AN ANALYSIS OF FATAL EVENTS IN THE CONSTRUCTION INDUSTRY 2012

Prepared for: **Office of Statistical Analysis**
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This report is based upon OSHA-inspected fatal events in construction during calendar year 2012. The data analyzed were provided by Dave Schmidt, Director, Office of Statistical Analysis, Occupational Safety and Health Administration. John Wagner, M.S., Research Associate III conducted the study and prepared this report. The author thanks Dr. John R. Moore and Thomas E. Cressler II for their critique and suggestions which added measurably to the report. The author is solely responsible for all interpretations, conclusions and any errors found in the report.

Executive Summary

The Occupational Safety and Health Administration (OSHA) inspected 462 fatal construction incidents (excluding non-work related causes), involving 473 fatalities, in calendar year 2012. Seven of the 31 proximal causes classified in this report accounted for 251 (54.3 percent) of the fatal events investigated. They were: (1) "fall from/through roof": 61 events (13.2 percent); (2) "crushed/run-over by highway vehicle: 40 events (8.7 percent); (3) "fall from/with structure (other than roof)": 38 events (8.2 percent); (4) "fall from/with ladder": 33 events (7.1 percent); (5) "electric shock from equipment installation/tool use": 28 events (6.1 percent); (6) "crushed/run-over/trapped of operator of construction equipment": 26 events (5.6 percent); and (7) "lifting operation: failure of equipment, inappropriate lifting, all loading and unloading by crane operations": 25 events (5.4 percent).

A comparison of the year-to-year ranks of the proximal causes during the 1991-2012 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 10 (2.2 percent) of the events were multi-fatality events which accounted for an additional 11 (2.3 percent) of the fatalities.

Other findings included:

- Initiation. In 287 (62.1 percent) of the fatal events the victim was judged to be the primary initiator of the cause; in 134 events (29.0 percent) the victim was judged to be simply in the wrong place at the wrong time; in 30 events (6.5 percent) another employee was judged to be the primary initiator of the cause; in 6 events (1.3 percent) the victim and another employee were judged to be primary initiator of the cause; and 5 events (1.1 percent) could not be classified.

- Task. In 457 of the events (98.9 percent) the victim was judged to be performing work at the task site when injured; in 4 events (0.9 percent) the victim was going to or from work or not working when injured; and in 1 event (0.2 percent) no classification was possible.
- Timing. During the work week the most fatal events happened on Tuesday with 105 events (22.7 percent), followed by Wednesday with 93 events (20.1 percent) and Thursday with 86 events (18.6 percent); and the most fatal events happened between the 10^{th} and 11^{th} hour with 48 events (10.4 percent) followed by fatal events happening between the 11^{th} and 12^{th} hour with 44 events (9.5 percent).

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 51 fatal events was "crushed/run-over by highway vehicle" accounting for 24 events (47.1 percent). The leading contributing cause of these 24 events was "highway vehicle lost control and entered well-identified work zone" accounting for 9 events (42.9 percent).

Table of Contents

List of Tables in Text

List of Figures in Text

Appendices

I. Introduction

This report focuses on the direct causes of fatal events that occurred in the calendar year 2012 in the construction industry. Nineteen 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 2011.

II. Data

The data analyzed in this report, provided by OSHA, consist of fatality case file narratives and coded data of the 462 fatal events inspected by OSHA which accounted for 473 fatalities in construction during calendar year 2012. 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 provide 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, the analysis excluded non-accidental fatalities on construction sites or contractor yards (such as deaths from non-work related heart attacks, strokes, seizures,

[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), An Analysis of Fatal Events in the Construction Industry, 2009 (2011), An Analysis of Fatal Events in the Construction Industry, 2010 (2012), and An Analysis of Fatal Events in the Construction Industry, 2011 (2013). 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.

etc.) as well as fatalities of construction workers killed off-site in traffic accidents; in 1991-2011 these fatalities accounted for about 4.2 percent of OSHA-inspected fatal construction events but about 8.7 percent in 2012. 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 2012, 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 (61 or 13.2 percent of total events), followed by "crushed/run-over by highway vehicle" (40 or 8.7 percent of total events). The third leading cause was "fall from/with structure (other than roof)" (38 or 8.2 percent of total events); the fourth leading cause was "fall from/with ladder" (33 or 7.1 percent of total events); the fifth leading cause was "electric shock from equipment installation/tool use" (28 or 6.1 percent of total events); the sixth leading cause "crushed/run-over/trapped of operator of construction equipment (26 or 5.6 percent of total events); and the seventh leading cause was "lifting operation: failure of equipment, inappropriate lifting, all loading and unloading by crane operations (25 or 5.4 percent of total events). The number and relative frequencies of the remaining causes of the 462 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, 2012

Event Causes	Description	Number of Events and Victims: Events	Number of Events and Victims: Victims	Percent of Events
1.	asphyxiation/inhalation of toxic vapor	5	8	1.1
2.	caught in/struck by stationary equipment	3	3	0.6
3.	crushed from collapse of structure	19	20	4.1
4.	crushed/run-over of non-operator by operating construction equipment	22	22	4.8
5.	crushed/run-over/trapped of operator by operating construction equipment	26	26	5.6
6.	crushed/run-over by construction equipment during maintenance/modification	7	8	1.5
7.	crushed/run-over by highway vehicle/non-construction equipment	40	42	8.7
8.	drown, non-lethal fall	2	2	0.4
9.	electric shock by touching exposed wire	9	9	1.9
10.	electric shock by equipment contacting power source	23	23	5.0
		Event		Percent
	a. ladder	2		0.4
	b. scaffold	2		0.4
	c. crane/lifting equipment/boom/dump truck	9		1.9
	d. contact while handling materials such as gutters, iron rods, etc.	10		2.2
11.	electric shock from equipment installation/tool use	28	28	6.1
12.	electric shock, other	1	1	0.2
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	7.1
15.	fall from/through roof	61	61	13.2
		Event		Percent
	a. fall off of roof	38		8.2
	b. fall through roof other than skylight	7		1.5
	c. fall through skylight or other opening	16		3.5
16.	fall from highway vehicle/construction equipment	3	3	0.6
17.	fall from/with scaffold	17	17	3.7
18.	fall from/with bucket (aerial lift/basket)	11	11	2.4
19.	fall from/with structure (other than roof)	38	39	8.2
		Event		Percent
	a. fall with collapse of structure	13		2.8
20.	fall from/with platform or catwalk	5	5	1.1
21.	fall through opening (other than roof)	10	10	2.2

