Frontiers of Engineering Management
DOI 10.15302/J-FEM-2016035

ENGINEERING MANAGEMENT REPORTS

Fei Dai, Yoojung Yoon, Hota V. GangaRao

State of Practice of Construction Site Safety in the USA

Abstract The construction industry has long been plagued with a high number of fatalities in the USA. Much safety improvements have been made after the USA Congress passed the Occupational Safety and Health Act in 1970. However, this industry still suffers from a disproportionately high rate of work-related fatalities in comparison to other industries. To provide a holistic view of current construction safety practices and corresponding performance, this paper reviews statistics of construction fatalities and their causes. It then presents efforts led to prevent work-related accidents and injuries by the federal safety agencies and the industry. Additionally, advantages and limitations of current practices in terms of construction safety have been discussed along with promotion of aspects in construction work environment.

Keywords: workplace safety, construction industry, safety strategy, accident prevention, review work

1 Introduction

The USA construction industry suffers from the highest number of fatalities among all industries (U.S. Bureau of Labor Statistics, 2015a). As shown in *Figure 1*, approximately one in five worker deaths (i.e., 899 out of 4,386 in 2014) in private industry were in construction (U.S. Department of Labor, 2015b). For each construction worker fatality, approximately, five-million-dollar loss is estimated (Public Citizen, 2012), resulting in a total of 4 billion to 5 billion dollar loss in year 2014. To protect the nation's construction workforce, it is of paramount importance to understand the current state of safety-practices approaches and make effective strategies to improve on-site construction safety performance.

Herein, origins and characteristics of construction injuries are profiled using the data collected from the USA Bureau of Labor Statistics (BLS) and the Center for Construction Research and Training (CPWR). In addition, current measures for accident prevention and safety protection taken by the USA Occupational Safety and Health Administration (OSHA) and the USA National Institute for Occupational Safety and Health (NIOSH) including its Fatality Assessment and Control Evaluation (FACE) program are highlighted.

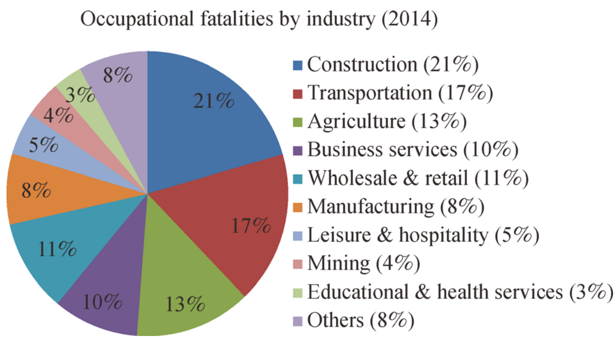

Figure 1. Occupational fatalities by industry in 2014 (U.S. Bureau of Labor Statistics, 2016).

According to BLS and CPWR (Center for Construction Research and Training, 2013; U.S. Department of Labor, 2015b), the leading hazards that have caused construction fatalities are: 1) Falls to a lower level, 2) highway incidents, 3) contact with electric power, 4) object strikes, and 5) others. Construction fatalities through falls to lower levels account for one third of worker deaths (Center for Construction Research and Training, 2016). To minimize construction fatalities, OSHA has enforced safety regulations and implemented safety measures, including training and outreach services. However, safety regulations on construction sites have been continuously violated. As per FACE (NIOSH FACE Reports, 2015), falls, slip and caught (in-between), object-strikes, and burns are common types of accidents which occurred due to inappropriate handling of machinery (e.g., overloading causing tip-over of a tower crane, and not securing a bulldozer from movement before leaving it unattended) and/or ignorance of safety requirement. For example, negligence in wearing a personal fall-arrest system and lack of inspection of equipment to

Manuscript received May 25, 2016; accepted August 15, 2016

Fei Dai (✉), Yoojung Yoon, Hota V. GangaRao
Department of Civil and Environmental Engineering, West Virginia University, Morgantown, WV 26506-6103, USA
Email: fei.dai@mail.wvu.edu

identify damage or deficiencies come under the category of ignoring safety needs.

In this paper, the authors synthesized the field data generated by others to shed light on advantages and limitations of current practices in construction safety. In addition, other endeavors are described to promote safer construction work environment.

