THE USE OF COMPUTER TECHNOLOGY ON THE IMPLEMENTATION AND DEVELOPMENT OF PROJECT-SPECIFIC SAFETY PROGRAMS

By

CASEY R. LEWIS

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN BUILDING CONSTRUCTION

UNIVERSITY OF FLORIDA

2004

Copyright 2004

by

Casey R. Lewis

This document is dedicated to my parents for their continuous encouragement and support.

ACKNOWLEDGMENTS

I would like to thank my parents for their encouragement and support of my educational pursuits. I would like to thank Dr. Jimmie Hinze of the M.E. Rinker Sr. School of Building Construction at the University of Florida for his insight and guidance during my graduate studies. I would like to thank Brent Anderson, MSBC, for his assistance during the completion of this research. Finally, I would like to thank Katie Cantrell for her patience and support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Science in Building Construction

THE USE OF COMPUTER TECHNOLOGY ON THE IMPLEMENTATION AND DEVELOPMENT OF PROJECT-SPECIFIC SAFETY PROGRAMS

By

Casey R. Lewis

August 2004

Chair: Jimmie Hinze
Major Department: Building Construction

In recent decades, the concern for worker safety has been on the rise in the construction industry. The development of project-specific safety plans has become increasingly common among construction firms as an effective tool to address the impacts of injuries and establishing proactive safety policies on their jobsites.

There has also been a rise in the use of computers as a tool for the efficient management of construction projects. The management of safety, however, is not typically addressed through many project management software programs. Currently, software applications available in various formats and stages of development are attempting to address this issue.

In this study, the role of computers for the development and implementation of project-specific safety plans was addressed through a review of literature, an examination of prototype safety management software, and a survey questionnaire of construction professionals. The survey questionnaire and review of current literature were used to

determine general trends among contractors regarding their use of computer technology for developing and implementing job specific safety programs. The following trends and conclusions were identified:

- Management-level personnel such as the project manager or safety director were typically responsible for the development of project safety plans.
- The application and extent of project safety programs within the participating companies vary.
- The use of computers and mobile technology to develop project safety plans is currently performed at a minimal to moderate level.
- Computer technology has had a greater impact on larger companies.
- Computer literacy exists within construction management personnel.
- There is no comprehensive project-specific safety management software application currently utilized for developing and implementing safety plans.
- Most companies are receptive to new software applications for addressing safety on their projects.
- There are good opportunities for the use of safety related software in the construction industry.

CHAPTER 1
INTRODUCTION

Safety in the workplace has become a growing concern for many industries in recent decades, especially the construction industry. Construction workers are exposed to unique risks inherent in the performance of their work that exposes them to many potentially hazardous conditions on the jobsite. As a result, the construction industry has experienced a disproportionate number of injuries and fatalities when compared with most other industries. Construction firms are beginning to realize the human and economic benefits to their organizations when there is an increased and active awareness of workplace safety. “It is appropriate to consider construction work as inherently dangerous if no proactive steps are taken to improve the work conditions and to ensure that the work is undertaken in a safe manner” (Hinze, 1997). Proactive approaches to safety management and hazard awareness can benefit construction companies through decreased costs associated with injuries and the contribution to the overall productivity of projects.

Background

The role of safety management to support other project management tasks is becoming more significant as the costs, schedule, and human impacts of injuries on jobsites impact the overall success of projects. In addition to construction companies, many owners are also making an increased effort to ensure that work performed by contractors on their projects is performed safely. The influences of schedule, cost, and other project related issues can be easily managed through documentation and

management of information and processes. In contrast, impacts associated with safety and injury occurrence can often be difficult to categorize. Because many of the costs and influences resulting from injuries can be indirect or hidden, the difficulty can lie in justifying the expenditure of company resources on safety. In spite of the fact that the construction industry employers, insurers, labor groups, and regulators generally agree that improved safety benefits everyone, the perceived dilemma is how to balance the daily trade-off between true costs of losses due to accidents and health ailments and the costs and inconveniences involved in delivering effective safety programs (Jones, 2000). The incorporation of safety into the management of other project related tasks allows for an increased ability to prevent the occurrence of jobsite injuries.

Technology and Safety

In the construction industry, the management of projects is strongly influenced by costs and schedule. To facilitate management related activities, many construction firms utilize computer technology for documenting, expediting, and communicating project related data. “Computer technology has led to the development of better field management systems, and such systems have enabled construction contractors and managers to monitor field operations more effectively” (Elliot, 2000). The ability of the computer to efficiently process, store, and retrieve information has increased both the amount of data produced and the overall productivity of management tasks on the construction site. The use of computer technology can assist project management to effectively develop and control project-specific safety issues.

