Construction is a high-hazard industry due to its complex nature. In the U.S., the industry frequently experiences the highest number of fatal work injuries. Although construction accounts for less than 5% of the U.S. workforce, about 20% of occupational fatal injuries occur in this industry.

Maintaining an injury-free workplace in construction is difficult due to the inherent uncertainty of the built environment. However, site management can reduce incidents if root causes are properly identified and eliminated.

Site personnel can identify root causes by conducting effective and thorough incident investigations that are both retrospective and prospective in that lessons learned from incidents are incorporated into continuous improvement efforts. Behm and Powell (2014) define incident investigation as “a documented and discoverable analysis of how an organization solves OSH issues stemming from incidents and near misses.” The main aim is to identify the root causes that led to undesired outcomes so that management can implement appropriate corrective and preventive actions.

Many OSH professionals agree that improving the quality of incident investigation reports can lead to improved safety performance. This article proposes a construction incident investigation framework that relies on the six sigma DMAIC (define, measure, analyze, improve, control) cycle.

Six Sigma
Six sigma is a statistical quality improvement system. Companies implementing these strategies report improved production, shorter project schedules and reduced costs (Karakhan, 2011). Six sigma strategies also reportedly improve safety performance. For example, Honeywell International, DuPont, General Electric and Bechtel Jacobs have used six sigma to improve OSH (ReVelle, 2004). However, the construction industry has not broadly applied this approach.

DMAIC Cycle
The DMAIC cycle is a disciplined, well-structured methodology used not only to locate the causes of defects within a production system, but also to eliminate the root causes of defects and improve production quality (Karakhan & Alsaffar, 2013). The process encompasses defining the problem, measuring, then analyzing the data to discover possible root causes, improving the process to eliminate root causes of defects and sustaining the success over time (Ferreira & Lopes, 2010). Let’s take a closer look at each phase of the cycle.

**Define Phase**
The define phase consists of identifying the process and defining the scope of the problem. This phase essentially involves identifying inputs and outputs of a process. Applied to an incident investigation, the investigation team determines the type of event (e.g., near-hit, injury, fatality), then identifies workers involved in the operation, subcontractors and all other interacting project teams.

At this point, the team can share illustrative tools to increase understanding. One example is a SIPOC diagram, which the team uses to consider suppliers (S), process inputs (I), the process itself (P), process outputs (O) and customers (C) of the output. It helps to define “the boundaries and critical elements of a process without getting into so much detail” (Karakhan, 2011). This tool helps depict the safety input and responsibilities of each party in the field.

**Measure Phase**
The main goal of the measure phase is to assess safety performance and collect relevant data to answer the questions of what and how. When investigating an event, the first step is to determine frequency and severity, which helps pinpoint the incident’s effect on worker safety, morale, project schedule and project cost.

The four levels of severity associated with a workplace incident are: 1) negligible (e.g., near-hit); 2) low severity level (e.g., minor injury); 3) moderate severity level (e.g., injury requiring medical treatment or involving lost workdays); and 4) high severity level (e.g., disabling or fatal injury). Note that negligible and low-severity-level incidents do not necessarily mean low safety risk. Since safety risk is the product of frequency, severity and exposure (Jannadi & Almishari, 2003), a high frequency of low-severity injuries may affect safety performance.

Conducting an employee survey and focus-group interviews with workers involved in or affected by the incident is an effective way to collect relevant data before anchoring those data to the questions of interest in the next DMAIC phase. Site safety audits, safety checklists and worker observations are other common ways to collect useful data.

**Analyze Phase**
The third stage of DMAIC is the analyze phase. Data obtained during the previous stages are analyzed to determine cause-and-effect relationships as a precursor to identifying primary incident root causes. This stage paves the way for strategies that management can implement to eliminate hazards and improve safety performance.

To address root causes and identify potential improvement opportunities, the team should examine both lagging and leading indicators by reviewing investigation reports, OSHA recordable injuries, site safety audits, job safety analyses, job hazard analyses and similar information. However, before selecting improvement strategies, the team must ensure that root causes, not simply symptoms, are identified.

During this phase, the investigative team often uses graphical tools such as histograms, Pareto charts and cause-and-effect fishbone diagrams (Karakhan, 2011). Figure 1 depicts a cause-and-effect fishbone diagram created by cross-functional teams at Honeywell to identify leading injury causes (Rancour & McCracken, 2000). After identifying incident causes, the team can use a technique such as failure mode and effects analysis to assign a risk value to each cause (Rancour & McCracken, 2000).

The five-why technique is another commonly used root-cause analysis tool. It is a systematic problem-solving technique used to explore cause-and-effect relationships (Serrat, 2009). The technique consists of asking “why” five times in succession. Remember two important caveats when using this technique (Manuele, 2016):

1. Ask why, not what or who.
2. Fewer than five why-type questions may be sufficient.
Improve Phase

The main goal of investigating incidents is to detect causes of failure, then implement effective countermeasures to prevent incident recurrence and improve project safety performance. Based on information gathered and the analysis performed during the first three phases, potential corrective and preventive measures are considered during the improve phase.

Control Phase

The investigative team must understand the difference between corrective and preventive actions. Corrective actions correspond to incident symptoms and usually aim to absorb and contain incident impacts. Preventive actions aim to predict and prevent incidents before they occur. However, unless root causes are properly identified early in the process, these actions cannot be effective (Powell, 2013). Corrective and preventive actions can take various forms. For example, management might deliver employee awareness training if the investigation has revealed that workers’ safety perception is lacking.

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Control Phase

The control phase includes verifying and sustaining safety gains realized after implementing injury prevention countermeasures. Sustaining safety performance improvement over time is critical (Powell, 2013). However, doing so can be a significant challenge (Granger, 2012).

In a production environment, when the six sigma DMAIC cycle is implemented to drive quality performance improvement, quality circles are used to involve employees in the decision-making process (Karakhan, 2011). Quality circles are teams of workers who meet periodically (e.g., weekly) to discuss ways to improve quality performance.

In the construction environment, management can implement safety circles to involve construction workers in the site’s

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safety effort, which will likely lead to better outcomes (Powell, 2013). Management should select a few workers to join safety circles, and assign foremen or site superintendents to lead these groups.

Conclusion
Today’s competitive construction environment has little margin for error. Safety performance affects worker morale, productivity, project schedule and cost. The six sigma DMAIC cycle is a problem-solving framework that a construction employer can use to define, measure, analyze, improve and control defects, including workplace hazards. Applying the DMAIC cycle to incident investigations also helps create a collaborative environment, promotes a team approach to safety and encourages continuous improvement.

References


Ali Karakhan is a Ph.D. student in the School of Civil and Construction Engineering at Oregon State University. He holds a B.S. in Building and Construction Engineering from University of Technology, Baghdad, and an M.S. in Civil Engineering from University of Baghdad, where he worked before starting his doctoral studies. Karakhan’s research interests include construction safety, prevention through design, sustainable construction, multicriteria decision-making analysis and quality management.

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