CPWR THE CENTER FOR CONSTRUCTION RESEARCH AND TRAINING

Crane-Related Deaths in Construction and Recommendations for Their Prevention

Revised and Updated November 2009

Expanded analysis: Inclusion of secondary Source coding and keyword search increases crane deaths

Introduction & Summary

CPWR issued the report *Crane-Related Deaths in Construction and Recommendations for Their Prevention*, on June 17, 2008. The report analyzed data from the Census of Fatal Occupational Injury (CFOI), produced within the Bureau of Labor Statistics (BLS). The CFOI data were fatality narratives with a primary Source code of "cranes."

CPWR researchers decided to re-examine the data when further review showed many fatalities of workers struck by crane loads were not being counted under the primary CFOI Source codes for cranes. Lead researcher, CPWR's Director of Safety Research Michael McCann, Ph.D., counted CFOI secondary source codes for cranes and used "crane" in a key word search of the CFOI narratives of construction fatalities from 1992 through 2006, the same period as the 2008 report.

The new findings almost doubled the number of workers killed in construction crane-related incidents. In the 2008 report, the average number of workers killed annually was 22. In the new report, the average number of worker deaths involving construction cranes was 42 a year. The 2008 report identified a total of 323 deaths involving cranes, while the new report identified 632 deaths involving cranes. This revised report with its expanded analysis will confirm that many worker deaths attributed to cranes were not being identified as such from 1992 through 2006.

The revised report also showed one big similarity with the 2008 report: the most frequent cause of death remained overhead power line electrocutions. Like the previous report, this report provides information on the cause of death, types of cranes involved in fatalities, and construction trade and employer size associated with the incident.

This 2009 report updates, expands and replaces the initial 2008 report.

CPWR began examining crane fatalities in 2008 after three major crane incidents occurred within a 10-week period from mid-March to late May. The three incidents – two in New York City and one in Miami – were responsible for the deaths of 10 construction workers and one bystander, and injuries to 19 construction workers, 11 first responders, and one bystander.

The numbers of construction crane-related deaths continued to climb in 2008, and McCann began collecting data from a variety of Internet sources on U.S. construction crane-related injuries and deaths between Jan.1, 2008 and Dec.31, 2008. He used the Internet for incident reporting as the CFOI records were not yet available for 2008. There was a total of 55 deaths and 99 injuries of construction workers in 88 incidents in 2008. These incidents were also responsible for the deaths of four bystanders and injuries to 15 bystanders and 11 rescue workers. More information about crane incidents during 2008, which did not appear in the June 2008 report, can be found on Page 5 of this report.

Because construction cranes can also pose a hazard to the public, McCann found examples of U.S. construction crane-related deaths of workers and bystanders from news reports dating from 1978 to 2008. These examples can be found in Table 5. McCann used news reports as there is no BLS data to cover both workers and bystanders.

The data within this report refer only to construction cranes. Crane-related fatalities among workers in manufacturing or other industry sectors have been excluded.

Clearly, the safe operation of cranes could be improved. The efforts to improve crane safety and revise the 1971 Crane Standard have been in the works for years. In 2003, OSHA formed a Crane and Derrick Negotiated Rulemaking Advisory Committee (C-DAC) consisting of representatives from industry, labor and government to develop a new safety standard for the construction industry that would aid in reducing fatalities. The committee first met in July 2003, and reached a consensus on regulatory language for the new standard on July 9, 2004. Four years later, and after considerable external pressure, OSHA published the proposed crane and derrick rule for public comment in the Federal Register on Sept. 16, 2008, with a deadline for public comment of Dec. 8, 2008. This deadline was later extended to Jan. 22, 2009. A public hearing was held March 17-19 with a deadline for post-hearing comments of June 18, 2009.

This CPWR report and recommendations provides new information to heighten awareness of crane hazards and recommends training, inspection and proper operation of this equipment to prevent future injuries and deaths.

Report Authors

Michael McCann, PhD, CIH, is director of safety research at CPWR – The Center for Construction Research and Training, the research, development, and training arm of the Building and Construction Trades Department, AFL-CIO.
Janie Gittleman, PhD, MRP, is associate director of safety and health research for CPWR – The Center for Construction Research and Training.
Mary Watters, MFA, is communications director for CPWR – The Center for Construction Research and Training.

