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Strategies for Improving Hazard Recognition

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Strategies for Improving Hazard Recognition

**Prepared by
Construction Industry Institute
Research Team 293, Strategies for HSE Hazard Recognition**

**Research Summary 293-1
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Executive Summary

Although injury rates in the construction industry have declined significantly in the last 40 years, the rate of safety improvement has recently slowed substantially. Organizations that hold safety as a core value have expressed a strong desire for new methods that accelerate safety improvement. One of the current weaknesses revealed by recent research is the lack of adequate hazard recognition skills among construction personnel on diverse and dynamic projects (Carter and Smith 2006; Center for Disease Control and Prevention 2012). To address this problem, Construction Industry Institute (CII) Research Team (RT) 293 set out to develop transformative strategies and practical hands-on tools that directly improve workers' skills for recognizing and communicating hazards. Hazard recognition is a core competency upon which all other safety processes are built. Without strong hazard recognition skills, even safety planning activities that are potentially highly effective (e.g., job hazard analyses and site audits) will not achieve their objectives.

The first phase of the study involved developing a comprehensive list of hazard recognition strategies from safety literature used in a diverse range of industries, including aerospace, the military, manufacturing, mining, construction, and many others. The research team identified more than 100 hazard recognition techniques that were either new to construction or not used specifically as hazard recognition improvement tools. The team used the nominal group technique—a research technique that capitalizes on the expertise of a group—to select the three with the greatest potential for step-change improvement. The three strategies include the following: 1) a pre-job safety meeting quality measurement (SMQM) maturity model that facilitates continuous improvement of the pre-job hazard identification and communication process; 2) a hyper-realistic augmented training environment—called the System for Augmented Virtuality Safety (SAVES)—that immerses workers in a jobsite simulation; and 3) a visual-cue-based Hazard Identification and Transmission (HIT) Board that records hazards during task evaluation and in real time as the job progresses.

Because the three strategies were new to construction and were completely conceptual, the research team developed prototype versions of each tool in the second phase of the study. After completing these prototypes, the team conducted empirical field tests in the third phase to verify the strategies' effectiveness with active work crews. Specifically, the team used the multiple-baseline testing (MBT) approach for experimental field testing because it would allow for the establishment of a cause-and-effect relationship between the strategies and hazard recognition improvement. This empirical data collection and analysis method provides a more objective measurement than the more subjective survey method of assessment.

The results of the team's experimental field testing indicate that workers identify less than half of hazards in their immediate work environment before work begins. Alarming, this logically means that more than half of hazards are not identified and discussed prior to work. Fortunately, the field tests reveal that the SMQM model, SAVES system, and HIT Board caused net weighted overall improvements in hazard recognition skill of 31 percent, 27 percent, and 30 percent, respectively. To validate these results, the research team used skill tests with high-resolution photographs of diverse construction settings both before and after the application of the three strategies.

The implications of these findings are that this suite of new hazard recognition methods can be used to dramatically improve hazard recognition. This possible improvement is especially important because workers' ability to identify hazards is essential to their ability to protect themselves. Moreover, the workers' ability to correctly identify hazards improves the job hazard analyses process, site audits, and all other safety management initiatives. This research summary describes the background for the research, the three strategies that were tested, the specific field testing protocol, and the results and conclusions of the research effort.

Introduction

Construction workers are highly susceptible to occupational injuries. Research indicates that the fatality and disabling injury rates in the construction industry is about three times higher than the all-industry average (Pinto et al. 2011). Such high injury rates are due in part to workers' inability to recognize and respond to potential hazards in the dynamic environments typical of construction (Carter and Smith 2006).

Figure 1 represents a simple conceptual model of a safety management approach that is centered on hazard recognition skills. In this model, an injury occurs when a hazard is present, and an individual is actually exposed to it in the absence of adequate controls. As shown in the framework, hazards that are not proactively recognized are not included in the risk evaluation process. This often results in a sub-optimal safety management program.

