AN ANALYSIS OF FATAL EVENTS IN THE CONSTRUCTION INDUSTRY 2015

Prepared for: **Office of Statistical Analysis**
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Prepared by: **Construction Industry Research and Policy Center**
University of Tennessee, Knoxville

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This report is based upon OSHA-inspected fatal events in construction during calendar year 2015. 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 507 fatal construction incidents (excluding non-work related causes), involving 513 fatalities, in calendar year 2015. Seven of the 31 proximal causes classified in this report accounted for 269 (53.1 percent) of the fatal events investigated and 260 (50.7 percent) of the fatalities. They were: (1) "fall from/through roof": 68 events (13.4 percent); (2) "fall from/with structure (other than roof)": 39 events (7.7 percent); (3) "fall from/with ladder": 37 events (7.3 percent); (4) "struck by falling object/projectile": 37 events (7.3 percent); (5) "electric shock from equipment installation/tool use": 34 events (6.7 percent); (6) "crushed/run-over/trapped of operator of construction equipment": 27 events (5.3 percent); and (7) "fall from/with scaffold": 27 events (5.3 percent).

A comparison of the year-to-year ranks of the proximal causes during the 1991-2015 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 5 (1.0 percent) of the events were multi-fatality events which accounted for an additional 6 (1.2 percent) of the fatalities.

Other findings included:

- Initiation. In 355 (70.0 percent) of the fatal events the victim was judged to be the primary initiator of the cause; in 112 events (22.1 percent) the victim was judged to be simply in the wrong place at the wrong time; in 26 events (5.1 percent) another employee was judged to be the primary initiator of the cause; in 2 events (0.4 percent) the victim and another employee were judged to be primary initiator of the cause; in 2 events (0.4 percent) the safety equipment failed; and 10 events (2.0 percent) could not be classified.

- Unrelated Fatalities. In 2015 there were 183 deaths from heart attack and stroke, 3 from homicide, 2 from suicide, 4 from drugs, 30 from automobile accidents and 2 from other causes were reported in case files.
- Task. In 503 of the events (99.2 percent) the victim was judged to be performing work at the task site when injured, in 1 event (0.2 percent) the victim was going to or from work or not working when injured and 3 events (0.6 percent) could not be classified.
- Timing. During the work week the most fatal events happened on Wednesday with 98 events (19.3 percent) each, followed by Tuesday with 97 events (19.1 percent), Monday with 92 events (18.1 percent), Friday with 85 events (16.8 percent), Thursday with 81 events (16.0 percent), and Saturday and Sunday with 54 combined events (10.7 percent). The most fatal events happened between the 11^{th} and 12^{th} hour with 62 events (13.6 percent) followed by fatal events happening between the 13^{th} and 14^{th} hour with 48 events (10.5 percent and between the 9^{th} and 10th hour and the 10^{th} and 11^{th} hour, each with 46 events (10.1 percent). Most fatal events happened during normal construction work hours, 7^{th} hour to the 17^{th} hour, 379 events (83.3 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 30 fatal events was "crushed/run-over by highway vehicle" accounting for 11 events (36.7 percent). The leading contributing causes of these 11 events was "highway vehicle lost control and entered well-identified work zone" with 5 events (45.5 percent), "highway vehicle struck victim (flagger) signaling traffic at the beginning of marked work zone", "highway vehicle struck victim installing signs or traffic signals in an unprotected zone" and "highway vehicle struck

shadow vehicle protecting moving vehicle from which victim was performing work, crushing victim" each with 1 event (9.1 percent) and 3 events (27.3 percent) could not be categorized.

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I. Introduction

This report focuses on the direct causes of fatal events that occurred in the calendar year 2015 in the construction industry. Twenty-two 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 2014.

II. Data

The data analyzed in this report, provided by OSHA, consist of fatality case file narratives and coded data of the 507 fatal events inspected by OSHA which accounted for 513 fatalities in construction during calendar year 2015. 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-eight 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].

[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), An Analysis of Fatal Events in the Construction Industry, 2011 (2013), An Analysis of Fatal Events in the Construction Industry, 2012 (2014), An Analysis of Fatal Events in the Construction Industry, 2013 (2015), and An Analysis of Fatal Events in the Construction Industry, 2014 (2016). 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, MA, ME, 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.

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, automobile accidents, homicides, suicides, drugs and other causes. In 2015 these fatalities accounted for 224 events (30.6 percent) of OSHA-inspected fatal construction events. Although the Occupational Safety and Health Administration requires employers to report fatalities 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 (Electrical - 2016, Roofing - 2014, Steel Erection - 2009) lead us to believe these inconsistencies continue although at a lower rate. Also, the narratives of fatal events in the OSHA data base, OSHA Information System (OIS), seem to be less descriptive than those in the previous Integrated Management Information System (IMIS) data base reducing the ability to interpret the intent of poorly written event descriptions. Some coding categories have reduced detail, i.e. "fall from ladder" is now just "fall", further reducing the ability to interpret poorly written event descriptions. Finally, the

coding of categories is more frequently missing than in IMIS. 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); and (4) contract value of the construction project; 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 2015, 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 (68 or 13.4 percent of total events), followed by "fall from/with structure (other than roof)" (39 or 7.7 percent of total events). The third leading cause was "fall from/with ladder" (37 or 7.3 percent of total events); the fourth leading cause was "struck by falling object/projectile" (37 or 7.3 percent of total events); the fifth leading cause was "electric shock from equipment installation/tool use" (34 or 6.7 percent of total events); and the sixth and seventh leading causes were "crushed/run-over/trapped of operator by operating construction equipment" and "fall from/with scaffold" (each with 27 or 5.3 percent of total events). These seven event causes account for a majority of events (269 or 53.1 percent of total events). The number and relative

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

frequencies of the remaining causes of the 507 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.)