Table 1. Construction Fatality Event Causes, 2012 (continued)

Event Causes	Description	Number of Events and Victims: Events	Number of Events and Victims: Victims	Percent of Events
22.	fall, other or unknown	1	1	0.2
23	fire/explosion/scalding	9	11	1.9
24.	hyperthermia/hypothermia	14	14	3.0
25.	hit, crushed, fall during lifting operations	25	25	5.4
26.	struck by falling object/projectile (including tip-over)	23	23	5.0
27.	crushed/suffocation from trench collapse	12	12	2.6
28.	crushed while unloading-loading equipment/material (except by crane)	9	9	1.9
29.	shock/burn from lightning	1	1	0.2
30.	crushed other	1	1	0.2
31.	unknown cause or other	4	5	0.9

		Event	Percent
a.	Other	3	0.6

Total	**462**	**473**	**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 by Highway Vehicle. A worker working in a work zone is struck by an out-of-control highway vehicle.
>
> 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 over-reaches 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.
>
> 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.)
>
> Lifting operation: failure of equipment, inappropriate lifting, all unloading by crane operations. A worker spotting or rigging loads for a crane is struck by lifted materials/equipment or a worker is struck by a crane boom collapse.

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 7 fatality causes included events with multiple fatalities. The fatality cause with the most victims per event was “asphyxiation/inhalation of toxic vapor” with 5 events and 8 victims or 1.6 victims per event and the largest loss in a single event was 3. All other multiple fatality events had only two victims per event.

The data for construction fatalities in 2012 showed that 7 of the fatal events (1.5 percent) involved multiple fatalities. The multiple-fatality events averaged 2.1 fatalities per event and accounted for an additional 11 fatalities (2.3 percent) and a total of 21 fatalities (4.4 percent) of the 473 individuals killed in 2012.

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 2012 OSHA data. If homicides had been reported they would have been excluded from the analysis as they have been in prior years.

Table 2 compares the ranks of the causes in 2012 with the average rank of the causes of fatal events during the period 1991-2011. It can be seen that the overall rank pattern of the causes in 2012 is very similar to the rank pattern in 1991-2011. An overall statistical comparison of the correlation of the rank in 2012 with the average rank in 1991-2011 was calculated using a Spearman rank correlation procedure.[5] The correlation obtained was + 0.85, $p < 0.001$, indicating that the ranks of the causes in the two time periods are highly and positively correlated, i.e., did not change significantly between 1991-2011 and 2012[6]. The Spearman rank-

[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.

order correlation between 2011 and 2012 causes was calculated and found to be + 0.87, $p < 0.001$, indicating also that the pattern changed very little between 2011 and 2012.

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.

Falls continues to be the leading fatality cause. Falls represent 38.7 percent of 2012 construction fatal events and for the 1991-2011 period 37.2 percent of construction fatal events. Crushed/run-over by construction equipment and highway vehicles is a major cause of construction fatalities that bears watching. These fatal events were 20.2 (2009), 20.6 (2010), 22.4 (2011), and 20.6 (2012) percent of fatal construction events and for the 1991-2011 period 19.3 percent.

Table 2. Comparison of Ranks of Causes of Fatal Events in 1991 - 2011 with 2012

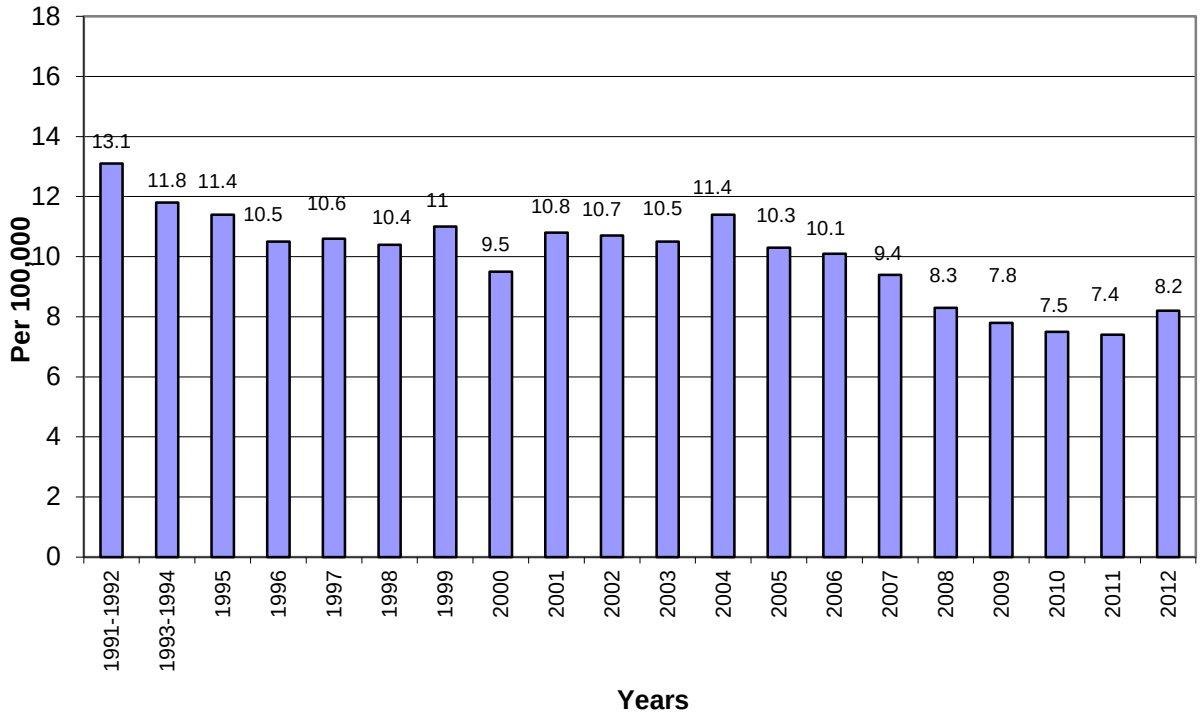
Event	1991 - 2011 Average			2012		
	Number	Percent	Rank	Number	Percent	Rank
1. asphyxiation/inhalation of toxic vapor	8.2	1.3	22	5	1.1	22
2. caught in/struck by stationary equipment	5.6	0.9	23	3	0.6	24
3. crushed from collapse of structure	25.4	4.1	11	19	4.1	11
4. crushed/run-over of non-operator by operating construction equipment	48.5	7.8	3	22	4.8	10
5. crushed/run-over/trapped of operator by operating construction equipment	34.4	5.5	5	26	5.6	6
6. crushed/run-over by construction equipment during maintenance/modification	12.8	2.0	19	7	1.5	20
7. crushed/run-over by highway vehicle	24.7	4.0	12	40	8.7	2
8. drown, non-lethal fall	5.3	0.9	24	2	0.4	26
9. electric shock by touching exposed wire	20.1	3.2	14	9	1.9	18
10. electric shock by equipment contacting power source	39.0	6.3	4	23	5.0	8
11. electric shock from equipment installation/tool use	32.3	5.2	6	28	6.1	5
12. electric shock, other	3.4	0.5	28	1	0.2	27
13. elevator (struck/crushed by elevator or counter weights)	2.6	0.4	29	0	0.0	29
14. fall from/with ladder: includes collapse/fall of ladder	28.0	4.5	8	33	7.1	4
15. fall from/through roof	74.0	11.9	1	61	13.2	1
16. fall from highway vehicle/construction equipment	4.6	0.7	27	3	0.6	24
17. fall from/with scaffold	23.5	3.8	13	17	3.7	12
18. fall from/with bucket (aerial lift/basket)	13.7	2.2	17	11	2.4	15
19. fall from/with structure (other than roof)	53.1	8.5	2	38	8.2	3