Typically, when reviewing construction documentation and conducting field observations, management can rely on experience to identify hazards associated with work tasks. A fundamental but often incorrect assumption underlying such an approach is that workers are as capable as management at predicting work sequences and associated hazards. Unfortunately, new workers may be unfamiliar with construction processes and incapable of recognizing their hazards. In order to enhance hazard recognition skills, employers often put workers through formal hazard recognition training programs. Such current training methods are based on conventional classroom instructional techniques, which often fail to adequately engage workers. Especially challenging is engaging the attention of younger (Generation Y) workers.

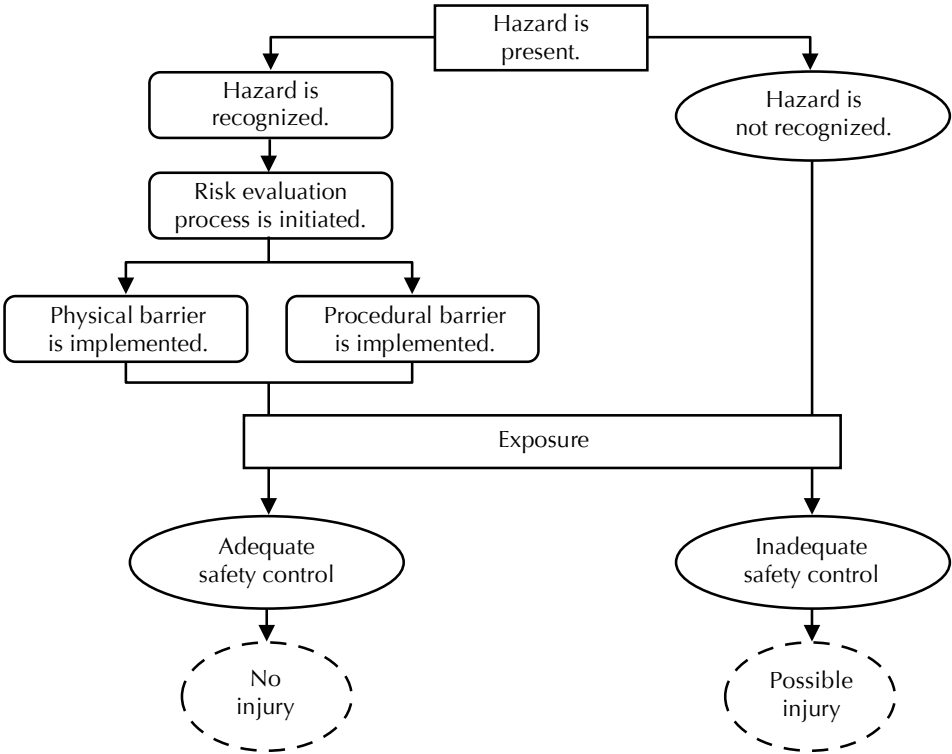


Figure 1. Conceptual Safety Management Protocol

In response to this imminent need, RT 293 explored new hazard recognition improvement strategies in a multi-phase study. The research team developed and refined three transformative hazard recognition strategies that incorporate essential theories from the field of psychology and other behavioral sciences. To ensure that these strategies do indeed increase hazard recognition skills, the team performed experimental field trials using the multiple-baseline testing (MBT) approach. The remainder of this research summary describes the state of hazard recognition programs in the industry, new methods identified through literature review and group brainstorming, the RT 293 approach to selecting the three strategies with the greatest potential for step-change improvement, the team's methods of experimental field testing and validation, the salient results, and the implications of these results.

Hazard Recognition Background

Several formal and systematic approaches have been developed to improve hazard recognition in construction. These methods can be broadly classified as either predictive or reactive in nature. Predictive hazard recognition methods such as the Job Hazard Analysis (JHA) require workers to mentally visualize activities that they will undertake to complete specific work tasks. Based on the activities, workers attempt to identify all relevant and potential hazards. Other programs, such as task analysis and regular safety task-planning sessions, follow very similar approaches. Such methods, although they have contributed significantly to safety improvement, have some inherent limitations. First, hazard recognition methods that focus on isolated job-tasks or procedures fail to recognize additional hazards that may arise due to adjacent work and/or any changes in scope, work methods, and/or conditions (Rozenfeld et al. 2010). Second, the approach assumes that workers can correctly predict how tasks will be performed and can identify the hazards associated with these predictions. Finally, these strategies operate under the assumption that workers are able to recognize all hazards associated with the daily tasks that are to be performed (Fleming 2009).