Methods

Construction industry fatality data for the two-digit BLS Standardized Industrial Classification (SIC) Codes 15, 16 and 17 for 1992 through 2002 were identified from the Census of Fatal Occupational Injuries (CFOI) database. For 2003-2006, the 2002 North American Industry Code System (NAICS) codes 236-238 were used, as NAICS replaced the SIC Codes beginning in 2003. The resulting data were entered into a Microsoft Excel 2003 database for analysis.

The primary source of injury or illness identifies the object, substance, bodily motion, or exposure that directly produced or inflicted the injury. The secondary source of injury identifies the object, substance, or person that generated the source of injury or that contributed to the event or exposure. Coding for the source and secondary source are based on the Occupational Injury and Illness Classification (OIICS) manual. More information on OIICS can be found at http://www.bls.gov/iif/oshoiics.htm. The worker activity describes what the worker was doing at the time of the fatal injury or exposure. Worker activity is an internal codes used by the Census of Fatal Occupational Injuries (CFOI) program.

Construction worker deaths related to cranes were identified by selecting all records with the Primary Source and Secondary Source code 34* (Cranes). In addition, the construction record narratives were searched for the word "crane." Records involving aerial lifts, and scissor lifts were excluded, but crane man baskets were included.

The CFOI narratives, along with event, occupation and establishment codes of the crane-related deaths were used to classify deaths by cause, occupation and establishment size. This 2009 report, like the 2008 report, identifies the main causes of death, the types of cranes involved in fatal incidents, the trades of those who died, and the size of the employer experiencing the greatest number of fatalities.

Information on construction crane injuries and deaths from January through December, 2008 was gathered from the following Internet sources: CraneAccidents.com, Washington State Department of Labor and Industries, Google, Internet news articles, OSHA Underground, Cranes Today, and The Weekly Toll.

Results

1992-2006 CFOI Study

The revised 2009 study identified a total of 632 crane-related construction worker deaths involving 611 crane incidents from 1992-2006 (including 17 multiple deaths incidents causing 38 deaths) compared to a total of 323 deaths in 307 incidents in the previous 2008 study. The revised average is 42 deaths per year.

Four main types of cranes have been associated with crane-related fatalities. Of the 611 fatal crane incidents, only 375 were identified from the CFOI record as to type of crane.

Of these, 292 (78%) involved mobile or truck cranes. Forty-five of the fatal incidents involved overhead or gantry cranes (12%), 18 involved tower cranes (5%), and 11 involved floating or barge cranes (3%). The remaining nine reports did not meet BLS publication requirements for confidentiality reasons.

Causes of death

The main causes of death in the original study were overhead power line electrocutions (32%), crane collapses (21%), and struck by crane booms/jibs (18%). Struck by crane loads only accounted for 7% of deaths. The revised study has a vastly different list. While electrocution from overhead power lines remained the leading cause of death, accounting for one-fourth of all crane-related fatalities, the second leading cause was being struck by a crane load, which accounted for 21% of all deaths. This new data indicates that a vast number of crane-related deaths were not categorized as such in the CFOI Primary Source code. The remaining causes were struck by cranes or crane parts (20%), crane collapses (14%), falls (9%), and caught in/between crane parts (5%). Seven percent of crane-related fatalities were listed as "other causes."(*See* Table 1.)

Details of causes

Overhead power lines electrocution was the leading cause of crane-related deaths. Of the total 632 crane-related deaths, 157 were caused by overhead power line electrocutions (25%). Over half of all electrocutions (53%) were associated with the crane boom, cable or load/load line contacting an overhead power line. The rest involved contact of an overhead power line with unspecified parts of the crane. Table 2 describes worker activities leading to electrocutions. Those activities involved workers on foot touching or guiding the crane load or cables, which killed 81 workers and accounted for more than half of all electrocution deaths. Other major activities resulting in electrocution were workers operating the crane – including seven operators who were electrocuted after jumping from the crane, and 20 workers on foot touching the crane itself.

