4	3.3	14	11	2.3	16
10. electric shock by equipment contacting power source	42.3	6.4	4	16	3.4	13
11. electric shock from equipment installation/tool use	33.6	5.1	7	32	6.8	4
12. electric shock, other	3.7	0.6	28	3	0.6	25
13. elevator (struck/crushed by elevator or counter weights)	2.8	0.4	29	0	0.0	29
14. fall from/with ladder: includes collapse/fall of ladder	27.9	4.3	10	33	7.0	3
15. fall from/through roof	77.0	11.7	1	55	11.7	1
16. fall from highway vehicle/construction equipment	4.9	0.8	26	4	0.9	23
17. fall from/with scaffold	23.6	3.6	13	30	6.4	5
18. fall from/with bucket (aerial lift/basket)	14.2	2.2	18	15	3.2	14
19. fall from/with structure (other than roof)	56.7	8.6	2	37	7.9	2

Table 2. Comparison of Ranks of Causes of Fatal Events in 1991 - 2008 with 2009 (continued)

<u>Event</u>	<u>1991 - 2008 Average</u>			<u>2009</u>		
	<u>Number</u>	<u>Percent</u>	<u>Rank</u>	<u>Number</u>	<u>Percent</u>	<u>Rank</u>
20. fall from/with platform or catwalk	15.6	2.4	16	5	1.1	20
21. fall through opening (other than roof)	17.8	2.7	15	12	2.6	15
22. fall, other or unknown	5.5	0.8	25	2	0.4	27
23. fire/explosion/scalding	13.2	2.0	20	4	0.9	23
24. hyperthermia/hypothermia	4.7	0.7	27	9	1.9	18
25. hit, crushed, fall during lifting operations	33.7	5.1	6	24	5.1	9
26. struck by falling object/projectile (including tip-over)	28.6	4.4	9	24	5.1	9
27. crushed/suffocation from trench collapse	29.6	4.5	8	17	3.6	12
28. crushed while unloading-loading equipment/material (except by crane)	12.8	1.9	21	5	1.1	20
29. shock/burn from lightning, other	14.3	2.2	17	9	1.9	18
Total	656.3	100.0		470	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 (1991-2009)



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 primary, immediate contributor to the event; (2) person(s) other than 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; (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 470 events: (1) victim primary initiator of event: 270 events (57.4) percent; (2) victim and another employee primary initiator: 3 events (0.6 percent); (3) person other than victim primary initiator: 30 events (6.4 percent); (4) wrong place at wrong time: 150 events (31.9 percent); and (5) unknown: 17 events (3.6 percent).

An additional classification of the 470 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) 456 (97.0 percent) of the fatal events involved workers performing work at their task site; (2) 8 (1.7 percent) of the events involved workers going to or from work or not working; and (3) 6 (1.3 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 Tuesday had the largest number of events, 106, followed by Monday and Wednesday, each with 82 events. The number of Thursday and Friday fatal events is the same for each, 77. 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, 2009

<u>Day</u>	<u>Number of Events</u>	<u>Percent</u>
Monday	82	17.4
Tuesday	106	22.6
Wednesday	82	17.4
Thursday	77	16.4
Friday	77	16.4
Saturday	33	7.0
Sunday	13	2.8
Total	470	100.0

Table 4 shows the distribution of fatal events by hour (military) of the day. It can be seen that the 14-15 hour period and the 13-14 hour period contained the most fatal events, 62 and 59, respectively. 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 177 of the fatal events occurred in the 8-12 hour period and a nearly equal number, 178, occurred in the 13-17 hour period are not surprising. Three-fourths of the fatal events occurred during these eight hours.

Table 4. Distribution of Fatal Construction Events by Hour, 2009

<u>Hour</u>	<u>Number of Events</u>	<u>Percent</u>
0-1	3	0.6
1-2	4	0.9
2-3	1	0.2
3-4	3	0.6
4-5	0	0.0
5-6	3	0.6
6-7	5	1.1
7-8	18	3.8
8-9	37	7.9
9-10	51	10.9
10-11	49	10.4
11-12	40	8.5
12-13	33	7.0
13-14	59	12.6
14-15	62	13.2
15-16	29	6.2
16-17	28	6.0
17-18	13	2.8
18-19	10	2.1
19-20	3	0.6
20-21	0	0.0
21-22	9	1.9
22-23	4	0.9
23-24	6	1.3
Total	470	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 2009, 59 workers were killed in 57 events while working on highway/road projects. On-site operating construction equipment was involved in 18 fatal events (31.6 percent).