The development of a project specific safety plan establishes the safety procedures on a particular project and communicates the company’s commitment to safety. “The project safety program is a comprehensive written accident prevention program covering

all aspects of on-site construction operations and activities associated with a particular contract" (Hinze, 1997). The use of computer technology to develop and implement project specific safety programs facilitates the efficient access to safety related information. In addition, the electronic format of material within the safety management program allows for the integration of safety information with other electronically formatted material such as the construction schedule. The effective management of safety and health on the jobsite can contribute to overall success of the company and individual projects. Computers can assist project staff in planning, organizing and controlling safety within the overall construction process. Promising advances in the field of computer technology continue to develop various programs to perform various job-related tasks with increased efficiency. It addition to the function provided by computer programs, computer literacy of the intended users plays an important role in both the usefulness and effectiveness of the program.

Research Objectives

The objective of this study was to explore the means by which Florida commercial contractors use technology to develop and implement project specific safety plans on their job sites. The use of computer software for the creation and implementation of safety and health objectives on the job site is a relatively new development when compared to other project specific applications available to the construction industry. Increased awareness of the benefits of safety and health related practices within the construction environment have created demands for more comprehensive and ubiquitous tools to effectively manage their application. This study is intended to establish general trends in the use of computers by commercial contractors and to determine the extent to which they are utilized for the management of safety and health on the job site.

CHAPTER 2
LITERATURE REVIEW

Concern for worker safety in the construction industry has gained increasing awareness in recent decades. “Since the 1970’s, the construction industry’s incidence of injuries and illnesses resulting in lost work time typically has exceeded the national rates by a wide margin – usually by more than 60 percent” (U.S Department of Labor, 2003). During the 1990’s a dramatic reduction in injuries and illnesses involving lost work time occurred. “In 1993 the rate gap [of lost worktime incidents per 100 full-time workers] nearly closed between construction and certain other hazardous industries” (U.S Department of Labor, 2003). Although the number of injuries has decreased in recent years, the frequency of injuries remains disproportionately high compared to other industries. “The statistics have remained reasonably constant over the past several years: the construction industry employs approximately 5% of the industrial work force, but has generally accounted for nearly 20% of all industrial worker fatalities” (Hinze, 1997).

Rising premiums for liability insurance and workers’ compensation have impacted construction overhead costs and attracted the interests of both the construction industry and facility owners. “As contractors [are] sought for projects, it [becomes] common to consider only those firms with a demonstrated history of good safety performance” (Hinze, 1997). The increasing awareness of the impact of safety and health of workers to the construction process has contributed to the increased presence of safety management practices as an essential and necessary role in the successful performance and control of

projects. “Today a firm must be effective in terms of cost control, schedule control, financial management, quality control, owner relations, personnel management, and safety management – just to survive” (Eubanks, 1994). “By effectively managing safety and health, dramatic improvements can be accomplished within the construction industry. Project managers can plan, organize and control safety and health objectives on construction sites. Thus safety is proactively integrated along with cost, production, quality, and the schedule of the project” (Kartam, 1995).

Costs of Safety

Beyond the measures taken by the individual construction worker, it is accepted that accident prevention is the responsibility of management (Hinze, 1997). To improve the effectiveness of their safety program, it is important that companies utilize the support and commitment of financial and human resources to guide safety policies, and practices. “Jobsite managers who treat productivity and safety as two related parts of job performance generally have been shown to be the better producers in terms of job cost and schedule. Based on the jobsite managers’ actions, workers on the job know what the real priorities are. Workers will reflect those priorities in their own decisions affecting safety” (Eubanks, 1994). The process of managing the costs associated with construction tasks can contribute to the application of procedures and their subsequent effectiveness when utilized in the management of projects. “Safety must be cost effective. And safety management is cost effective. But, to see that clearly, we must be able to evaluate our cost of accidents in much the same way we evaluate results of our (direct) cost control program” (Eubanks, 1994). “Costs are incurred on a project whenever an accident occurs on a project. Those costs can be quite dramatic when the accident involves an injury” (Hinze, 2000).

Cost of Injuries vs. Investment in Safety

The difficulty in establishing cost information regarding safety lies in accurately accounting for money involved in the prevention of and/or the consequences of injury occurrences. “A distinction must be made between the costs of safety and the costs of injuries” (Hinze, 2000). These costs can be distinguished by the degree of certainty in which they occur. Additionally they can be further quantified by direct or indirect costs as a result of the activity in question. By categorizing the types of costs incurred on a construction project, the relationship between the cost of injuries and the cost of safety can be more easily distinguished and quantified.

