



Analysis of U.S. Construction “Fatal Four” Fatalities investigated by OSHA in 2019

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Due to the dangerous nature of construction work, thousands of U.S. construction workers are injured and hundreds are killed on American worksites each year. In 2019, the U.S. construction industry accounted for one thousand and sixty-one (1,061) work-related fatalities, which amounts to a five percent (5%) increase from the previous year and the largest total number of annual worker deaths since 2007. This research study examined the Occupational Safety & Health Administration (OSHA) construction fatality investigation findings during 2019 and organized these data points into four (4) major fatality-type categories and forty-nine (49) detailed types of events to identify potential trends for these fatal incidents.

Key Words: Fatal Four, OSHA, construction, safety, accidents

Introduction

Construction is an inherently dangerous industry that comprises a wide range of activities where workers are exposed to a variety of occupational hazards (OSHA, 2021). Data obtained from the U.S. Bureau of Labor Statistics (BLS) indicate that close to five thousand (5,000) U.S. construction workers died on-the-job between 2015 to 2019, which averages to nearly three (3) construction fatalities per day (BLS, 2020). During this same time period, OSHA states the U.S. construction industry accounted for approximately twenty percent (20%) of all workplace fatalities in the United States, but only employed roughly five percent (5%) of the workforce (OSHA, 2021). One thousand and sixty-one (1,067) of those construction deaths occurred in 2019. This 2019 number depicts a 5 percent (5%) increase from the previous year and represents the largest total number of U.S. construction fatalities since 2007 (BLS, 2020). Incidents involving ‘falls to a lower level’ and ‘caught-in/between collapsing materials’ were largely responsible for the increase in construction fatalities in 2019 (Brown, et.al, 2021).

Table 1. OSHA fatal four hazards

Hazard Type	Example Situations
Caught-in/Between Hazards	trench cave-in, run-over/roll-over by equipment, caught-in equipment, crushed by material/equipment, asphyxiation, inhalation of toxic vapor

Electrocution Hazards	Shock by touching exposed wires, shock by equipment/tool contacting power source
Fall Hazards	fall from ladder, fall from roof, fall through skylight, fall through unguarded floor opening, fall from structure
Struck-by Hazards	struck-by highway vehicle/construction equipment/falling material, power saw kick-back

The Occupational Safety & Health Administration (OSHA) has identified the four leading causes of fatalities in the construction industry (OSHA, 2011). They are referred to as either OSHA's "Fatal Four Hazards" or the "OSHA Focus Four Hazards". These top-4 hazards are listed in Table 1.

According to calculations conducted by the Center to Protect Workers' Rights (CPWR), the "Fatal Four" caused roughly sixty four percent (64.3%) of all construction fatalities for the year 2019. Falls historically remain the leading cause of all deaths in construction (Brown, et.al, 2021). Workers often work from heights, such as ladders, scaffolding, roofs, and aerial lifts. Falls, however, are not the only hazard to construction workers. Other potential hazards include:

- Crushed by motorized construction equipment
- Struck by falling tools or material
- Exposure to energized wires
- Trench cave-ins
- Fires/explosions
- Exposure to chemicals/low-oxygen atmospheres

Before hazards can be eliminated or reduced, they must be first identified. The data analysis of the study in this paper will review the trends of fatal construction accidents investigated by OSHA in 2019 into four (4) major fatality-type categories and forty-nine (49) detailed types of events to help identify potential trends of common hazards found in "Fatal Four" incidents for various work activities. Supervisors and workers can then use this information to help address hazards in similar current or future work.

Research Methodology

The Occupational Safety & Health Administration (OSHA) conducts an inspection for most work-related fatalities and records a descriptive narrative of each investigated incident through the use of an *OSHA 170- Fatality and Catastrophe Investigation Summaries* form. The author submitted a request under the *Freedom of Information Act* in September 2020 for the dataset of OSHA inspections of construction fatalities conducted between 2015 to 2019. The information dataset was sent as a Microsoft Excel spreadsheet file by Gretta Jameson, OSHA Directorate of Construction, to the author via email in May 2021. Microsoft Excel was used by the author to sort and organize this information. Data received for this five-year time period was comprised of two thousand nine hundred and thirty-nine (2,939) lines of data. This information was reorganized and sorted by the author in order to group and analyze the information. Only the 2019 information from this dataset was used for this paper.