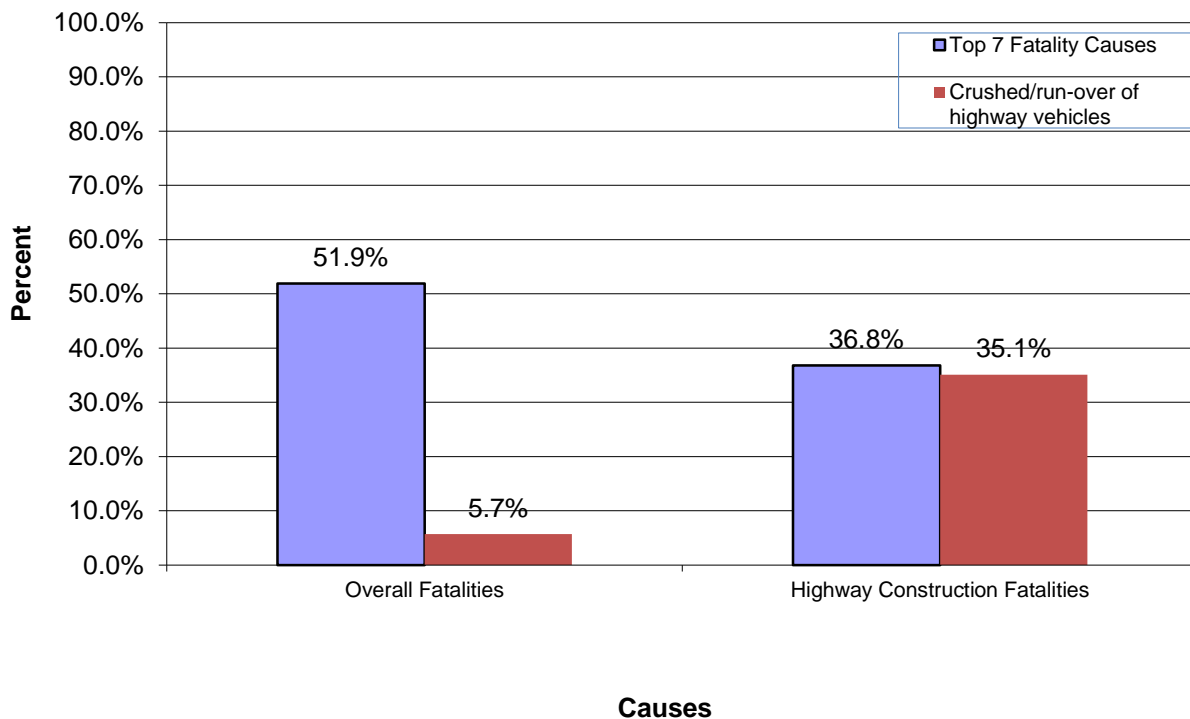
Table 5 ranks the direct causes of the fatal events by their frequency. The table shows that the leading causes were “crushed/run-over by highway vehicle” (20 events or 35.1 percent), followed by “crushed/run-over of nonoperator by operating construction equipment” (12 events or 21.1 percent), and “crushed/run-over of operator by operating construction equipment” (6 events or 10.5 percent). Other event causes are shown in Table 5.

