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OSHA-Investigated Electrocution Fatalities in the Construction Industry, 2015-2019

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Electrocutions are preventable, but still rank as the third leading cause of death on U.S. construction jobsites between 2015 to 2019. Eight percent (8%), or 401 of the 5,172 construction-related fatalities between 2015 and 2019 were due to *electrocution*. The research study presented in this paper reviewed the 310 investigations conducted by the Occupational Safety and Health Administration (OSHA) on the electrocution-related construction fatalities that occurred between 2015-2019 to identify potential trends for these fatal electrocution incidents. This study found that *contact with energized wires*, especially overhead powerlines, were responsible for the majority of construction worker fatal electrocutions. As a result, this study points out the most common electrocution hazards to help construction practitioners mitigate the propensity and frequency at which these fatal events occur.

Key Words: Electrocution, 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 numerous occupational hazards (OSHA, 2021). Data obtained from the United States (U.S.) Bureau of Labor Statistics (BLS) indicate that over five thousand (5,172) U.S. construction workers died on-the-job between 2015 to 2019, which averages to nearly three construction fatalities per day (BLS, 2020). During this same time period, OSHA states the U.S. construction industry accounted for approximately 20% of all workplace fatalities in the United States, but only employed roughly 5% of the workforce (OSHA, 2021).

The Occupational Safety and Health Administration (OSHA) has identified 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 1) Caught-in/Between Hazards e.g. Trench cave-in, run-over/roll-over by equipment, caught-in equipment, crushed by material/equipment, asphyxiation, inhalation of toxic vapor, 2) Electrocution Hazards e.g. shock by touching exposed wires, shock by equipment/tool contacting power source, 3) Fall Hazards e.g. fall from ladder, fall from roof, fall through skylight, fall through unguarded floor opening, fall from structure, and 4) Struck-by Hazards Struck-by e.g. highway vehicle/construction equipment/falling material, power saw kick-back.

According to calculations conducted by the Center to Protect Workers' Rights (CPWR), the "Fatal Four" caused roughly sixty-five percent (65.2%, or 3,373 out of 5,172) of all construction fatalities for the years 2015-2019. *Falls* historically remain the leading cause of all deaths in construction, while *Struck-Bys* and *Electrocution*s, and *Caught-in/Betweens* are responsible for the second, third, and fourth most fatalities respectively (Brown et al., 2021).

While the percentages and number of fatalities distributed between the "Fatal Four" categories are useful, they don't provide enough detail to understand the work-related circumstances behind the worker deaths. A previous study conducted by Jenkins (2022) reviewed the *Fatality and Catastrophe Investigation Summaries* (OSHA 170 form) that were generated in response to construction-related fatality events investigated by OSHA between 2015 – 2019. The study identified nine types of events that led to worker electrocution fatalities. This study uses the nine fatal electrocution types to take a comprehensive look at the 310 electrocution-related fatality events investigated by OSHA between 2015 – 2019. By doing so, the factors and situations that lead to these incidents are highlighted. The findings are useful for construction practitioner's, supervisors, and field employees so that they can proactively identify existing or potential hazards in current or future construction work.

Literature Review

After a comprehensive review of recent safety-related literature, the authors found that limited research exists on electrocution-related fatalities in construction. Of these studies, only two utilized a similar research approach and analysis discussed in this paper.

Janicak (2008) investigated 492 construction worker fatalities involving contact with electricity between 2003–2006. *Contact with overhead power lines* was the most frequent fatal event in construction accounting for 47%, or 232 deaths out of the 492 electrocution fatalities during this four-year time period. *Contact with wiring, transformers, or other electrical components* was second-most with 34% (or 169 deaths out of the 492 total) of the fatalities.

A similar study by Zhao et. al (2014) examined data from FACE (Fatality Assessment and Control Evaluation) investigations conducted by National Institute of Occupational Safety and Health (NIOSH) for the 140 construction-related electrocution fatalities that occurred over 132 events between 1989-2010. This study found that *direct contact with electrical wire*, which included overhead and underground power lines, accounted for 40% of the construction fatalities, while *electrical incidents with construction equipment* accounted for 28% of the fatalities.