2 Statistics of fatal injuries in the USA construction industry

The passing of the Occupational Safety and Health Act in 1970 has largely ameliorated the performance improvements in construction safety. It has been deemed to be a direct response to the enforcement of the OSHA regulations for few decades following the act. In recent years, however, the construction industry still maintains a disproportionately high rate of work-related fatalities in comparison to other industries. *Figure 2* presents the number of employees recruited in construction in the USA between 2005 and 2014. Here, the official data for construction employment and fatalities in 2015 is not available as of the time the authors prepare for the manuscript. Therefore, it is not included in our analysis. According to *Figure 2*, this industry was severely hit by the economic recession in 2007–2009, but had a recovery trend between 2012 and 2014. Based on the employment numbers and the numbers of worker fatalities, the rate of construction fatalities from 2005 to 2014 was calculated. The fatality rate in year n is defined as the number of worker fatalities per 100,000 full-time equivalent workers (FTEs) in the same year, and is calculated by the number of worker fatalities in year $n \times 100{,}000$/(the number of construction employees in year n). *Figure 3* illustrates the number and rate of fatalities in the USA construction industry between 2005 and 2014. Based on *Figure 3*, it is observed that the fatality rate dropped from 11.1 in 2005 to 8.6 in 2011, but increased to 9.2 deaths per 100,000 FTEs in 2014. Besides, more fatalities were incurred in construction than other industries. For instance, out of 4,386 worker fatalities in private industry in year 2014, 20.5% were in construction, which means one in five worker deaths were in construction.

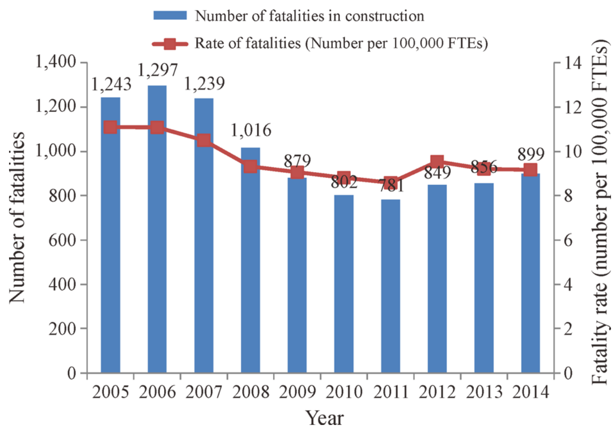

Figure 3. Number and rate of fatalities in the USA construction industry, 2005–2014 (U.S. Bureau of Labor Statistics, 2015b, 2015c).

The Center for Construction Research and Training (CPWR) has revealed the leading hazards that cause worker deaths in construction. As shown in *Figure 4*, 868 workers died from falls, which accounts for over one-third (35%) fatalities in construction. The second, the third, and fourth leading hazards for construction fatalities were transportation incidents (29%), contact with objects (17%), and exposure to electrics power (13%). Out of all fall-related fatalities in construction, 616 (or 71%) were laborers, roofers, foremen, carpenters, and painters, among which roofers had the highest risk, with a rate of 33.2 deaths per 100,000 FTEs—That is ten times the average rate of all construction fatalities (i.e., 3.3 deaths per 100,000 FTEs). The occupation with the second highest risk of fall fatalities was ironworkers, with a rate of 18.4

Figure 2. Construction population in the USA, 2005–2014 (U.S. Bureau of Labor Statistics, 2015b).

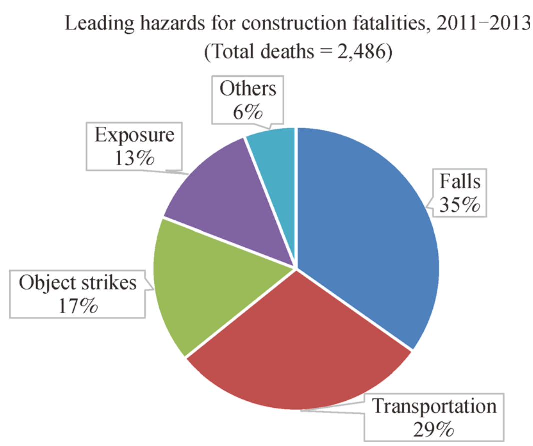

Figure 4. Distribution of leading hazards that causes construction fatalities, 2011–2013 (Center for Construction Research and Training, 2016).

deaths per 100,000 FTEs, more than twice the rate of the third riskiest occupation which was welders (Center for Construction Research and Training, 2016).

