# Owner's Role in Construction Safety

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**Abstract:** Despite dramatic improvements in recent decades, the construction industry continues to be one of the industries with the poorest safety records. Recent improvements are due, in part, to the concerted efforts of owners, contractors, subcontractors, and designers. While past safety studies have investigated the roles of contractors, subcontractors, and designers, the owner's impact on construction safety has not been previously investigated. This paper will present the results of a study on the owner's role in construction safety. Data were obtained by conducting interviews on large construction projects. The relationship between project safety performance and the owner's influence was examined, with particular focus on project characteristics, the selection of safe contractors, contractual safety requirements, and the owner's participation in safety management during project execution. By identifying practices of owners that are associated with good project safety performances, guidance is provided on how owners directly impact safety performance.

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## Introduction

Accident data prepared by the Bureau of Labor Statistics ⟨www.bls.gov⟩ show that the construction industry has performed much worse than the average of all industries (see Fig. 1). Although the safety performance of the construction industry has improved dramatically in the 1990s, injury rates in the construction industry are still 50% higher than that of all industries, lagging all industries by about 10 years. With an average employment of approximately 7% of the industrial workforce, the construction industry has regularly accounted for over 1,100 construction worker deaths per year or nearly 20% of all industrial worker fatalities ⟨www.bls.gov⟩. These accidents have also resulted in great economic losses. The research conducted by Everett and Frank (1996) concluded that the total costs of construction accidents accounted for 7.9–15.0% of the total costs of new, nonresidential projects. A more recent, but unpublished, research study by Coble and Hinze (2000) showed that the average workers' compensation insurance costs could be conservatively estimated as constituting 3.5% of the total project costs.

In order to reduce and eventually eliminate construction accidents, researchers have explored techniques implemented by different construction parties to realize the "zero-injury objective." Owners, architectural/engineering firms (designers), contractors, and subcontractors have different roles in preventing accidents to achieve an injury-free worksite (Hinze 1997; Gambatese 1996; Toole 2002). The contractor is undoubtedly the pivotal party to control job-site safety. Practices and approaches taken by contractors to improve project safety have been extensively investigated in past research studies (Levitt and Samelson 1993; Hinze 1997; Hinze 2002). Subcontractor safety as influenced by the general contractor in various sizes of projects was investigated by Hinze and Figone (1988, for small and medium projects), and Hinze and Talley (1988, for large projects). Designers can reduce safety hazards in the working environment by considering worker safety issues in their design decisions. Hinze and Gambatese (1996) gathered various "best practices" for designers to address safety issues in their designs and developed a safety design tool to help designers eliminate hazards when making decisions. The involvement of owners has been regarded as an essential requirement for the zero injuries objective (Hinze and Gambatese 1996). However, no previous study has thoroughly investigated the owner's influence on construction safety.

The owners of projects (also called facility clients or project buyers) are the primary consumers of construction services, the sources of project financing, and, in many cases, the end users of the facilities (Hinze 2001). Their impact on project construction safety is significant. For example, in the research conducted by Liska et al. (1993), it was found that an important prerequisite attributed to excellent safety performance was the involvement of the owner in not only preproject planning, including financially supporting the contractor's safety program, but also in the day-to-day project safety activities. In the construction accident causation model developed by Suraji et al. (2001), construction accidents are caused by inappropriate responses to certain constraints and the environment. In the model, owner (client) responses are the actions, or failure to act, of the owner in response to constraints that emerge during the development of the project scope. These include, for example, reducing the project budget, adding new project criteria, changing project objectives, and ac-

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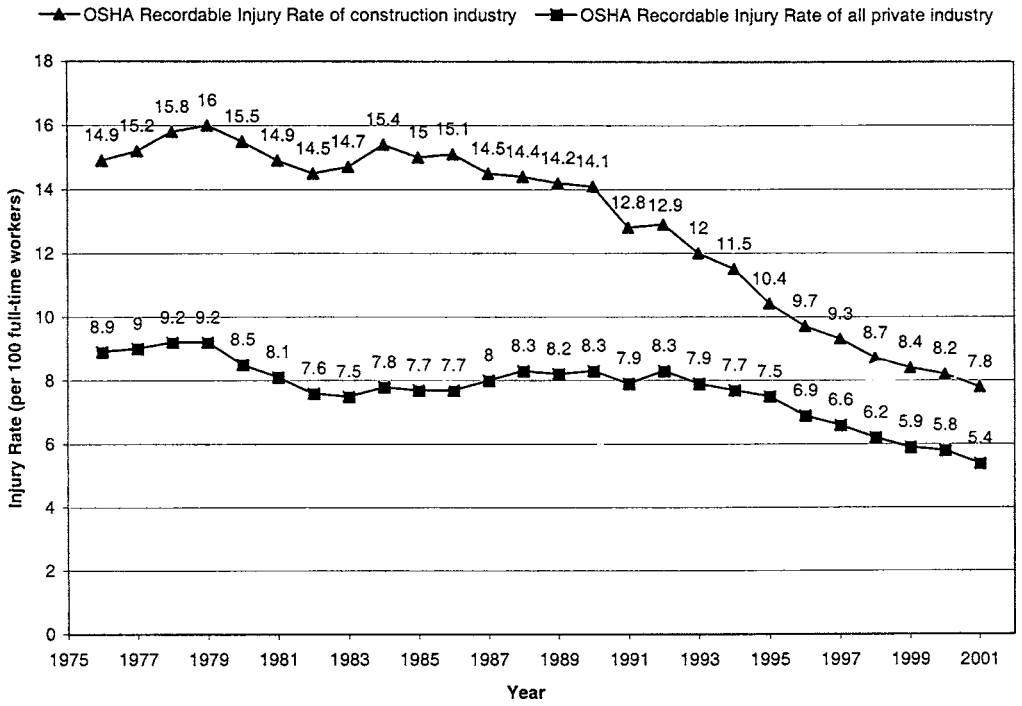


**Fig. 1.** Injury rate of construction and all private industry (data source: ⟨www.bls.gov⟩)

celerating the design or construction efforts of the project. All these elements can play contributing roles in accident causation.