Table 1. Construction Fatal Event Causes, 2015

Event Causes	Description	Number of Events and Victims: Events	Number of Events and Victims: Victims	Percent of Events
1.	asphyxiation/inhalation of toxic vapor	10	10	2.0
2.	caught in/struck by stationary equipment	2	2	0.4
3.	crushed from collapse of structure	19	19	3.7
4.	crushed/run-over of non-operator by operating construction equipment	26	26	5.1
5.	crushed/run-over/trapped of operator by operating construction equipment	27	27	5.3
6.	crushed/run-over by construction equipment during maintenance/modification	17	17	3.4
7.	crushed/run-over by highway vehicle/non-construction equipment	16	19	3.2
8.	drown, non-lethal fall	6	6	1.2
9.	electric shock by touching exposed wire	15	15	3.0
10.	electric shock by equipment contacting power source	19	21	3.7
		Event		Percent
	a. ladder	5		1.0
	b. scaffold	1		0.2
	c. crane/lifting equipment/boom/dump truck	8		1.6
	d. contact while handling materials such as gutters, iron rods, etc.	5		1.0
11.	electric shock from equipment installation/tool use	34	34	6.7
12.	electric shock, other	0	0	0.0
13.	elevator (struck/crushed by elevator or counter weights)	4	4	0.8
14.	fall from/with ladder: includes collapse/fall of ladder	37	37	7.3
15.	fall from/through roof	68	68	13.4
		Event		Percent
	a. fall off of roof	43		8.5
	b. fall through roof other than skylight	3		0.6
	c. fall through skylight or other opening	22		4.3
16.	fall from highway vehicle/construction equipment	3	3	0.6
17.	fall from/with scaffold	27	28	5.3
18.	fall from/with bucket (aerial lift/basket)	10	10	2.0
19.	fall from/with structure (other than roof)	39	39	7.7
		Event		Percent
	a. fall with collapse of structure	10		2.0
20.	fall from/with platform or catwalk	8	8	1.6
21.	fall through opening (other than roof)	9	9	1.8

Table 1. Construction Fatal Event Causes, 2015 (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	0.4
23.	fire/explosion/scalding	5	5	1.0
24.	hyperthermia/hypothermia	9	9	1.8
25.	hit, crushed, fall during lifting operations	21	21	4.1
26.	struck by falling object/projectile (including tip-over)	27	27	7.3
27.	crushed/suffocation from trench collapse	22	22	1.4
28.	crushed while unloading-loading equipment/material (except by crane)	7	7	1.6
29.	shock/burn from lightning	2	2	0.4
30.	crushed other	0	0	0.0
31.	unknown cause or other	6	6	1.2

		Event	Percent
a.	Other	4	0.8

Total	**507**	**513**	**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 seven most frequent causes of fatal events as listed in Table 1.

> Fall from/through roof. A 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 an unsecured ladder when he/she over-reaches, missteps, slips, or simply loses balance..
>
> Struck by falling object/projectile. A worker walking near a building under construction was struck by a brick that fell from an upper level. An operating tool kicked back striking the employee in the head.
>
> 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.)
>
> Fall from/with scaffold. A worker slips/trips and falls from a scaffold; a scaffold is overloaded, causing the scaffold to collapse with the worker on it; a worker assembling/dis-assembling a scaffold falls from the scaffold.

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 28 fatality causes where no event had multiple fatalities; 3 fatality causes included events with multiple fatalities. The fatality cause with the most victims per event was “crushed/run-over by highway vehicle/non-construction equipment” with 16 events and 19 victims or 1.2 victims per event and the largest loss in a single event was 3. Multiple fatality events averaged 2.2 fatalities per event. A single event, “crushed/run-over by highway vehicle/non-construction equipment” resulted in three fatalities.

Most events involve a single fatality; however a few events involve multiple fatalities and these events most often occur in a few of the event causes. In the prior 10 years, 2005-2014, multiple fatalities in a single event of an event cause occurred in eight of the 10 years for "collapse of structure", "crushed/run-over by highway vehicle/non-construction equipment", "fire/explosion/scalding", and "trench collapse"; seven of the 10 years for "asphyxiation/inhalation of toxic vapor" and "fall from/with structure (other than roof)". The second or even the third fatality in an asphyxiation event is often someone attempting a rescue of worker.

The data for construction fatalities in 2015 showed that 5 of the fatal events (1.0 percent) involved multiple fatalities. The multiple-fatality events averaged 2.2 fatalities per event and accounted for an additional 6 fatalities (1.2 percent). The 5 fatal event causes had a total of 62 fatalities (12.1 percent) of the 513 individuals killed in 2015.

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 three homicides in the 2015 OSHA data. Homicides and other non-construction events are excluded from this analysis as they have been in prior years.

Table 2 compares the ranks of the causes in 2015 with the average rank of the causes of fatal events during the period 1991-2014. It can be seen that the overall rank pattern of the causes in 2015 is very similar to the rank pattern in 1991-2014. An overall statistical comparison of the correlation of the rank in 2015 with the average rank in 1991-2014 was calculated using a Spearman rank correlation

[4] Drudi, Dino and Mark Zak," Work–Related Multi-Fatality Incidents," Monthly Labor Review, Vol. 127, No. 10, October 2004.

procedure.[5] The correlation obtained was + 0.91, $p < 0.001$, indicating that the ranks of the causes in the two time periods are highly and positively correlated, i.e., did not change significantly between 1991-2014 and 2015[6]. The Spearman rank-order correlation between 2014 and 2015 causes was calculated and found to be + 0.89, $p < 0.001$, indicating also that the pattern changed very little between 2014 and 2015.

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 40.0 percent of 2015 construction fatal events and 37.4 percent for the 1991-2014 period 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), 20.6 (2012), 21.4 (2013) and 20.5 (2014) percent of fatal construction events and for the 1991-2014 period 19.0 percent.

[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.

Table 2. A Comparison of Ranks of Causes of Fatal Events in 1991 - 2014 with 2015