It is worth noting that the occupations in construction who have experienced high fatality rates typically work as individual contractors or as employees for small establishments (1–10 employees) and are so called underserved populations. These small construction establishments often use minimal protective measures thanks to challenges such as the lack of safety related knowledge and tight budget (Kaskutas, Dale, Nolan, Patterson, Lipscomb, & Evanoff, 2009; Olbina, Hinze, & Ruben, 2011). For instance, a survey conducted by Sa, Seo, and Choi (2009) showed that most residential roofers in the USA work for small employers with fewer than 10 employees. Roofers in these establishments often work without proper training (Moore, & Wagner, 2014), and under unique stresses related to work-family conflict and below the awareness of most of the spectrum of safety and health regulators and researchers (Smith-Jackson et al., 2011). Moreover, only half of the roofers have received high school or equivalent diploma (National Center for O*NET Development, 2015) and a significant number of roofers are ethnic minorities (Arcury et al., 2014), who have been revealed among the highest occupational injury rates in the construction industry (Dong, Men, & Ringen, 2010; Dong, Wang, & Daw, 2010). Considering these factors, special attention is required for such populations.

3 Factors contributing to construction fatal injuries

It is well known that the high incidence rate of fatalities results from the inherent traits of construction (Choudhry, & Fang, 2008). Given the hazardous nature of construction sites, studies have discussed various factors affecting the occurrence of construction accidents, which can be primarily grouped into worker factors (e.g., gender, age, work experience, and unsafe acts), environmental and equipment factors (e.g., occupational accident type, and source of injury), project factors (e.g., project type, and project duration), management factors (e.g., company size, and safety management systems), and time factors (e.g., time of accident) (Cheng, Lin, & Leu, 2010). Theories of accident causation models have been employed to ascertain the causes of accidents which are usually occurred in a complex coincidence of many variables in a single time and space (Abdelhamid, & Everett, 2000). According to Moraru, Băbuț, & Cioca (2013), prevention of the unintended accidents through understanding interdependencies of these variables is almost impossible, therefore many studies tried to explain the accident causation models in terms of safety culture and workers' risk-taking behavior. Safety culture is the atmosphere created by shared beliefs, practices, and attitudes among workers towards safety in an organization and thus affects characteristics of individual workers (Dedobbeleer, & Béland, 1998). It is a subset of, and clearly influenced by, organizational culture (Center for Construction Research and Training, 2016). In contrast, the worker's risk-taking behaviors are behaviors with potentially negative outcomes. The poor risk perception level of workers explains why workers take unsafe behavior (Du Toit, 2012; Flin, Mearns, O'Connor, & Bryden, 2000). Based on the value expectancy theory, workers behave riskily in that they expect maximum outcomes (Weinstein, 1988). The unfavorable workplace to safety and overload tasks beyond the physical and psychological capabilities of workers can also be the reasons of the workers' risk-taking behavior (Abdelhamid, & Everett, 2000). The positive and neutral emotional states may be more prone to engage workers in risk-taking behaviors because they perceive less risk in the work environment (Tixier, Hallowell, Albert, Van Boven, & Kleiner, 2014).

4 Safety efforts led by OSHA and NIOSH

The above knowledge from these research works lays a basis for understanding reasons of construction site accidents and further promotion of safety strategies for construction site workers. In this section, the key federal safety and health agencies, namely OSHA and NIOSH are introduced, and their primary safety measures are presented.

4.1 OSHA safety regulations and implementation

OSHA stands for the Occupational Safety and Health Administration, an agency of the USA Department of Labor. Its responsibility is to improve worker safety and health protection. On December 29, 1970, President Nixon signed the Occupational Safety and Health (OSH) Act. This Act created OSHA, which formally came into being on April 28, 1971. The mission of OSHA is to assure safe and healthy working conditions for working men and women including construction taskforce by setting up and enforcing standards and by providing training, outreach, education and assistance. The primary jobs that OSHA does to carry out its mission are (1) developing job safety and health standards and enforcing them through worksite inspections, and (2) providing training programs to increase knowledge about occupational safety and health. In specific, under the OSH law, OSHA defines and enforces employer responsibilities which are to provide a safe workplace by acts such as "examining workplace conditions to make sure they conform to applicable OSHA standards", "making sure employees have and use safe tools and equipment and properly maintain this equipment", "using color codes, posters, labels or signs to warn employees of potential hazards", and "establishing or updating operating procedures and communicate them so that employees follow safety and health requirements". In the meanwhile, OSHA regulates the workers' right to get training from employers on a variety of health and safety hazards and standards that employers must follow. Some required training covers topics such as fall hazards, equipment hazards, confined spaces, noise, personal protective equipment, chemical hazards, along with a set of other subjects. The training must be in a language and vocabulary workers can understand.