The OSHA inspection report dataset included the following elements:

- OSHA Inspection number for each fatality investigation
- North American Industry Classification System (NAICS) number of companies/industries
- Incident date and time
- Total number of fatalities for the incident
- Description of event with keywords

The 2019 data were provided by OSHA in six hundred and eleven (611) lines of data and represented five hundred and eighty-one (581) of the one thousand and sixty-one (1,061) U.S. construction fatalities in 2019. The author reviewed the detailed descriptions of each incident provided on each *OSHA 170 form* by inputting the inspection number provided in the OSHA dataset into the *OSHA Inspection Information* website found at <https://www.osha.gov/pls/imis/inspectionNr.html>.

All OSHA investigated construction fatality incidents in 2019 were classified by the author into one of the four major "Fatal Four" fatality categories of either *Falls*, *Struck-By*, *Caught-in/Between*, or *Electric shock*. Afterwards, the incidents were then separated into one of forty-nine (49) detailed fatality event descriptions. This event list of fatality was initially based on the twenty-nine event types presented in the Banik (2010) paper. This 'list' increased to forty-nine detailed events by the author based on review of the 2015-2019 OSHA Inspection Data. These forty-nine detailed event types allow a clearer analysis of the events related to the "Fatal Four" fatalities.

Once all *OSHA 170 Fatality and Catastrophe Investigation Summaries* were reviewed and data points were sorted by the author, the following initial information was found:

- Thirty-seven (37) of the incidents in the dataset had multiple inspection reports. These inspection numbers for these spreadsheet lines were still used to help determine the cause of the referenced fatality.
- Three (3) incidents were deemed not construction work-related incidents and therefore not included by the author in the final total of five hundred and eighty-one (581) fatalities. For example, a family of four was killed in their new home by carbon monoxide poisoning due to faulty workmanship and, therefore, not considered work-related.
- A total of five hundred and seventy-one (571) investigations were conducted for the five hundred and eighty-one (581) construction-related fatalities. The author organized the inspection report information by event type and fall height (if applicable/given).
- A majority of the 2019 OSHA construction fatality investigations (559 out of 571 investigations, or 98%) involved a single victim. The remaining twelve investigations (2%) involved 2 to 3 victims, which includes the infamous Hard Rock Casino collapse in New Orleans that killed three construction workers in a single event.

Study Results

As previously mentioned, the five hundred eighty-one (581) construction fatalities investigated by OSHA in 2019 were categorized by the author as either a *Fall* (44%, or 257 out of 581), *Struck-By* (16%, or 93 out of 581), *Caught-in/Between* (20%, or 114 out of 581), *Electric Shock* (11%, or 63 out of 581), or *Other* (9%, or 54 out of 581) event based on the descriptive narrative provided in each of the *OSHA Form 170* inspection reports. Note that the fifty-four (54) fatalities grouped into the "Other" category and are not discussed in this particular paper. The detailed events for the 'Fatal Four' incidents are, however, discussed further in the following sections of this paper.

Caught-In/Between Fatalities

The "Caught-in/Between" fatalities were divided into thirteen (13) of the sixty (60) different events and are shown in Table 2. It should be noted that the 'caught-in/between' category experienced a total of seven (7) multiple fatalities within the same event. These multiple fatalities include three (3) trench collapses (with two fatalities each), one (1) tower crane collapse with two (2) fatalities, one (1) event where two workers were fatally crushed by a falling utility pole, another single (1) event where two (2) workers were asphyxiated by vapors in a tank, and the one (1) *Hard Rock Casino* building

collapse event in New Orleans that resulted in the deaths of three (3) workers. The detailed 'caught-in/between' construction worker fatality incidents in 2019 are listed in Table 2.

Table 2. Detailed events for caught-in/between fatalities

Item #	Description of caught-in/between events
1.1	Asphyxiation/inhalation of toxic vapor/poison
1.2	Caught-in stationary equipment
1.3	Crushed from collapse of structure
1.4	Crushed/run over of non-operator by operating construction equipment
1.5	Crushed/run over/trapped operator by operating construction equipment
1.6	Crushed/trapped operator between manlift controls and structure/material
1.7	Crushed/run over by construction equipment during maintenance/modification
1.8	Crushed while unloading/loading equipment or material
1.9	Crushed/run-over by highway vehicle
1.10	Struck or crushed by elevator/counter-weights
1.11	Caught-in/crushed/suffocation by trench collapse
1.12	Caught-in/between unknown source/other/not listed
1.13	Crushed by falling material/non-motorized equipment

Overall, there were one hundred and fourteen (114) 'caught-in/between' fatality events investigated by OSHA in 2019. The detailed 'caught-in/between' construction worker fatality incidents in 2019 are shown in Figure 1.