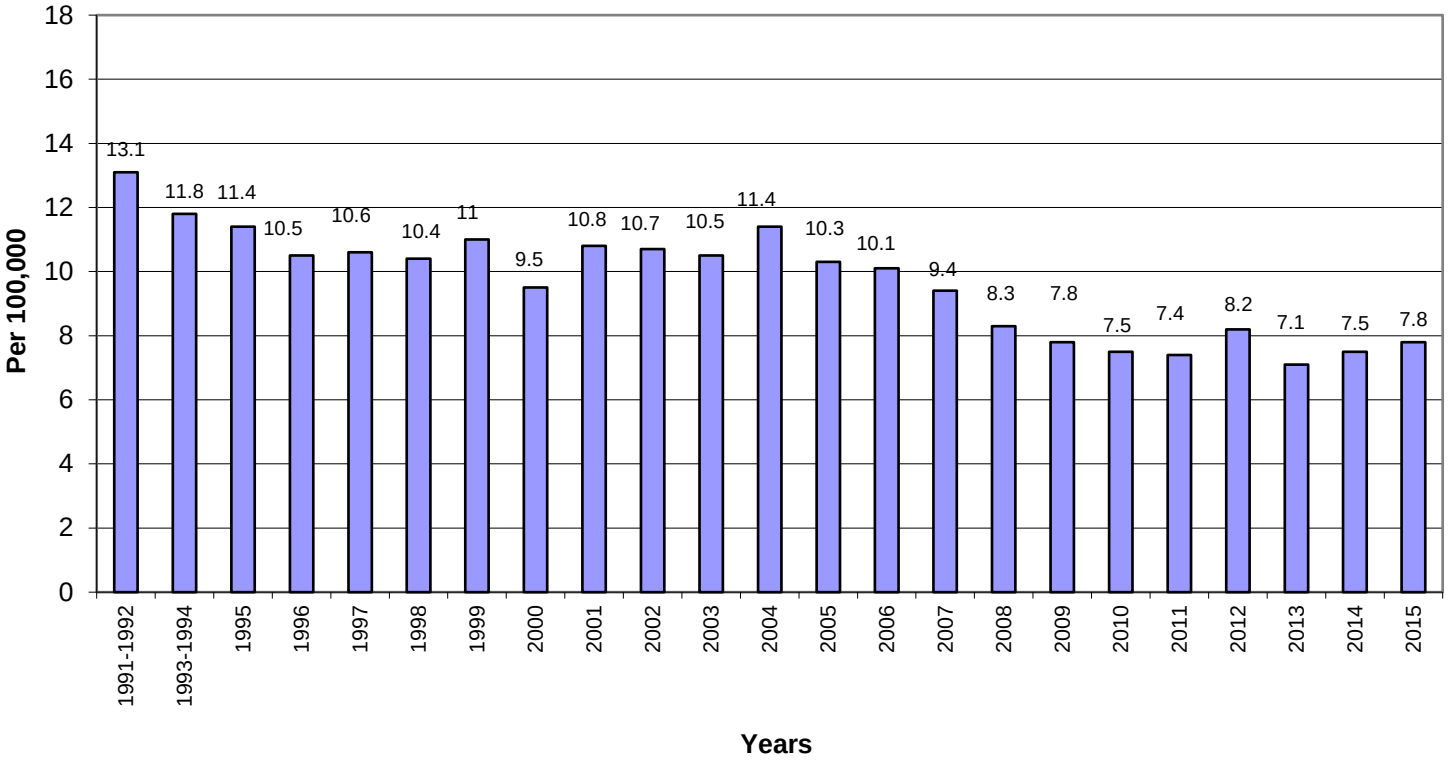
Event	1991 - 2014 Average			2015		
	Number	Percent	Rank	Number	Percent	Rank
1. asphyxiation/inhalation of toxic vapor	8.1	1.3	22	10	2.0	16
2. caught in/struck by stationary equipment	5.3	0.9	24	2	0.4	27
3. crushed from collapse of structure	24.3	4.0	12	19	3.7	11
4. crushed/run-over of non-operator by operating construction equipment	45.5	7.6	3	26	5.1	8
5. crushed/run-over/trapped of operator by operating construction equipment	33.9	5.6	5	27	5.3	6
6. crushed/run-over by construction equipment during maintenance/modification	12.4	2.1	19	17	3.4	13
7. crushed/run-over by highway vehicle	25.2	4.2	11	16	3.2	14
8. drown, non-lethal fall	5.1	0.8	25	6	1.2	23
9. electric shock by touching exposed wire	18.7	3.1	14	15	3.0	15
10. electric shock by equipment contacting power source	36.3	6.0	4	19	3.7	11
11. electric shock from equipment installation/tool use	32.0	5.3	6	34	6.7	5
12. electric shock, other	3.0	0.5	28	0	0	29
13. elevator (struck/crushed by elevator or counter weights)	2.5	0.4	29	4	0.8	25
14. fall from/with ladder: includes collapse/fall of ladder	28.5	4.7	8	37	7.3	3
15. fall from/through roof	71.9	11.9	1	68	13.4	1
16. fall from highway vehicle/construction equipment	4.4	0.7	27	3	0.6	26
17. fall from/with scaffold	23.2	3.9	13	27	5.3	6
18. fall from/with bucket (aerial lift/basket)	13.5	2.2	16	10	2.0	16
19. fall from/with structure (other than roof)	50.8	8.4	2	39	7.7	2

Table 2. A Comparison of Ranks of Causes of Fatal Events in 1991 - 2014 with 2015 (continued)

Event	1991 – 2014 Average			2015		
	Number	Percent	Rank	Number	Percent	Rank
20. fall from/with platform or catwalk	12.6	2.1	17	8	1.6	20
21. fall through opening (other than roof)	15.3	2.5	15	9	1.8	18
22. fall, other or unknown	5.0	0.8	26	2	0.4	27
23. fire/explosion/scalding	11.7	1.9	20	5	1.0	24
24. hyperthermia/hypothermia	5.6	0.9	23	9	1.8	18
25. hit, crushed, fall during lifting operations	30.5	5.1	7	21	4.1	10
26. struck by falling object/projectile (including tip-over)	26.7	4.4	9	37	7.3	3
27. crushed/suffocation from trench collapse	26.2	4.4	10	22	4.3	9
28. crushed while unloading-loading equipment/material (except by crane)	11.5	1.9	21	7	1.4	22
29. shock/burn from lightning, other	12.5	2.1	18	8	1.6	20
Total	**602.1**	**100.0**		**507**	**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 (1991-2015)



The number of fatal events per 100,000 construction establishment employees had been declining for seven years before increasing to 8.2 in 2012. The number of fatal events per 100,000 construction establishment employees decreased from 8.2 in 2012 to 7.1 in 2013 then increased to 7.5 in 2014 and 7.8 in 2015. The previous trend of declining fatalities per 100,000 construction employees may have ended.

[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 ur general categories: (1) victim(s) was 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; (5) safety equipment failed; and (6) 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 and third categories 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 fourth category includes, for example, most structure and trench collapses, struck by projectile/falling objects, and lightning. The fifth category, safety equipment failure, may be more frequent but case files seldom mention safety equipment in reporting the accident event.

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 507 events: (1) victim primary initiator of event: 355 events (70.0 percent); (2) victim and another employee primary initiator: 2 events (0.4 percent); (3) person other than victim primary initiator: 26 events (5.1 percent); (4) wrong place at

wrong time: 112 events (22.1 percent); (5) safety equipment failed: 2 events (0.4 percent); and (6) unknown: 10 events (2.0 percent).

Table 3. Fatal Event Initiated by, 2015

	Events	Percent
Victim	355	70.0
Combination	2	0.4
Other Employee	26	5.1
Wrong Place at Wrong Time	112	22.1
Safety Equipment Failure	2	0.4
Unknown	10	2.0
Total	**507**	**100.0**

Over the last ten years, the victim was the primary initiator of the event for 58.3% of the events. The victim being in the "Wrong place at the wrong time" averaged 28.2% of the events, followed by another person with 9.4%, and combination of victim and another person with 0.9%. The totals for 2014 and 2015 are very similar. The proportion events due to the action of the victim has been trending upward.