Table 2. Comparison of Ranks of Causes of Fatal Events in 1991 - 2011 with 2012 (continued)

Event	1991 - 2011 Average			2012		
	Number	Percent	Rank	Number	Percent	Rank
20. fall from/with platform or catwalk	13.8	2.2	16	5	1.1	22
21. fall through opening (other than roof)	16.1	2.6	15	10	2.2	16
22. fall, other or unknown	5.1	0.8	26	1	0.2	27
23. fire/explosion/scalding	12.5	2.0	20	9	1.9	18
24. hyperthermia/hypothermia	5.3	0.8	24	14	3.0	13
25. hit, crushed, fall during lifting operations	31.7	5.1	7	25	5.4	7
26. struck by falling object/projectile (including tip-over)	27.0	4.3	10	23	5.0	8
27. crushed/suffocation from trench collapse	27.9	4.5	9	12	2.6	14
28. crushed while unloading-loading equipment/material (except by crane)	11.7	1.9	21	9	1.9	18
29. shock/burn from lightning, other	13.5	2.2	18	6	1.3	21
Total	**623.9**	**100.0**		**462**	**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 (1991-2012)



The number of fatal events per 100,000 construction establishment employees declined for the previous seven years. The number of fatal events per 100,000 construction establishment employees increased from 7.4 in 2011 to 8.2 in 2012.

[7] Bureau of Labor Statistics, National Employment, Hours, and Earnings, CES, Table B-1 www.bls.gov/ces/cesbtabs.htm

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) a combination of victim(s) and another employee was (were) the primary (3) person(s) other than victim(s) was (were) the primary, immediate contributor to the event; (4) no individual directly contributed to the event, i.e., the victim(s) was at the wrong place at the wrong time; and (5) 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 non-operators, 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 462 events: (1) victim primary initiator of event: 287 events (62.1 percent); (2) victim and another employee primary initiator: 6 events

(1.3 percent); (3) person other than victim primary initiator: 30 events (6.5 percent); (4) wrong place at wrong time: 134 events (29.0 percent); and (5) unknown: 5 events (1.1 percent).

An additional classification of the 462 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) 457 (98.9 percent) of the fatal events involved workers performing work at their task site; (2) 4 (0.9 percent) of the events involved workers going to or from work or not working; and (3) 1 (0.2 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 from the narratives 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, 105 (22.7 percent) followed by Wednesday with 93 events (20.1 percent), Thursday with 86 events (18.6 percent), and finally Monday with 84 fatal events (18.2 percent). 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, 2012

Day	Number of Events	Percent
Monday	84	18.2
Tuesday	105	22.7
Wednesday	93	20.1
Thursday	86	18.6
Friday	57	12.3
Saturday	26	5.6
Sunday	11	2.4
Total	**462**	**100.0**

Table 4 shows the distribution of fatal events by hour (military) of the day. It can be seen that the 10-11 hour period contained the most fatal events, 48 (10.4 percent). 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 168 (36.4 percent) of the fatal events occurred in the 8-12 hour period and 139 (30.1 percent) occurred in the 13-17 hour period is a little surprising. In prior years with the exception of 2011 and 2004, the number of fatal events has been approximately equal for each four hour period.

Two-thirds (66.4 percent) of the fatal events occurred during 8-12 hour period and the 13-17 hour period. This is a little surprising because in the prior nine years the percent of fatal events during these eight hours has ranged from 72.6 to 77.9 percent with a median of 75.0 percent.

Table 4. Distribution of Fatal Construction Events by Hour, 2012

Hour	Number of Events	Percent
0–1	2	0.4
1–2	2	0.4
2–3	5	1.1
3–4	2	0.4
4–5	4	0.9
5–6	4	0.9
6–7	6	1.3
7–8	16	3.5
8–9	35	7.6
9–10	41	8.9
10–11	48	10.4
11–12	44	9.5
12–13	24	5.2
13–14	40	8.7
14–15	37	8.0
15–16	33	7.1
16–17	29	6.3
17–18	11	2.4
18–19	6	1.3
19–20	9	1.9
20–21	1	0.2
21–22	3	0.6
22–23	1	0.2
23–24	8	1.7
Unknown	51	11.0
Total	**462**	**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 2012, 53 workers were killed in 51 events while working on highway/road projects (11.0 percent of the total fatal events). On-site operating construction equipment was involved in 10 fatal events (2.2 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" 24 events (47.1 percent), followed by "crushed/run-over of non-operator by operating construction equipment" and "crushed/run-over of operator by operating construction equipment" each with 5 events (9.8 percent) and "fall from/with collapse of structure" 4 events (7.8 percent). Other event causes are shown in Table 5.

