Safety on Large Building Construction Projects

By Jimmie Hinze,[1] Associate Member, ASCE, and Paul Raboud[2]

Abstract: Large building construction projects in Canada were studied to assess the degree that policies and practices of a company or project influence worker safety, as measured in terms of injury frequency. Results showed that company-level practices influence safety performance. Safety performances were better on projects of companies that employed a full-time company safety officer; those which exhibited stronger top-management support for safety; those which conducted safety meetings for supervisors; and those which monitored the safety performances of their supervisors. Lower injury rates were also noted on projects that employed a project safety officer; those on which specific job site safety tours were conducted; and those which included safety issues in regularly held coordination meetings. Better safety performances occurred on projects which employed more sophisticated scheduling methods. It was also noted that better safety results occurred when the owner or the owner's representative was included in coordination meetings. Job pressures, particularly those imposed by budgetary constraints, were found to adversely affect safety performance.

Introduction

Safety is often considered an issue supported by everyone. Unfortunately, when it comes to spending money on safety, many people do not feel it is vital to the success of projects. Thus, it is not normally a cost code item, and it is subject to cutbacks if budgetary constraints develop. This stems from the failure of many to recognize that an effective safety program can reduce job accidents and directly or indirectly reduce project costs.

Identifying the appropriate means of achieving or maintaining acceptable safety performances, particularly on large projects, was the focus of the study herein described. Specifically, this study was conducted to identify project-level and company-level policies that can improve project safety performance.

Literature Review

Past studies have focused on managerial styles and how they can influence safety performance. Studies have also focused on the efforts that should be undertaken at the corporate level to improve job performance. These studies provided the basis for the formulation of this research study, and will be described briefly.

Research has shown that construction foremen, through their leadership methods, directly influence the safety performances of their crews

[1]Assoc. Prof., Dept. of Civ. Engrg., 121 More Hall, FX-10, Univ. of Washington, Seattle, WA 98195.

[2]Proj. Mgr., Bird Constr. Co., Inc., Toronto, Canada.

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(Samelson 1982; Field 1974). Similarly, studies have shown that project superintendents play a significant role in determining the safety performances on their projects (Hinze 1976). Studies have also shown that top managers can influence project safety (Levitt and Parker 1976; Gans 1981). In virtually all of these studies, safety performances are shown to be improved when workers are treated with respect and in a humanitarian fashion. Some basic findings from these studies are that workers perform more safely when they are properly oriented to the job; when they are not placed under undue pressure; and when they are respected as individuals (Hinze 1978; Hinze and Gordon 1979; Banki 1979).

In addition to supervisory styles, safety is influenced by company policies. Several studies on construction safety have shown this result. One study of the policies of San Francisco Bay area construction firms showed that firms with more sophisticated safety programs had better safety records (Levitt and Parker 1976). The same finding was noted in a study that surveyed the largest 100 construction firms in the United States (Hinze and Harrison 1981). Small firms, on the other hand, are most effective in minimizing job-related injuries through effective project control (Hinze and Pannullo 1978).

Research Methodology

The findings of past safety research studies provided the framework with which this study was developed. This study differed from the prior research efforts in that it was designed to identify factors that influence safety performance at the project level.

This study focused on large building construction projects that were under construction in six major Canadian cities, located in four provinces. Most of these construction sites were high-rise building projects. The size of these projects ranged from $5,000,000 to $400,000,000 (Canadian currency), with the median-sized project being $28,500,000.

Projects were identified through contractor associations located in each of the cities included in the study. Ideally, projects of interest to this study were those of significant value with a substantial portion of the project completed. Once a project was identified, a telephone call was made to the general contractor in charge to determine the appropriate contact individual. In many cases, the contact person identified was either the project safety director or the project superintendent.

The contact person on each project was then interviewed by telephone. Through this telephone interview procedure, each company representative was asked a series of questions about the means by which the project was controlled, and the nature of the formalized safety program. These interviews were usually completed in less than one hour. Through this procedure a total of 24 general contractors were contacted. These firms were all large construction companies with annual volumes of business ranging from $60,000,000 to $1 billion (Canadian currency).

The interviews focused on the practices and policies being employed on the projects. In addition, information was obtained on the number of medical doctor-case injuries that had been incurred by each general contractor's employees, and the corresponding number of worker hours that had been accumulated on the project. With this information, it was

possible to calculate a measure of the project safety performance in terms of medical doctor-case injuries per 1,000,000 hours of worker exposure.

