Designing For Safety in the Construction of Single Family Homes

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Abstract: The construction industry has the third highest fatality rate among the nine major industrial groups in the United States. Falls from or through roofs have been the leading causes of these fatalities for the past two decades. This study assesses the proximal cause of fatalities occurring during the construction of single-family homes. The study encompasses not only new construction but also fatalities which may occur in association with re-modeling or alterations, and additions to existing single-family homes. An examination of more than seventy case files selected from a three year time period indicated that the leading causes of fatal events for this type of construction are various types of falls, electrocutions, and crushing incidents. In addition we determined that nearly every incident reviewed could have been avoided provided the proper preventative measures were taken. Potential preventative measures may be but are not limited to the provision of adequate safety and training courses the existence of a competent person on site, or the proper use of safety equipment.

Background: Falls, electrocutions, and crushing incidents were the leading causes of fatal incidents occurring during the construction of single-family homes during the period 2003-2005. This study aims to examine why these fatalities occurred and various circumstances surrounding the incident.

Methods: Seventy-seven case files from OSHA inspections of fatal incidents occurring during the new construction, re-modeling or alterations, and additions to single-family homes were reviewed.

Results: Falls from roofs was the leading fatality cause. Several organizational or physical conditions were present at many fatal sites; the most frequent was that no training had been provided for the use of personal fall arrest systems.

Conclusions: Presence of a competent, diligent person at the site would have prohibited most fatalities. The leading citations were 29 CFR 1926.21 (b)(2) and 29 CFR 1926.501 (b)(13).

Suggestions: Potential preventative measures may be but are not limited to the provision of adequate safety and training courses, the existence of a competent person on site, or the proper use of safety equipment. Action taken at the design stages and reconsideration of materials used for construction may lessen the potential of these fatal incidents.

Key Words: fatal incidents; OSHA form 170; 29 CFR 1926

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Introduction:

As identified in a study conducted by the Construction Industry Research and Policy Center at The University of Tennessee, Knoxville falls, electrocutions, and crushing incidents were the leading incident types resulting in a fatality for all construction types from 1991-2001.[1] The results from this study indicate that the same types of fatal incidents, with similar magnitude, are known to occur in the construction of single-family homes. This information further suggests that the parties associated with the construction of single-family homes should continue to be held accountable for their actions in much the same manner as those responsible for other construction types. Beginning to understand the circumstances related to these incidents and considering alternative preventative measures within one specific building disciple will help us to understand similar situations in a larger context. Our hope is that through investigation, analysis, contemplating alternative considerations, increased communication and raising awareness we can work with the Occupational Safety & Health Administration to improve the health and safety in construction and lessen the number of fatal incidents.

Beyond offering more specific training and the writing of new safety standards we feel it may prove to be beneficial to investigate how the designs of our single-family homes can be improved upon in order to create a safer work environment. Further, we believe that increased communication among builders, architects, engineers, contractors, owner and union representatives as well as safety, health and insurance professionals is needed if we are to see fewer fatalities on construction sites. Increasing communication of site related issues and scheduling details such as the arrival and placement upon arrival of materials may lessen the occurrence of fatal incidents. Further investigation into the design and implementation of prefabricated components and building systems may also be a way to create a safer environment for building.

Methods

Since 1991, The Construction Industry Research and Policy Center (CIRPC) at the University of Tennessee, Knoxville has analyzed the causes of fatal incidents in the construction industry for the Occupational Safety & Health Administration (OSHA) using the narrative descriptions of fatal construction events from the OSHA Form 170 [Schriver

and Cressler, 2004]. CIRPC analyzes data in an effort to identify and rank the leading categories of causes of fatal events in construction, assists OSHA in identifying factors that contribute to fatal incidents, and suggests intervention strategies aimed at preventing similar types of incidents.

States with Federal OSHA Programs[1] provide the data to be analyzed by the CIRPC. OSHA inspects only those fatal events where an employee is a victim, omitting events where a self-employed person or independent contractor is a victim. Of the x,xxx case files received from 2003-2005 seventy-seven fatalities provided the data for the analysis reported in this study. The data collected form the seventy-seven fatal incidents consisted of victim's occupation, age, contributing organizational/physical factors (that may have contributed to the fatalities), day of the week, time of day, cost of the project, type of work being preformed, and citations.