Struck by crane loads was the second leading cause of death. Of the 132 crane load deaths, 32% occurred while loading/unloading, 14% while flagging/directing/guiding the crane load, 7% while operating the crane, and 15% involving other crane-related work. A crucial fact is that 32% of struck by crane load deaths involved workers not involved with crane work. The major causes of struck-by-load deaths were: load came loose from rigging (19%); a rigging cable or strap broke (14%); load struck worker when the crane turned, tilted or otherwise lost control of load (11%); load shifted or rotated and struck worker (10%); the load came loose and struck rigger while being loaded/unloaded (8%); and load straps/braces/buckles/safety latches/sling clips failed or broke (8%), In 33% of cases, the case narratives provided no indication as to why loads struck workers. In the 2008 report, the second leading cause of death was crane collapse.

Struck by crane or crane part was the third leading cause of death. Of the 125 deaths, 64 involved being struck by falling crane booms/jibs. Of these, 36 deaths involved dismantling the boom (56%), six involved lengthening the boom (9%), eight involved

breaking of the boom or boom cable (13%), and 14 involved other causes (22%). In this 2009 study, struck by crane, struck by crane booms/jibs, and struck by other crane parts were combined to give a more comprehensive view of the problem of worker deaths from "struck by" incidents**.** In the 2008 report, researchers singled out "struck by crane boom or jib" and "struck by cranes" as separate categories. "Struck by crane boom or jib" was the third leading cause of death in the 2008 report, responsible for killing 59 workers.

Crane collapses killed 89 workers and were the fourth leading cause of death. Of the 81 crane collapses, 34 involved mobile cranes (42%). An unstable, uneven or icy surface on which the crane was sitting accounted for 12 fatalities (15%). Overloading the crane accounted for another 10 deaths (12%). In seven cases (9%), the crane load or boom shifted. In 56% percent of the reported cases, there was not enough information provided to ascertain the cause of the collapse in the narrative. One-third of the narratives failed to identify the type of crane involved in the fatality. In the 2008 report, crane collapses killed 68 workers and was listed as the second leading cause of death.

Fatalities by Construction Trade

More construction laborers were killed in crane-related incidents than any other trade, even operating engineers. They experienced 191 crane-related deaths between 1992 and 2006 (30%), followed by 101 deaths of heavy equipment operators (16%) In addition, 86 supervisors/managers/administrators died in crane-related incidents (14%), as did 42 ironworkers (7%), and 41 carpenters (6%). Other trades with fewer numbers of deaths included welders and cutters, electrical workers, mechanics, sheet metal workers, and truck drivers (totaling 27%). (*See* Table 3.)

Fatalities by Employer Size

Overall, 188 of the 632 construction workers (30%) were employed by establishments with fewer than 10 employees (s*ee* Table 4). Of these 188 workers, 29 were self-employed. One-third of all workers killed (33%) were employed by establishments with between 11 and 99 employees. One hundred and nine individuals (17%) worked for employers with 100 or more employees. There was no employer size noted in the narrative for 125 workers (20%).

Construction Crane Injuries and Deaths from January through December, 2008

Due to the rash of reported construction deaths in the first six months of 2008, CPWR collected data via an Internet search from January through December 2008, as BLS/CFOI data were not available. The findings revealed a total of 97 construction crane incidents involving injuries and deaths. There was a total of 55 deaths and 99 injuries of construction workers in 88 incidents, and four deaths and 26 injuries of non-construction

workers (15 bystanders and 11 rescue workers) in 15 of the 97 crane incidents. These incidents involved 88 mobile cranes, 7 tower cranes, and 2 other cranes.

The causes of the 88 incidents resulting in **construction worker deaths and injuries** were:

- 34 crane collapses (39%), involving 26 deaths and 58 injuries
- 12 overhead power line contacts (14%), involving 10 deaths and eight injuries
- 12 struck by crane load incidents (14%), involving six deaths and 10 injuries
- 10 struck by other crane part incidents (11%), involving six deaths and seven injuries
- 20 other causes (21%) – including seven highway incidents, six falls, three caught in/between, three struck by non-crane falling objects, and one struck by lightning. These incidents resulted in seven deaths and 16 injuries.