An additional classification of the 507 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: 503 (99.2 percent) of the fatal events involved workers performing work at their task site and 1 (0.2 percent) of the events involved workers going to or from work or not working.

Table 4. Activity of Victim, 2015

Activity	Events	Percent
Working Task at Site	503	99.2
Going to/from Task & Not Working	1	0.2
Unknown	3	0.6
Total	**507**	**100.0**

Historically, "working task" ranged from a high of 99.4% for 2014 to a low of 81.1% in 2004. The range for "Going to and from work" or "Not working" is 18.9% in 2004 to 0.2% in 2015. This category has not been above 5% since 2005.

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.

In 2015 there were 224 non-construction related fatalities included in the OSHA reports, based on our interpretation of records for these fatalities[8].

Table 5. Non-Construction Related Fatalities, 2015

	Events	Percent
Heart Attack	177	79.0
Automobile Accident	30	13.4
Drug Related	4	1.8
Homicide	3	1.3
Stroke	3	1.3
Seizure	3	1.3
Suicide	2	0.9
Asthma	1	0.4
Other	1	0.4
Total	**224**	**100.0**

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 6 shows the distribution of fatal events by day of the week. The largest number of fatalities occurred on Wednesday with 98 events (19.3 percent). Tuesday had the second largest number

[8] Heart attack, stroke, or seizure events were included in the study when a medical examiner determined it was caused by the work activities.

of events, 97 (19.1 percent) followed by Monday with 92 events (18.1 percent), Friday with 85 events (16.8 percent) and Thursday with 81 events (16.0 percent). This year the fatal events are approximately equally distributed across the normal five day work week. Saturday and Sunday combined had 54 events (10.7 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 6. Distribution of Fatal Construction Events by Day of Week, 2015

Day	Number of Events	Percent
Sunday	12	2.4
Monday	92	18.1
Tuesday	97	19.1
Wednesday	98	19.3
Thursday	81	16.0
Friday	85	16.8
Saturday	42	8.3
Total	**507**	**100.0**

Table 7 shows the distribution of fatal events by hour (military) of the day. The following percentages represent recorded event times. Event times were missing for 4.6 percent of 2013 events, 1.9 percent of 2014 events and 10.3 percent of 2015 events. We assume the events with missing time were similarly distributed.

It can be seen that the 11-12 hour period contained the most fatal events, 62 (13.6 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 186 (40.9 percent) of the fatal events occurred in the 8-12 hour period and 153 (33.6 percent) occurred in the 13-17 hour period is a little surprising.

A similar difference occurred in 2014. In a majority of the prior years, 2004-2013, the number of fatal events has been approximately equal for each four hour period.

Nearly three-fourths (74.5 percent) of the fatal events occurred during 8-12 hour period and the 13-17 hour period. From 2004 through 2014 the percent of fatal events occurring during these eight hours has ranged from 72.2 to 78.7 percent with a median of 74.8 percent.

Table 7. Distribution of Fatal Construction Events by Hour, 2015

Hour	Number of Events	Recorded Time Events Percent	All Events Percent
0–1	17	3.7	3.4
1–2	1	0.2	0.2
2–3	0	0.0	0.0
3–4	1	0.2	0.2
4–5	1	0.2	0.2
5–6	3	0.7	0.6
6–7	5	1.1	1.0
7–8	26	5.7	5.1
8–9	32	7.0	6.3
9–10	46	10.1	9.1
10–11	46	10.1	9.1
11–12	62	13.6	12.2
12–13	33	7.3	6.5
13–14	48	10.5	9.5
14–15	43	9.5	8.5
15–16	22	4.8	4.3
16–17	21	4.6	4.1
17–18	19	4.2	3.7
18–19	12	2.6	2.4
19–20	4	0.9	0.8
20–21	4	0.9	0.8
21–22	3	0.7	0.6
22–23	3	0.7	0.6
23–24	3	0.7	0.6
Unknown	52		10.3
Total	**507**	**100.0**	**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 2015, 33 workers were killed in 30 events while working on highway/road projects (5.9 percent of the total fatal events). On-site operating construction equipment was involved in 12 fatal events (2.4 percent).

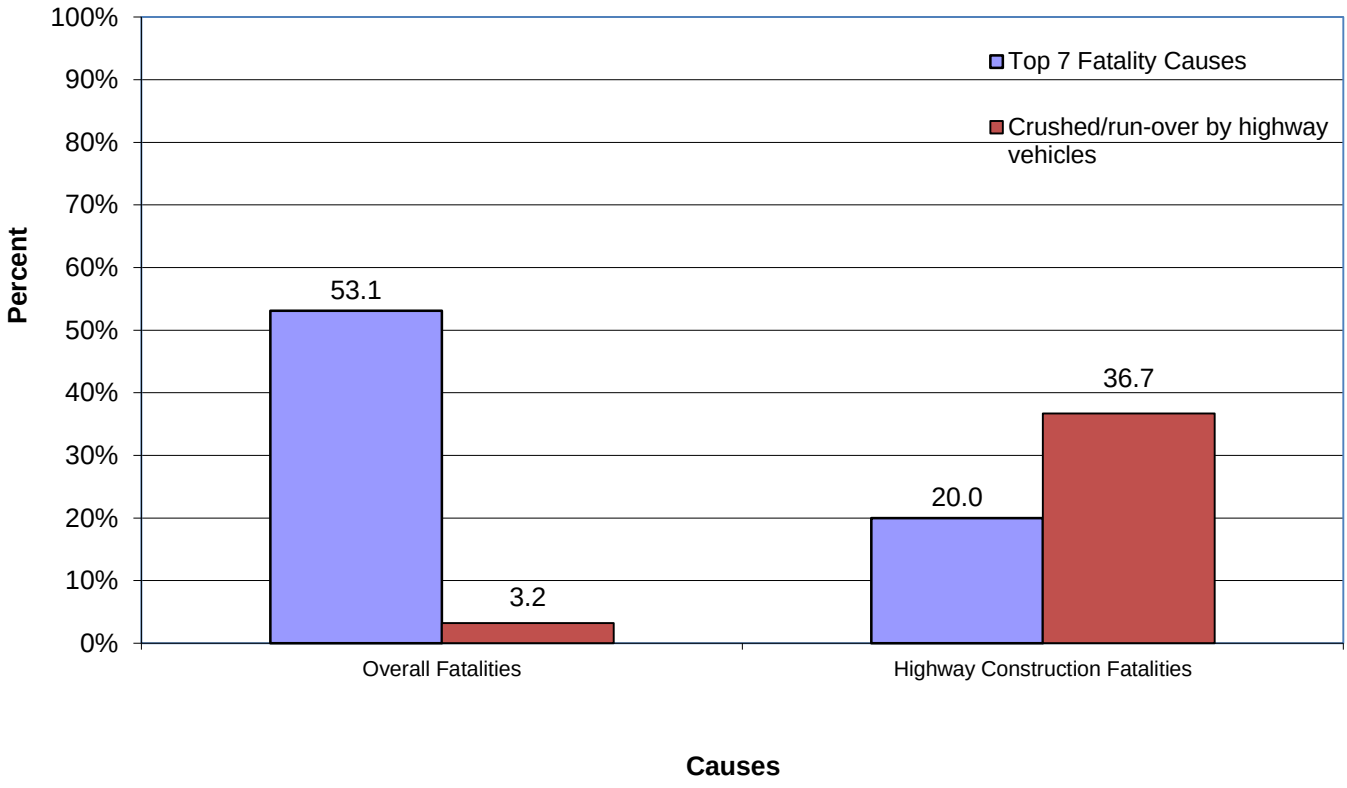
Table 8 ranks the direct causes of the fatal events by their frequency. The table shows that the leading causes were "crushed/run-over by highway vehicle" 11 events (36.7 percent), followed by "crushed/run-over of non-operator by operating construction equipment" 7 events (23.3 percent) and "crushed/run-over of operator by operating construction equipment" 5 events (16.7 percent) and "crushed from collapse of structure" 2 events (6.7 percent). Other event causes are shown in Table 8.