In the past, there was a reluctance of owners to become involved in matters related to construction safety for fear of incurring added liability exposure (Sikes et al. 2000). However, since the 1980s more owners, especially owners with large construction budgets, have voluntarily expanded their role to proactively promote worker safety. A series of studies conducted at the University of Washington in the early 1990s demonstrated that owner's concern for construction safety was increasing (Hinze 1997). The major reasons include the following.

1. The rising costs of health care and workers' compensation are not being ignored by owners (Hinze and Appelgate 1991). Owners realize that the costs of injuries are ultimately reflected in the costs of their construction projects (Gambatese 2000).
2. Litigation involving owners has escalated in the past three decades. For example, in the case of Phillips versus United Engineers & Constructors, Inc., and Plasteel Products Corp., 500 N.E. 2d 1265 (1986), the owner was sued, but was not held responsible, for a worker's fall from a catwalk during steel erection. In another case Rigatti versus Reddy, 723 A.2d 1283 (1999), the owner was similarly cleared of being responsible for a roofer's fall. A different court sentiment appeared in the case of Stark versus Rotterdam Square, 603 N.Y.S.2d 347 (1993), where the owner of a mall was held liable for injuries suffered by a roofer when he fell through a hole cut into the roof. Because of these types of lawsuits, many owners have come to realize that reducing the frequency and severity of construction injuries is the only sure way of reducing their potential liability for worker injuries (Levitt and Samelson 1993).

As a result of these changing attitudes about liability, many owners are taking more active roles in construction safety. The study described here investigated the relationship between project safety performances and the owner's involvement in construction safety.

## Literature Review

Owners can favorably impact construction safety by selecting safe contractors, encouraging designers to address safety issues in the designs, and participating in safety management during construction (Hinze 1997). To the extent possible, the owners, through their project representatives, should participate with the contractors in all project safety activities, including but not limited to new employee orientation, safety meetings, jobsite safety audits and accident investigations, training, incentive programs, and other safety related programs (Gambatese 2000).

One of the earlier studies on the owner's role in construction safety by Levitt et al. (1981) reached the conclusion that construction owners who selected or prequalified contractors based on safety performance, and/or who got involved in construction safety management, had fewer accidents on their projects. In the study conducted for the Business Roundtable (1982), questionnaires were sent to owners and contractors to identify safety requirements owners placed on construction contractors and specific practices of owners that emphasized safety with contractors. The responses that were associated with better safety performances included: Requiring the use of a system of permits before performing potentially hazardous activities, requiring the contractor to designate a responsible supervisor for safety coordination on the job site, providing the contractor with safety guidelines that must be followed, and so on.

In Levitt and Samelson (1993), it was stated that the owners with the safest construction projects tended to use many of the following strategies with their contractors:

- Stress safety as part of the contract during the pre-job walkaround;

- Require short-term permits, rather than ongoing permits, for hazardous activities;
- Conduct safety audits of the contractor during construction;
- Require safety training of all project employees;
- Maintain statistics on the contractor's safety performance;
- Set goals for construction safety;
- Include general safety guidelines in the body of the contract;
- Set up a construction safety department to monitor contractor safety;
- Require immediate reporting of all worker accidents;
- Investigate the contractors' accidents;
- Always include safety on the agenda at owner-contractor meetings;
- Provide contractors with special safety guidelines they must follow;
- Require the contractor to assign safety coordination responsibilities to someone on site; and
- Reimburse the contractor's safety costs in full.

The American Society of Civil Engineers (ASCE) moved to the forefront in the trend to involve owners in safety when it issued ASCE's Policy Statement 350 on construction site safety in 1998. The statement outlines ASCE's view that "improving construction site safety requires attention and commitment from all parties involved." The policy states that safety should be addressed "for each project on a project specific basis," and that owners should "take an active role in project safety." Various ways owners can actively address safety were given in the policy.

- Assigning overall project safety responsibility and authority to a specific organization or individual (or specifically retaining that responsibility) that is qualified in construction safety principles, rules, and practices appropriate for the particular project;
- Including prior safety performance as a criterion for contractor selection;
- Designating an individual or organization to monitor safety performance during construction; and
- Designating in the contract documents those parties responsible for the final approval of shop drawings and details.

An owner, to be actively involved in construction safety, might consider several contractual issues. Many of the issues relate to the safety obligations placed on the contractor. Hinze (1997) suggested that contract provisions may include the following requirements:

- Submittal of a project-specific safety plan;
- Mandatory development of a job hazard analysis;
- Regular safety meetings with supervisory personnel;
- A designated project safety coordinator;
- Mandatory reports on accident investigations, safety inspections, and safety meetings;
- Inclusion of subcontractors in the safety program;
- Compliance with the owner's safety guidelines; and
- Establishment of an effective worker orientation program.

Gambatese (2000) summarized various ways in which owners can actively address safety, including:

- Ensure that safety is addressed in project planning and design;
- Consider safety performance when selecting a constructor;
- Address safety in the construction contract;
- Assign safety responsibility during construction; and
- Participate in project safety during construction.

In summarizing the literature, the owner's involvement in construction can be demonstrated through their selection of safe contractors, arrangement of contractual safety requirements, and proactive participation in safety management during project execution.