The Center for the Protection of Worker Rights (CPWR, 2018) analyzed data on fatal injuries and published the 6th Edition of *The Construction Chart Book: The U.S. Construction Industry and Its Workers*. This study found that between 2011-2015, deaths due to electrocution accounted for over eight percent (8.3%, 364 deaths) of all fatalities in construction. The CPWR study also stated that even though electrocution was more common among electrical workers, many electrocution deaths also occurred among non-electricians, such as construction laborers and roofers. The sources of electrocution deaths were quite different for electrical and non-electrical workers. While power lines and transformers were responsible for the majority of electrocution deaths among electrical workers, exposure to energized equipment/machines and tools caused a majority of the electrocution deaths among non-electrical workers.

Figure 1 shows the number of construction fatalities due to the "Fatal Four" for the years 2015-2019 (Brown, et al., 2021).

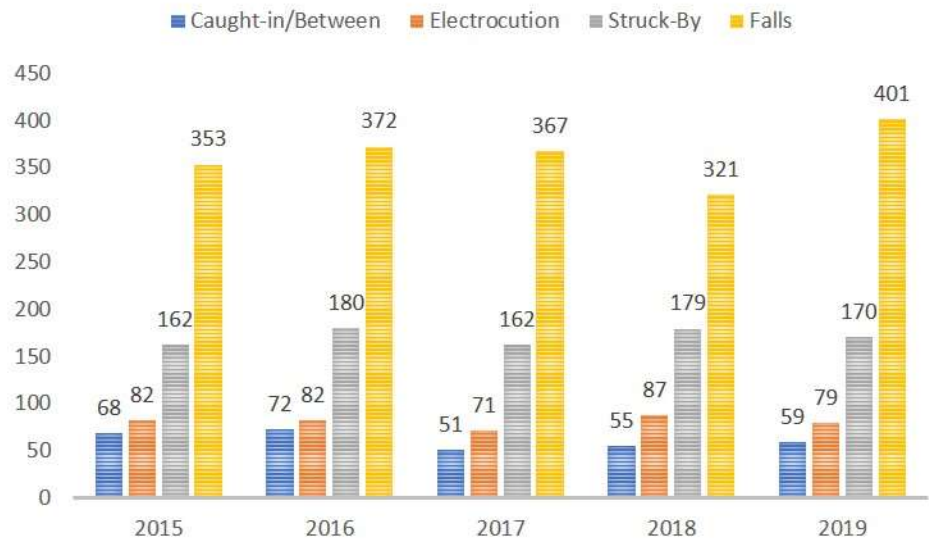

Figure 1. "Fatal Four" fatalities in construction, 2015-2019

As shown in Figure 1, *Electrocutions* were responsible for 401, or roughly 8% of the overall fatalities in construction between 2015 to 2019. During this same time period, OSHA was able to investigate 310 fatality events that led to 316 construction workers deaths during this time period. The multiple-fatality events for the *electrocution* events are discussed in Table 3 later in this paper.

While these studies demonstrate that working with or around electricity can be dangerous, the information does not reveal the whole story of these fatality events. More can be learned from a detailed look at the fatality investigation data.

Research Methodology

The Occupational Safety & Heath 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. A request was made 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 the OSHA Directorate of Construction via email in May 2021. Microsoft Excel was used by the authors to sort and organize this information. Data received for this five-year time period was comprised of 2,938 lines of data which amounted to 2,789 construction fatalities investigated during this time period. This information was reorganized and sorted by the authors in order to group and analyze the information.

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 authors 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) to categorize each incident.