Audits of safety violations in the construction workplace are also a responsibility of OSHA. The safety violations, defined by the USA Department of Labor, are noncompliance of OSHA safety standards that may not cause immediate deaths or injuries but can lead to future accidents in the workplace (U.S. Department of Labor, 2015a). To implement the compliance of the safety standards, OSHA typically dispatches professional compliance officers to perform programmed inspections of establishments based on factors such as injury incidence rates, previous citation history, or random selection without advance notice. A compliance officer, accompanied by employer representatives, will walk through the work area to inspect for safety hazards, and when complete, discuss with the contractor the unsafe conditions she/he identified and then issue or recommend a citation and a penalty for the apparent violations (Occupational Safety and Health Administration, 2015).

4.2 NIOSH endeavors and FACE program

The OSH Act of 1970 also established the NIOSH, which is part of the USA Centers for Disease Control and Prevention, in the USA Department of Health and Human Services. NIOSH is the sole federal government organization charged with conducting occupational safety and health research. Its mission is to develop new knowledge in the field of occupational safety and health and to transfer that knowledge into practice. NIOSH construction program provides leaderships to prevent work-related illness, injury, disability, and death by gathering information, conducting research, and translating the knowledge gained into products, solutions, and services tailored to meet construction needs. The NIOSH Office of Construction Safety and Health consists of program structures and focus areas including intramural research, extramural investigator-initiated grants, and national construction center—CPWR. All research efforts and initiatives concentrate on the areas including surveillance of incidents to identify areas of severity, assessment of risk factors that contribute to injuries, design of solutions that control injury risks, and dissemination of the resulting safety knowledge and implementation of evaluations (as shown in *Figure 5*).

Through research, NIOSH provides scientific evidences and recommendations as a basis for OSHA to develop, modify, and improve occupational safety standards, rules,

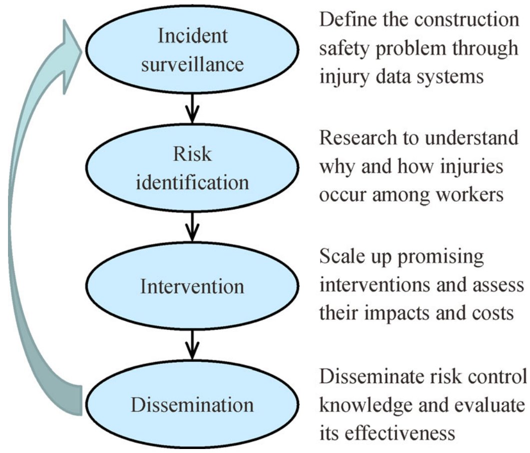

Figure 5. NIOSH research focuses on construction safety.

and regulations. For instance, at the Division of Safety Research (DSR) of NIOSH, Morgantown, WV, research safety engineers have performed testing on load impacts and instability during ingress and egress of scissor lifts as well as sudden falls of manikins from different elevated locations. The findings are to be used to provide quantifiable information for recommending safe operational procedures in the work practice of "entering, exiting, and working procedures at an elevation" for scissor lifts. At SDR, research is also being conducted to examine the head-brain responses to the impacts of construction helmets. The results are planned to provide scientific evidence that can be used to develop standards for safety improvements of construction helmet manufacturing.

The FACE program was initialized by the NIOSH and is an effort for the prevention of occupational fatality. The elements of the FACE program include tracking all work-related acute trauma fatalities, conducting investigations of a select number of these incidents, and distributing information for the prevention of future fatal injuries. Currently, this program has two components. The first is NIOSH in-house FACE that began in 1982. It works with states who voluntarily notify NIOSH of traumatic occupational fatalities resulting from targeted causes such as confined spaces, electrocutions, machine-related, falls from elevation, deaths of youths under 18 years of age, deaths of Hispanic workers, and street/highway construction work zone fatalities. In contrast, the second is NIOSH state-based FACE that began in 1989. Currently, seven state health or labor departments have cooperative agreements with NIOSH for conducting surveillance, targeted investigations, and prevention activities at the State level using the FACE model. The seven states are California, Washington, Kentucky, Massachusetts, Michigan, New York, and Oregon. Both in-house and state-based FACE programs generate reports regarding investigations of fatal occupational injuries and prevention recommendations nationwide. For instance, NIOSH FACE recently reported on Report No. 2013-04 "Hispanic worker dies after being hit with a projectile from a nearby commercial lawnmower-North Carolina", Report No. 2013-01 "Hispanic scrap yard worker dies when struck by material handler at metal recycling facility—South Carolina", etc. State FACE produced reports such as Report No. 2015OR002 "Crane operator killed by falling steel beam", Report No. 2015KY030 "Driver exits burning semi-truck and falls to his death", Report No. 2015KY020 "Granite installation company owner struck by falling granite slab—Kentucky", etc.