## Research Methodology

The purpose of this research was to identify how and to what extent owners influence construction safety performance. It was decided that this type of study could be ideally conducted with input from construction practitioners. This would ensure the relevance of the findings to actual construction settings. Such findings could then be readily interpreted for direct field implementation by others.

This research began with a pilot study consisting of mailed surveys sent to large owner firms that were known to have large construction budgets, as listed in the ENR Top 425 Owners (ENR 2001). The purpose of the pilot study was to establish and refine hypotheses to be tested in the research, based on information related to construction safety at the owner company level.

The primary study consisted of interviews conducted with representatives of owners on selected construction sites. The interview data consisted of more detailed information than was obtained in the mailed pilot study, and therefore constituted the major data collection phase. All of the findings of the research reported here are based on the data collected through the project interviews.

In the project interview stage, a questionnaire was used that was developed on the basis of the literature review, pilot study results, and refined through input from the Construction Industry Institute (CII) Project Team No. 190. (Note that this research was funded by the National Institute for Occupational Safety and Health, but was also authorized as a project by CII.) The questionnaire was finalized after the first three interviews were conducted. The questionnaire was focused on collecting information on the project safety performance, along with information related to four categories.

- The project description;
- The owner's selection of safe contractors;
- The owner's safety requirements in the contract documents; and
- The owner's participation in safety management during project execution.

The questionnaire contained many questions that could be answered by simply checking an appropriate box, e.g., yes or no. The questionnaire was designed to be administered through an interview, but the individual being interviewed would be given a copy of the questionnaire to simplify the process. The researcher conducting the interview would capture all the information.

Two major criteria were established in order for projects to be included in the study, including projects must be under construction or were recently completed (within the past 2 years) and projects must have expended at least 100,000 worker hours.

Members of the CII Project Team No. 190 identified most of the projects. There were approximately twenty project team members, representing both owners and contractors, and they identified projects with which their firms were directly involved or projects with which they had some familiarity. Some other owners and contractors were contacted by the researchers to identify other large construction projects. Often either the owner or the contractor on the project, or both, were CII members; however, CII membership was not a criterion for inclusion in the study. Many owners of projects were not affiliated with CII. Approximately 120 projects were identified. Of these, approximately 100

were contacted to seek their participation in the study. Few of the individuals contacted refused to participate, however, there were difficulties in arranging convenient times to conduct some interviews. A total of 81 interviews were conducted in this research.

Persons interviewed were generally site representatives of the owners, including construction managers, safety managers, and safety coordinators. The face-to-face project interviews generally took 1 1/2–2 1/2 h to conduct. Whenever face-to-face interviews were economically infeasible, the interviewee was asked to fill out the questionnaire and return it to the researchers by fax machine or e-mail. For questionnaires returned this way, a follow-up telephone interview, lasting about 1/2–1 h, was conducted to clarify any questions and to clarify any incomplete or vague responses.

In the data analysis of this study, the total Occupational Safety and Health Administration (OSHA) recordable injury rate (the total number of OSHA recordable injuries occurring for every 200,000 worker hours or the total recordable injury rate, hereinafter referred to as TRIR) was the dependent variable. The rationale of measuring project safety performance with TRIR was demonstrated in Hinze (1997). The TRIR is also a safety measure that is uniformly understood in the construction industry. The practices of owners and characteristics of the projects were the independent variables. In this research, two steps were conducted to analyze the data collected through project interviews.

1. Frequency of use of each safety management technique was summarized to provide a holistic view of the extent of use of safety techniques on construction projects, i.e.; the most common practices of owners to emphasize construction safety were identified.
2. Nonparametric statistical tests (primarily the Mann–Whitney U test and Kruskal–Wallis test) were conducted to compare the median safety performances of projects using certain safety management techniques with those that did not. The techniques with significantly different values of TRIR were identified.

Since the study was an exploratory one, the significance level of hypothesis testing was set as 0.10, instead of 0.05. It means that there was only a 10% probability that the relationship was due to a chance occurrence. Nonetheless, most findings being presented were significant at the 0.05 level.

## The Projects Interviewed

Of all the projects on which interviews were conducted, 59 projects provided the TRIR data and satisfied all the criteria to be included in the data analysis. These 59 projects included 49 U.S. projects, seven projects in Canada, and three international projects with U.S. owners and U.S. contractors. The study included primarily petrochemical and manufacturing facilities with a few civil, residential, and commercial projects. Project size descriptors (as measured in terms of worker hours and in total contracted project cost) and the TRIRs of the 59 projects included in the final analysis are shown in Table 1. Six projects reported having no OSHA recordable injuries (TRIR=0). Although the safety performances and sizes of the projects ranged widely, it is apparent that the safety performances of most projects (median of 1.48) were much better than the construction industry average of about 7.8 for the year 2001 (see Fig. 1). Thus, the projects included in this research generally enjoyed much better success in safety than the construction industry as a whole. This research primarily investigated those owner practices that had a direct impact on influencing the safety performances realized on the projects.

**Table 1.** Safety Performances and Sizes of the Projects Included in the Research

| Statistic | | Total worker hours expended | Total estimated cost of the project[a] ($) | Total recordable injury rate |
|---|---|---|---|---|
| Mean | | 2,426,210 | 379,440,000 | 1.95 |
| Mode | | 200,000 | 15,000,000 | 0 |
| Standard deviation | | 5,155,050 | 861,740,000 | 1.94 |
| Minimum | | 100,000 | 3,500,000 | 0 |
| Maximum | | 26,300,000 | 5,000,000,000 | 9.25 |
| Sum | | 143,146,400 | 21,248,700,000 | 115.11 |
| Percentiles | 25 | 275,000 | 15,250,000 | 0.58 |
| | 50 | 627,000 | 78,350,000 | 1.48 |
| | 75 | 2,284,000 | 306,250,000 | 2.73 |

[a]These data are based on 59 projects, however, only 56 projects provided the project cost information.