All OSHA-investigated construction fatality incidents in 2015-2019 were classified by Jenkins (2022) into one of the four major "Fatal Four" fatality categories. Each fatality was designated as either a *Fall*, *Struck-By*, *Caught-in/Between*, *Electrocution*, or *Other* by using information obtained from the *Fatality and Catastrophe Investigation Summaries* (OSHA 170 forms) produced during the OSHA investigations during this four-year time period. After the OSHA-investigated fatalities were categorized, each incident was individually sorted into one of 60 detailed fatality events based on the descriptions presented in the OSHA 170 forms. The study presented in this paper focuses on the nine of the sixty detailed events that were identified as *Electrocution* fatalities. The list of the nine detailed 'electrocution' events are shown in Table 1.

Table 1

Detailed events for electrical shock fatalities

Electrical shock by touching exposed wire
Electrical shock by arc to the ground
Electrical shock by ladder contacting power source
Electrical shock by scaffolding contacting power source
Electrical shock by crane/boom truck/drum truck contacting power source
Electrical shock by contacting power source while handing materials
Electrical shock from tool use
Shock/burn from flashback/lightning
Electrical shock, other/not specified

Study Results

As previously mentioned, there were 2,789 construction fatalities that were investigated by OSHA between the years 2015-2019. These investigated fatalities were categorized by Jenkins (2022) as either a *Fall* (41.5%, or 1,158 out of 2,789), *Struck-By* (15.4%, or 429 out of 2,789), *Caught-in/Between* (19.6%, or 546 out of 2,789), *Electrocution* (11.5%, or 316 out of 2,789), or as an *Other* (11.3%, or 340 out of 2,789) event based on the descriptive narrative provided in each of the *OSHA Form 170* inspection reports. This paper will focus on the OSHA investigation results for the 310 events responsible for 316 construction worker fatalities due to *Electrocutions* between 2015-2019.

Electrical Shock Fatalities

OSHA investigated 316 *Electrocution* fatalities that were distributed among 310 events between the years 2015-2019. 'Electrical Contractors' accounted for over thirty percent (31%, or 96 out of 310 events) of electrocution fatalities during this time period. A total of twenty-five different *North*

American Industry Classification System (NAICS) numbers for contractors experienced an electrocution fatality event according to OSHA's Inspection Reports. The top-5 affected contractors are shown in Table 2.

Table 2

Top-5 NAICS numbers for OSHA-inspected electrocutions, 2015-2019

NAICS Number	NAICS Description	No. of Fatality Events	Most Common Incident
238210	Electrical Contractors	96	Contact exposed wire
238130	Plumbing, Heating, and Air Conditioning	34	Contact exposed wire
237130	Power and Communications	32	Contact high-voltage line
238160	Roofing Contractors	30	Ladder contacting power
236118	Residential Remodelers	12	Contact exposed wire

These OSHA-investigated 'electrical shock' fatalities were sorted into nine different detailed events. The nine detailed 'electrical shock' events that resulted in construction worker fatalities between 2015-2019 are listed in Figure 2.