Results:

80% of the seventy-seven case files reviewed attribute the direct cause of death to one of four categories: falls (44%), electrocutions (18%), crushing incidents (9%), and trenching (9%) (fig. 1). Falls from or through roofs, through an opening (other than roof; ex. stairwell, equipment opening, or other opening in floor), and from/with ladder are the leading types of falls resulting in a fatal incident. Electrocution by touching an exposed wire/source and equipment coming into contact with exposed wire/source are the leading fatality causes of electrocutions. The leading crushing incidents are those resulting from the equipment operator being crushed/run-over/or trapped by the equipment. Trenching incidents are most often the result of no sloping/benching/shoring of the walls of the trench to prevent the collapsing of the earth.[2]

[1] AL, AR, CO, CT, D.C., DE, FL, GA, ID, IL, KS, LA, ME, MA, MO, MS, MT, ND, NE, NH, NJ, NY, OH, PA, RI, SD, TX, WI, and WV.

[2] American Journal of Industrial Medicine 45: 522-527 (2004) Wiley-Liss, Inc., Neglecting Safety Precautions May Lead to Trenching Fatalities

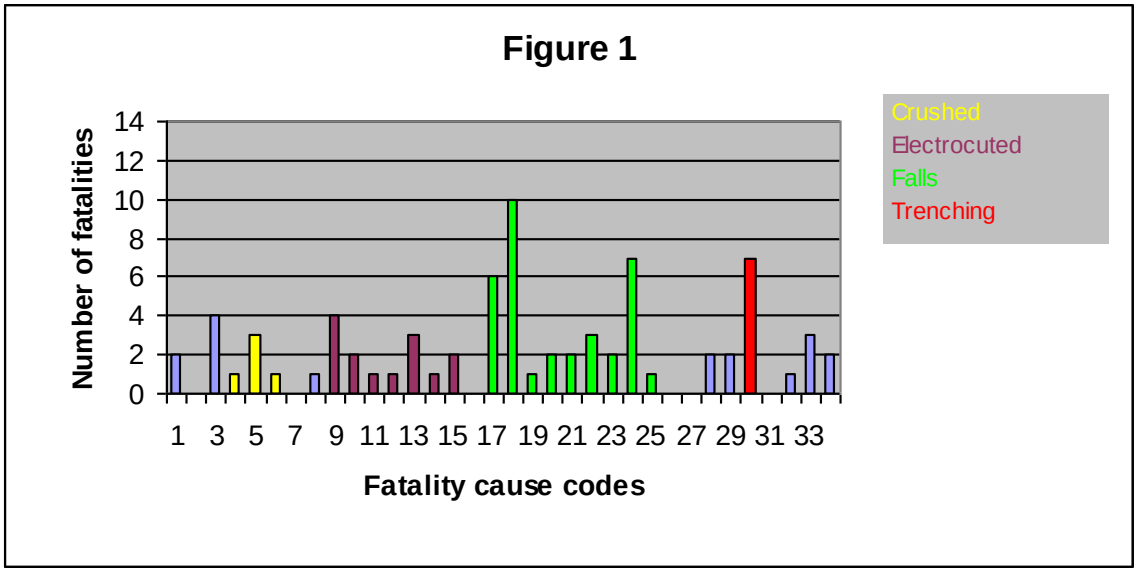
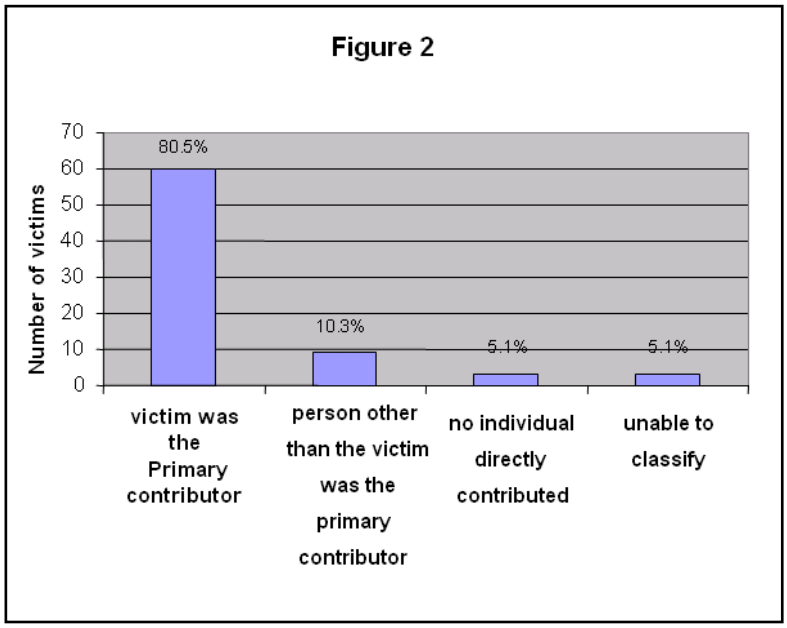
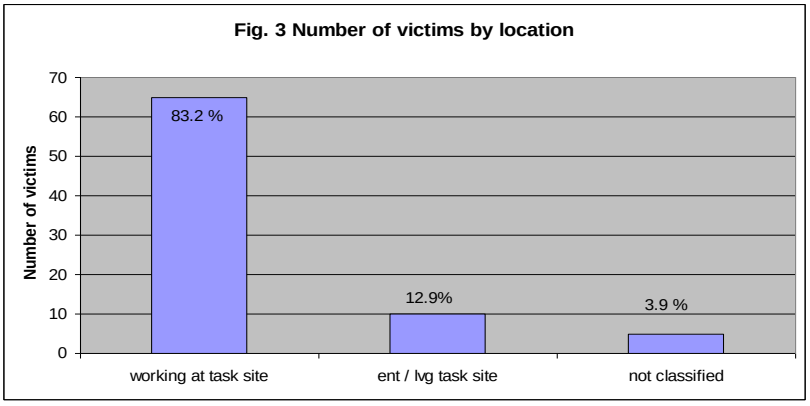
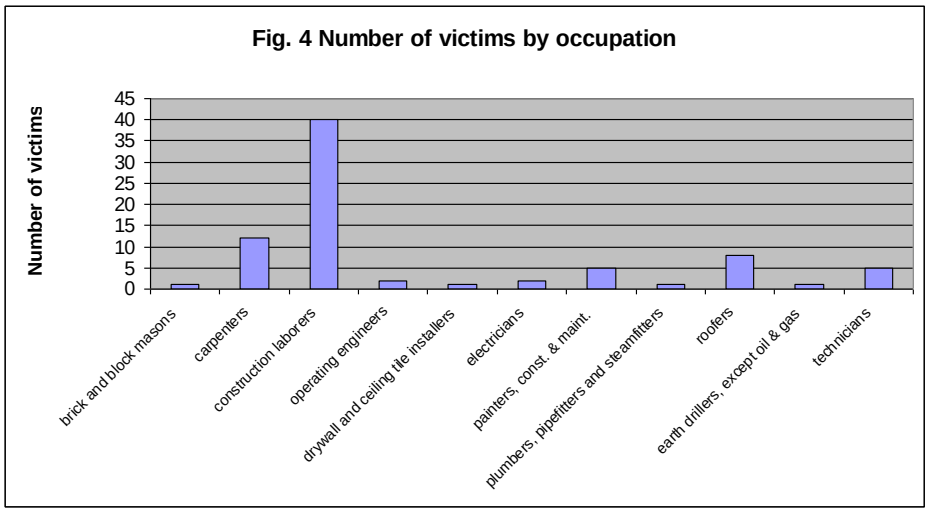


Figure 2 shows that in more than 80% of the case files reviewed the victim was the primary immediate contributor to the occurrence of the fatal event. Approximately 10% of the time a person other than the victim was the primary immediate contributor to the event. As shown in figure 3 more than 83% of the time the victim was identified as actively working at their job related task when the incident occurred. This is in comparison to the less than 13% of victims found to be entering or leaving the task site when the incident occurred.