Among the 59 projects, 46 reported information on all types of injuries, including lost-time injuries, OSHA recordables, and first-aid injuries. Injuries occurring on these projects were categorized by severity, and the ratio between the different types of injuries was determined, as shown in the injury pyramid in Fig. 2. Heinrich (1959) suggested that the ratio between major injuries, minor injuries, and no-injury accidents was 1:29:300. The pyramid in Fig. 2 could be simplified by reporting the ratio between lost-time, OSHA recordable, and first-aid injuries as being roughly 1:10:300. Note that the information is based on 102,000,000 worker hours of exposure.

## Frequencies of Owner's Practices

Before testing whether different practices of owners made a difference in the safety performances achieved on their projects, the most popular and frequently used safety practices were listed. These practices included:

1. Prime contractor reported injury statistics to the owner (100%), and the types of injuries reported were lost-time injuries (100%), OSHA recordable injuries (100%), environmental issues (91.5%), and near misses (88.1%).
2. The owner's site safety representative was generally an employee of the owner (88.1%) instead of a consultant (11.9%). This person was generally a member of the project management team (91.5%), and had authority to stop unsafe work (94.9%). The job responsibilities of the safety representative generally included:

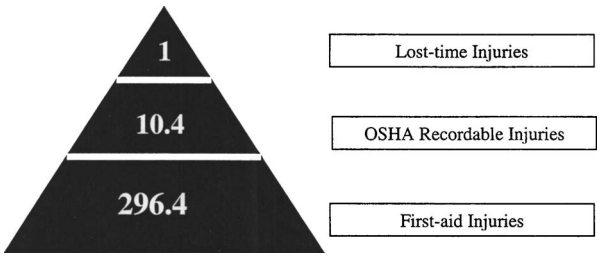


**Fig. 2.** Injury pyramid for the projects

- Monitoring safety management and performance of the contractor on a daily basis (89.8%);
- Enforcing safety rules (89.8%);
- Conducting site safety inspections and audits (89.8%);
- Reviewing safety performance on site and submitting reports to the home office (88.1%);
- Reviewing contractors' safety reports (88.1%); and
- Coordinating safety efforts on site (81.4%).

3. Owner's site safety representative reviewed the safety performance of the contractor on a regular basis (98.3%). They would check the project lost-workday injury rate (94.9%), the project recordable injury rate (94.9%), and the project first-aid injury rate (88.1%).
4. When selecting contractors, safety was generally a consideration of most owners (94.9%). Among the criteria used by owners to evaluate the safety performances of contractors, the overall quality of the safety program was the most frequently mentioned measure (88.1%). The owner's evaluation of contractor safety performance would make a difference between getting the contract or not (88.1%). When contractors had some safety statistics of concern, the contractors could show that they had made major changes in their program and still be considered for contract award (94.9%).
5. Owners included a variety of safety requirements in their contracts, the most frequently used provisions are the following:
   - Contractor must comply with the local, state and federal safety regulations (100%);
   - Contractor must report all lost time injuries to the owner (98.3%);
   - Contractor must report all OSHA recordable injuries to the owner (96.6%);
   - Contractor is required to provide specified PPE (hard hats, safety glasses, and gloves) (96.6%);
   - Contractor must implement a substance abuse program (96.2% of U.S. projects only, as drug testing is not common on Canadian projects);
   - Contractor must conduct weekly safety meetings for the workers (93.2%);
   - Contractor must comply with safety requirements beyond the OSHA regulations (88.1%);
   - Contractor must participate in site safety audits (88.1%);
   - Contractor must implement a permit system when performing hazardous activities (line breaks, lockout/tagout, excavations, proximity to power lines, confined space entry, hot work, etc.) (88.1%); and
   - Contractor must submit a site-specific safety plan (84.7%).
6. Owners impose the same safety requirements on subcontractors and lower tier subcontractors (91.5%).
7. Most owners require specific items to be included in the contractor's safety program (98.3%), and included the subcontractors in the safety program as well (94.9%). The safety program items that were required by most owners included:
   - Substance abuse program (95.83% for U.S. projects only);
   - Regular safety meetings (94.9%);
   - Incident reporting and accident investigations (93.2%);
   - Regular safety inspections (91.5%);
   - Training on the hazards related to the tasks being performed (89.8%);
   - OSHA specific regulations (88.1%);
   - Specific safety training sessions (86.4%); and
   - Preproject safety planning (86.4%).
8. Other safety practices of owners included:
   - Construction safety issues were specifically addressed in the design (98.3%); and
   - Owner required every worker on site to receive orientation training (96.6%).

**Table 2.** Relationship between TRIR and Project Characteristics

| Project characteristic | Response | Counts | Median | Significance level[a] |
|---|---|---|---|---|
| (a) Type of projects | **All others** | 51 | 1.30 | 0.07 |
| | **Shutdown** | 8 | 2.20 | |
| | **Total** | **59** | **1.48** | |
| (b) Type of project owner (excluding shutdown projects) | **Private** | 45 | 1.20 | 0.02 |
| | **Public** | 6 | 2.67 | |
| | **Total** | **51** | **1.30** | |
| (c) Type of projects (excluding shutdown projects) | **Petrochemical** | 25 | 0.84 | <0.01 |
| | **Manufacturing** | 16 | 2.47 | |
| | **Total** | **41** | **1.20** | |
| (d) Type of contract | **Other** | 44 | 1.68 | 0.03 |
| | **Design-build** | 15 | 0.69 | |
| | **Total** | **59** | **1.48** | |
| (e) Worker hours (in thousand hours) | **100–1,000** | 36 | 1.96 | 0.04 |
| | **1,000 up** | 23 | 0.92 | |
| | **Total** | **59** | **1.48** | |
| (f) Number of work shifts | **1 shift** | 37 | 1.17 | <0.01 |
| | **2 or 3 shifts** | 22 | 2.20 | |
| | **Total** | **59** | **1.48** | |
| (g) Number of workdays per week | **4 or 5** | 34 | 1.18 | 0.03 |
| | **6 or 7** | 25 | 2.00 | |
| | **Total** | **59** | **1.48** | |

[a]One-tail level of significance by the Mann–Whitney U test.