Reactive and retrospective methods of hazard recognition usually rely on past experience or injuries to determine potential hazards for a given work-setting. Often, employers compile lessons learned from past projects and then disseminate the material through training that involves conventional instruction. Like the predictive hazard recognition methods, the retrospective methods have various weaknesses. First, past incidents and near misses are often not reported, and reports are often not thorough enough for learning and future improvement (Dong et al. 2011). Second, injury records reflect only a small subset of potential scenarios that resulted in injuries (Rozenfeld et al. 2010). Third, in environments as dynamic as the construction industry, generalizing accidents across different settings is often invalid. Finally, transferring such an enormous

amount of information to workers by means of inefficient instructional methods is unrealistic (Fleming 2009).

To ensure effective learning, hazard recognition training programs must be tailored to the learning styles of the workers. Traditional lecture-based training programs in which the trainee plays a dependent or passive role are often ineffective for training adult learners. Adult workers learn better when programs are based on the principles of andragogy (adult learning), which allow the workers to be involved in building context, setting objectives, cooperatively and interactively delivering instructional material, and forming plans (Knowles et al. 2012). Methods that encourage active participation and visual learning are particularly effective. Given these requirements for effective adult education, RT 293 based the three interactive strategies it tested—SMQM, SAVES, and the HIT Board—on an easily internalized mnemonic for the different energy sources that underlie hazards; the team hypothesized that such a combination of techniques would efficiently engage workers during the hazard recognition training process and improve their cognitive retrieval of hazards types when tested.

Research Methods

The objective of this study was to develop and test new, potentially transformative hazard recognition strategies for step-wise improvement in safety performance. The research team aimed to develop techniques that incorporated industry best practices and relevant theories from psychology and other behavioral sciences. The team conducted research in three segregated but interrelated phases that each addressed current weaknesses in safety training, planning, and execution. In the first phase, the team drew up a comprehensive list of hazard recognition strategies, and then used the nominal group technique to select three for further development and testing. The chosen techniques were SMQM, SAVES, and the HIT Board. In the second phase, because these three safety strategies were new to the industry, the team developed and refined them for use on the construction jobsite. In the third and final phase, the team field tested the three strategies to determine their impacts on hazard recognition skills. The overall aim of this research was to experimentally test the hypothesis that an appropriately designed strategy causes a measurable increase in the proportion of hazards identified and communicated before work begins.

Phase I: Selection of Transformative Hazard Recognition Program Elements

The objective of the first phase, as shown in Figure 2, was to select hazard recognition program elements that could significantly improve hazard recognition levels on construction worksites. The research team gathered this information from an extensive review of safety literature across multiple industries, including construction, mining, manufacturing, chemical, and the military. The team also gathered data from benchmarking reviews of hazard recognition elements used by CII member organizations, and from brainstorming sessions on elements that are theoretically implementable but not generally utilized. From this extensive review, the team identified more than 100 program elements.