Figures 4 and 5 indicate that 52% of the victims were construction laborers and most victims were between 30 and 40 years of age. Figure 6 and 7 indicate the day of week and the time of day for which the analyzed incidents occurred. Lastly, figure 8 depicts that 59% of the incidents occurred on a job site where the total cost of the work was estimated at below $50,000.



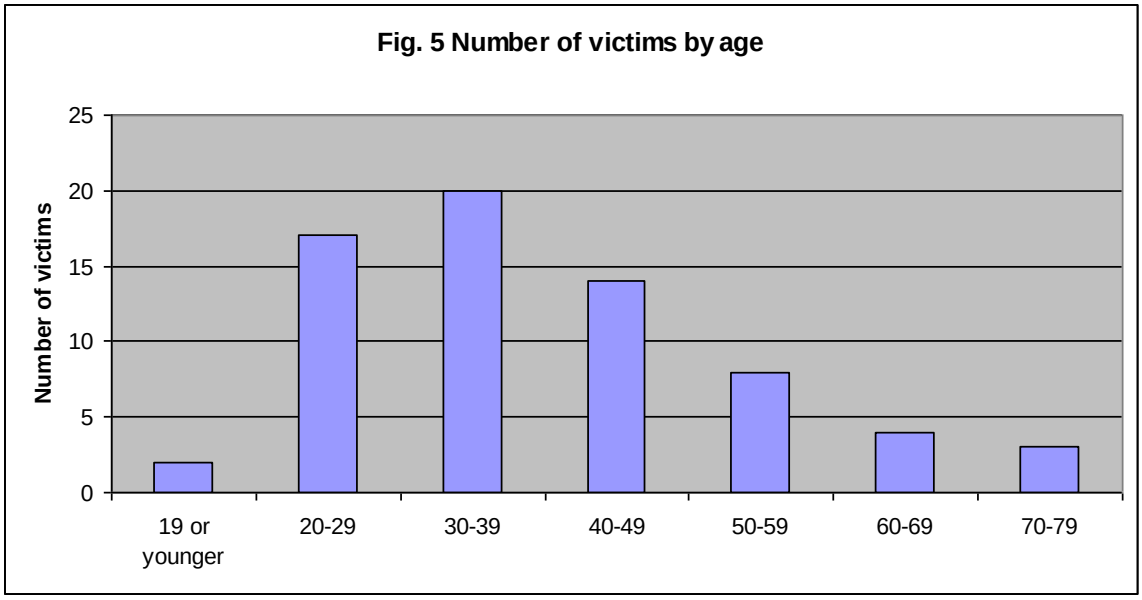


Fig. 5 Number of victims by age
Number of victims
25
20
15
10
5
0
19 or younger
20-29
30-39
40-49
50-59
60-69
70-79

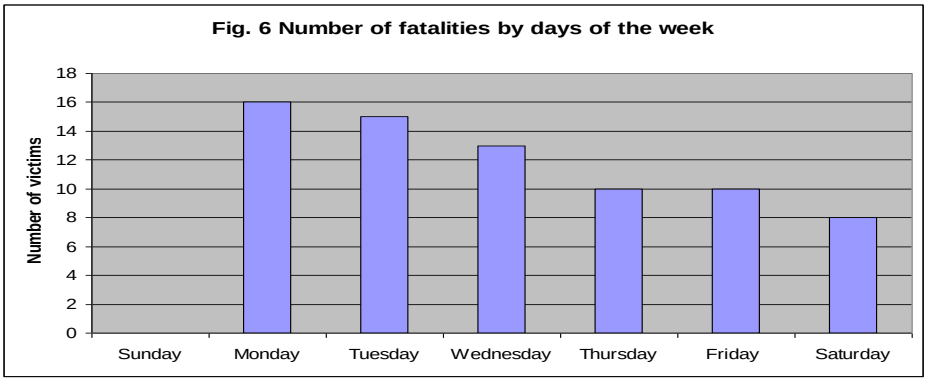


Fig. 6 Number of fatalities by days of the week
Number of victims
18
16
14
12
10
8
6
4
2
0
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday

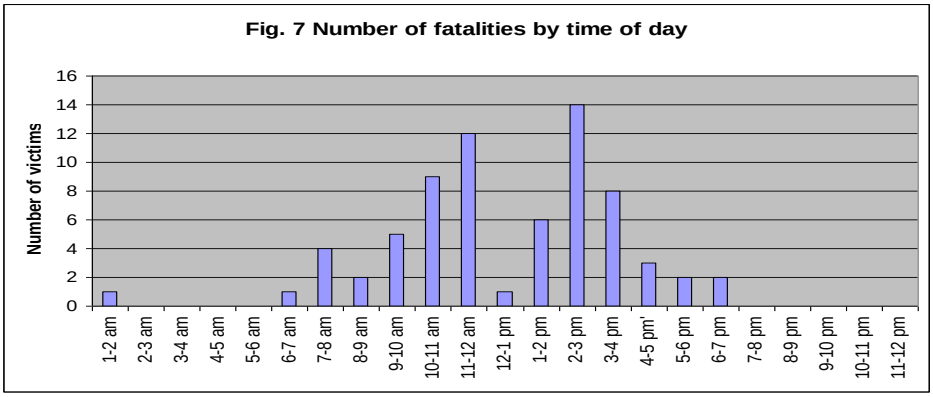


Fig. 7 Number of fatalities by time of day
Number of victims
16
14
12
10
8
6
4
2
0
1-2 am
2-3 am
3-4 am
4-5 am
5-6 am
6-7 am
7-8 am
8-9 am
9-10 am
10-11 am
11-12 am
12-1 pm
1-2 pm
2-3 pm
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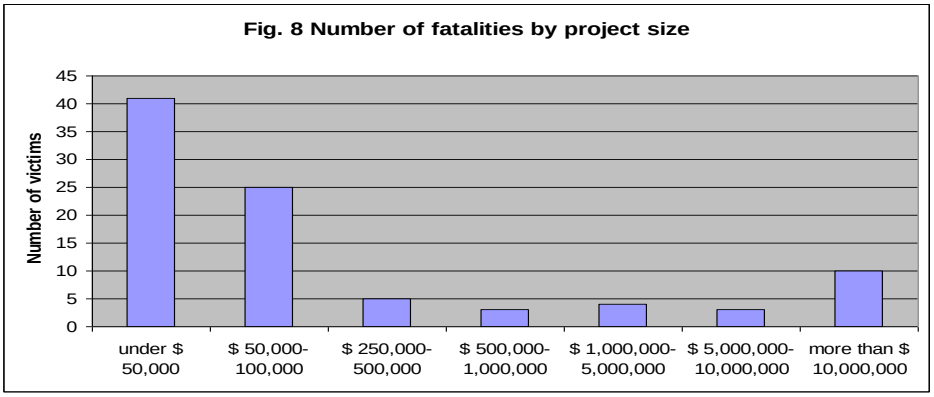
7-8 pm
8-9 pm
9-10 pm
10-11 pm
11-12 pm



Discussion:

Falls from or through roofs, through an opening, and from/with ladder are the leading fall types identified in the study. This indicates that as general construction laborers are actively involved in roofing work or other work which requires them to be at elevated heights they are not protecting themselves against the potential risks by utilizing personal fall arrest systems. The most common form of electrocution among the fourteen identified incidents was a result of a non-electrician coming into contact, by touching, an exposed wire source. Among the seven identified fatalities discovered as a result of a crushing incident five were the result of an operator being crushed/run-over/or trapped by the construction equipment. All seven trenching related deaths occurred while work was being performed within a trench without proper sloping, benching, or shoring of the walls of the trench or the utilization of a standard trench box.

The high number of victims determined to be the primary and immediate contributor to their own fatal incident was not anticipated prior to the study. This information suggests that an even greater importance should be given to the training and enforcement of safety practices in the construction of single family homes. Because victims are often working alone and responsible for numerous job related tasks there is an increased need to raise their awareness associated with their abilities to recognize and appropriately act in response to potential job related hazards. Because such a large number of incidents were determined to have occurred while the victim was actively involved with their job related task at the time of the incident increased awareness through education could have a profound effect on the number of fatalities. This information allows us to conclude with

confidence that most if not all of these fatal incidents are preventable provided increased safety training and the enforcement of a diligent competent person is on site.