## Factors Associated with Safety Performance

Based on the data collected in the project interviews, nonparametric statistical analyses were conducted to establish the strength of the relationships between the TRIR (dependent variable) and project characteristics and owners' practices (independent variables) in four categories:

- Project characteristics;
- The selection of safe contractors;
- The contractual safety requirements; and
- The owner's involvement in safety management.

### *Project Characteristics*

The size of the project, labor arrangements for the project, type of project, and other characteristics were examined to determine if they were related to the project safety performance. These factors were analyzed, and the results are shown in Table 2.

Shutdown projects (defined as upgrade and modification work in operating industrial plants) were found to have poorer safety performances than other types of projects [see Table 2(a)]. The median TRIR of the eight shutdown projects included in this research was higher than the median TRIR of the other projects. Shutdowns are characterized as having tight schedules (typically from a few days to 8 weeks), significant amounts of overtime work, frequently working multiple shifts, and generally having a rapid buildup of the workforce (with many workers new to the

project). When workers and managerial personnel work extended hours for 1 or 2 months, the possibility of human errors increases, and so will the probability of injury causation.

It was suspected that private projects may have an advantage in achieving better safety performances than public projects [see Table 2(b)]. Since many public projects are awarded through the competitive bidding process, public project contracts are frequently awarded to contractors without regard to their ability to deliver a safe project. Private owners may take into account factors other than simply awarding the contract to the lowest bidder. Nevertheless, some public agencies, especially federal agencies, may require the contractor to comply with their own safety requirements, in addition to the OSHA regulations. However, the involvement of the owners in the safety management of public projects was generally viewed as being inadequate, when compared to the extent of owner involvement on private projects.

Safety performances on manufacturing projects were consistently not as good as on petrochemical projects [see Table 2(c)]. Note that residential and commercial projects were not included in this comparison, primarily because only a few such projects were in the entire sample. From the limited data, it appeared as if the residential and commercial projects were not as good as the manufacturing projects in the area of safety. It should be mentioned that owners of many manufacturing projects were aggressive in their efforts to improve project safety performance. Several respondents stated that their emphasis on safety in the manufacturing sector was a relatively recent initiative. Since it takes time to be successful in making significant changes in the safety culture of a company, it may be only a matter of time before additional improvements in safety performance are realized on manufacturing projects. Although their safety performances were not as good as the petrochemical projects, the manufacturing projects in this study were already much better than the construction industry TRIR average of 7.8 ⟨www.bls.gov⟩.

One method of enhancing safety is to conduct a constructability review as part of the design process (Hinze and Wiegand 1992; Hinze and Gambatese 1996; Jergeas and Van der Put 2001). This review helps to coordinate the safety efforts of designers and the work performed on site (Fischer and Tatum 1997). Comparisons were made of the safety performances of design-build projects with projects constructed under other contracting arrangements. Design-build firms, including engineering, procurement, and construction (EPC) firms, have a direct incentive to focus on construction safety during the design phase as it is their own employees who are impacted by their design efforts. In other arrangements, the design team is often considered to be separate from the construction effort and does not address construction safety in the design. Results [see Table 2(d)] show that design-build (EPC) projects had significantly better safety performances than did projects with other forms of contracting arrangements. Although the subject of addressing safety during the design phase was not specifically examined, nearly all owners reported that they addressed construction safety in the design phase.

Despite the complexity involved, safety performances on the large projects were quite good [see Table 2(e)]. This held true for all large projects, including shutdown projects, petrochemical projects, and manufacturing projects. Strong safety performances on large projects have been reported in other construction safety research. In general, the very large and quite small contractors have better safety performances, while medium sized companies have poorer safety performances (Hinze 1997). These results reaffirm that large projects have better than average safety records.

The number of shifts worked and the number of workdays worked per week are often dictated by the owner's schedule requirements. Tight deadlines often mean that shift work or overtime work will be necessitated. On the projects involved in this research, it was found that projects with one shift had significantly better safety performances than those with more than one shift [see Table 2(f)]. Projects with 4-day (primarily those working four-tens) or 5-day workweeks had significantly better safety performances than those working more than 5 days per week [see Table 2(g)]. Note that if the eight shutdown projects are excluded from the analysis, the difference of TRIRs between projects with different shifts was still significant, while the difference of TRIRs between projects with different workweeks was no longer statistically significant. From these results, it is reasonable to suspect that fatigue can contribute to increasing the number of human errors, and that days off for rest and recovery may contribute to injury-free work.

### Selection of Safe Contractors

Selecting a safe contractor for project execution is an important function for the owner to achieve better safety performance. In this research, it was found that most private owners would not consider awarding contracts to contractors with poor safety records. Some owners maintain their own database of the safety performance history of all parties with whom they have contracted, namely contractors, subcontractors, and vendors. From this, they develop and maintain an approved bidder list and only these firms are given the opportunity to submit bids on their projects.

This study examined the selection criteria used by the owners to evaluate each contractor's safety performance. The results of data analysis show that owners placing higher priorities on safety when reviewing the overall performances of contractors reported better safety performances [see Table 3(a)]. The most proactive owners mentioned that during their review procedure, the weight of safety performance should be at least as high (6 or 7 on a scale of 1–7, with 7 as the highest level of emphasis on safety) as the weight given to cost.