Table 5. Frequency of Fatality Causes in Highway/Road Construction, 2009

<u>Description</u>	<u>Frequency</u>	<u>Percent</u>
Crushed/run-over by highway vehicle	20	35.1
Crushed/run-over of non-operator by operating construction equipment	12	21.1
Crushed/run-over of operator by operating construction equipment	6	10.5
Crushed/run-over by construction equipment during main/mod.	2	3.5
Crushed/suffocation from trench collapse	2	3.5
Electric shock by equipment contacting power source	2	3.5
Fall from highway vehicle/construction equipment	2	3.5
Struck by falling object/projectile	2	3.5
Electric shock from equipment installation/tool use	2	3.5
Caught in/struck by stationary equipment	2	3.5
Fall from/with structure	1	1.8
Hit/crushed/fall during lifting operation	1	1.8
Hyperthermia/Hypothermia	1	1.8
Unknown cause or other	2	3.5
Total	57	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 overall had 244 events (51.9 percent) of the total 470 events compared with only 27 events (5.7 percent) for “crushed/run-over by highway vehicle.” For highway/road construction fatal events, the top 7 fatality causes had 21 events (36.8 percent) and “crushed/run-over by highway vehicle” had 20 events (35.1 percent) of the 57 fatal events. It should be noted that the top 7 fatal event causes which accounted for over 50 percent of the total events still accounted for more than one-third of the highway/road work construction fatal events. However, the “crushed/run-over by highway vehicle” cause increased significantly from less than 6 percent overall to over 35 percent for highway/road construction.

Figure 2. Highway Construction Fatality Cause Comparison (2009)



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). It can be seen that mid-day period had the most events, 7 events (35.0 percent), followed by early morning, 4 events (20.0 percent), dawn and late-afternoon each with 3 events (15.0 percent), mid-morning with 2 events (10.0 percent) and evening with 1 event (5.0 percent).

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, 2009

<u>Time</u>	<u>Frequency</u>	<u>Percent</u>
Early Morning: 24:00 - 5:00	4	20.0
Dawn: 5:00 - 8:00	3	15.0
Mid-Morning: 8:00 - 11:00	2	10.0
Mid-Day: 11:00 - 14:00	7	35.0
Late-Afternoon: 14:00 - 17:00	3	15.0
Evening: 17:00 - 20:00	1	5.0
Late Night: 20:00 - 24:00	0	0.0
Total	20	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 seven 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, accounting for 8 (40.0 percent) of the fatal events. This sub-category was followed by the situations where flaggers were struck by highway vehicles passing work zones, representing 5 (25.0 percent) of the events and highway vehicles striking victims by entering an inadequately marked and protected work zones, representing 3 (15.0 percent) of the events. Three of the event descriptions (15.0 percent) were 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”, 2009

<u>Sub-Category</u>	<u>Frequency</u>	<u>Percent</u>
1. highway vehicle lost control and entered (by swerving or inadvertently entering) well-identified work zone, striking victim	8	40.0
2. highway vehicle struck victim installing signs or traffic signals in unprotected work zone	1	5.0
3. highway vehicle struck victim (flagger) signaling traffic at beginning of marked work zone.	5	25.0
4. highway vehicle struck victim working (paving) in unprotected work zone	0	0.0
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	0	0.0
7. highway vehicle struck victim by entering inadequately marked and protected work zone	3	15.0
8. unknown	3	15.0
Total	20	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 (1995-2008 with 2009)

