

# **Improving Safety Performance on Large Construction Sites**

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## **Abstract**

A recent safety study conducted on large construction sites, valued between \$50 million and \$600 million, in North America revealed that construction safety performance is influenced by a number of factors. It is clear from the research results there is no single safety practice that can be implemented to ensure that safety performance is optimal. Instead, a concerted effort is required in which several different practices must be implemented. Factors that are influential in impacting safety performance include demonstrated management commitment, project safety staffing, safety planning, training and education, worker involvement, rewards and recognition, subcontractor management, drug testing, and accident investigations. The research disclosed that there are various ways of addressing these practices. It is also evident that the construction industry is maturing and is aggressively seeking new and innovative ways to establish safety as a primary objective. In a study of 38 large construction projects, four had achieved an Occupational Safety and Health Administration (OSHA) recordable injury rate of zero.

## **Keywords**

Best practices, jobsite safety, safety programs

## **1. Introduction**

The safety performance of the construction industry has consistently been below that of most other industries. Despite this, the construction industry has made considerable improvements in safety performance in the past two decades. Statistical data provide documented proof that improvements have indeed been made in the safety performance of the construction industry. For example, the OSHA recordable injury rate in 1990 in the United States was 14.2 and in 2000 it had dropped to 7.71. What is not clear is how these improvements were actually achieved. Many different safety practices have been devised, adopted and implemented in recent years, but it is not clear which particular

practices are responsible for these improvements. Are certain practices particularly effective in impacting safety performance or do they all contribute to improved performance?

Safety improvements are particularly evident on large construction projects. While safety performance may be good on some small projects, it is on large construction projects that safety performance is consistently quite good. The safety performance records on large projects are also generally quite reliable as a large number of worker hours are expended on a single project. Since most firms involved in large projects are willing to provide the results of their safety efforts, a great deal can be learned by studying the safety practices implemented on large projects. These can then be considered for implementation on other construction projects.

## **2. Background**

A number of safety studies have been conducted to identify effective safety practices in large construction firms. In a 1981 study of the 100 largest construction firms in the U.S., safety practices were identified that were associated with better safety performances. Firms with better safety records were those with full-time safety officers with considerable authority and when full-time safety officers were assigned to most company projects. These safety officers hired their own subordinates and they reported directly to the company president or vice president. Additionally, it was found that safety performances were better when all new workers received formal orientation. It was also found that safety performances were better in those firms providing safety incentive awards for their workers and foremen (Hinze and Harrison 1981).

In a Construction Industry Institute study on high-rise construction projects in Canada, additional factors were identified that influenced safety performance. The findings showed that safety performances on projects were better when full-time safety officers were assigned to projects and when top management actively and visibly participated in the safety program. Better safety performances were also noted on projects where individual records were kept on the safety performances of the foremen, where jobsite safety inspections were conducted on a regular basis, and where safety was discussed in the regularly held coordination meetings. It was observed that better safety performances occurred on projects that were either under budget or on budget and better performances also existed when contracts were negotiated instead of being competitively bid (Hinze and Raboud 1988).

A report released by the Construction Industry Institute (1993) identified five high impact techniques for achieving zero accidents. These included pretask/preproject planning, safety orientation and training, safety incentive programs, alcohol and substance abuse programs, and accident/incident investigations.

In another study of a survey of the top 400 contractors, several practices were identified as favorably influencing safety performance (Eich 1996). For example, better safety performances were reported by those firms that gave incentive awards for safe crew performance (as opposed to safe individual performance), that imposed sanctions for unsafe behavior, that provided formal orientation training to all new employees, that held periodic safety dinners, and that implemented drug testing programs.

One recent study showed that representatives of large construction firms tended to agree with the findings of the zero accidents study. They also stated that they had made

changes since the zero accidents results were publicized (Hinze and Wilson 1998). It was evident that changes had taken place in the construction industry, but that there was no clear evidence as to their effectiveness.