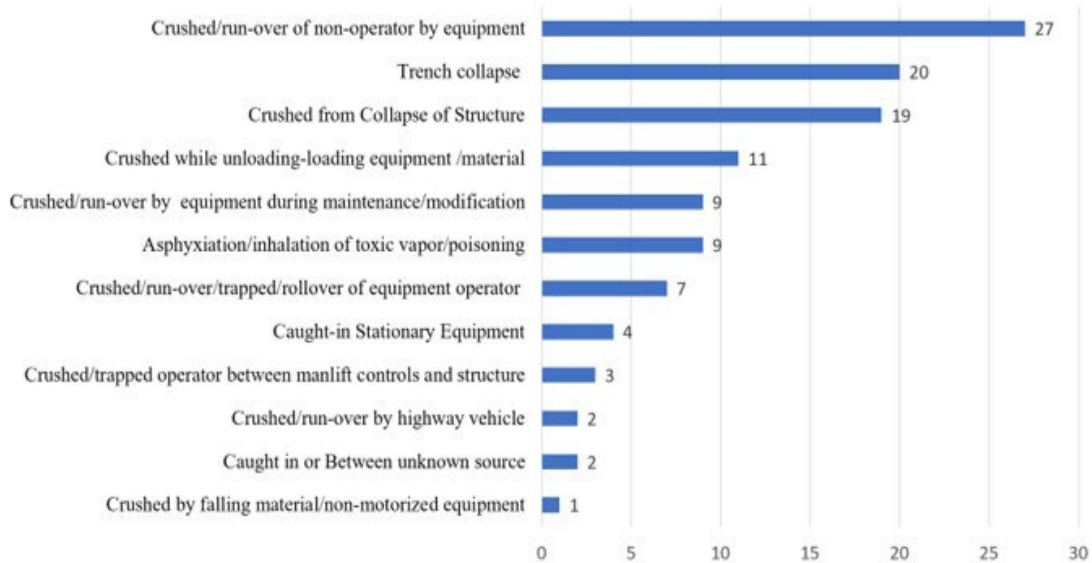


Figure 1. OSHA inspected 'caught-in/between' construction fatalities in 2019

Being 'crushed or run-over by a non-operator' accounted for the highest percentage (23.6%, or 27 out of 114) in this category. These particular events occurred when the victims worked in close proximity of construction equipment. There were sixteen different types of construction equipment involved the 'crushed/run over' events. The top-three types of equipment involved in these fatality incidents were dump trucks (8 incidents or 29.6%), front-end loaders (3 incidents, or 11.1%), and skid-steer

equipment (2 incidents, or 7.4%). Being killed in a trench collapse (17.5%, or 20 out of 114) and getting crushed by the collapse of a structure (16.7%, or 19 out of 114) were respectively the second and third leading causes of construction worker fatalities in the 'caught-in/between' category.

Electrical Shock Fatalities

There were there were sixty-three (63) 'electrical shock' fatality events investigated by OSHA in 2019. The 'electrical shock' fatalities were divided into nine different events as shown in Table 3.

Table 3. Detailed events for electrical shock fatalities

Item #	Description of electrical shock events
2.1	Electrical shock by touching exposed wire
2.2	Electrical shock by arc to the ground
2.3	Electrical shock by ladder contacting power source
2.4	Electrical shock by scaffolding contacting power source
2.5	Electrical shock by crane/boom truck/drum truck contacting power source
2.6	Electrical shock by contacting power source while handling materials
2.7	Electrical shock from equipment installation/tool use
2.8	Shock/burn from flashback/lightning
2.9	Electrical shock, other

The 'electrical shock' category was responsible for one multiple fatality event. This occurred when two workers were electrocuted when the 35-foot aluminum extension ladder they were moving contacted the overhead power service line. The detailed 'electrical shock' events that resulted in construction worker fatalities in 2019 are listed in Figure 2.