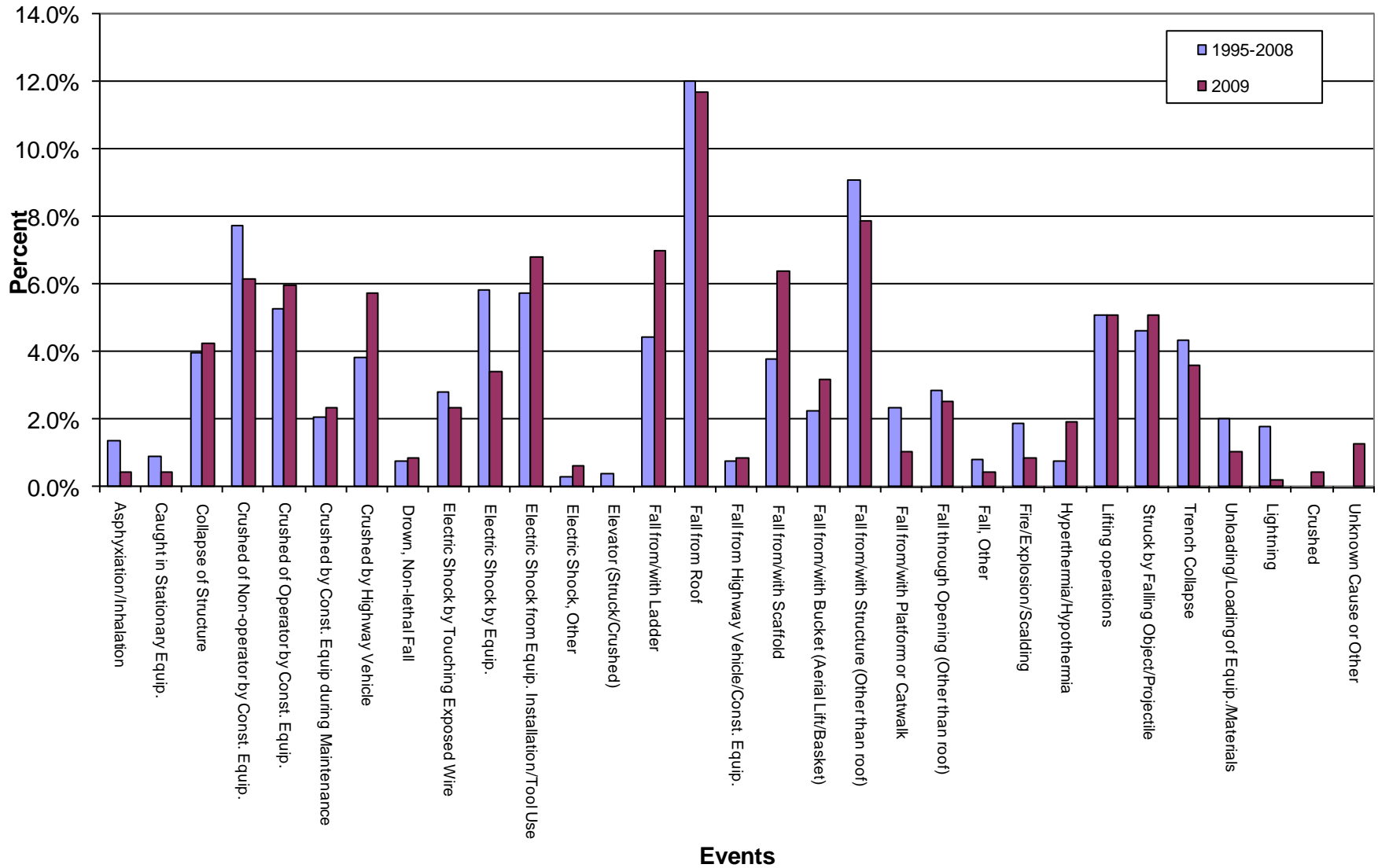


Figure B2. Comparison of Construction Fatality Events (2009)