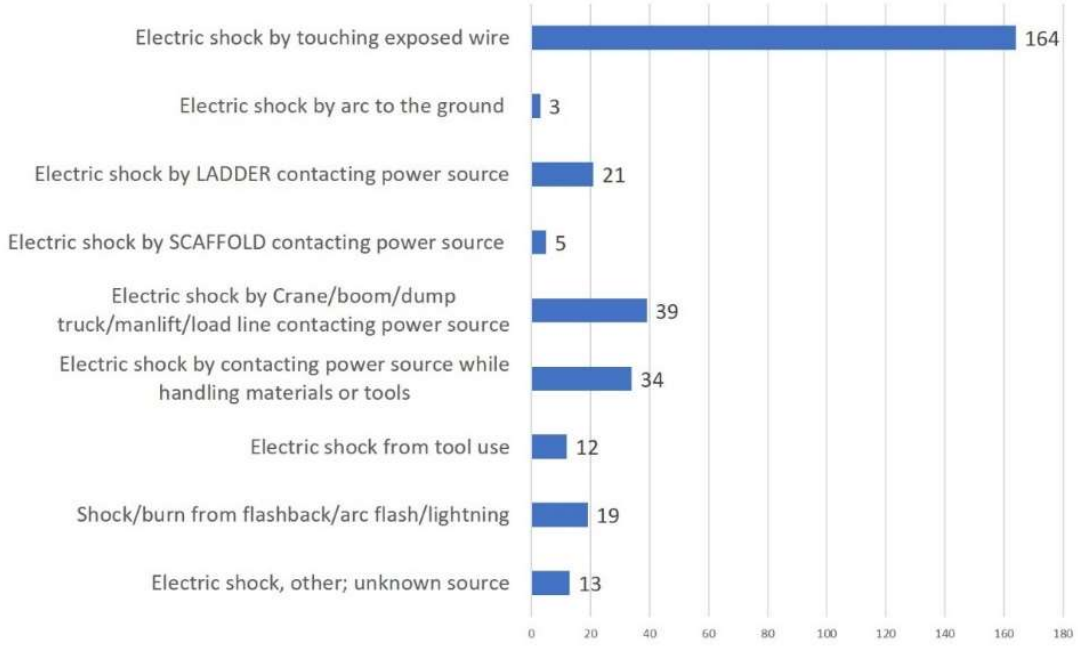

Figure 2. Construction electrocution events investigated by OSHA, 2015-2019

As shown in Figure 2, *electrical shock by touching exposed wire* accounted for the majority (52.9%, or 164 out of 310) of electrocution-related events in construction investigated by OSHA between 2015 and 2019. Working in *Close Proximity to Live Wire* was responsible for 68 (or 41.5%) of the

164 *Electric Shock by Exposed Wire* events, or 21.9% (68 out of 310) of the overall 'electrocution' fatalities.

Fatalities designated as *electrical shock by touching exposed wire* were also found to occur within areas designated as 'confined spaces' such as attics (8 events), crawl spaces (3 events), above-ceiling (2 event), and an equipment pit (1 event). Workers were also electrocuted by 'personally contacting buried utilities' (4 events).

There were also 18 fatal events due to *Equipment Installation* (*HVAC Equipment*, 10 events, *Other Equipment*, 8 events) and 10 events involving work on *Distribution Panels* in this category. *Personal Contact with Overhead Powerlines* added another 41 (or 25%) of the 164 *Electric Shock by Exposed Wire* events, which occurred when the workers were high enough to 'personally contact the overhead powerline'. These individual 41 events are included in the 132 'overhead powerline' events discussed in Figure 4 later in this paper.

The remaining 55 events (or 33.5%) related to 'touching exposed live wires' were work involving *Light Fixtures* (20), *Junction Boxes* (14), and *Transformers* (3). The distribution of events involving *Electric Shock by Touching Exposed Wire* is shown in Figure 3.

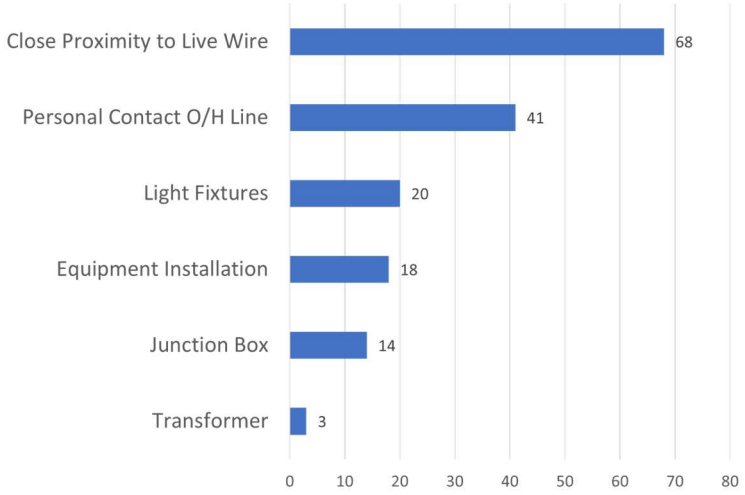

Figure 3. Distribution of electric shock by touching exposed wire events, 2015-2019