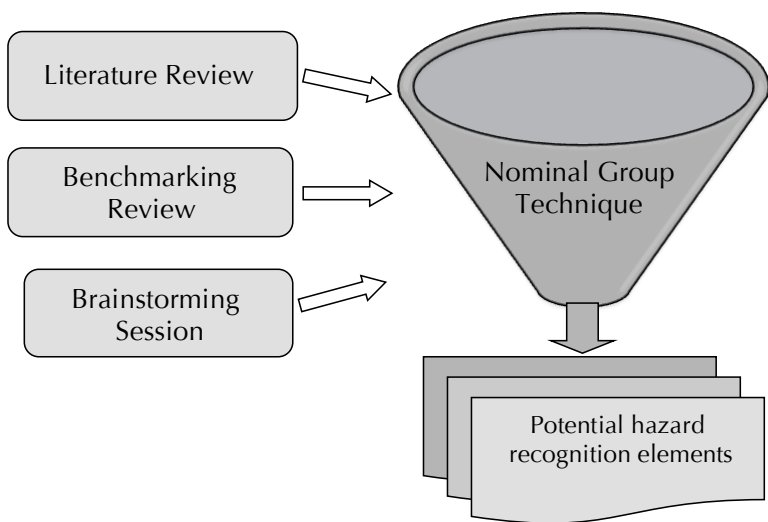


Figure 2. Selection of Hazard Recognition Elements

The next step was to short-list the most promising elements for further refinement and testing. Strategies that were inappropriate for dynamic environments such as construction, or that could not be reasonably developed or adjusted for construction were eliminated. Next, the research team served as an expert panel to rate the strategies, using a 1–5 Likert scale, with a 1 rating meaning “strongly disagree” and a 5 rating meaning “strongly agree.” (For details on the rating criteria, see Appendix A.) The team members rated the strategies using the nominal group technique (NGT), which required them to rank the strategies, discuss the results, and re-rank the strategies several times until group consensus was achieved. This process was facilitated by a group decision support software application called Grouputer. It allowed team members to use their personal computers simultaneously and anonymously to rate each strategy. This form of parallel rating effectively reduced any bias that might be due to dominance or the “bandwagon effect” (Kennedy and Clinton, 2009). (For more detail on the NGT process used for this study, please see Research Report 293-11.)

The 14 research team experts who rated the strategies each had more than 10 years of safety management experience. In total, the team members had accumulated more than 352 years of construction safety management experience during their careers. In addition to their professional experience, seven members were Certified Safety Professionals (CSP), and five were Certified Hazardous Materials Managers (CHMM). The team also included one or more members who had obtained the following licenses: Professional Engineer (PE); Occupational Health and Safety Technologist (OHST); Compliance Safety and Health Officer (CSHO); and Certified Industrial Hygienist (CIH). A broad range of industry sectors were represented on the team, and several members were active in various health and safety committees, e.g., the American Society of Safety Engineers, the National Safety Council, the Accident Prevention Association, and local safety councils. The team also had five members with master's degrees, and six with bachelor's degrees in safety-related fields of study.

The NGT process yielded 1,400 ratings. To effectively compare ratings among experts, mean ranks were computed for each criterion. When mean ranks are used, the strategy that is rated highest for a criterion by most of the experts is assigned the highest rank for that criterion. The average of the ranks is then accumulated across all the criteria to determine the relative effectiveness score for each strategy. Table 1 shows the results of these calculations. As shown, the pre-job safety meeting quality measurement tool emerged as the strategy with the highest potential, followed by the augmented virtual reality training environment.

Table 1. Relative Effectiveness Score for
Top 10 Hazard Recognition Program Elements

Hazard recognition strategy elements	Relative effectiveness score
1. Pre-job safety meeting quality measurement tool	74.71
2. Augmented and interactive reality training environment	58.29
3. Senior leadership engagement in JSA process	55.89*
4. Physical area hazard simulation	55.49**
5. Safety situational-awareness training	55.25***
6. Hazard identification board	54.92
7. Foreman one on one with employee	52.76
8. Precursory visual cues	49.48
9. JSA post-kick-off audit	48.81
10. Video/photo monitoring and feedback	44.40

* Combined with 1

** Not testable with available resources

*** Combined with 2

Phase II: Development of Transformative Hazard Recognition Strategies

The objective of the second phase was to build and refine the top three hazard recognition strategies identified in the previous phase. (See Table 1.) After discussing the results of the NGP process, the research team decided to combine several complementary strategies. The first such combination was the pairing of the pre-job safety meeting quality measurement tool with senior leadership engagement in the jobsite safety audit (JSA) process. From this combination, the team developed the Pre-job Safety Meeting Quality Measurement (SMQM) maturity model. To create the second strategy, the team combined the hazard identification board with precursory visual cues to form the visual-cue-based Hazard Identification and Transmission (HIT) Board. The team then combined the augmented and interactive virtual reality training