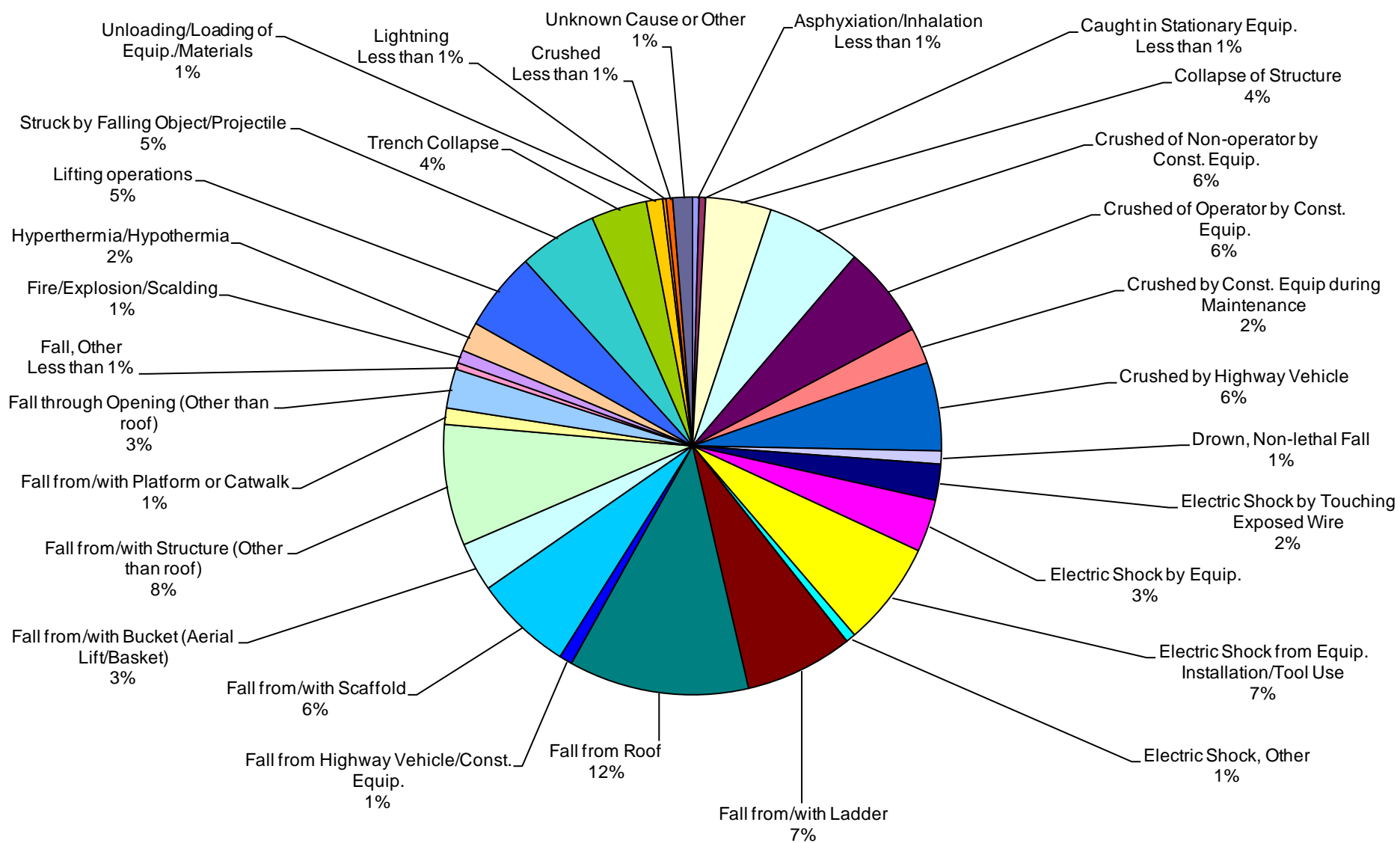


Figure B3. Comparison of Construction Fatality Events (1995-2008)