In performing the data analysis, simple correlations using Kendall's Tau-*b* were made between the dependent variable (injury incidence rate) and the independent variables (responses to interview questions). The correlation coefficients, with a possible range of values from −1.0 to +1.0, indicate the degree to which two variables are related. A correlation coefficient of 0 means that no relationship exists between the two variables being compared. Depending on the magnitude, a positive correlation coefficient indicates the degree to which an increase in one variable is associated with an increase in another variable, i.e., a perfect relationship will result in a correlation coefficient of +1.0. To insure that reliable measures of incidence rates were being used, only projects on which the general contractors had accumulated at least 15,000 hours of worker exposure were included in the final analysis. Because some projects were in the earlier stages of construction (few worker hours expanded), the final sample size was reduced to 14.

In addition to the interviews with the general contractors, information was also collected from subcontractor representatives. This was done through additional telephone interviews with the subcontractors on each project. Each subcontractor was asked several questions concerning the general contractor's performance on the project.

Results

The findings will be presented as they relate to company size, company-level safety policy, project-level safety policy, project coordination, and economic pressures. The correlation coefficient and level of significance will be presented for each statistically significant finding. The level of significance is a measure of the probability that a particular result might be obtained at random when no true relationship exists between two variables. That is, the level of significance is a measure of the strength of a finding. It is common to use a level of significance of 0.05 as being statistically significant while 0.10 is assumed to indicate a tendency toward significance.

Company Size and Injury Occurrence

Company size, as defined in terms of dollar value of annual contracts awarded, was compared with injury frequencies. The results of the correlation test showed that the larger firms generally had better safety records (Tau-$b = -0.39$, $p = 0.036$). This supports a previous study that also showed that among large construction firms the safe companies tended to be the larger ones (Hinze and Harrison 1981).

Company-Level Safety Programs and Injury Occurrence

Questions were asked concerning how safety was addressed at the corporate level. The significant findings related to company-level policies and practices are shown in Tables 1 through 4.

The findings show that top management must be supportive of safety in order for safety efforts to be most effective. This support is evidenced by

TABLE 1. Type of Company Safety Officer and Injury Occurrence

Person in charge of company safety (1)	Number (2)	Average injury frequency (3)	Tau-*b* (4)	*p* (5)
Full-time safety director	3	51		
Part-time safety director	6	65		
No safety director	4	105		
			0.56	0.006

TABLE 2. Top Management Support of Safety and Injury Occurrence

Does top management discuss safety? (1)	Number (2)	Average injury frequency (3)	Tau-*b* (4)	*p* (5)
Yes	9	64		
No	5	81		
			0.36	0.06

TABLE 3. Supervisory Safety Meetings and Injury Occurrence

Company holds safety meetings for supervisors (1)	Number (2)	Average injury frequency (3)	Tau-*b* (4)	*p* (5)
Yes	11	62		
No	3	100		
			0.39	0.05

TABLE 4. Safety Monitoring of Supervisors and Injury Occurrence

Are records kept of supervisor safety performance? (1)	Number (2)	Average injury frequency (3)	Tau-*b* (4)	*p* (5)
Yes	8	40		
No	6	109		
			0.52	0.01

the appointment of a full-time safety director (Table 1). The findings, however, show that safety should not be vested exclusively in that position. Top managers must continue to be involved in the safety program. One way that this can be done effectively is for top managers to discuss safety, along with other topics, when field visits are made (Table 2).

The company must also recognize that the supervisors are the key to the success of the safety program at the job level. Two effective means of demonstrating this are by holding special safety meetings for supervisors, and by monitoring the safety performance of individual supervisors. By holding separate safety meetings for supervisors, the company can be assured that appropriate information is being communicated to responsible individuals. Monitoring safety performances of individuals communicates to supervisors that safety is important. Of course, it would be expected that supervisors that have outstanding safety performances should be

recognized for their achievements. Otherwise, the monitoring effect would not be expected to affect performance.

Project-Level Safety Programs and Injury Occurrences

At the project level, safety programs would be expected to be more clearly defined and specifically focused. Information was sought to identify those characteristics of project-level safety programs that were associated with better safety performances. The findings are shown in Tables 5 through 7.

As with the company-level safety programs, the results showed that safer performances are noted on those projects having individuals specifically appointed as safety officers (Table 5).

The findings also indicate the favorable influences that job-site safety inspections have on safety performances (Table 6). These are not to be regarded as job visits whereby one occasionally looks for safety infractions. Instead, these are tours of the job whereby the sole function is to inspect the job for safety. This often requires a strong commitment when other aspects of the project demand attention.

Although safety is a topic that must be specifically addressed, it is not to be isolated from other project functions. Results show that projects with better safety records were those that included safety in the regularly held coordination meetings (Table 7).