5 Safety efforts led by the industrial community

In recent years, safety performance of the construction industry appears to be a response not only to safety compliances but also to safety initiatives taken by the industrial community. The interest in construction safety presents the trend of being higher than it used to be. This is reflected by the increasing number of studies that have been conducted to examine the practices for considerable improvements of safety performance in construction (Findley, Smith, Kress, Petty, & Enoch, 2004; Hinze, Hallowell, & Baud, 2013; Jaselskis, Anderson, & Russell, 1996; Sawacha, Naoum, & Fong, 1999). In exercising safety practices, an early study was sponsored by the Construction Industry Institute (CII), known as zero-injury techniques (Nelson, & Haggard, 1993). Its results have identified five high-impact safety techniques for construction, including: (1) Safety pre-project/pre-task planning, (2) safety orientation and training, (3) written safety-incentive program, (4) alcohol- and substance-abuse program, and (5) accidents/incidents investigations. This was arguably for the first time that a major research endeavor for construction safety enumerated the most effective safety-initiative areas. Later, the CII sponsored a second safety study titled Safety Plus: Making Zero Accidents a Reality to examine best safety practices (Hinze, 2002). This study has identified nine areas that are vital to achieving the world-class construction safety performance, including: (1) Management commitment, (2) staffing for safety, (3) planning: Pre-project and pre-task, (4) safety education: Orientation and specialized training, (5) worker involvement, (6) evaluation and recognition/reward, (7) subcontract management, (8) accident/incident investigations, and (9) drug and alcohol testing. In addition to these efforts, there are other safety initiatives that have been implemented by the industry such as implementation of safety committees, near-miss reporting programs, worker-safety perception surveys, suggestion-box programs, rewarding workers only when they performed work in a safe manner, etc. Recently, another effort led by (Hinze, Hallowell, & Baud, 2013) focused on comprehensiveness of safety strategies that have been implemented by industry-leading companies. Findings from this study revealed that 22 practices were implemented by 100% of a total of 104 sampled projects and 14 practices differentiate safety performance based on testing of their correlations to the project's recordable injury rate. The detailed practices are shown in Tables 1 and 2. The implications are that the 22 practices implemented in all projects can be considered a basis of a safety program, and the 14 differentiators are the keys to improve the safety performance.

Table 1

Safety Practices Implemented in All Sampled Projects (Hinze, Hallowell, & Baud, 2013)

No.	Safety practices implemented in all sampled projects
1	Health and safety manual
2	Specific safety prequalification
3	Subcontractors participation in general contractor's orientation and training
4	Subcontractors safety standards compared with general contractor
5	Safety leadership training for foremen
6	Management review of craft-worker training
7	Safety during constructability reviews
8	Safety in scheduling
9	Written site-safety plan
10	Heavy-equipment inspection and approval program
11	Lock-out tag-out policy
12	100% hard-hat policy
13	Stop-work policy
14	Emergency response plan for the project
15	Job-hazard analyses
16	Workers involvement in hazard assessment
17	Safety goals development and communication
18	Safe-behavior reward and recognition
19	Near-misses investigation
20	Foremen involvement in accident investigation
21	Foremen involvement in hazard assessment
22	Regular scheduled meetings for safety personnel

Another effort led by (Alarcón, Acuña, Diethelm, & Pellicer, 2016) revealed that safety planning and resources, management safety training, workers safety training, management commitment, and audits and certifications are the categories that have most positive impacts on the reduction of the accident rate compared with companies without any category implemented. This study also argued that safety incentives and rewards is the category that is most effective; in which companies that do not implement any practice in this category have an accident rate 51% higher than companies that do implement this category. Moreover, this study pointed out that it is not that the more

Table 2

Safety Practices That Differentiate Safety Performance (Hinze, Hallowell, & Baud, 2013)

No.	Safety practices that differentiate safety performance
1	Site-specific safety orientation for all managers
2	Foreman involvement in safety policy
3	On-site medical facilities
4	Worker-to-worker-observation program
5	Minimum ratio of workers to safety professionals
6	First-aid log is maintained
7	Owner's review and approval of safety plan
8	Worker involvement in perception surveys
9	100% steel-toed boots policy
10	Participation of all contractors in safety meetings
11	Contract sets minimum ratio of safety supervisors to workers
12	Formal safety review team determines disciplinary actions
13	Contract imposes work-hour restrictions for workers
14	Safety considered during the design phase

the safety practices are implemented in a construction company, the better this company will achieve its safety performance; instead, choice of practices is more important than the number of practices implemented (Alarcón, Acuña, Diethelm, & Pellicer, 2016). The most optimized practices combination, in this study, was concluded to be workers' safety training, management safety training, and audits and certifications; however, it is argued that a tailor-made safety strategy based on different situations with a company or project is necessary but how to determine it remains challenging.