Table 8. Frequency of Fatal Causes in Highway/Road Construction, 2015

Cause	Number of Events	Percent
Crushed/run-over by highway vehicle	11	36.7
Crushed/run-over of non-operator by operating construction equipment	7	23.3
Crushed/run-over of operator by operating construction equipment	5	16.7
Crushed from collapse of structure	2	6.7
Electric shock by touching exposed wire with crane/lifting equipment/boom/dump truck	1	3.3
Struck by falling object/projectile	1	3.3
Caught in/struck by stationary equipment	1	3.3
Hyperthermia/hypothermia	1	3.3
Unknown cause or other	1	3.3
Total	**30**	**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 269 events (53.1 percent) of the total 507 events compared with 11 events (36.7 percent) for "crushed/run-over by highway vehicle." For highway/road construction fatal events, the top 7 fatality causes (shown in Table 8) had 28 events (93.3 percent) and "crushed/run-over by highway vehicle" had 11 events (36.7 percent) of the 30 fatal events. It should be noted that the top 7 fatal event causes which accounted for over 53.1 percent of the total events also accounted for 20.0 percent of the highway/road work construction fatal events. However, the "crushed/run-over by highway vehicle" cause increased significantly from 3.2 percent overall to over 36.7 percent for highway/road construction.

Figure 2. Highway Construction Fatality Cause Comparison (2015)



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 9 shows fatal events caused by victim being crushed/run-over by highway vehicles by time of day (1-24 hours). For the previous years, 2004 through 2014, a majority of these events occurred from mid-morning through late-afternoon (8-17 hour period) and ranged from 47 percent to 80 percent with a median 60 percent. In 2015, 20 events (66.7 percent) occurred during the 8-17 hour period.

This year, 2015, 6.7 percent of the fatal events occurred in the early morning (0-5 hour period) and 10.0 percent in the late night (20-24 hour period). For the previous years, 2004 to 2014, the late night and early morning periods, fatalities rose from 6.7 percent in 2006 to 40 percent in 2010, fell back to 5.7 percent in 2013 and rose to 31.3 percent in 2014.

It seems clear that road work practices are changing to avoid traffic congestion when possible. This shift should result in a greater proportion of fatalities during early morning and late evening work hours. Whether the change in the proportion of 2015 fatalities occurring during the early morning and late night times represents a continuation from the trend of years prior to 2013 remains to be determined. Regardless, it is not possible to calculate fatality rates for these time-of-day periods without knowing the hours worked in each period. More information about conditions which contribute to fatalities in highway/roadway construction would seem to an area worthy of further investigation.

Table 9. Construction Fatalities Caused by "Crushed/Run-Over by Highway Vehicle" by Time of Day, 2015

Time	Frequency	Percent
Early Morning: 24:00 - 5:00	2	6.7
Dawn: 5:00 - 8:00	1	3.3
Mid-Morning: 8:00 - 11:00	7	23.3
Mid-Day: 11:00 - 14:00	8	26.7
Late-Afternoon: 14:00 - 17:00	5	16.7
Evening: 17:00 - 20:00	2	6.7
Late Night: 20:00 - 24:00	3	10.0
Unknown	2	6.7
Total	**30**	**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 four sub-categories of "crushed/run-over by highway vehicle". Table 10 shows these sub-categories and their frequency.

Table 10. Frequency of Sub-Categories of "Crushed/Run-Over by Highway Vehicle", 2015

Sub-Category	Frequency	Percent
Highway vehicle lost control and entered (by swerving or inadvertently entering) well-identified work zone, striking victim	5	45.5
Highway vehicle struck victim (flagger) signaling traffic at beginning of marked work zone	1	9.1
Highway vehicle struck victim installing signs or traffic signals in unprotected work zone	1	9.1
Highway vehicle struck shadow vehicle protecting moving vehicle from which victim was performing work, crushing victim	1	9.1
Unknown	3	27.3
Total	**11**	**100.0**

Forty-five percent of the events were in one of four sub-categories "highway vehicle lost control and entered well identified work zone, striking victim" (5 events). One event (9.1 percent) occurred in unprotected work zones and might have been avoided by marking the work zones.

Observation

The quality of the descriptions and information about the 2015 fatal events has deteriorated compared to 2014 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.

In 2015, the number of missing data elements has increased in some categories and one data element, construction operation, is no longer available in the records provided. The project

value of the construction activity where a fatal event occurred was missing in 60 percent of the fatal events compared to 37 percent in 2013 and 41 percent in 2014; the end-use type of the construction project was missing in 32 percent of the fatal events compared to 9 percent in 2013 and 26 percent in 2014; the type of project was missing in 30 percent of fatal events compared to 10 percent in 2013 and 25 percent in 2014; and the time of day of the fatal events was missing in 10 percent of the fatal events compared to 5 percent in 2013 and 2 percent in 2014. Two thousand thirteen is the first year NAICS coding was used and 2015 had no missing codes.

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. In 2014 and 2013 all of the event times for road work fatalities were recorded and in 2015 7 percent were missing.