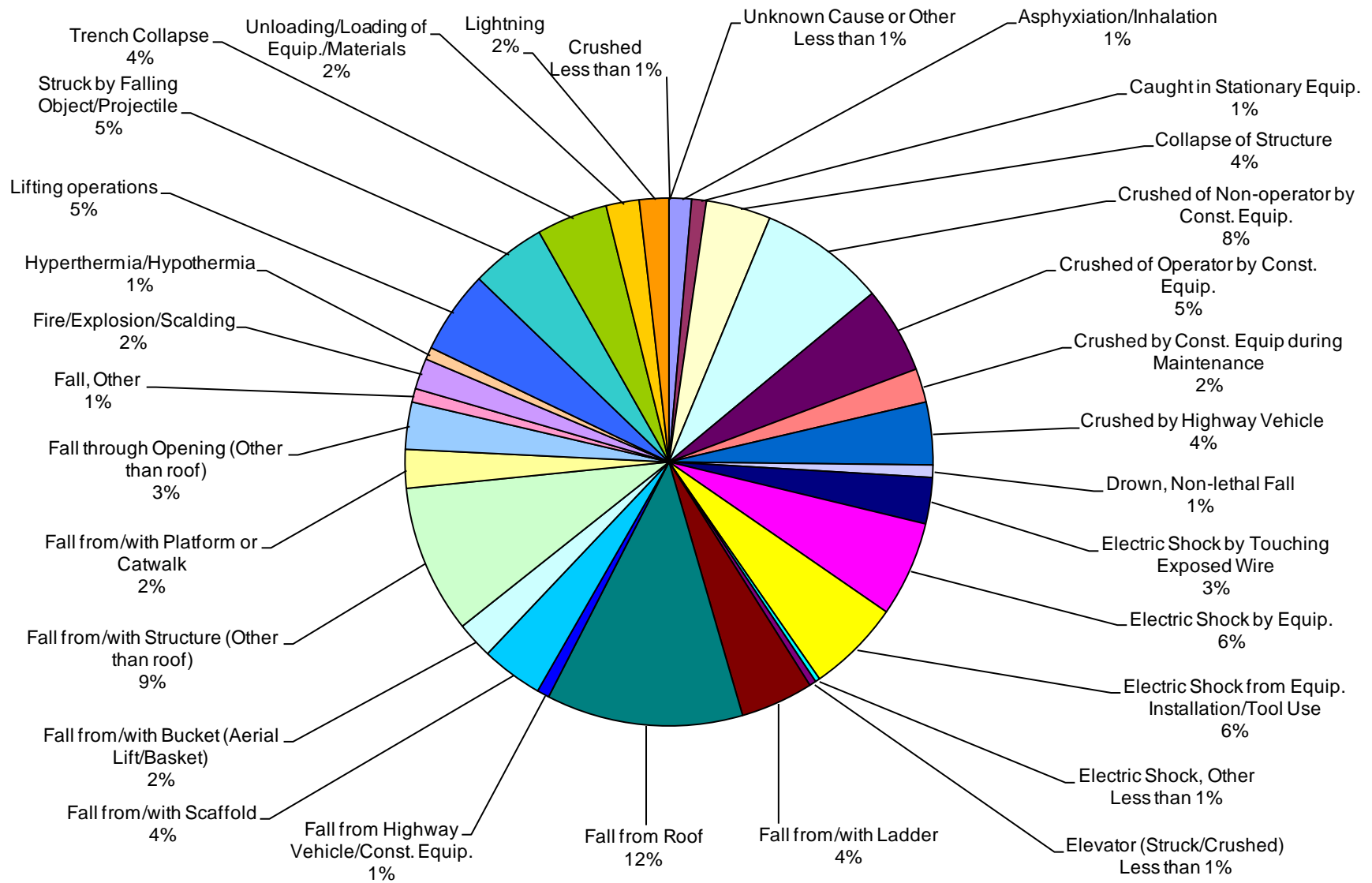
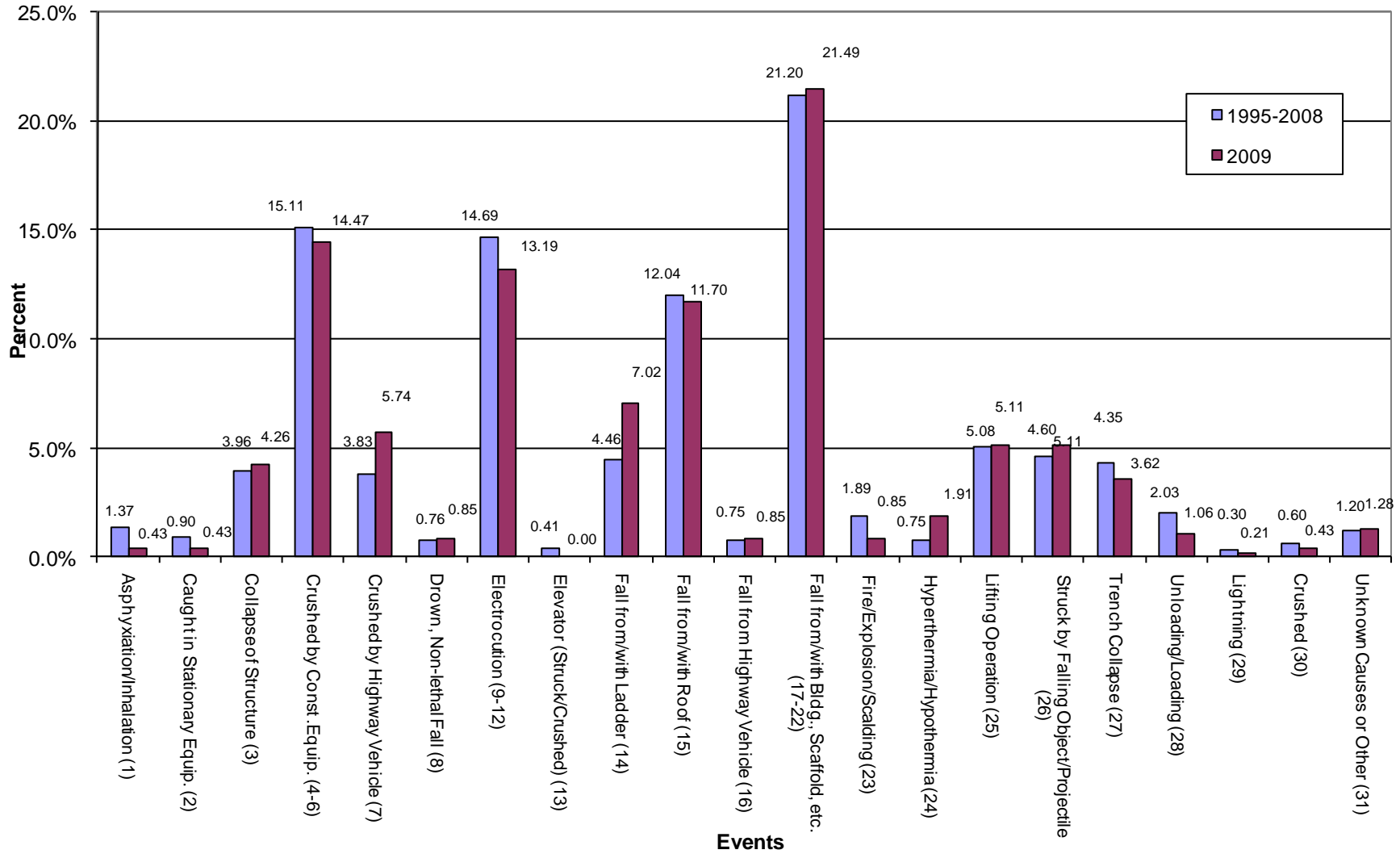