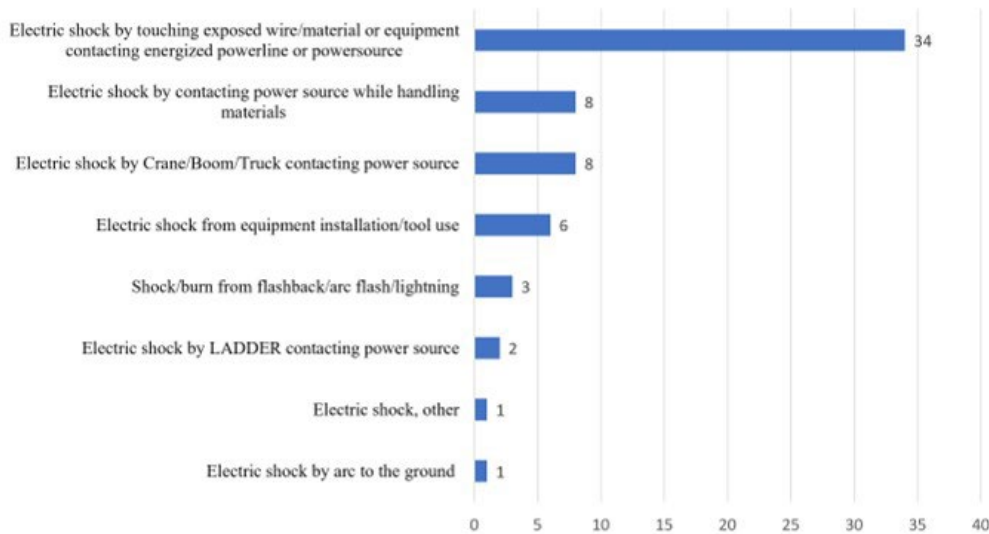


Figure 2. OSHA inspected 'electrical' construction fatalities in 2019

Overall, the 'electrical shock' fatalities investigated by OSHA accounted for almost eleven percent (10.8%, or 63 out of 581) of the fatalities investigated by OSHA in 2019. The incidents responsible for the most electrical shock fatalities were by far the thirty-four (34) 'touching an exposed wire'

events, which included *working on electrical equipment/electrical panels* (32.2%, or 11 out of 34 incidents), *personal contact with the overhead power line* (29.4%, or 10 out of 34 incidents), and *light installation* (also 29.4%, or 10 out of 34 incidents). It appears that working with energized components and the lack of lock-out/tag-out procedures led to most of the 'electrical shock' fatalities. This also includes contacting the overhead power line due to being in close proximity to an active electrical line. Working in manlifts, bucket trucks, aerial lifts and on the roof caused most of the *contact with overhead power line* events.

Fall Fatalities

Fall events accounted for the majority of the fatality incidents (44.2%, or 257 out of 581) inspected by OSHA. Overall, there were twenty (20) detailed events related to fall fatalities. The 'fall' fatality incidents investigated by OSHA in 2019 were primarily one victim incidents. The exception was the one aerial lift tip over event caused by operating the equipment on uneven ground (no height was provided on the report) that killed two workers. The detailed 'fall' events that resulted in construction worker fatalities in 2019 are listed in Table 4.

Table 4. Detailed events for fall fatalities

Item #	Description of fall events
3.1	Fall from/with ladder (includes collapse of ladder)
3.2	Fall from ladder/equipment due to electric shock
3.3	Fall from roof
3.4	Fall through skylight
3.5	Fall through roof other than skylight
3.6	Fall from trusses/bar joists
3.7	Fall from highway vehicle/construction equipment/crane
3.8	Fall from scaffold
3.9	Fall from aerial lift basket
3.10	Ejected from aerial lift basket
3.11	Fall from aerial lift tip over
3.12	Fall from structure (other than roof or trusses/bar joists)
3.13	Fall by collapse or failure of structure
3.14	Fall from platform or catwalk
3.15	Fall from unguarded wall opening/elevator shaft
3.16	Fall through floor opening
3.17	Fall through ceiling
3.18	Fall, same level (slip/trip)
3.19	Fall down stairs
3.20	Fall, other or unknown

It should be noted that item 3.18—*Fall, same level (slip/trip)* did not apply in the 2019 data. OSHA provided heights for one hundred ninety-three (193) of the two hundred and fifty-seven fatality cases investigated in 2019. These fall heights ranged from two feet (2') where a worker stepped out of the back of a box truck and fell two feet to the ground up to two hundred feet (200') where the victim was killed during a floor collapse during the demolition of a building. The average height for falls that resulted in a construction worker fatality was around twenty-seven (27) feet. As shown in Figure 3, 'falls from roof' accounted for the most fatalities (26%, or 67 out of 257) in this category. Ten (10) of the sixty-seven (67) OSHA inspection reports for the 'fall off roof' fatalities did not provide the height that the victim fell. For the remaining fifty-seven (57)

'fall from roof' fatalities, the height ranged between 6 feet (transferring from roof to ladder) to 120 feet (twelve stories) and averaged a fatal fall height around twelve feet (12'). Eighty percent (80.7%, or 46 out of 57) of the 'fall from roof' incidents involved falls of 30 feet high or lower.