The causes of the 15 incidents resulting in **bystander deaths and injuries** were:

- six highway collisions (40%), involving one death and six injuries
- four crane collapses (27%), involving three deaths and 14 injuries (including 11 rescue workers)
- three other causes (20%), involving two work zone collisions and one struck by falling crane boom, resulting in four injuries.

The 97 crane incidents involving deaths and injuries occurred in 35 states, with deaths occurring in 28 states. New York, Texas and Florida had a total of 32 crane incidents that resulted in 23 deaths and 56 injuries of construction workers, one death and four injuries of bystanders, and 11 injuries to rescue workers.

Conclusions and Recommendations

The findings of these analyses indicate the number of crane-related deaths and injuries is significant and do not only involve construction workers but also innocent bystanders. The main causes of worker deaths were electrocution by overhead power line, struck by crane parts or crane loads, or crane collapse. It appears that half of all electrocution deaths were suffered by workers guiding crane loads; they were touching the load or cables when the crane came in contact with an overhead power line. More than half of the deaths were among workers in two trades: construction laborers and heavy equipment operators. Employees working for small contractors (10 or fewer employees) represented a large portion (about one-third) of the total number of deaths. This group, together with employers with 11 to 99 employees, made up 66% of all construction deaths. More than a three-quarters of all crane-related deaths involved mobile cranes, although 235 of the 610 incidents did not identify the type of crane in the narrative.

Possible explanations for these findings are a lack of worker and supervisor training, lack of jobsite safety plans and traffic control, lack of adequate crane inspections, and lack of proper investigation and reporting of crane incidents and fatalities that could help identify the causes of crane-related deaths.

Specific recommendations to reduce and prevent future injuries and fatalities are as follows:

First, crane operators should be adequately trained and tested as qualified operators. . The proposed OSHA standard requires certification of crane operators. Presently 17 states and six cities[¶] (including New York City) require certification or licensing of crane operators, and some have their own certification program. Certification is often done by a nationally accredited crane operator testing organization, such as the National Commission for the Certification of Crane Operators (NCCCO).

Second, riggers who attach the load to the crane and signalpersons who visibly or audibly direct the crane operator on where to place the load should be adequately trained and tested.

Third, crane inspectors should be adequately trained. OSHA requires that employers designate a competent person[♈] to inspect machinery and equipment prior to each use, and during use, to make sure it is in safe operating condition [29 CFR 1926.550(a)(5)]. OSHA also requires annual inspections. These inspectors should be qualified and be able to demonstrate their expertise. For the maritime industry, OSHA accredits crane certifiers through an examination (29 CFR Part 1919).

Fourth, in addition to other mandated inspections, cranes must be inspected thoroughly by a qualified crane inspector after being assembled or modified, such as the "jumping" of a tower crane. Crane parts should be inspected before assembly.

Fifth, according to the proposed OSHA standard on cranes, only trained workers should assemble, modify or disassemble cranes, and they should always be under the supervision of a person meeting both the definition of qualified person** and competent person specified in the standard. In many instances, especially with rented cranes, there are no trained personnel present when cranes are set up and dismantled.

Sixth, crane loads should not be allowed to pass over street traffic. If rerouting is not possible, then streets should be closed off when loads pass over streets and pedestrian walkways. Presently crane loads are not allowed to pass over construction workers.

Seventh, more complete reporting of data, particularly after a crane collapse, is necessary. OSHA and the industry should conduct more thorough investigations of crane-related fatalities and capture more complete data in its reporting system, including inspection results, type of activity causing fatality, relevant environmental conditions, and training of involved workers.