### **3. Research Methodology**

With the changes that had taken place in construction safety practices, a proposal was submitted to the Construction Industry Institute to study factors that impact safety performance on large projects. This proposal was funded and resulted in the research that is reported here.

The object of this research was to identify those contractor practices on large construction projects that are particularly effective in favorably impacting safety performance. The projects to be included in this study were large construction sites, those valued from \$50 million to \$600 million. All known projects that satisfied the size criteria were contacted and asked to participate in the study. All identified projects that met the size criterion were included in the study sample.

The research consisted of conducting personal interviews with a contractor representative who was resident on the construction project. On most projects this was the safety representative but in some instances it was the project manager. The ten-page questionnaire addressed many safety issues including jobsite characteristics, owner involvement in project safety, safety staffing, safety planning, training and education, safety meetings, incentives, safety audits, drug testing, subcontract management, accident investigations, insurance company involvement in the safety process, inclusion of OSHA in the safety process, and safety performance information. Interviews were generally conducted in one to two hours. In a few instances, interviews were conducted over the telephone. In total, 38 interviews were conducted.

### **4. Data Analysis**

The data analysis identified the safety performances associated with differing types of practices being implemented on construction sites. Of particular interest in this research were findings that identified those practices that were particularly effective in enhancing safety performance. Effectiveness was measured in terms of the OSHA (Occupational Safety and Health Administration) recordable injury rate that equated to the number of OSHA recordable injuries incurred per 200,000 worker hours of exposure. For this study, the median OSHA recordable injury rate was 2.0 injuries per 200,000 hours. It should be noted that the average OSHA recordable injury rate for the construction industry for this same period was nearly eight, so it should be evident that the large projects generally experienced good safety performance.

In this research, four of the large projects reported OSHA recordable injury rates of zero and 21 reported lost workday injury rates of zero. Although the projects included in this research generally experienced good safety performance records, the analysis focused on identifying those policies and practices that were associated with particularly good injury rates. The findings of particular interest were those policies and practices that were found to show a statistically significant correlation (using Kendal's correlation) with the OSHA recordable injury rate. Findings were considered to be statistically significant if the level of significance was less than 0.05 and a tendency

towards was assumed to exist if the level of significance was between 0.05 and 0.10. For the findings presented, it should be noted that some interview participants were not responsive to some questions.

## 5. Research Results

### 5.1 Demonstrated Management Commitment

No reasonable manager would admit to having no regard for the safety of workers. Safety is fundamental and it is generally regarded as being a goal worth achieving. The key to success lies in the demonstration of that commitment to safety. There are of course many ways that this can be achieved and done. In the end, it is not what management says, but what it does. For example, the research showed that safety performances were better when top managers were involved in more frequent jobsite safety inspections (see Table 1).

**Table 1: How often does someone from the home office make safety inspections?**

Response	Number	Median Injury Rate
Weekly, bi-weekly, or monthly	24	1.38
Quarterly	14	2.57

Correlation Coefficient = 0.24

Level of Significance = 0.03

### 5.2 Safety Staffing

On large construction projects, most with hundreds of field workers employed, it is not possible for the safety needs of the workers to be adequately addressed by the site supervisors. The site supervisors need additional assistance and this is where safety personnel can be particularly helpful. Safety personnel can serve as a safety resource that can make a significant difference. But how many safety personnel are needed to adequately address the needs of the site supervisors? The unique site conditions will dictate the answer to some extent. Certainly, the safety personnel must be viewed as resources that are at the disposal of the site supervisors to promote the safety mission. The research showed that better safety performances were realized when the ratio of workers to safety personnel was small (see Table 2). In addition, it was found that better safety performances existed on projects where the project safety director reported directly to someone in the home office, rather than have reporting responsibilities to someone in line management at the project level. The safety director's focus can clearly remain focused on safety issues when the reporting is to someone who is not directly affiliated with the project (see Table 3).