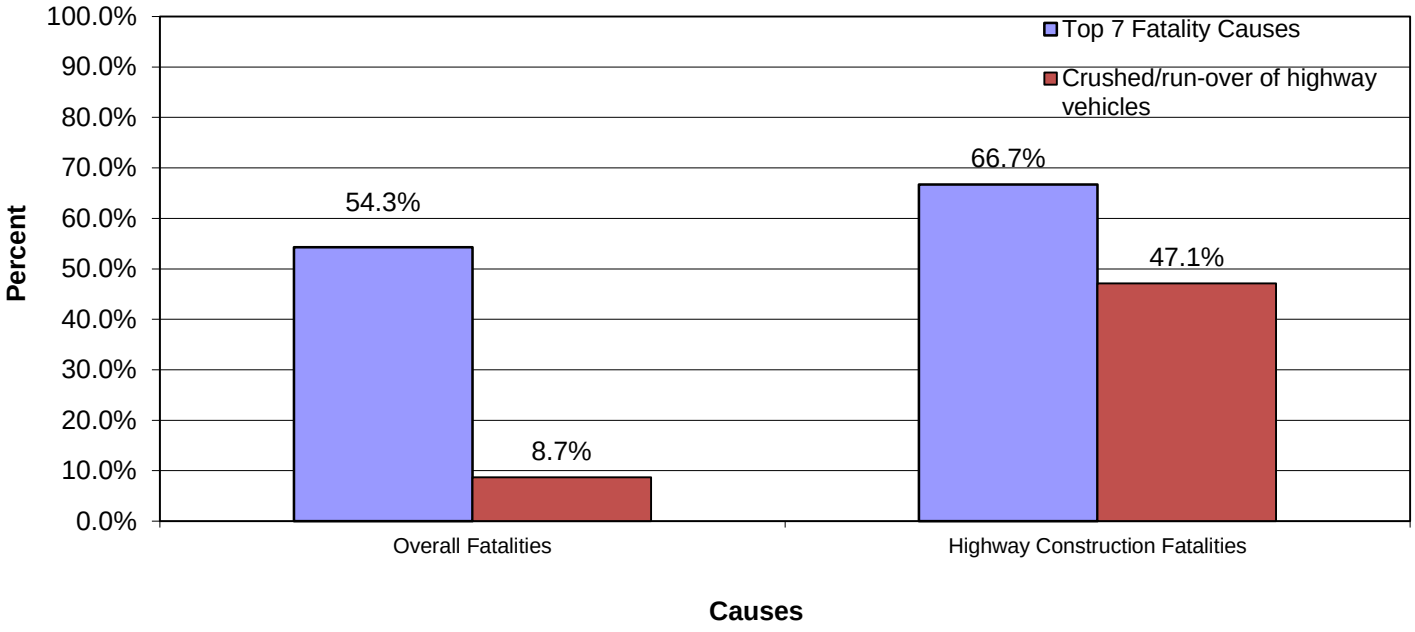
Table 5. Distribution of Fatality Causes in Highway/Road Construction, 2012

Cause	Number of Events	Percent
Crushed/run-over by highway vehicle	24	47.1
Crushed/run-over of non-operator by operating construction equipment	5	9.8
Crushed/run-over of operator by operating construction equipment	5	9.8
Fall from/with collapse of structure	4	7.8
Crushed while unloading-loading equipment/material	3	5.9
Electric shock by equipment contacting power source	3	5.9
Fall from highway vehicle/construction equipment	2	3.9
Struck by falling object/projectile	1	2.0
Hyperthermia/Hypothermia	1	2.0
Crushed/run-over by construction equipment during main/mod.	1	2.0
Lifting operation-equipment failure, inappropriate lifting	1	2.0
Fall from/with bucket	1	2.0
Total	**51**	**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 251 events (54.3

percent) of the total 462 events compared with only 40 events (8.7 percent) for "crushed/run-over by highway vehicle." For highway/road construction fatal events, the top 7 fatality causes (shown in Table 5) had 46 events (90.2 percent) and "crushed/run-over by highway vehicle" had 24 events (47.1 percent) of the 51 fatal events. It should be noted that the top 7 fatal event causes which accounted for over 54.3 percent of the total events also accounted for 66.7 percent of the highway/road work construction fatal events. However, the "crushed/run-over by highway vehicle" cause increased significantly from 8.7 percent overall to over 47.1 percent for highway/road construction.

Figure 2. Highway Construction Fatality Cause Comparison (2012)



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 crushed/run-over by highway

vehicles by time of day (1-24 hours). For the previous six years, 2006 through 2011, a majority, ranging from 47 percent to 80 percent, of the construction fatalities caused by "crushed/run-over by highway vehicle" have occurred from mid-morning through late-afternoon (8-17 hour period) excluding the two unknowns from the calculation. This year 47 percent of the fatalities occurred during these hours and 37 percent of the fatalities occurred between late night (20-24 hour period) and early morning (24-5 hour period). For the previous six years, 2006 through 2011, the late night and early morning period fatalities rose from 7 percent to 29 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, 2012

Time	Frequency	Percent
Early Morning: 24:00 - 5:00	4	19.0
Dawn: 5:00 - 8:00	2	19.5
Mid-Morning: 8:00 - 11:00	5	23.8
Mid-Day: 11:00 - 14:00	2	9.5
Late-Afternoon: 14:00 - 17:00	2	9.5
Evening: 17:00 - 20:00	1	4.8
Late Night: 20:00 - 24:00	3	14.3
Unknown	2	9.5
Total	**21**	**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 to look for specific situations in which these fatalities occurred. The often brief narratives of highway construction fatalities 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.