Questions were asked about how owners evaluated the past safety performances of contractors. Various measures of safety performance have been identified by Diaz and Cambrera (1997), Garza et al. (1998), and Sawacha et al. (1999). The results of this study show that owners used varying criteria to measure safety performances of the contractors. Consistent with the findings by Hinze et al. (1995), some owners felt that the workers' compensation experience modification ratio (EMR) is a lagging and inaccurate indicator, and no longer relied on it as a safety indicator. Owners using the EMR as a safety indicator did not report notably better safety performances [see Table 3(b)].

In contrast, the TRIR is also a lagging indicator, but safety performances of projects were significantly better when the owners used the TRIR as one of the measurements for evaluating contractors [see Table 3(c)]. Note that public works projects were excluded from this analysis because public owners are often unable to take safety criteria into consideration when they award contracts. Those owners using the TRIR were asked if a TRIR threshold value was established, namely, a value above which safety performance was deemed to be unacceptable. The safety performances of projects with more stringent TRIR requirements (threshold values less than 2) were significantly better than on projects using more lenient threshold values (threshold values greater than 2) or projects where no TRIR limits were established [see Table 3(d)].

**Table 3.** Relationship between TRIR and the Selection of Safe Contractors

| The selection of safe contractors | Response | Counts | Median | Significance level[a] |
|---|---|---|---|---|
| (a) Importance of safety in review of contractor's overall performance | ⩽5 | 24 | 2.13 | 0.05 |
| | ⩾6 | 35 | 1.2 | |
| | **Total** | **59** | **1.48** | |
| (b) Was EMR (experience modification rating) used to evaluate contractor safety performance? | **No** | 11 | 1.54 | 0.23 |
| | **Yes** | 45 | 1.48 | |
| | **Total** | **56** | **1.51** | |
| (c) Was TRIR used to evaluate contractor safety performance? (excluding public works) | **No** | 6 | 2.50 | 0.03 |
| | **Yes** | 44 | 1.32 | |
| | **Total** | **50** | **1.89** | |
| (d) What is the threshold value of TRIR of contractors? (excluding public works) | ⩾2 **or none** | 39 | 1.67 | 0.04 |
| | <2 | 11 | 0.84 | |
| | **Total** | **50** | **1.89** | |
| (e) Are qualifications of safety staff reviewed when evaluating contractors? | **No** | 14 | 2.48 | 0.06 |
| | **Yes** | 42 | 1.32 | |
| | **Total** | **56** | **1.51** | |
| (f) Are qualifications of the project team reviewed when evaluating contractors? | **No** | 18 | 2.48 | <0.01 |
| | **Yes** | 38 | 1.2 | |
| | **Total** | **56** | **1.51** | |

[a]One-tail level of significance by the Mann–Whitney U test.

Qualifications of the contractor's safety personnel and qualifications of the project management team were considered by some owners when selecting contractors. The more proactive owners would review these qualifications by conducting personal interviews with them and also by making site visits to projects where they were assigned at the time. The resultant TRIR was found to be lower on projects where the owners had a practice of considering the qualifications of the contractor's safety personnel and also the qualifications of the project management team [see Table 3(e and f)].

In summary, the most proactive owners no longer rely on the lagging indicators, such as the EMR, to measure safety performance of contractors. Instead, they turn to dynamic measurements of safety performance, which can better portray the safety performance potential and safety management capabilities of contractors. Viable measures, or leading indicators, include an assessment of the contractor's safety program, reviewing the qualifications of the safety personnel, and reviewing the qualifications of the project management team.

### *Contractual Safety Requirements*

The construction contract is the legal document that prescribes the responsibilities of different parties involved in the project (Hinze 2001). In the interviews, questions were asked about how the owners addressed construction safety in their contract documents. Among the seventeen listed safety requirements included in the questionnaire, two were found to be significantly related with project safety performances, namely, "the contractor was required to place at least one full-time safety representative on site", and "the contractor was required to submit the résumés of key safety personnel for the owner's approval" (see Table 4). Three additional requirements (minimum training, site specific safety plan, safety policy of the firm) were found not significantly associated with the project safety performance, but considerable differences existed between the TRIRs (see Fig. 3).

**Table 4.** Relationship between TRIR and Contractual Safety Requirements

| Contractual safety requirements | Response | Counts | Median | Significance level[a] |
|---|---|---|---|---|
| The contractor was required to place at least one full-time safety representative on site | **No** | 10 | 1.87 | 0.08 |
| | **Yes** | 49 | 1.3 | |
| | **Total** | **59** | **1.48** | |
| The contractor was required to submit the résumés of key safety personnel for the owner's approval | **No** | 17 | 2.81 | <0.01 |
| | **Yes** | 42 | 1.2 | |
| | **Total** | **59** | **1.48** | |

[a]One-tail level of significance by the Mann–Whitney U test.

### *Owner's Involvement in Safety Management*

In addition to promoting project safety performance through the careful selection of contractors and the inclusion of carefully selected safety provisions in the contract, owners can be active participants in safety management during project execution. Several questions were asked about specific practices of owners that were expected to favorably influence safety performances of projects. These practices included owner participation in safety recognition programs, monitoring of safety performance, funding safety initiatives, accident reporting, accident investigations, safety training and orientation programs, and so on. Table 5 presents those items included in the project safety programs that were associated with better safety performances.