Overall, there were 132 (or 42.5%) of the 310 overall 'electrocution' fatal events that involved *contact with overhead powerlines* which were responsible for a total of 138 deaths. This number of events includes the 41 that were classified as *Personal Contact with Overhead Power Lines*. These personal contact events commonly occurred from *bucket trucks* and *aerial lifts*. Other ways workers came into contact (either directly or indirectly) with overhead powerlines included via *material, tools*, or *equipment*. The 132 sources (i.e. tasks and conditions) which caused workers to contact overhead electrical powerlines are identified in Figure 4.

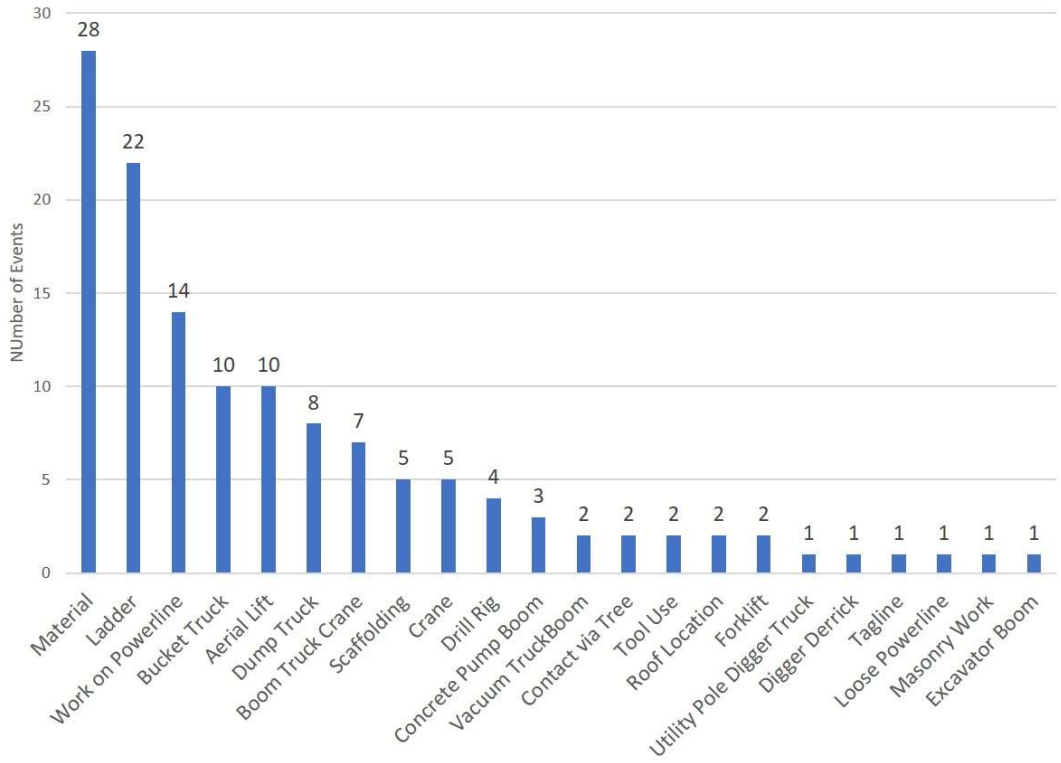

Figure 4. Sources of overhead powerline contact

Handling Materials accounted for the majority (28 out of 132, or 21,1%) of the *Overhead Powerline* incidents. 'Material' included structural steel elements (5 events, or 3.8%), extension poles for tools/bull floats (4 events, or 3%), aluminum street light pole/flag pole (4 events, or 3%), roofing materials/metal gutter/flashing (4 events, or 3%), and rebar (3 events, or 2.2%). The extension pole lengths involved in the fatal electrocution events were 6 feet, 10 feet, 23 feet and 29 feet in length. Workers used a variety of equipment to access their work and, unfortunately, get too close to overhead powerlines. This equipment included ladders (22 events, or 16.7%), bucket trucks (10 events, or 7.5%), aerial lifts (10 events, or 7.5%), and scaffolding (5 events, or 3.8%). Lengths of the metal extension ladders used in the electrocutions included lengths of 24 feet (one event), 32 feet (2 events), 35 feet (one event), 40 feet (six events), and 'no length given' for eight of the metal extension ladders. The remaining four ladder-related events included four aluminum shingle ladders used by roofers (one ladder at 35 feet and three ladders with no length given). Motorized equipment (dump truck, boom truck, crane, concrete pump, forklift, and excavator) used to haul or lift construction material accounted for 26 (or 19.6%) of the 132 electrocution fatality events.

Lastly, the *Electrocution* category accounted for five multiple fatality events in 2015-2019 resulting in 11 total fatalities. Therefore, it is important to note that safety incidents involving electrical shock have far reaching consequences. The descriptions of these multiple fatality events shown in Table 3 were taken directly from the OSHA Inspection Detail Reports.

Table 3

Construction electrocution multiple-fatality events investigated by OSHA, 2015-2019

Date	Fatality Event	No. of Fatalities
April 3, 2015	Employee #1 and Employee #2 were moving a **35-foot shingle ladder** to a different part of the roof of a residential house. As the employees moved the ladder, it came into contact with overhead power lines that were approximately 30 feet above the ground and 17 feet away from the dwelling. Employee #1 and Employee #2 were electrocuted.	2