Table 7. Frequency of Sub-Categories of "Crushed/Run-Over by Highway Vehicle", 2012

Sub-Category	Frequency	Percent
Highway vehicle lost control and entered (by swerving or inadvertently entering) well-identified work zone, striking victim	9	42.9
Highway vehicle struck victim installing signals in unprotected work zone.	3	14.3
Highway vehicle struck victim who walked into traffic zone	3	14.3
Highway vehicle struck victim (flagger) signaling traffic at beginning of marked work zone	2	9.5
Highway vehicle struck victim working (paving) in unprotected work zone	2	9.5
Highway vehicle struck shadow vehicle protecting moving vehicle from which victim was performing work, crushing victim	1	4.8
unknown	1	4.8
Total	**21**	**100.0**

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 9 (42.9 percent) of the fatal events. This sub-category was followed by situations where a highway vehicle struck a victim installing signals in an unprotected work zone and a highway vehicle struck a victim who walked into the traffic zone, each accounting for 3 (14.3 percent) of the fatal events. Highway vehicles striking a flagger signaling traffic at the beginning of a marked work zone and highway vehicles striking a victim working paving in an unprotected zone, each accounted for 2 (9.5 percent) of the fatal events. Five (25 percent) of the fatal events that could be classified occurred in unprotected work zones. These fatal events may have been avoided by marking the work zones.

Observation

The quality of the descriptions and information about the 2012 fatal events has deteriorated compared to 2011 and earlier years. Previously we have commented about the descriptive statements often not including sufficient detail to clearly identify the root cause of a fatal event; in some cases only a one or two word comment, e.g. run-over, died, fell off building. Inadequate descriptions have become more frequent.

However, this year, 2012, the number of missing data elements has increased dramatically. The project value of the construction activity was missing in 29 percent of the fatal events compared to 7 percent in 2011; the construction operation being performed was missing in 25 percent of the fatal events compared to 13 percent in 2011; the end-use type of the construction project was missing in 16 percent of the fatal events compared to 3 percent in 2011; the type of project was missing in 14 percent of fatal events compared to 3 percent in 2011; and the time of day of the fatal events was missing in 11 percent of the fatal events compared to 2 percent in 2011.

Road work seems to be shifting to times when there is less traffic, generally in the late evening and early morning hours. The hour of a fatal event is especially important in assessing the impact of this change in road work patterns; however, more than 9 percent of the time the fatal event time was missing compared to none missing in 2011.

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. hyperthermia/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 Fatal Events (1995-2011 with 2012)

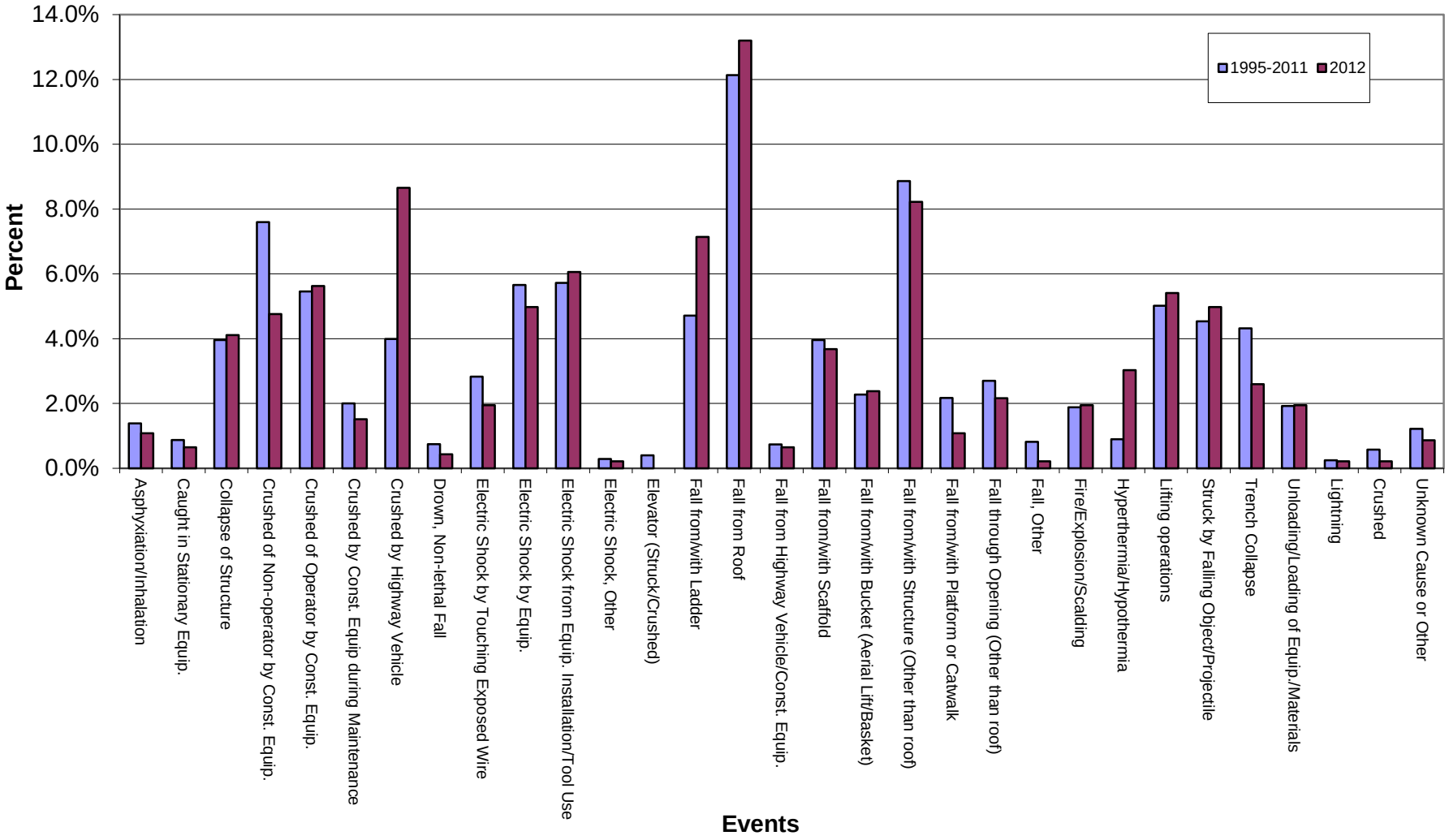


Figure B2. Comparison of Construction Fatal Events (2012)