Owners impose requirements on the contents that contractors

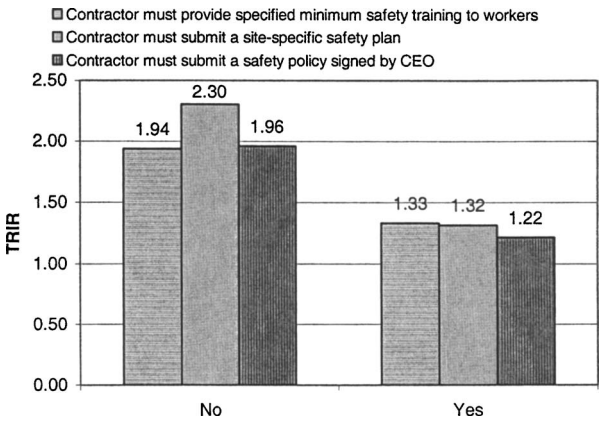


**Fig. 3.** Other contractual safety requirements associated with TRIR (not statistically significant)

**Table 5.** Relationship between TRIR and the Owner's Requirements in Contractor's Project Safety Program

| Owner's requirements in safety program | Response | Counts | Median | Significance level[a] |
|---|---|---|---|---|
| (a) Does the owner require an emergency plan to be included in the contractor's safety program? | **No** | 8 | 2.59 | 0.04 |
| | **Yes** | 49 | 1.22 | |
| | **Total** | **57** | **1.43** | |
| (b) Does the owner require daily JSAs to be included in the contractor's safety program? | **No** | 9 | 2.18 | 0.06 |
| | **Yes** | 48 | 1.21 | |
| | **Total** | **57** | **1.43** | |
| (c) Does the owner require a substance abuse program to be included in the contractor's safety program? | **No** | 4 | 3.25 | 0.02 |
| | **Yes** | 53 | 1.30 | |
| | **Total** | **57** | **1.43** | |

[a]One-tail level of significance by the Mann–Whitney U test

must include in their project safety programs. The inclusion of the following safety program elements was associated with better project safety performances [see Table 5(a–c)]:

- Emergency plans (medical and hazardous materials) implemented;
- Daily job safety analysis (JSAs) conducted on the project site; and
- A substance abuse program must be implemented.

Generally, near misses are defined as unplanned events that could potentially cause human injury or property damage. Although different owners may have different definitions for near misses, many proactive owners require contractors to report near misses to them, and the owners then participate in investigating the near misses. They regard near misses as valuable, but inexpensive, warnings of unsafe trends on site. Table 6(a) shows that better safety performances were achieved on projects where owners' safety representatives monitored near misses. Also, if the number of near misses exceeded the number of OSHA recordable injuries on the project, better safety performances were realized [see Table 6(b)].

Projects where owners tracked the individual safety performances of each contractor on site had significantly better safety performances than projects where this was not done [see Table 6(c)]. Evaluating the safety performance of each contractor can help in selecting safe contractors on future projects and this can also help the owner to identify any weaknesses in the current safety programs being implemented by each contractor. Additionally, it was found that if the owners incorporated the safety statistics of the contractors into their own safety performance statistics, the projects achieved better safety performances [see Table 6(d)]. By including the safety records of the contractors in their own safety statistics, the owners essentially adopt the philosophy that any injuries on the project are a negative reflection on their own safety performances. Ideologically, the owner actually regards the contractor's employees as its own employees, and recognizes the value of protecting and caring for them.

Positive reinforcement is one mechanism by which individuals are encouraged to repeat certain types of behavior. One such approach in the area of safety is to implement a safety recognition program that recognizes and rewards workers who have exhibited good safety behavior. Analysis of the data showed that when the

**Table 6.** Relationship between TRIR and the Owner's Participation in Project Safety Management

| Owner's participation in safety management | Response | Counts | Median | Significance level |
|---|---|---|---|---|
| (a) Does the owner's representative monitor near misses on the project? | **No** | 11 | 2.18 | 0.06[a] |
| | **Yes** | 47 | 1.22 | |
| | **Total** | **58** | **1.46** | |
| (b) Comparison of OSHA recordable injuries and near misses recorded on the project | **More recordables** | 26 | 2.43 | <0.01[a] |
| | **More near misses** | 33 | 0.84 | |
| | **Total** | **59** | **1.48** | |
| (c) Does the owner maintain injury statistics by contractor? | **No** | 26 | 2.13 | 0.03[a] |
| | **Yes** | 33 | 1.19 | |
| | **Total** | **59** | **1.48** | |
| (d) Are the contractor's safety performance statistics included in the owner's safety performance statistics? | **No** | 22 | 1.88 | 0.03[a] |
| | **Yes** | 37 | 1.19 | |
| | **Total** | **59** | **1.48** | |
| (e) Are some funds provided to the contractor, above and beyond the contract amount, to promote project safety? | **No** | 24 | 2.28 | 0.01[a] |
| | **Yes** | 35 | 1.20 | |
| | **Total** | **59** | **1.48** | |
| (f) The owner participates in the safety recognition program | **No** | 12 | 2.92 | <0.01[a] |
| | **Yes** | 44 | 1.15 | |
| | **Total** | **56** | **1.46** | |
| (g) Safety training methods used on the project | **Contractor only** | 11 | 1.69 | 0.06[b] |
| | **Owner only** | 17 | 2.18 | |
| | **Both** | 29 | 0.84 | |
| | **Total** | **57** | **1.48** | |
| (h) Hours of monthly refresher safety training received by the workers | **None** | 11 | 2.73 | 0.07[b] |
| | **1 to 3 hours** | 34 | 1.64 | |
| | ⩾4 hours | 14 | 1.18 | |
| | **Total** | **59** | **1.48** | |
| (i) Is there any means of verifying the comprehension of safety orientation? | **No** | 11 | 2.53 | <0.01[a] |
| | **Yes** | 48 | 1.20 | |
| | **Total** | **59** | **1.48** | |
| (j) The owner participates in safety meetings and toolbox meetings | **No** | 10 | 2.26 | 0.01[a] |
| | **Yes** | 46 | 1.19 | |
| | **Total** | **56** | **1.46** | |
| (k) The owner's representative monitors project safety inspection records on a regular basis | **No** | 11 | 1.69 | 0.01[a] |
| | **Yes** | 47 | 1.20 | |
| | **Total** | **58** | **1.46** | |
| (l) The owner's representative monitors the project near miss rate on a regular basis | **No** | 11 | 2.18 | 0.06[a] |
| | **Yes** | 47 | 1.22 | |
| | **Total** | **58** | **1.46** | |
| (m) Is zero TRIR set as a safety objective by the owner before project commencement? | **No** | 40 | 1.64 | 0.10[a] |
| | **Yes** | 19 | 1.43 | |
| | **Total** | **59** | **1.48** | |

[a]One-tail level of significance by the Mann–Whitney U test.