Figure B4. Comparison of Construction Fatal Events (1995-2008 and 2009)



APPENDIX C

Table C1. Construction Fatal Events by End-Use Type, 2009

<u>End Use</u> <u>Type</u>	<u>Description</u>	<u>Number of</u> <u>Events</u>	<u>Percent</u>
1	Bridge	17	3.6
2	Commercial Building	101	21.5
3	Contractor's Yard/Facility	8	1.7
4	Excavation, Landfill	7	1.5
5	Highway, Road, Street	57	12.1
6	Manufacturing Plant	25	5.3
7	Multi-Family Dwelling	31	6.6
8	Other Building	65	13.8
9	Other Heavy Construction	18	3.8
10	Pipeline	10	2.1
11	Power line, Transmission Line	11	2.3
12	Power plant	10	2.1
13	Refinery	3	0.6
14	Sewer/Water Treatment Plant	13	2.8
15	Shoreline Development, Dam, Reservoir	2	0.4
16	Single Family or Duplex Dwelling	73	15.5
17	Tower, Tank, Storage Elevator	10	2.1
18	Missing	9	1.9
	Total	470	100.00

Table C2. Construction Fatal Events by Type of Project, 2009

<u>Project Type</u>	<u>Description</u>	<u>Number of Events</u>	<u>Percent</u>
1	New, Addition and Alteration Construction	309	65.7
2	Maintenance, Repair and Demolition	125	26.6
3	Other	27	5.7
4	Missing	9	1.9
	Total	470	100.0

Table C3. Construction Fatal Events by Four-Digit SIC, 2009

<u>Description</u>	<u>SIC</u>	<u>Number of Events</u>	<u>Percent</u>
General Contractors - Single Family Houses	1521	12	2.6
General Contractors - Residential Buildings Other than Single Family	1522	8	1.7
Operative Builders	1531	1	0.2
General Contractors - Industrial Building and Warehouses	1541	7	1.5
General Contractors - Non-residential Buildings, other than Industrial and Warehouse	1542	15	3.2
Highway and Street Construction, Except Elevated Highways	1611	39	8.3
Bridge, Tunnel, and Elevated Highway Construction	1622	14	3.0
Water, Sewer, Pipeline, and Communications and Power Line Construction	1623	39	8.3
Heavy Construction, Not Elsewhere Classified	1629	23	4.9
Plumbing, Heating and Air-Conditioning	1711	22	4.7
Painting and Paper Hanging	1721	13	2.8
Electrical Work	1731	43	9.1
Masonry, Stone Setting, and Other Stone Work	1741	18	3.8
Plastering, Drywall, Acoustical, and Insulation Work	1742	8	1.7
Terrazzo, Tile, Marble, and Mosaic Work	1743	1	0.2
Carpentry Work	1751	20	4.3
Floor Laying and Other Floor Work	1752	1	0.2
Roofing, Siding, and Sheet Metal Work	1761	61	13.0
Concrete Work	1771	12	2.6
Water Well Drilling	1781	3	0.6
Structural Steel Erection	1791	22	4.7
Glass and Glazing Work	1793	3	0.6
Excavation Work	1794	18	3.8
Wrecking and Demolition Work	1795	15	3.2
Installation or Erection of Building Equipment, Not Elsewhere Classified	1796	4	0.9
Special Trade Contractors, Not Elsewhere Classified	1799	48	10.2
Total		470	100.0