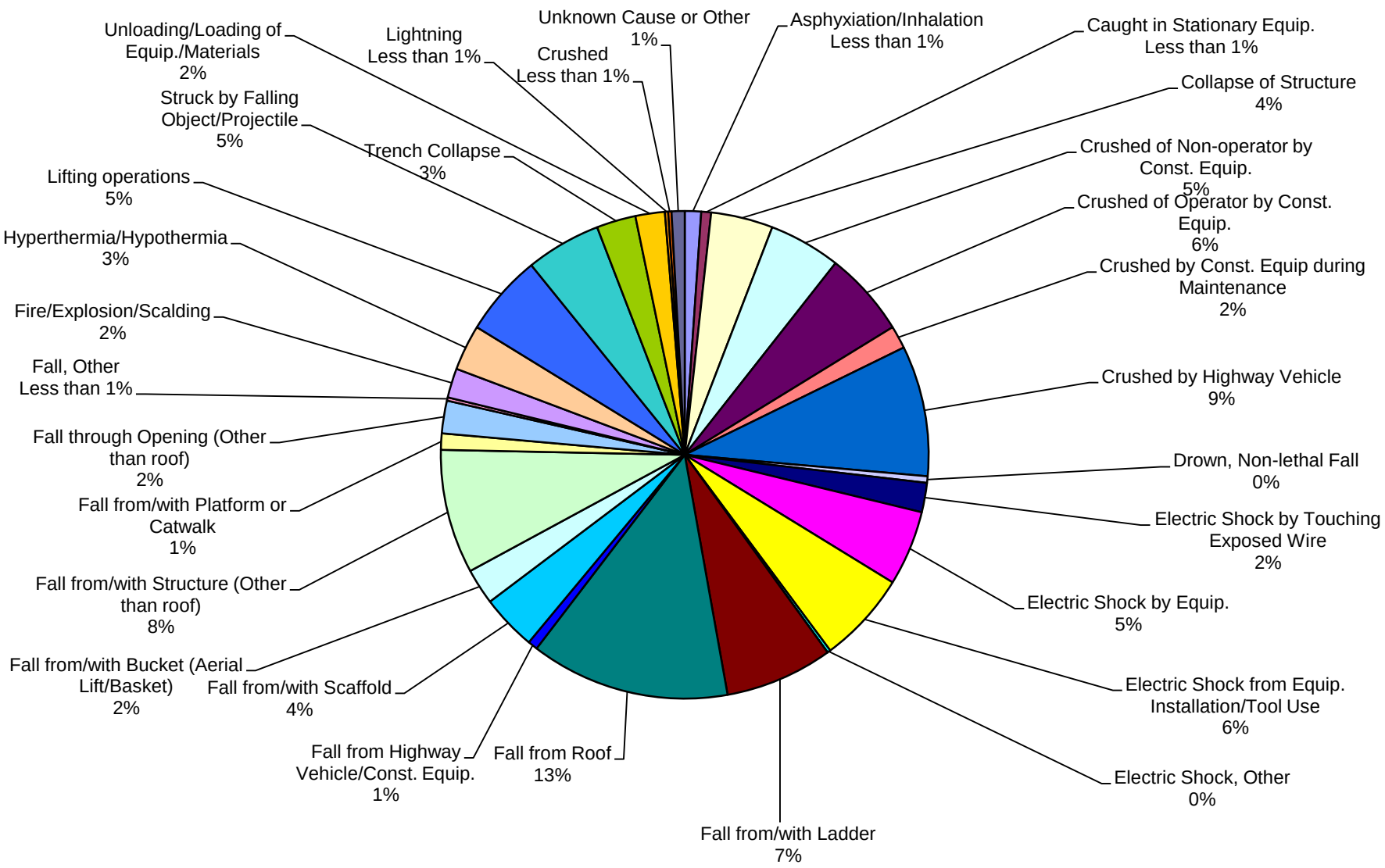


Figure B3. Comparison of Construction Fatal Events (1995-2011)