6 Discussions

The legislation, research agencies, associations, and industrial entities are all dedicated to prevention and reduction of construction accidents and injuries. These efforts have led to significant improvements of the safety performance in the construction industry over past decades. It is a consensus that the value of a worker's life is countless and therefore it can never be enough in developing better ways to promote a safe work environment of the nation's construction workforce. Retrospectively reviewing the existing efforts, many are appreciated, and several are thought to be the keys to better safety performance. They are:

(1) Continuously improving safety regulations and rules by a diversity of methods such as accident reporting programs, lessons review, and investment in research;

(2) Enforcing safety regulations and rules by dispatching professional compliance officers to perform inspection of violations, zero tolerance of safety violations, exposure of violations and violating companies to public, and tough penalties and lawsuits;

(3) Enforcing safety training and reviewing the effectiveness;

(4) Deepening safety operations and product manufacturing standards through regular executive meetings, investigations, research, and working with standard institutes such as American National Standards Institute (ANSI);

(5) Establishing training centers for research, training, and service programs such as the Center for Construction Research and Training (CPWR);

(6) Establishing work-related acute trauma fatalities tracking, recording, investigation, and information distribution programs such as the NIOSH FACE program;

(7) Funding research on safety measures, especially measures for underserved worker population such as residential roofers;

(8) Promoting self-motivated safety initiatives among the industrial organizations such as implementation of safety committees, implementation of safety trainings, near-miss reporting programs, and rewarding workers who adhering to the safety process as well as based on the results.

For the construction industry, studies have identified positive practices or key factors for prevention of site accidents. Impacts of these practices and/or factors on injury reduction in construction were examined. In spite of these, opportunities and room for improvement still exist. Some are discussed here.

The current practice of sending compliance officers to perform the safety inspection plays a vital role in reducing safety hazards in construction sites. However, such practice also has its limits. That is, the process is expensive grounded that it requires highly trained taskforce with safety knowledge and expertise which demands high investment. Considering the large and increasing number of construction projects that are being built in the USA (Gavin, 2015), this problem may cascade further, as this process is manual and slow and hence there is a lack of enough compliance officers to meet the inspection requirements. This is echoed by OSHA (Occupational Safety and Health Administration, 2010), noted in OSHA at Forty: New Challenges and New Directions as one of its significant challenges: "We are a small agency; with our state partners we have about 2,000 inspectors responsible for the health and safety of 130 million workers, employed at 7 million worksites around the nation." As a result, there is a need for innovative strategies that allow for appropriate tackling of the above-mentioned challenge. To alleviate this situation, investigating strategies through innovation and adoption of advanced information and communication technologies, along with abilities augmented from machine learning, data science, and artificial intelligence might be of help.

Moreover, traditionally safety performance has been measured by metrics such as OSHA recordable injury rates, Days Away, Restrictions and Transfers (DART) injury rates, and Experience Modification Ratio (EMR) that are gathered after losses have been incurred and cost assessments have been made. Such measurements are classified as lagging indicators, whose value remains questionable as they record data of incidents after facts (Hinze, Thurman, & Wehle, 2013) and fail to provide enough information for future safety performance in the workplace (Mengolini, & Debarberis, 2008). As an alternative, leading indicators are measures used to predict future levels of safety performance (Hinze, 2005), through monitoring current information about conditions, processes, and activities that can drive identification, elimination, or control of risks in the workplace (Hallowell, Hinze, Baud, & Wehle, 2013). Because such measures are preventive (Toellner, 2001), they are useful to contractors to devise intervention methods that fix any weakness identified before an incident occurs (Hinze, 2005).

In addition, studies (Sawacha, Naoum, & Fong, 1999) have highlighted the importance of safety training in safety performance improvement of construction. Unfortunately, during the training, the typical education modes involve PowerPoint presentations, written safety protocols, and classroom-style settings. Such education modes do not facilitate active, inductive, context-based learning that is essential for effective andragogy (i.e., adult learning), and therefore often fail to achieve their desired objectives (Bhanbadri, & Hallowell, 2015). In the future endeavors, improvements in safety training material and modes to enhance the learning effectiveness present opportunities to decrease construction related fatalities.