> The costs associated with injuries consist of direct and indirect costs of injuries. . . .[T]hese are the costs that are incurred as a consequence or result of the occurrence of accidents in which injuries are sustained. In other words, in the absence of injuries, there are no injury costs. This is a certainty. What is not certain is whether or not there will be an injury. On the other hand, the costs of safety are those which are incurred as a result of an emphasis being placed on safety, whether it be in the form of training, drug testing, safety incentives, staffing for safety, personal protective equipment, safety programs, etc. These are costs that are a certainty for any implementation of some facet of the safety program. (Hinze, 2000)

The relationship of the costs of injuries and the investment in safety is affected by probability of occurrence. “The hypothesis is that injury occurrence (consequently injury cost) will be high when there is a low emphasis on safety and that injury occurrence will be low when the emphasis on safety is high” (Hinze, 2000). This hypothesis suggests that a certain point exists in which the relative cost of injuries and level of effort and emphasis on safety will cross as shown in Figure 2-1.

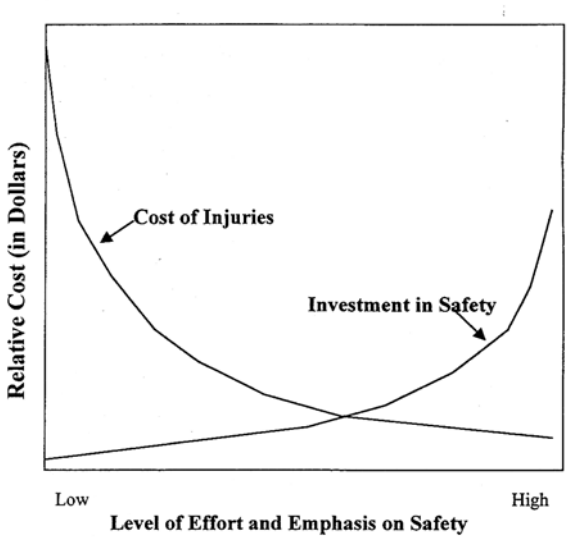

Figure. 2-1. The relationship of the cost of injuries and the investment in safety. (Hinze, 2000)

"From an economic perspective there seems to be an optimal level of emphasis to be placed on safety. From a practical point of view, this level is rarely achieved with the emphasis generally being far below the optimal" (Hinze, 2000). In the comparison shown in Figure 2-1, a certain probability in determining cost and injury occurrence is assumed Actual costs applied to injuries can only take into account those that have occurred or are expected to occur. "The dollars spent on safety cannot be directly measured against the injuries that did *not* occur. [T]remendous or gross approximations will need to be made to estimate the costs of injuries that might have occurred. These are all uncertainties that make it difficult to sell the need to make expenditures on safety on a purely economic basis" (Hinze, 2000).

An alternative method for analyzing the relationship between the cost of injuries and the investment in safety takes into account the probability of future uncertainties by the use of a decision tree as shown in Figure 2-2.

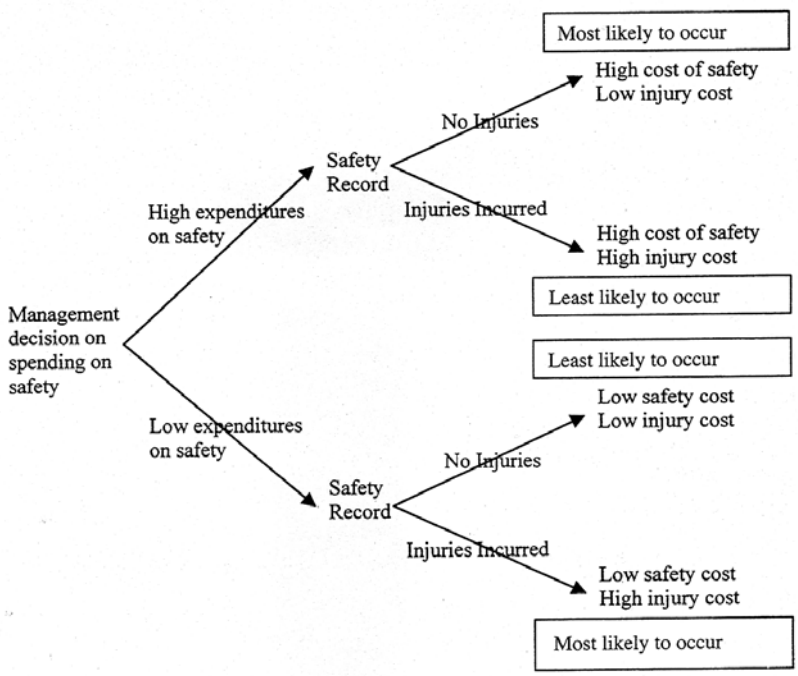

Figure 2-2. Relationship of the emphasis on safety to injury occurrence. (Hinze, 2000)