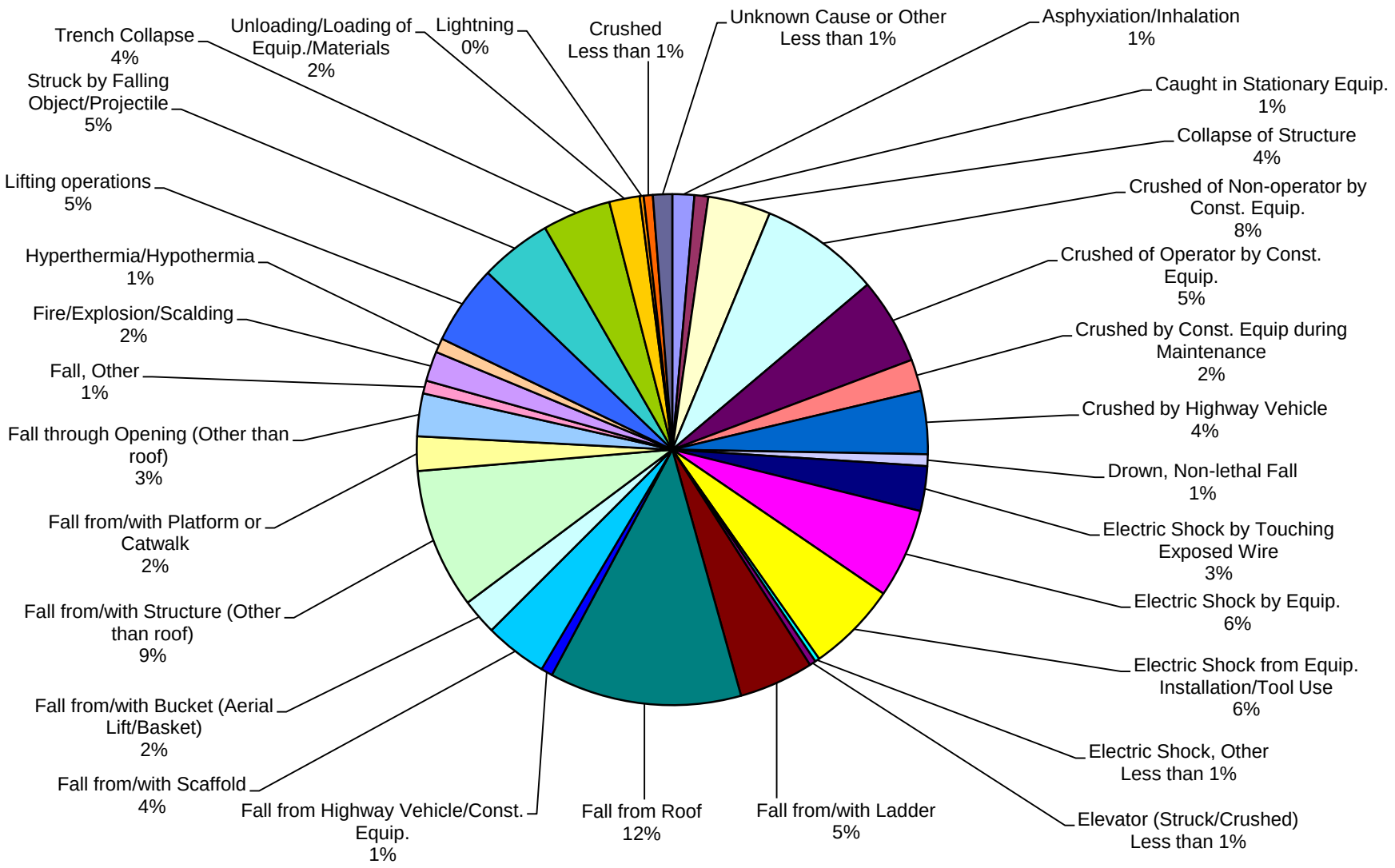
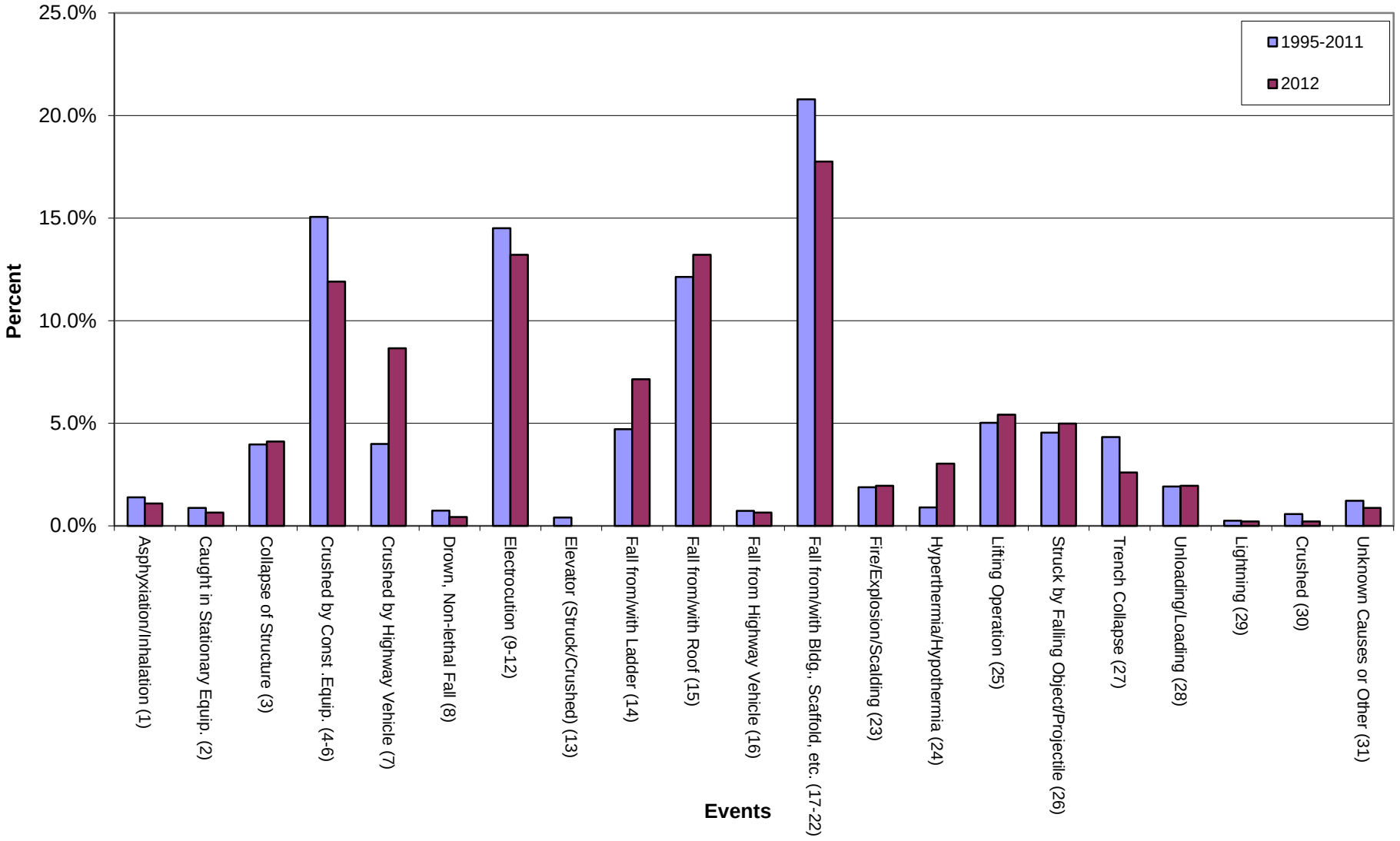


Figure B4. Comparison of Grouped Construction Fatal Events (1995-2011 and 2012)