September 28, 2015	Employees #1, #2 and #3 were operating an **excavator** when the boom of the excavator contacted the overhead power line. The power line broke and fell to the ground. The employees working near the falling power line were electrocuted. Employees #1 and #2 were killed. Employee #3 was hospitalized.	2
January 14, 2017	Employees #1, #2 and #3 were un loading and staging structural metal beams with a **boom truck crane**. The truck-mounted crane was unloading steel beams from an open top container when the boom truck cable touched an overhead high-power line causing electrical current to flow down the steel beam into the arms and bodies of Employees #1, #2 and #3, who were on the ground.	3
October 8, 2018	Employee #1 and Employee #2 were operating a **concrete pump truck** when the boom and hose touched the overhead power line carrying 13,000 volts. Employee #1 and Employee #2 were electrocuted.	2
July 24, 2019	Employees #1 and #2, employed by a construction company, were putting away the **35-foot aluminum extension ladder** they had used while painting the exterior of a house. The ladder contacted the house's overhead power service line, and electricity was conducted through the aluminum to the employees. Both Employee #1 and Employee #2 were electrocuted.	2

'Struck by Lightning" also contributed 14 of the OSHA-inspected construction worker fatalities between 2015-2019. All fourteen of these 'lightning' fatalitites involved workers being exposed outdoors during storm conditions. Seven (7 out of 14, or 50%) of these ligtning fatalities involved roofers being hit by lightning while on the roof.

Conclusion

The objective of this study was to examine electrocution-related construction fatalities investigated by OSHA between 2015-2019. Overall, OSHA investigated 310 'electrocution' events that were responsible for 316 construction worker fatalities between 2015-2019. The findings show that the

majority of electrocution fatalities, unfortunately continue to happen as a result of coming into contact with exposed wires. Particularly when individuals are working around 'overhead powerlines', which led to 132 events resulting in 138 construction worker deaths. Similar studies have pointed to these types of events (Janicak, 2008; Zhao et al., 2014), yet the construction industry has failed to mitigate these preventable accidents. Some simple steps might help reduce or eliminate the exposure when working around overhead powerlines. For example, maintaining an adequate and safe working distancing from the hazard including knowing in advance the overall dimensions of the material and/or equipment required to complete the task. Also, using non-conductive ladders at all times, especially when working on or around electricity. These two sources of contact accounted for twice as many events/incidents than any of the other sources reported by OSHA.

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