**Table 2: Number of workers per safety person.**

Workers per Safety Person	Number of Projects	Median Injury Rate
1 to 20	3	1.11
45 to 70	3	2.81
100 to 150	8	2.92
181	1	5.1
500	1	8.04

Correlation is not statistically significant (Note: several projects did not provide these data)

**Table 3: To whom does the safety representative report?**

Response	Number	Median Injury Rate
Staff (Main Office/ Safety Director)	19	1.38
Line (Project Manager)	16	2.41

Correlation Coefficient = 0.20      Level of Significance = 0.07

### 5.3 Safety Planning

Safety planning is vital to project safety. There are two types of safety planning. One consists of pre-project planning and the other consists of pre-task planning. Note that pre-project safety planning and pre-task safety planning are synonymous with pre-project planning and pre-task planning, respectively. When planning is done, whether at the project or task level, it is important that safety be addressed along with the other aspects of performing the work, as safety cannot be addressed as a distinct and separate issue. Safety simply must be integrated into the planning process. One means of integrating safety into the project is by preparing a site-specific safety program. Through a site specific safety program the contractor identifies all major job hazards and devises means of addressing them to maintain a safe project. These are commonly employed on large projects, and they have been shown to favorably impact jobsite safety (see Table 4).

**Table 4: Is there a site-specific safety program for the project?**

Response	Number	Median Injury Rate
Yes	34	1.76
No	4	5.43

Correlation Coefficient = 0.20      Level of Significance = 0.08

### 5.4 Safety Training and Education

Worker training, especially worker orientation training, has been recognized as vital to achieving good safety performance. As a result, it is common on large construction sites for orientation to be offered. The issue that is important to worker safety is that the orientation must be provided to all workers and it must be formalized (standardized to ensure that every worker receives the same quality of orientation training). As in past construction safety research, new worker orientation continues to be of vital importance to safety (see Table 5). Findings show that training must continue beyond the orientation training, and this training must be provided to both workers and supervisory personnel (see Table 6). Safety training also appears to be most effective, as evidenced by lower injury rates, when there is some means of measuring the effectiveness of the training.

**Table 5: Does every worker on the project receive orientation training?**

Response	Number	Median Injury Rate
Yes	30	1.76
No	8	5.72

Correlation Coefficient = 0.24      Level of Significance = 0.05

**Table 6: How much additional training do workers receive each month?**

Response	Number	Median Injury Rate
Less than 4 hours	10	3.76
More than 4 hours	17	1.07

Correlation Coefficient = -.35      Level of Significance = 0.01

### 5.5 Worker Involvement

One of the newest innovations in the area of safety in the construction industry is the increased involvement of workers in the safety process. Workers should be viewed as a resource for ideas. The adage that “two heads are better than one” certainly applies here. If a foreman has five workers in the crew, that supervisor has ready access to the experiences and perspectives of five different individuals that can each contribute in a unique way. Not only will the ideas being generated be richer, but there will also be an increase in worker satisfaction. There are various ways that worker ideas can be tapped. Better safety performances were noted to occur on projects that organized safety committees (see Table 7), that conducted formal worker observations, also referred to as behavior-based safety (see Table 8), and where worker safety perception surveys were conducted (see Table 9). Suggestion box programs and pre-task planning were also conducted. Others may also be employed, depending on the ingenuity of the supervisor and project team.