7 Conclusions

This paper summarized current state of construction safety practice. It profiled characteristics of construction fatalities using the data collected from BLS and CPWR. This was followed by presentation of current measures taken by OSHA and the industry. Finally, discussions based on existing measures and recent studies were made to shed light on benefits and limits of current safety practice in construction and set the stage for further endeavors needed to promote a safer and healthier construction work environment.

References

Abdelhamid, T. S., & Everett, J. G. (2000). Identifying root causes of construction accidents. *Journal of Construction Engineering and Management*, 126, 52–60.

Alarcón, L. F., Acuña, D., Diethelm, S., & Pellicer, E. (2016). Strategies for improving safety performance in construction firms. *Accident; Analysis and Prevention*, 94, 107–118.

Arcury, T.A., Summers, P., Rushing, J., Mills, T., Grzywacz, J. G., Mora, D., & Quandt, S. A. (2014). *Occupational safety perceptions, personal protective equipment use, and injury experience of Latino roofers*. The 142nd APHA Annual Meeting and Exposition.

Bhanbadri, S., & Hallowell, M. R. (2015). *Live safety demos: New method to enhance situational awareness and situational interest through emotional engagement*. ICSC15-The CSCE International Construction Specialty Conference, Vancouver, Canada.

Center for Construction Research and Training. (2013). *The Construction Chart Book: The U.S. Construction Industry and Its Workers* (5th ed.). Silver Spring, MD: CPWR.

Center for Construction Research and Training. (2016). *Third Quarter—Fatal and nonfatal injuries among construction trades between 2003 and 2014*. Retrieved from http://www.cpwr.com/sites/default/files/publications/Third%20Quarter%20QDR%20final_2.pdf

Cheng, C., Lin, C., & Leu, S. (2010). Use of association rules to explore cause-effect relationships in occupational accidents in the Taiwan construction industry. *Safety Science*, 48, 436–444.

Choudhry, R. M., & Fang, D. (2008). Why operatives engage in unsafe work behavior: Investigating factors on construction sites. *Safety Science*, 46, 566–584.

Dedobbeleer, N., & Béland, F. (1998). Is risk perception one of the dimensions of safety climate. *Occupational Injury: Risk Prevention and Intervention*, 73–81.

Dong, X. S., Men, Y., & Ringen, K. (2010). Work-related injuries among Hispanic construction workers-evidence from the medical expenditure panel survey. *American Journal of Industrial Medicine*, 53, 561–569.

Dong, X. S., Wang, X., & Daw, C. (2010). Fatal and nonfatal injuries among Hispanic construction workers. *CPWR Data Brief*, 2(2), 1–19.

Du Toit, W. J. (2012). *The relationship between health and safety and human risk taking behaviour in the South African electrical construction industry (Doctoral Dissertation, Nelson Mandela Metropolitan University)*. Retrieved from http://www.master-builders.co.za/resources/docs/News-Articles-2012PDFs/100512_Relationship_between_H_S_Human_Risk_taking_Behaviour_in_-South_African_Electrical_Construction_Ind.pdf

Findley, M., Smith, S., Kress, T., Petty, G., & Enoch, K. (2004). Safety program elements in construction: which ones best prevent injuries, control costs? *Professional Safety*, 49(2), 14–21.

Flin, R., Mearns, K., O'Connor, P., & Bryden, R. (2000). Measuring safety climate: Identifying the common features. *Safety Science*, 34, 177–192.

Gavin, J. (2015). *2015 Construction Outlook: An economic recovery finds its footing*. Retrieved from http://www.ecmag.com/section/your-business/2015-construction-outlook-economic-recovery-finds-its-footing

Hallowell, M. R., Hinze, J. W., Baud, K. C., & Wehle, A. (2013). Proactive construction safety control: Measuring, monitoring, and responding to safety leading indicators. *Journal of Construction Engineering and Management*, 139, 04013010.

Hinze, J. (2002). Safety plus: Making zero accidents a reality. *CII Research Report*, 160–111.

Hinze, J. (2005). *A paradigm shift: Leading to safety*. The Proceedings of the 4th Triennial International Conference Rethinking and Revitalizing Construction Safety, Health, Environment and Quality.

Hinze, J., Hallowell, M., & Baud, K. (2013). Construction-safety best practices and relationships to safety performance. *Journal of Construction Engineering and Management*, 139, 04013006.

Hinze, J., Thurman, S., & Wehle, A. (2013). Leading indicators of construction safety performance. *Safety Science*, 51, 23–28.