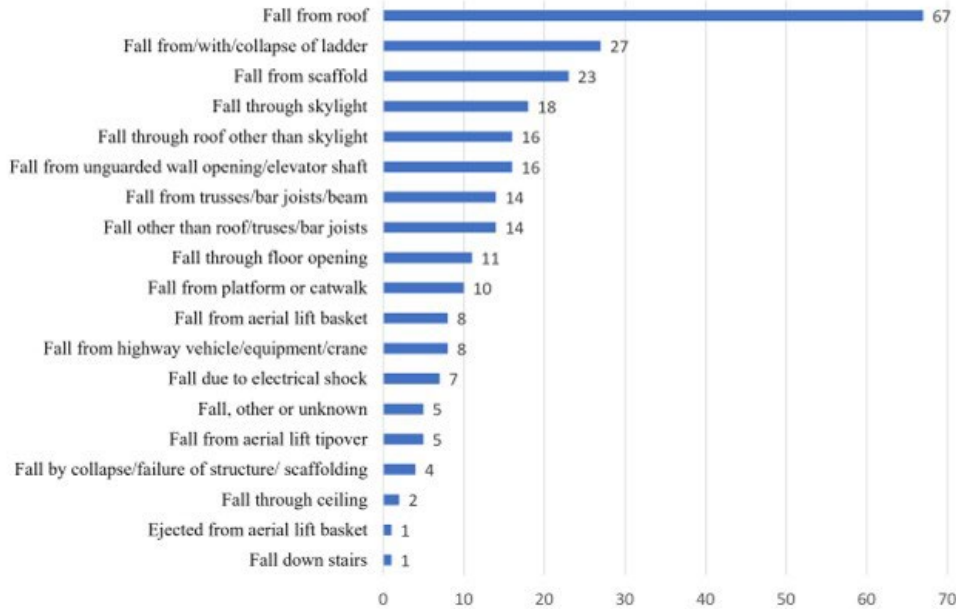


Figure 3. OSHA inspected 'fall' construction fatalities in 2019

Four (4) of the 'fall from roof' victims were wearing a harness and lanyard when they fell. In these four cases, one victim unhooked his lanyard to egress from the roof via ladder while the remaining three victims wore a harness and lanyard, but were not attached to an anchor point. Forty-six (46) of the fifty-seven (57) 'fall from roof' fatalities were roofing contractors (NAICS code 238160).

'Falls from ladder' (10.5%, or 27 out of 257) and 'falls from scaffolding' (8.9%, or 23 out of 257) were the second and third most causes of construction worker fall fatalities. There is no mention as to the type of ladder used or any factors that resulted in the 'fall from ladder' incidents. Fall heights for the 'fall from ladder' fatal incidents ranged from three feet (3') to thirty feet (30'). Fall heights for the 'fall from scaffolding' fatalities ranged from three feet (3') on a mobile Baker-type scaffolding to forty-five feet (45') scaffolding (type not given).

Roof-related fatalities also included 'fall through skylight' (18 out of 257 fall fatalities) and 'fall through roof other than skylight' (16 out of 257) incidents. If these two types of incidents were added together with the 'fall from roof' fatalities discussed earlier, then "roof-related" incidents actually accounted for one hundred and one (101) or thirty-nine percent (39%) of all fall fatalities investigated by OSHA in 2019.

Struck-by Fatalities

There were three (3) multiple fatality incidents in this category. Two (2) of those incidents involved road construction workers getting hit by motor vehicles in work zones and one incident involved a gable truss collapse. Overall, there were seven (7) detailed events related to 'struck-by' fatalities as shown in Table 5.

Table 5. Detailed events for struck-by fatalities

Item #	Description of struck-by events
4.1	Struck-by highway vehicle
4.2	Struck-by of non-operator by construction equipment
4.3	Struck-by of operator by construction equipment
4.4	Struck-by falling object/material/equipment
4.5	Struck-by, unknown/other
4.6	Power tool amputation/saw kick back
4.7	Struck-by structure collapse

Struck-by events accounted for sixteen percent (16%, or 93 out of 581) of the fatality incidents inspected by OSHA. The distribution of construction worker fatalities due to ‘stuck-by’ incidents is shown in Figure 5. Note that items 4.6–Power tool amputation and 4.7–Stuck-by structure collapse did not apply in the 2019 data.