**Table 7: Does your project have a formal safety committee?**

Response	Number	Median Injury Rate
Yes	26	1.76
No	11	2.82

Correlation Coefficient = 0.22      Level of Significance = 0.07

**Table 8: Does the project have a formal behavior-based program?**

Response	Number	Median Injury Rate
Yes	23	1.38
No	15	2.82

Correlation Coefficient = 0.29      Level of Significance = 0.02

**Table 9: Does the company use safety perception surveys on the project?**

Response	Number	Median Injury Rate
Yes	19	1.33
No	19	2.82

Correlation Coefficient = 0.30      Level of Significance = 0.02

### 5.6 Rewards/Recognition

Among the different approaches that have been employed to improve jobsite safety, safety incentives are among those that have been explored for decades. Incentives are designed to be a form of positive reinforcement. That is, an incentive is given to workers who meet certain safety performance criteria. Where safety incentives are concerned, the incentive is generally given to workers or crews that do not have an OSHA recordable injury in a stipulated period of time. In this research, only four construction projects were identified that did not employ safety incentives. It was

interesting to note that these four projects actually reported lower injury rates than the projects that employed. While most projects did employ safety incentives, it is also clear that good safety performances can be attained without them.

Incentives are ideally a physical or visible demonstration of the commitment of the company to safety. The data were examined to determine if there were any unique techniques of using incentives that were more effective. For example, it was noted that among the projects that utilized safety incentives, better safety performances were reported when the incentives were given more frequently (see Table 10). Of course the traditional incentives are also criticized as being related to a negative measure of safety performance, worker injuries. The incentives are lost when an injury occurs. Many favor more pro-active approaches to safety in which the safe behavior of workers is rewarded. It has been argued that a worker may work in an unsafe manner, receive no injuries as the work is performed, and ultimately be rewarded for the efforts, despite the fact that the work was not performed safely. Basing incentives on safe behavior, rather than on injury occurrence, is more directly focused on the intent of promoting safe work. This type of program is more difficult to implement and maintain, but such programs have been shown to be very effective. Under this type of program, a worker who is observed as performing a task in a particularly safe manner is provided with an “on-the-spot” reward or token (for example, a sticker posted on the hard hat.). These tokens can be accumulated and later redeemed through a catalogue in which gifts of differing values can be obtained. While positive reinforcement has its obvious impacts on safety performance, it was found that better safety performances were also noted when sanctions (negative reinforcement) were imposed when workers failed to work safely (see Table 11, the question says subcontractors, is it the same as workers?).

**Table 10: How often are safety incentives given to workers?**

Response	Number	Median Injury Rate
Weekly, Biweekly, or Monthly	14	1.33
Quarterly	7	3.29

Correlation Coefficient = -0.01      Level of Significance = 0.01

**Table 11: Are sanctions in place for sub-contractors who violate safety procedures?**

Response	Number	Median Injury Rate
Yes	28	1.45
No	4	5.41

Correlation Coefficient = 0.27      Level of Significance = 0.04

## 5.7 Subcontractor Management

Subcontractors play an important role in construction, i.e.; subcontractors perform most of the construction work actually performed. Consequently, it is imperative that the safety practices on a project fully include the subcontractors’ workers or a double standard will be established. A double standard on safety can compromise the effectiveness of the safety program. It is important that all parties on the construction site follow the same safety procedures. Perhaps the most effective way to ensure that subcontractors will be safe is to conduct a thorough screening of the subcontractors before awarding the subcontracts (see Table 12). Once selected, subcontractors should be integrated into the overall project safety program. In addition, it is important that the

subcontractors prepare and submit site-specific safety plans. This will ensure that they have thoroughly examined their scope of work and can perform it safely (see Table 13).

**Table 12: Are subcontractors pre-qualified before consideration for the project?**

Response	Number	Median Injury Rate
Yes	31	1.38
No	6	4.72

Correlation Coefficient = 0.28      Level of Significance = 0.03

**Table 13: Are subcontractors required to submit site-specific safety plans?**

Response	Number	Median Injury Rate
Yes	27	1.38
No	5	3.84

Correlation Coefficient = 0.25      Level of Significance = 0.05

### 5.8 Drug Testing

Drug testing is a common practice on many construction projects. There are several different types of drug tests. These include pre-employment screening, post accident, random, and for cause testing. Drug testing is vital on construction projects to ensure that the workers on site are competent. Since the late 1980s and the early 1990s, drug-testing programs have become commonplace on most large construction sites (Gerber and Yacoubian 2001). There are differences in the manner in which some of these programs are implemented. Most projects conduct pre-employment drug screening tests, but fewer projects conduct random drug tests. The research findings show that projects implementing random drug tests had better safety performances (see Table 14). It was also found when these tests are conducted that projects have higher injury frequency rates when the percentage of positive tests is high.