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 (1995-2014 with 2015)

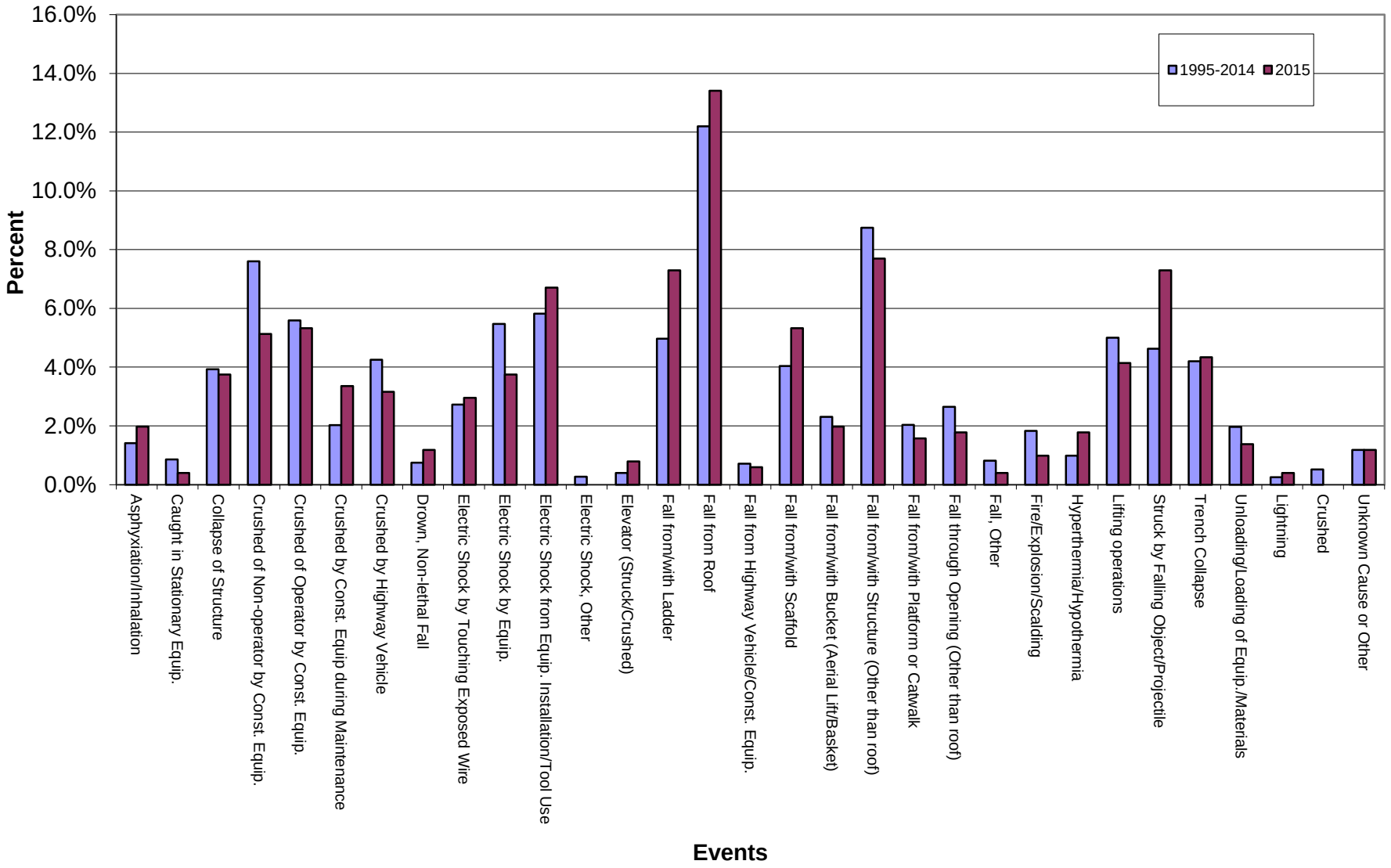


Figure B2. Comparison of Construction Fatal Events (2015)