APPENDIX C

Table C1. Construction Fatal Events by End-Use Type, 2012

End Use Type	Description	Number of Events	Percent
1	Single Family or Duplex	83	18.0
2	Multi-family	23	5.0
3	Commercial	75	16.2
4	Manufacturing	15	3.2
5	Refinery	1	0.2
6	Power plant	4	0.9
7	Sewer or Water Plant	6	1.3
8	Other Building	57	12.3
9	Highway/Road Work	51	11.0
10	Bridge	11	2.4
11	Tower, Tank, Storage Elevator	4	0.9
12	Shoreline, Dam, Reservoir	2	0.4
13	Pipeline	15	3.2
14	Excavation, Landfill	3	0.6
15	Power line, Transmission Line	17	3.7
16	Other Heavy Construction	14	3.0
17	Contractors Yard	6	1.3
18	Unknown	75	16.2
	Total	**462**	**100.0**

Table C2. Construction Fatal Events by Type of Project, 2012

Project Type	Description	Number of Events	Percent
1	New, Addition and Alteration	305	66.0
2	Maintenance, Repair and Demolition	71	15.4
3	Other	22	4.8
4	Missing	64	13.8
Total		**462**	**100.0**

Table C3. Construction Fatal Events by Four-Digit SIC, 2012

Description	SIC	Number of Events	Percent
General Contractors - Single Family Houses	1521	30	6.5
General Contractors - Residential Buildings Other than Single Family	1522	10	2.2
General Contractors – Operative Builders	1531	2	0.4
General Contractors - Industrial Building and Warehouses	1541	6	1.3
General Contractors - Non-residential Buildings, other than Industrial and Warehouses	1542	6	1.3
Highway and Street Construction, Except Elevated Highways	1611	47	10.2
Bridge, Tunnel, and Elevated Highway Construction	1622	10	2.2
Water, Sewer, Pipeline, and Communications and Power Line Construction	1623	33	7.1
Heavy Construction, Not Elsewhere Classified	1629	9	1.9
Plumbing, Heating and Air-Conditioning	1711	24	5.2
Painting and Paper Hanging	1721	21	4.5
Electrical Work	1731	38	8.2
Masonry, Stone Setting, and Other Stone Work	1741	5	1.1
Plastering, Drywall, Acoustical, and Insulation Work	1742	7	1.5
Carpentry Work	1751	20	4.3
Floor Laying and Other Floor Work	1752	1	0.2
Roofing, Siding, and Sheet Metal Work	1761	61	13.2
Concrete Work	1771	28	6.1
Water Well Drilling	1781	1	0.2
Structural Steel Erection	1791	24	5.2
Glass and Glazing Work	1793	1	0.2
Excavation Work	1794	18	3.9
Wrecking and Demolition Work	1795	11	2.4
Installation or Erection of Building Equipment, Not Elsewhere Classified	1796	7	1.5
Special Trade Contractors, Not Elsewhere Classified	1799	42	9.1
Total		**462**	**100.0**

Table C4. Construction Fatal Events by Project Value, 2012

Project Value Code	Cost	Number of Events	Percent
1	Under $50,000	118	25.5
2	$50,000-$250,000	61	13.2
3	$250,000-$500,000	27	5.8
4	$500,000-$1,000,000	21	4.5
5	$1,000,000-$5,000,000	52	11.3
6	$5,000,000-$20,000,000	24	5.2
7	$20,000,000 and over	26	5.6
8	Unknown	133	28.8
	Total	**462**	**100.0**

Table C5. Construction Fatalities by Construction Operation, 2012

Code	Description	Number of Fatalities	Percent of Fatalities
01	Backfilling and compacting	1	0.2
02	Bituminous concrete placement	1	0.2
05	Demolition	17	3.7
07	Elevator, escalator installation	2	0.4
08	Emplacing reinforcing steel	2	0.4
09	Erecting structural steel	14	3.0
11	Excavation	13	2.8
12	Exterior masonry	6	1.3
13	Exterior cladding	2	0.4
14	Exterior carpentry	18	3.9
15	Exterior painting	13	2.8
16	Fencing, installing lights, signs, etc.	3	0.6
17	Fireproofing	2	0.4
18	Forming	3	0.6
19	Forming for Piers or Pylons	1	0.2
20	Installing interior walls, ceilings, doors	3	0.6
21	Installing metal siding	1	0.2
22	Installing windows and doors, glazing	4	0.9
23	Installing culverts and incidental drainage	2	0.4
24	Installing equipment (HVAC and other)	22	4.8
25	Installing plumbing, lighting fixtures	14	3.0
26	Installing underground plumbing conduit	7	1.5
27	Interior Tile Work	2	0.4
29	Interior plumbing, ducting, electrical work	9	1.9
30	Interior carpentry	8	1.7
31	Interior painting and decorating	6	1.3
32	Landscaping	4	0.9
34	Paving	19	4.1
35	Pile driving	1	0.2
37	Placing bridge girders and beams	2	0.4
38	Plastering	1	0.2
41	Pouring concrete piers and pylons	2	0.4
42	Pouring concrete foundations and walls	11	2.4
43	Roofing	44	9.5
44	Seawall Construction, riprap placement	1	0.2

Table C5. Construction Fatalities by Construction Operation, 2012 (continued)

Code	Description	Number of Fatalities	Percent of Fatalities
45	Site clearing and grubbing	11	2.4
46	Site grading and rock removal	3	0.6
47	Stripping and curing concrete	2	0.4
48	Surveying	1	0.2
50	Temporary work (buildings, facilities)	13	2.8
51	Traffic protection	14	3.0
52	Trenching, installing pipe	19	4.1
53	Waterproofing	5	1.1
54	Steel Erection of Solid Web-Connecting	2	0.4
60	Steel Erection of Open Web Steel Joist - Connecting	1	0.2
65	Steel Erection Open Web Steel Joists-Landing Materials	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.)	2	0.4
70	Other Activities-Installing Ornamental and Architectural Steel	6	1.3
71	Other Activities-Post Decking Detail Work	2	0.4
00	Unknown/Missing	117	25.3
	Total	**462**	**100.0**