**Table 14: Are Random Drug Tests Conducted?**

Response	Number	Median Injury Rate
Yes	22	1.38
No	14	2.57

Correlation Coefficient = 0.21      Level of Significance = 0.07

### 5.9 Accident Investigations

Whenever an injury occurs, a message is communicated that something is wrong in the system. Injuries should not occur when everything takes place as planned. When a worker is injured, the initial and most important issue is that of obtaining prompt treatment for the injured worker. Once the injured worker has been attended to, attention will begin to focus on ensuring that a similar injury does not occur in the future. To do this, it will be important to understand the specific cause of the injury. This information can be obtained through a thorough investigation of the accident.

Accident investigations are important to identify the root causes of injuries. Once the root causes are identified, it is possible to begin to address the means by which such conditions can be avoided when similar tasks are performed in the future. Even if conditions cannot be entirely eliminated, it will be beneficial to simply be able to recognize the hazards harbored by given conditions. The research findings showed that the level of top management involvement in injury investigations also made a



difference. Safer performances were reported when top management was involved in the investigation of every worker injury (see Table 15).

**Table 15: Percent of OSHA recordable injuries investigated by top management**

Response	Number	Median Injury Rate
100% (all)	14	1.20
Less than 50% (none were from 51-99%)	10	6.89

Correlation Coefficient = 0.55      Level of Significance = 0.01

It is a common practice on large construction projects to investigate all accidents involving lost workday injuries and OSHA recordable injuries. An even better practice is to also investigate near miss accidents. Near miss accidents are incidents that do not result in injuries but which might have, had circumstances been slightly different. Near misses are like “wake up calls” that do not result in injuries. When near misses occur, management should seize the opportunity to investigate the root causes so that similar circumstances do not arise in which a future injury might occur. Firms that investigated more near misses reported safer performances.

### 5.10 Additional Analysis

There is much speculation about the particular policies or practices that are most effective at reducing construction worker injuries on large construction projects. The answer to this question was sought through regression analysis; unfortunately, the sample was too small to conduct an effective analysis. Instead, another approach was used to examine the data. Rather than examine the impact of a single practice on the safety performance on the project, the cumulative impact of implementing a group of practices was examined. The results showed that projects that implemented more safety practices (at least 90 percent of the best practices identified) had significantly better safety performances with injury frequency rates of 0.18. Similarly those projects that did not implement many of the safety practices (no more than 40 percent) reported high injury rates averaging 7.61. Clearly, there is no single practice that can be implemented that can ensure the safety performance on the project, i.e., a concerted effort is required that involves the implementation of several safety practices.

## 6. Summary

The research shows that the safety performances experienced on large construction projects have improved considerably in recent years, noticeably better than the construction industry in general. It is also clear that the safety practices being implemented have changed in recent years to further enhance safety performance. The subject areas in which safety performance was found to be noticeably impacted by the implementation of specific practices include the following:

1. Demonstrated management commitment
2. Safety staffing
3. Safety planning
4. Orientation and training
5. Worker involvement
6. Rewards and incentives

7. Subcontract management
8. Drug testing
9. Accident investigations

## 7. Conclusions

Safety performance on large construction projects is influenced by the implementation of a variety of safety practices. The construction industry has matured in recent years and the safety practices that have been implemented have helped show the industry that further improvements can be realized in safety performance. A few projects have achieved the zero injury objective and this phenomenon can be expected to increase on more projects in the future. It is noteworthy that there is no single practice that accounts for all the advances in safety performance. The collective impact of implementing several safety practices does indeed make a significant impact on safety performance.

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