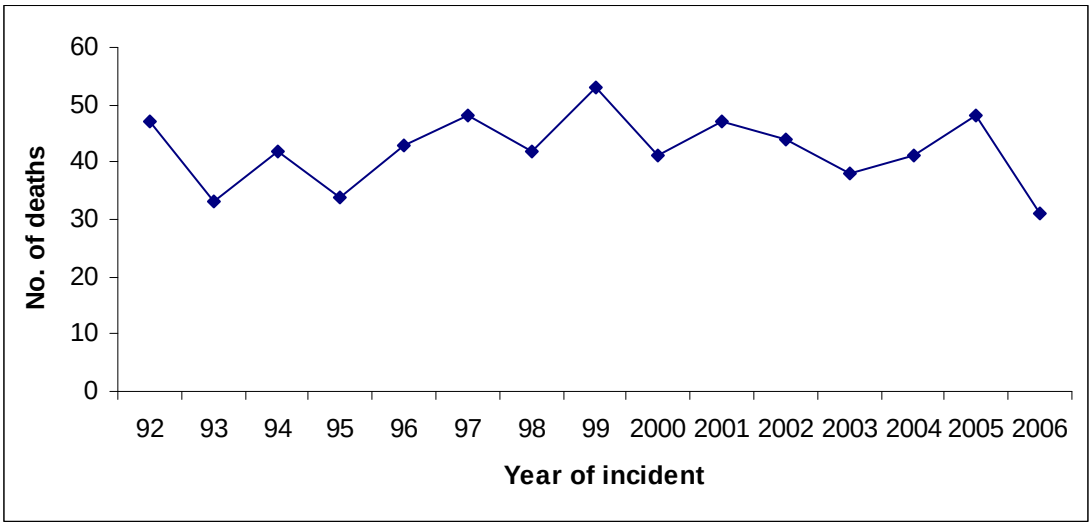
[¶] California, Hawaii, Maryland, Minnesota, Montana, Nevada, New Jersey, New Mexico, Utah, Washington (as of 2010), and West Virginia require or recognize NCCCO certification of crane operators as part of their state licensing program. Connecticut, Massachusetts, New York,

Oregon, and Rhode Island have their own licensing programs. Among cities, New Orleans, New York, and Omaha, Neb., require or recognize NCCCO certification of crane operators; Chicago, Los Angeles, and Washington, D.C., have their own licensing program.

♈ A competent person, according to OSHA, is one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous or dangerous to employees, and *who has authority to take prompt corrective measures* [italics added for emphasis] to eliminate them. [29 CFR 1926.32(f)]

** A qualified person means a person who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated the ability to solve/resolve problems relating to the subject matter, the work, or the project.

Figure 1. Crane-related deaths in construction by year, 1992-2006



Source: U.S. Bureau of Labor Statistics Census of Fatal Occupational Injuries Research File

Table 1. Causes of crane-related deaths in construction, 1992-2006

Cause of death	*# deaths*	*%*
Overhead power line electrocutions	157	25%
Struck by crane loads	132	21%
Struck by crane or crane parts*	125	20%
Crane collapses	89	14%
Falls**	56	9%
Caught in/between	30	5%
Other causes***	43	7%
Total	632	****

* Involved 18 cranes (including 13 run-over by mobile crane), 78 crane booms/jibs (64 due to falling booms/jibs), and 29 other crane parts
** Includes 21 falls from crane bodies, 9 from crane baskets, 8 from crane loads and 18 other falls.
*** Other causes include 12 highway incidents and 11 struck by objects other than crane loads or parts.
****Does not add to 100 due to rounding.
Source: U.S. Bureau of Labor Statistics Census of Fatal Occupational Injuries Research File

Table 2. Activity of construction workers electrocuted by overhead power lines, 1992-2006

Contact with overhead power lines	*#deaths*	*%*
Worker on foot touching/guiding load or cables	81	52%
Operating crane*	40	25%
Worker on foot touching crane	20	13%
Other**	16	10%
Total	157	***

* Includes 7 deaths of operators who jumped from crane
** Includes 6 deaths of workers on foot near but not touching crane
*** Does not add to 100% due to rounding.
Source: U.S. Bureau of Labor Statistics Census of Fatal Occupational Injuries Research File

Table 3. Trade of construction workers killed by cranes, 1992-2006.