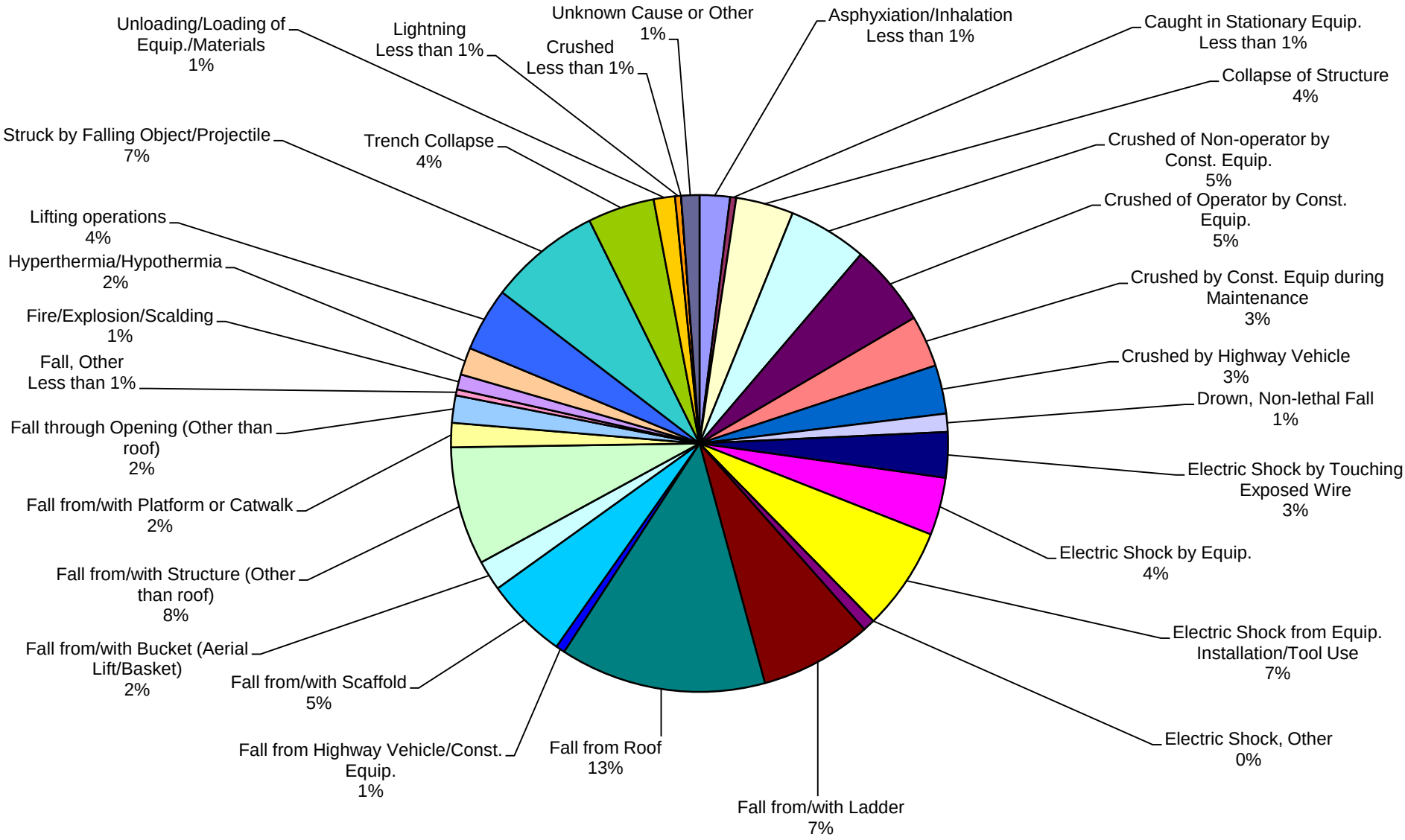


Figure B3. Comparison of Construction Fatality Events (1995-2014)

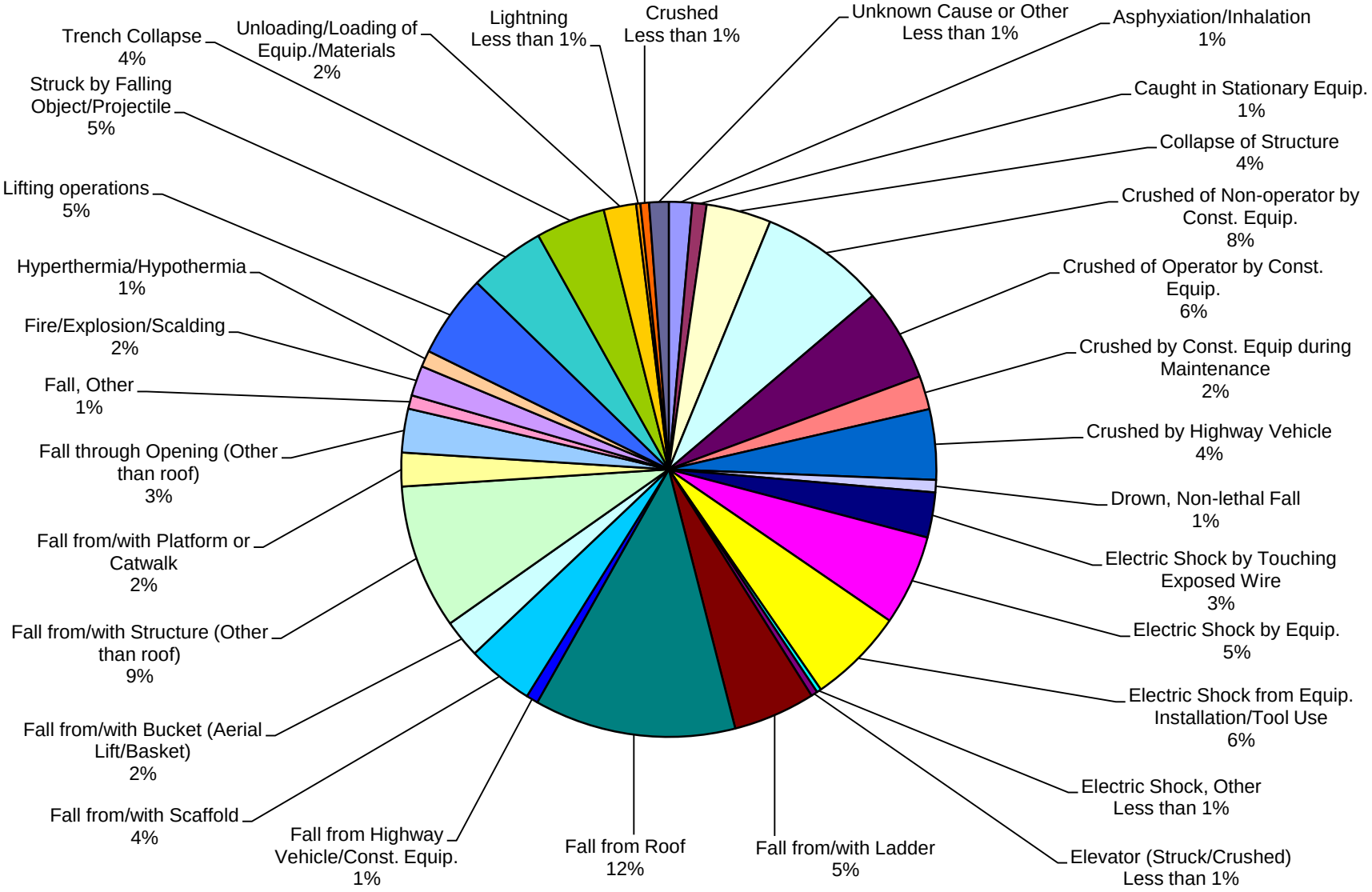
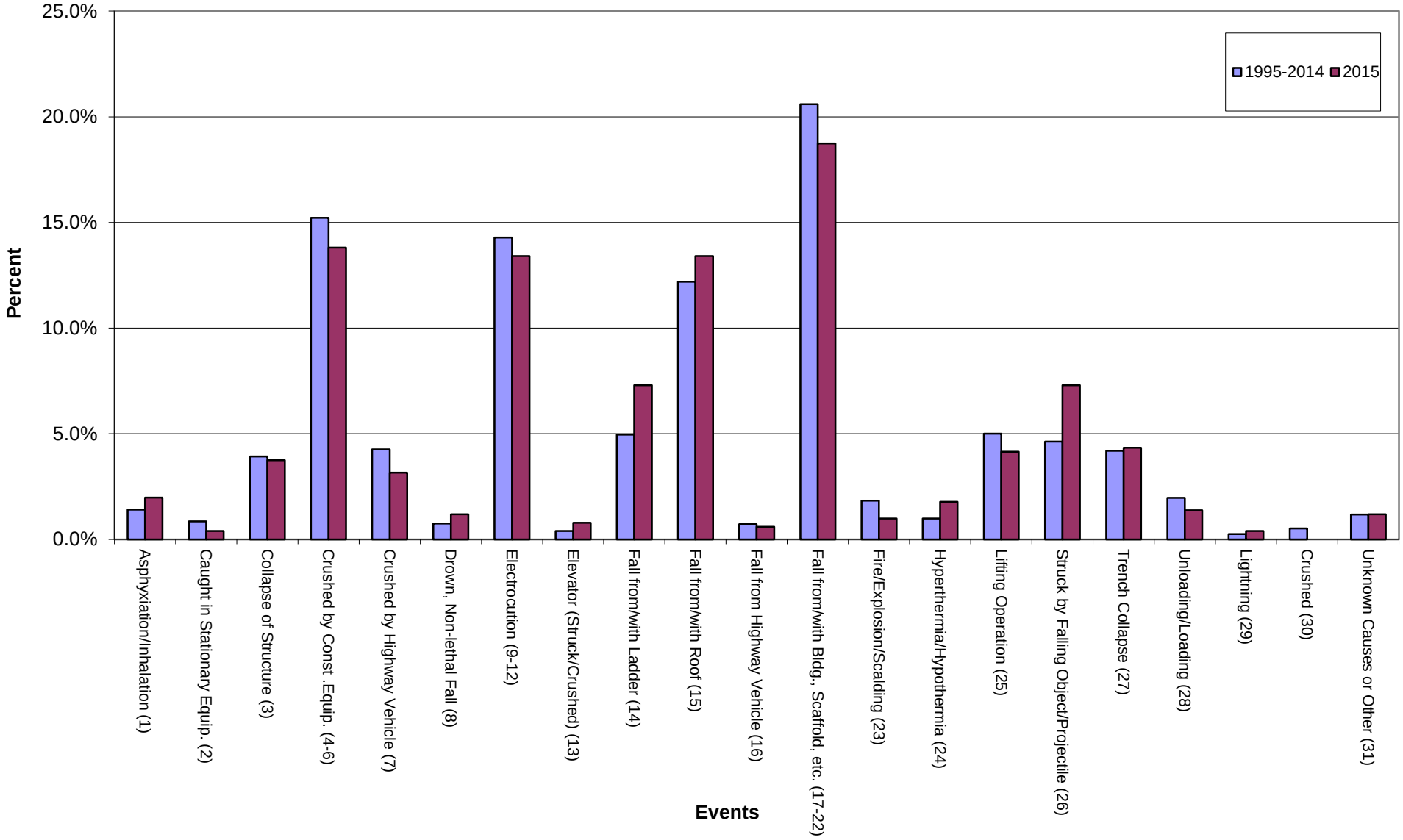