[b]Two-tail level of significance by the Kruskal–Wallis test.

owner provided some funds above and beyond the contract amount to promote safety, projects were more likely to achieve better safety performances [see Table 6(e)]. When the owner participated in the safety recognition programs, the safety performances were also better [see Table 6(f)]. These results demonstrate the positive influence owners have on project safety performances.

Orientation of workers is essential to provide workers with necessary knowledge for them to work safely. Table 6(g) shows that when both the owner and the contractor were involved in the safety training, projects reported better safety performances. Also, more hours (four or more) of monthly refresher safety training for workers can improve project safety performances [see Table 6(h)]. When the owner had a means to verify the comprehension of the safety orientation training received by workers, the safety performances were significantly better [see Table 6(i)]. Generally, the owner will require a test or exam after the safety orientation session to verify the comprehension of the training.

The owner's site safety representative may have various responsibilities. The study found that if the owner's safety representative participated in the safety meetings and tool-box meetings, the projects achieved better safety performances [see Table 6(j)]. Another consideration relates to how the owner's safety representative monitors project safety performance. Nearly all the owner's representatives monitored project safety performance by monitoring the incident rates on the projects, including the lost workday case injury rate, TRIR, and first aid injury rate. It was noted that monitoring safety inspection records was associated with significantly better safety performances [see Table 6(k)]. Also, when the owner's safety representative monitored the project near miss rate on a regular basis, the projects achieved better safety performances [see Table 6(l)].

Regarding the owner's expectations about safety performance, the results show that owners that established specific safety expectations reported better safety performances on their projects, especially those owners who set zero OSHA recordable injuries as their safety objective before project commencement [see Table 6(m)]. One owner commented "One can achieve the level of safety as he demonstrates to expect."

## Additional Information of Interest

In the study, some open-ended questions were asked. One question asked about the most important way for the owner to improve project safety performance. Although the answers varied considerably, the following points were frequently made.

1. Owner's management commitment: Both site management and home office personnel of the owner should have a clear understanding of the value of safety. Safety is no longer regarded as a priority only, instead, it should be integrated into the owner's values, always being placed first. Management should have a common view that zero injuries can and should be the safety objective.
2. Safety observation program: The philosophy is to address the front end of the accident chain and remind everyone on the project about safety. Techniques can include training and encouraging everyone to report unsafe acts, hazards on site, and near misses. This is followed by tracking the records and intervening when necessary to avoid unsafe acts.
3. Personal accountability: Safety roles and responsibilities of each site person, whether employed by the owner or the contractor, should be clearly defined and closely related to their performance evaluations.
4. Safety communication: Owners should set their expectations on safety from the very beginning and reinforce their emphasis on safety through continual efforts. Safety communication conveys safety experience and knowledge to the contractor. This can be done by discussing safety issues at the beginning of each meeting and by providing support of the safety efforts on site.
5. Implementation of the safety program: The safety program should be carefully developed, evaluated and modified as needed. Once defined, the safety program should be implemented firmly and consistently, and there should be no differences in the implementation for the employees of the owner, contractor or subcontractors.
6. Physical walk out and inspection: Owner personnel should not focus solely on the safety statistics reported by the contractors. They should "walk the talk," and be visible on the site to monitor the contractor's safety performance and show their support of the contractor's safety efforts.
7. Safety/constructability review of the design: Proactive owners start their safety efforts as early as the design phase, and it is an essential part of the total loss control program of many owners.
8. Safety culture: Caring for human life and health, caring for colleagues, and recognizing safe acts should be the philosophy commonly held on the project. The safety culture can be cultivated only through close cooperation of the owner and contractor, based on the values they share on safety.

## Summary and Conclusions

This study was focused on identifying the owner's role in construction safety, which was demonstrated through the project characteristics, the selection of safe contractors, the inclusion of safety requirements in the contract, and the owner's active participation in safety during project execution. Through analysis of the project interview data, it can be concluded that owners can positively influence project safety performances. Several practices of owners that were associated with better safety performances were identified.

Unlike practices in the past, owners of large projects are more actively participating in construction safety management in each stage of project execution, including project design, contractor selection, contract development, and the construction phase. They are making efforts to improve the project safety performance, with a focus on setting their expectations on zero injuries, selecting safe contractors, and developing the safety culture on their projects (through safety training and safety recognition programs, for example). Their efforts have paid off by the lower number of injuries on their projects. This may explain, in part, why the injury rates decreased dramatically in the past decade (see Fig. 1).

The study also found that petrochemical owners are among the most proactive owners in construction safety. This may be due to the traditional concern for safety in the petrochemical industry. Many petrochemical owners stated that the safety attitudes in their major line of business impact their philosophy on construction safety. Safety is necessitated by the considerable hazards existing in the petrochemical industry. These reasons may help explain why the safety performances of petrochemical projects are better than other types of projects. Further analysis of the data are provided in a companion paper.

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