Trades	*#deaths*	*%*
Construction laborers	191	30%
Heavy equipment operators*	101	16%
Supervisors/managers/administrators	86	14%
Ironworkers	42	7%
Carpenters	41	6%
Other trades **	171	27%
Total	632	100%

* Includes 62 crane and tower operators, 21 operating engineers and other construction equipment operators, and 7 hoist and winch operators.

** Includes 24 welders and cutters, 22 electrical workers, 21 mechanics, 17 sheet metal workers, 14 truck drivers, and 73 others.

Source: U.S. Bureau of Labor Statistics Census of Fatal Occupational Injuries Research File

Table 4. Size of establishment employing construction worker killed by cranes, 1992-2006.

Establishment Size	*#deaths*	*%*
1- 10 employees	188	30%
11-99 employees	210	33%
100 employees or more	109	17%
Not reported	125	20%
Total	632	100%

Source: U.S. Bureau of Labor Statistics Census of Fatal Occupational Injuries Research File

Table 5. Selected Fatal Crane Incidents Involving Bystanders

Date	Location	Description
4/27/78	Willow Island, WV	Crane lifting bucket of cement collapsed onto scaffold inside cooling tower. Construction workers: 51 dead Source: [Ward, 2008]
11/29/89	San Francisco, CA	Tower crane fell 16 stories while being jumped. Construction workers: 4 dead Bystanders: 1 dead; 22 injured Source: [Kilborn, 1989]
11/14/99	Milwaukee, WI	"Big Blue" tower crane collapsed at stadium and struck three workers in a crane basket. Winds 25-30 mph. Construction workers: 3 dead Source: [LaBar, 1999]
9/29/06	New York, NY	4-ton chunk of steel fell from crane crushing a taxi. Bystanders: 5 injured Source: [Kates, 2008]
11/16/06	Bellevue, WA	Crane collapsed on a condo. Construction workers: 1 injured Bystanders: 1 dead Source: [Jamieson, 2006].

3/15/08	New York, NY	Tower crane collapsed while being jumped, damaging several buildings. Construction workers: 6 dead, 13 injured Bystanders: 1 dead, 11 first responders injured Source: [Ware, 2008]
3/25/08	Miami, FL	20-foot section crane fell 30 stories while jumping the crane. Construction workers: 2 dead, 5 injured Source: [Walter, 2008]
5/30/08	New York, NY	Crane cab, boom, and machine deck separated from the tower mast and collapsed onto the street Construction workers: 2 dead, 1 injured Bystanders: 1 injured Source: [MSNBC staff, 2008]

References to Table 5

Jamieson, R. [2006]. "The Fall and Rise of a Crane Operator." *Seattle Post-Intelligencer*, Dec. 14.

Kates, B. [2008]. "Pain of the Cranes." *New York Daily News*, March 24.

Kilborn, P. [1989]. "San Francisco Crane Collapse was no Fluke." *New York Times*, Dec.17.

LaBar, G. [1999]. "Three Workers Die When "Big Blue' Falls at Stadium." *Occupational Hazards*, July 15.

MSNBC staff. [2008]. "Crane Collapse Kills Two and Unsettles New Yorkers," May 31.
www.msnbc.msn.com/id/24889155/print/1/displaymode/1098/ (Accessed May 30, 2008.)

OSHA [1990]. *Analysis of Construction Fatalities – the OSHA Database 1985-1989*. Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration.

Walter, L. [2008]. "Miami Crane Collapse Kills 2, Injures 5." *Occupational Hazards*, March 6.

*Ward, K. [2008]. " 'It Was Gone': String of Problems Led to 51 Deaths at Willow Island." *The Charleston Gazette*, April 27.

Ware, P. [2008]. "OSHA Begins Investigating Crane Collapse in New York that Killed Seven, Injured 24." *BNA OSH News*, March 20.

Research for this report was funded by CPWR – The Center for Construction Research and Training, using grant U54 OH008307 from the National Institute of Occupational Safety and Health (NIOSH). The contents are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

CPWR is a 501(c)(3) nonprofit research and training institution created by the Building and Construction Trades Department, AFL-CIO, and.serves as the research arm of the BCTD. CPWR provides safety and health research and information for the construction trades and industry. For more information, visit www.cpwr.com.