Jaselskis, E. J., Anderson, S. D., & Russell, J. S. (1996). Strategies for achieving excellence in construction safety performance. *Journal of Construction Engineering and Management*, 122, 61–70.

Kaskutas, V., Dale, A. M., Nolan, J., Patterson, D., Lipscomb, H. J., & Evanoff, B. (2009). Fall hazard control observed on residential construction sites. *American Journal of Industrial Medicine*, 52, 491–499.

Mengolini, A., & Debarberis, L. (2008). Effectiveness evaluation methodology for safety processes to enhance organisational culture in hazardous installations. *Journal of Hazardous Materials*, 155, 243–252.

Moore, J. R., & Wagner, J. P. (2014). Fatal events in residential roofing. *Safety Science*, 70, 262–269.

Moraru, R. I., Băbuț, G. B., & Cioca, L. I. (2013). *Linking risk prevention in working systems to occupational accident causation theories*. The 6th International Conference on Manufacturing Science and Educations.

National Center for O*NET Development. (2015). *O*NET OnLine, Summary report for: Roofers*. Retrieved from http://www.onetonline.org/link/summary/47-2181.00

Nelson, E. J., & Haggard, R. (1993). Zero injury techniques. *Construction Industry Institute*, 6–7.

NIOSH FACE Reports. (2015). *Fatality Assessment and Control Evaluation (FACE) program reports*. Retrieved from https://www.cdc.gov/niosh/face/inhouse.html

Occupational Safety and Health Administration. (2010). *OSHA at Forty: New challenges and new directions*. Retrieved from https://www.osha.gov/as/opa/Michaels_vision.html

Occupational Safety and Health Administration. (2015). *The OSHA Inspection: A step-by-step guide*. Retrieved from https://www.osha.gov/dte/grant_materials/fy10/sh-20853-10/osha_inspections.pdf

Olbina, S., Hinze, J., & Ruben, M. (2011). Safety in roofing. *Professional Safety*, 56, 44–52.

Public Citizen. (2012). *The Price of Inaction: A comprehensive look at the costs of injuries and fatalities in Maryland's construction industry*. Retrieved from http://www.citizen.org/documents/price-of-inaction-maryland-worker-safety-report.pdf

Sa, J., Seo, D. C., & Choi, S. D. (2009). Comparison of risk factors for falls from height between commercial and residential roofers. *Journal of Safety Research*, 40, 1–6.

Sawacha, E., Naoum, S., & Fong, D. (1999). Factors affecting safety performance on construction sites. *International Journal of Project Management*, 17, 309–315.

Smith-Jackson, T., Artis, S., Hung, Y. H., Kim, H. N., Hughes, C., Kleiner, B., & Nolden, A. (2011). Safety critical incidents among small construction contractors: A prospective case study. *Open Occupational Health and Safety Journal*, 3, 39–47.

Tixier, A. J. P., Hallowell, M. R., Albert, A., Van Boven, L., & Kleiner, B. M. (2014). Psychological antecedents of risk-taking behavior in construction. *Journal of Construction Engineering and Management*, 140, 04014052.

Toellner, J. (2001). Improving safety and health performance: identifying and measuring leading indicators. *Professional Safety*, 46, 42–47.

U.S. Bureau of Labor Statistics. (2015a). *National census of fatal occupational injuries in 2014 (Preliminary results)*. Retrieved from http://www.bls.gov/news.release/cfoi.nr0.htm

U.S. Bureau of Labor Statistics. (2015b). *Labor force statistics from the current population survey*. Retrieved from http://www.bls.gov/cps/

U.S. Bureau of Labor Statistics. (2015c). *Census of Fatal Occupational Injuries (CFOI)—Current and revised data*. Retrieved from http://stats.bls.gov/iif/oshcfoi1.htm

U.S. Bureau of Labor Statistics. (2016). *Table 2. Fatal occupational injuries by industry and selected event or exposure, 2014*. Retrieved from http://www.bls.gov/news.release/cfoi.t02.htm

U.S. Department of Labor. (2015a). *Federal employer rights and responsibilities following an OSHA inspection—1996*. Retrieved from http://www.osha.gov/Publications/fedrites.html

U.S. Department of Labor. (2015b). *Occupational Safety and Health Administration: Commonly used statistics: Construction's "Fatal Four"*. Retrieved from http://www.osha.gov/oshstats/commonstats.html

Weinstein, N. D. (1988). The precaution adoption process. *Health Psychology*, 7, 355–386.