Figure B4. Comparison of Grouped Construction Fatal Events (1995-2014 and 2015)



APPENDIX C

Table C1. Construction Fatal Events by End-Use Type, 2015

End Use Type	Description	Number of Events	All Events Percent	Events with Recorded End-Use Percent
1	Single Family or Duplex	60	11.8	11.8
2	Multi-family	49	9.7	21.5
3	Commercial	94	18.5	40.0
4	Manufacturing	6	1.2	41.2
5	Refinery	4	0.8	42.0
6	Power plant	3	0.6	42.6
7	Sewer or Water Plant	4	0.8	43.4
8	Other Building	53	10.5	53.8
9	Highway/Road Work	30	5.9	59.8
10	Bridge	9	1.8	61.5
11	Tower, Tank, Storage Elevator	2	0.4	61.9
12	Shoreline, Dam, Reservoir	0	0.0	61.9
13	Pipeline	7	1.4	63.3
14	Excavation, Landfill	4	0.8	64.1
15	Power line, Transmission Line	3	0.6	64.7
16	Other Heavy Construction	11	2.2	66.9
17	Contractors Yard	4	0.8	67.7
18	Unknown	164	32.3	100.0
	Total	**507**	**100.0**	

Table C2. Construction Fatal Events by Type of Project, 2015

Project Type	Description	Number of Events	All Events Percent	Events with Recorded Type of Project Percent
A	New Project, Alteration or Rehabilitation	269	53.1	53.1
B	Maintenance, Repair or Demolition	74	14.6	67.7
C	Other	11	2.2	69.8
	Unknown	153	30.2	100.0
Total		**507**	**100.0**	

Table C3. Construction Fatal Events by Six-Digit NAICS, 2015

NAICS Code	Description	Number of Events	All Events Percent	Events with Recorded NAICS Percent
236115	New Single-Family Housing Construction	12	2.4	2.4
236116	New Multifamily Housing Construction	4	0.8	3.2
236117	New Housing For-Sale Builders	2	0.4	3.6
236118	Residential Remodelers	19	3.7	7.3
236210	Industrial Building Construction	6	1.2	8.5
236220	Commercial and Institutional Building Construction	32	6.3	14.8
237110	Water and Sewer Line & Related Structures Construction	20	3.9	18.7
237120	Oil and Gas Pipeline and Related Structures Construction	9	1.8	20.5
237130	Power and Communication Line and Related Structures Construction	9	1.8	22.3
237210	Land Subdivision	2	0.4	22.7
237310	Highway, Street and Bridge Construction	49	9.7	32.3
237990	Other Heavy and Civil Engineering Construction	7	1.4	33.7
238110	Poured Concrete Foundation and Structure Contractors	16	3.2	36.9
238120	Structural Steel and Precast Concrete Contractors	22	4.3	41.2
238130	Framing Contractors	19	3.7	45.0
238140	Masonry Contractors	14	2.8	47.7
238150	Glass and Glazing Contractors	2	0.4	48.1
238160	Roofing Contractors	64	12.6	60.7
238170	Siding Contractors	6	1.2	61.9
238190	Other Foundation, Structure and Building Exterior Contractors	7	1.4	63.3
238210	Electrical Contractors	45	8.9	72.2
238220	Plumbing, Heating and Air-Conditioning Contractors	23	4.5	76.7
238290	Other Building Equipment Contractors	11	2.2	78.9
238310	Drywall and Insulation Contractors	8	1.6	80.5
238320	Painting and Wall Covering Contractors	14	2.8	83.2
238330	Flooring Contractors	2	0.4	83.6
238340	Tile and Terrazzo Contractors	3	0.6	84.2
238350	Finish Carpentry Contractors	4	0.8	85.0
238390	Other Building Finishing Contractors	4	0.8	85.8
238910	Site Preparation Contractors	41	8.1	93.9
238990	All Other Specialty Trade Contractors	31	6.1	100.0
Total		**507**	**100.0**	

Table C4. Construction Fatal Events by Project Value, 2015

Project Value Code	Cost	Number of Events	All Events Percent	Events with Recorded Project Value Percent
1	Under $50,000	49	9.7	9.7
2	$50,000-$250,000	23	4.5	14.2
3	$250,000-$500,000	27	5.3	19.5
4	$500,000-$1,000,000	33	6.5	26.0
5	$1,000,000-$5,000,000	39	7.7	33.7
6	$5,000,000-$20,000,000	14	2.8	36.5
7	$20,000,000 and over	16	3.2	39.6
8	Unknown	306	60.4	
	Total	**507**	**100.0**	**100.0**