TABLE 5. Type of Project Safety Officer and Injury Occurrence

Person in charge of project safety (1)	Number (2)	Average injury frequency (3)	Tau-*b* (4)	*p* (5)
Superintendent	11	84		
Project safety officer	3	18		
			−0.53	0.01

TABLE 6. Jobsite Safety Inspection and Injury Occurrence

Does the job supervisor or safety officer make specific jobsite safety tours? (1)	Number (2)	Average injury frequency (3)	Tau-*b* (4)	*p* (5)
Yes	6	40		
No	8	92		
			0.36	0.06

TABLE 7. Safety Inclusion in Coordination Meetings and Injury Occurrence

Is safety included in regularly held coordination meetings? (1)	Number (2)	Average injury frequency (3)	Tau-*b* (4)	*p* (5)
Yes	8	62		
No (or rarely)	4	87		
			0.44	0.04

Project Coordination and Injury Occurrence

Project coordination is perhaps one of the major tasks performed by project managers. Without carefully synchronized work tasks on the projects, confusion will develop between crafts and among subcontractors. A concerted effort is required to avoid the resulting chaos and wasted resources. The degree of coordination provided at the project level and the resultant impact on safety performance was investigated in this study. Tables 8, 9 and 10 show related findings of interest.

The findings suggest that greater sophistication in the means by which projects are scheduled results in fewer job injuries (Table 8). Not only must these schedules exist, but they must also be used (Table 9). In addition, the coordination effort must not be isolated to certain parties. The inclusion of the owner or the owner's representative in coordination meetings has a favorable impact on job safety (Table 10). It would appear that this coordination should also include the subcontractors. This was investigated in this study to some extent. Several subcontractors on each project were asked to rate the general contractor on the ability to provide good coordination on the project. The results of the subcontractor ratings of the general contractors showed that the general contractors who were rated better at coordinating the work had better safety records (Tau-b = −0.32, p = 0.009).

TABLE 8. Type of Schedule and Injury Frequency

Type of schedule (1)	Number (2)	Average injury frequency (3)	Tau-b (4)	p (5)
CPM	6	28		
Bar chart	8	102		
			+0.61	0.005

TABLE 9. Extent of Use of Schedule and Injury Occurrence

Extent of use (1)	Number (2)	Average injury frequency (3)	Tau-b (4)	p (5)
"A lot of use"	7	36		
Little or none	6	120		
			+0.45	0.03

TABLE 10. Type of Coordination Meetings and Injury Occurrence

Owner or architect included in coordination meetings (1)	Number (2)	Average injury frequency (3)	Tau-b (4)	p (5)
Yes	3	25		
No	11	83		
			+0.35	0.07

TABLE 11. Relationship of Budget Status to Injury Frequency

Budget status of project (1)	Number (2)	Average injury frequency (3)	Tau-*b* (4)	*p* (5)
Over budget	4	89		
On or under budget	7	33		
			−0.62	0.01

TABLE 12. Type of Contract and Injury Frequency

Type of contract (1)	Number (2)	Average injury frequency (3)	Tau-*b* (4)	*p* (5)
Negotiated	8	46		
Competitively bid	5	116		
			+0.32	0.09

Economic Pressures and Injury Occurrence

When economic pressures begin to impact a project, project management is often placed in a position of having to decide where to "cut corners." It is often alleged that safety is one of these "expendable" job overhead items that is reduced when conditions get too severe. In addition, managerial focus tends to concentrate on production "at any cost." This was considered in this study, as shown in Tables 11 and 12.

The results indicate that these allegations may, in fact, be true. Safety performance can be expected to suffer when economic pressures are brought to bear, i.e., safety suffers when a project runs over budget (Table 11). A related finding concerned the type of contract award. The contracts that were negotiated were on projects with better safety records (Table 12). This too seems to indicate, although not conclusively, that the bidding or contracting arena may affect safety performance.

Conclusion

On large projects, maintaining good safety performance must be a specific job function. The alienation among workers that often occurs on large projects may increase the chance of worker injuries. To counter this, it is important for safety to be addressed at a variety of managerial levels, beginning with top management.

Of the projects examined, it was noted that injury frequencies were lower on the larger projects, as measured in terms of the estimated or contracted amount. It is not reasonable to suspect that project size, in and of itself, is the fundamental variable influencing safety performance. The larger firms appear, however, to be more successful in implementing those practices and policies which improve project safety performances.

It is interesting that higher injury frequencies were noted on projects that were over budget and on those projects that were competitively bid. These findings indicate that project pressures, such as those imposed by budgetary problems or by the nature of the contract, are related to safety performances. Although this may appear to indicate that budgetary prob-

lems lead to higher injury frequencies, this causal relationship was not conclusively established. Further study in this area is warranted.

The results of this study are similar to the findings of two previous safety studies. The results of this study, however, are different in several respects. First, the results of this study pertain to the safety performances on particular projects. Previous studies have focused on company-wide safety records that represented the collective records of a variety of project types (Levitt and Parker 1976; Hinze and Harrison 1981). Second, the results of this study all pertain to similar types of construction projects, notably large building projects. Although the size of the sample is not large, the results are supportive of the other studies, and indicate that the findings, in general, can be applied to a variety of project settings.

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