Table C4. Construction Fatal Events by Project Value, 2009

<u>Project Value Code</u>	<u>Description</u>	<u>Number of Events</u>	<u>Percent</u>
1	Under \$50,000	157	33.4
2	\$50,000-\$250,000	88	18.7
3	\$250,000-\$500,000	36	7.7
4	\$500,000-\$1,000,000	45	9.6
5	\$1,000,000-\$5,000,000	65	13.8
6	\$5,000,000-\$20,000,000	34	7.2
7	\$20,000,000 and over	36	7.7
8	Missing	9	1.9
	Total	470	100.0

Table C5. Construction Fatalities by Construction Operation, 2009

<u>Code</u>	<u>Description</u>	<u>Number of Fatalities</u>	<u>Percent of Fatalities</u>
01	Backfilling and compacting	12	2.6
02	Bituminous concrete placement	1	0.2
04	Cutting concrete pavement	3	0.6
05	Demolition	29	6.2
06	Dredging	3	0.6
08	Emplacing reinforcing steel	2	0.4
09	Erecting structural steel	16	3.4
10	Erection of coffer dams, caissons	1	0.2
11	Excavation	23	4.9
12	Exterior masonry	17	3.6
13	Exterior cladding	4	0.9
14	Exterior carpentry	16	3.4
15	Exterior painting	10	2.1
16	Fencing, installing lights, signs, etc.	10	2.1
17	Fireproofing	1	0.2
18	Forming	1	0.2
19	Forming for Piers or Pylons	6	1.3
20	Installing interior walls, ceilings, doors	7	1.5
21	Installing metal siding	4	0.9
22	Installing windows and doors, glazing	7	1.5
23	Installing culverts and incidental drainage	1	0.2
24	Installing equipment (HVAC and other)	26	5.5
25	Installing plumbing, lighting fixtures	11	2.3
26	Installing underground plumbing conduit	5	1.1
27	Interior Tile Work (ceramic, vinyl, acoustic)	1	0.2
28	Interior masonry	3	0.6
29	Interior plumbing, ducting, electrical work	10	2.1
30	Interior carpentry	8	1.7
31	Interior painting and decorating	6	1.3
32	Landscaping	3	0.6
34	Paving	16	3.4
35	Pile driving	4	0.9
36	Placing bridge deck	3	0.6
38	Plastering	1	0.2
39	Pouring or installing floor decks	1	0.2
40	Pouring concrete floor at grade	4	0.9
42	Pouring concrete foundations and walls	4	0.9

Table C5. Construction Fatalities by Construction Operation, 2009 (continued)

<u>Code</u>	<u>Description</u>	<u>Number of Fatalities</u>	<u>Percent of Fatalities</u>
43	Roofing	55	11.7
45	Site clearing and grubbing	7	1.5
46	Site grading and rock removal	7	1.1
47	Stripping and curing concrete	1	0.2
48	Surveying	4	0.9
50	Temporary work (buildings, facilities)	21	4.5
51	Traffic protection	14	3.0
52	Trenching, installing pipe	17	3.6
53	Waterproofing	3	0.6
54	Steel Erection of Solid Web-Connecting	1	0.2
55	Steel Erection, Solid Web-Bolting, Detail Work	2	0.4
64	Steel Erection of Open Web Steel Joists-Moving Point to Point	1	0.2
66	Installation of Decking-Initial Laying Deck (Including Layout & Safety)	2	0.4
67	Installation of Decking-Final attachment deck (Welding/Shear Studs/Etc)	1	0.2
70	Other Activities-Installing Ornamental and Architectural Steel	6	1.3
71	Other Activities-Post Decking Detail Work	5	1.1
00	Missing	45	9.6
	Total	470	100.0