As indicated in figure 4 much of the work in the construction of single-family homes is being realized through the efforts of construction laborers. These individuals are not typically trained in any one area of specialization and are being required to perform many overlapping job related tasks. General knowledge and understanding of safety related practices on a job site could greatly decrease the number of fatal incidents associated with this group of people.

The potential economical gain of a single-family residential construction project is typically much less than that of a commercial project. Due to this there is perhaps less motivation for construction company owners and general contractors to enforce safety related practices and to even offer the means to obtain safety instruction. Because this is the reality I feel it becomes the responsibility and role of the architect, engineer, developer, plans examiner, manufacturer and inspector to consider alternative design and building strategies that may make construction safer.

Since the 1950's architects have increasingly given up a portion of their profession to builders and developers. Much of the residential development realized in the United States today is done without the slightest involvement of a licensed architect. Giving this responsibility back to the profession of architecture and enforcing that they fulfill their professional responsibility of ensuring health safety and welfare for the users of the building as well as those responsible for the construction of the building may have a profound effect on the number of fatal incidents in residential construction. Elevating the level of specificity required on construction documents necessary for permits would be one way to give this responsibility back to the architects.

It should become the role of the architect to anticipate and therefore appropriately detail drawings for the eventual safety related hazards which could potentially occur on the job site. Even in the case of spec. housing drawings should be created which clearly indicate potential site related complications due to the location of existing or planned utilities as well as other permanent and temporary obstacles. The architect should work closely with the owner/builder to anticipate scheduling/delivery of materials so that a site may be organized in an efficient and safe manner throughout the duration of a job.

In addition to site related issues architects and engineers could be challenged to incorporate safety related components into the actual pieces of the building parts. One example of this could be to design perimeter beams and beams above floor openings to support lifelines (minimum dead load of 5,400 lbs.). In addition to designing the points along the beams for the lifelines architects should be responsible for noting on the contract drawings which beams are designed to support lifelines, how many lifelines, and at what locations along the beams.

Practices such as the above listed suggestions are likely to only be implemented in high end custom single-family design and perhaps only at the owner/client request. Realizing the majority of fatal incidents analyzed in the study occurred on job sites where the total cost of the project was less than 50,000 suggests that we must also consider other alternatives related to more economically sensitive building strategies. I believe that through the implementation of prefabricated building components and systems the number of fatal incidents occurring on site could greatly reduce.

Many of the fatal incidents investigated in the study were a result of building practices related to additions, renovations or re-modeling work. Incorporating prefabricated standardized building components ensures a certain amount of regularity in functions to be preformed in the event of future work. This type of uniformity among the building trades could help diminish the eventual risks related to the work being preformed.

Choosing to incorporate components such as panelized stud wall systems, prefabricated steel structural frames, or pre-cast concrete systems will also mean choosing to work with a supplier who is specifically qualified at incorporating their system into the desired design. They will be licensed and bonded and most likely have their own trained professionals whom they will want to have installed the prefabricated system.

? Insert Case Study here of Dwell Design Invitational??

Remarks:

The findings of this investigation of fatal events occurring during the construction of single-family homes for the specified study period suggest that these events could have easily been prevented if a competent person onsite had followed OSHA regulations. Recognizing that identical fatal events are known to occur with similar frequency between single-family residential construction and all types of building construction suggests that the training

procedures, enforcement of OSHA standard safety policies, and citations issued should not be any different. What is apparent is that in addition to continued code enforcement, and increased safety training to ensure that a diligent competent person is onsite the primary persons involved in the building industry must expand the level of communication between one another. Architects and engineers need to accept and be held responsible for the anticipated level of liability which in large part is due to their proposed design criteria. Manufacturers, suppliers, plans examiners, and inspectors need to communicate the knowledge they have concerning common building practices and the results due to those practices. An increased level of awareness, responsibility, and communication will transform into openness in the desire to consider alternative building strategies which may lead to reduced numbers of fatal incidents.

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