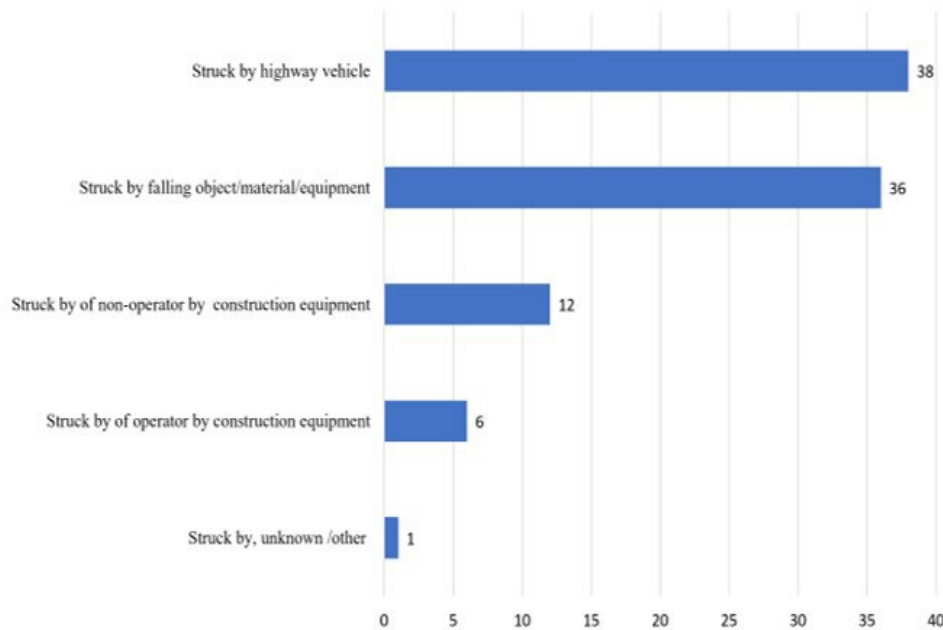


Figure 4. OSHA inspected ‘struck-by’ construction fatalities in 2019

As shown in Figure 4, thirty-eight (38) construction workers were killed after being struck-by a highway vehicle. Twenty-one (21, 55%) of these fatalities were related to roadwork. One (1) worker was killed while removing traffic cones, eight (8) workers were killed will working as a flagger/traffic control (one of these incidents involved a drunk driver), and twelve (12) workers were killed by motorists in roadway work-zones (one of these incidents also involved a drunk driver). Workers getting ‘struck-by falling objects/material/equipment’ (which included a non-operator being struck-by construction equipment tip over) was the second deadliest event for construction workers accounting for thirty-six worker deaths, or thirty-eight percent (38.7%, or 36 out of 93) ‘struck-by’ fatality events.

Summary of Study Findings/Conclusion

OSHA investigated 581 of the 1,061 U.S. construction workers fatalities in 2019. While events within the 'Falls' category were responsible for the majority of construction worker deaths in 2019, workers were also being killed by caught-in/between, electrical shock, and struck-by incidents. Note that the remaining fifty-four (54) fatalities in 2019 investigated by OSHA were categorized as "Other" by the author. These events, which include drownings and heart attacks, included eleven (11) detailed events, but were not discussed due to page limitations. Based on the results of this study, the top-5 fatality "Fatal Four" incidents are as shown in Table 6. These top-5 fatality events accounted for thirty-five percent (35%, or 202 out of 581) of the construction worker deaths investigated by OSHA in 2019.

Table 6. Top-5 construction worker fatality events investigated by OSHA in 2019

Ranking	Fatality Event	No. of Fatalities	Percentage (out of 581 fatalities)
1	Fall from roof	67	11.5%
2	Struck-by highway vehicle	38	6.5%
3	Struck-by falling objects/material/equipment	36	6.2%
4	Electrical shock by touching exposed wire	34	5.8%
5	Fall from/with ladder	27	4.6%

The analysis of the forty-nine (49) fatality events presented in this paper provide trend information on how construction workers are getting killed on the jobsite. Supervisors and their employees can use this information to plan safe work practices by proactively addressing these potential hazards in current or future work and can also be used as discussion points for worker safety training.

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