The diagram (Figure 2-2) incorporates expenditures and safety record to derive four general outcomes; two likely and two unlikely. The decision tree conceptualizes a path that can assist managers and project supervisors in allocating resources for optimal safety performance. "The factor that is most influential when safety emphasis is low is the assumption that no injuries will occur. The reality of the process is quite simple: if safety is emphasized, the occurrence of injuries can be expected to be low and, conversely, if no emphasis is placed on safety, the occurrence of injuries can be expected to be high" (Hinze, 2000).

True Costs of Accidents

Accurate accounting of the costs of safety, injuries, and the effects of injuries on a jobsite is a difficult task for many construction companies. "The quest for objective and accurate costing of accidents in construction continues, and to date it still remains the subject of much debate and research. At the heat of this debate there is however a general

consensus among engineers that measurement remains the backbone of any objective and scientific approach to defining this problem and finding a solution" (Al-Mufti, 1999).

To quantify and track the true costs of injuries, costs are generally divided into two main categories, direct and indirect. "The direct costs are those directly attributed to or associated with injuries. …[D]irect costs tend to be those associated with the treatment of the injury and any unique compensation offered as a result of being injured" (Hinze, 1997). In terms of investing in safety, direct costs include:

- Insurance (workers compensation, premiums, etc.)
- Substance abuse testing
- Staffing for safety (project safety representative, on-site medical aid, etc.)
- Training
- Personal protective equipment
- Safety committees
- Investigations
- Safety Programs
- Safety Incentives (Hinze, 2000)

Indirect costs of injuries are more elusive in identification and quantification. "The indirect costs are all other costs resulting from the injury that are not recovered through insurance coverage. Most of the indirect costs can be categorized as being related to the cost of lost productivity, damaged materials/equipment, and added administrative effort" (Hinze, 2000). Because of their association with other work and delayed or immeasurable impact, indirect costs can be difficult to track within many accounting systems. "Most cost control systems typically mask these as production costs or absorb them as overhead rather than recording them as costs attributable to accidents" (Eubanks, 1994). Indirect or hidden costs include costs and/or productivity impacts of the following:

- Productivity of injured worker
- Worker assisting injured worker

- Crew productivity
- Workers idled by watching
- Damaged materials/equipment
- Productivity of replacement worker
- Supervisory assistance
- Other impacts: OSHA and media. (Hinze, 2000)

Traditionally, indirect costs are calculated as a function of the direct cost of the incident. “Over 50 years ago, the indirect costs of injuries were determined to be four times the magnitude of the direct costs by H.W. Heinrich (1941), an employee of Traveler’s Insurance” (Hinze, 2000). With the escalating expenses associated with healthcare in the United States beginning in the 1980’s, it might be reasonable to expect the 1:4 ratio to be lower now (Hinze 1997).

> In the early 1990’s, the Construction Industry Institute (CII) culminated a study that examined the true costs of injuries. That study examined 834 injuries that were reported by 185 projects, constructed by more than one hundred firms in 34 states. This was a broad based detailed study that determined the indirect costs of medical case injuries were about the same as the direct costs and that the indirect costs of restricted activity/lost workday injuries were approximately twice the magnitude of the direct costs. (Hinze, 2000)

Understanding the costs associated with injuries can help managers promote a stronger emphasis on safety. “If the true costs of injuries were well defined, management would be in a better position to make informed decisions concerning safety. Rather than addressing safety from an altruistic point of view, construction managers should also consider safety from a more purely economic perspective” (Hinze, 1997).

The Safety Program

Purpose of the Safety Program

The development of a program for the management of safety on the jobsite is critical. “The project safety program is a comprehensive written accident prevention program covering all aspects of on-site construction operations and activities associated

with a particular project. . . .All of the strategies and tasks to be performed to achieve safety success on the project will be included in the safety program" (Hinze,1997). The scope, organization, and development of the safety program reflect the commitment of management to safety and the characterization of the safety culture within the company. "[S]afety is not a concept to be thought of as additional to the work itself; safety is to be considered an integral part of the work" (Hinze ,1997). The safety program is a tool that can be utilized in the coordination of project activities to manage the risks associated with the tasks to be performed. "Effective management of worker safety and health protection is a decisive factor in reducing the extent and severity of work-related injuries and illnesses and related costs" (U.S. Department of Labor, 1998).

Development of the Safety Program

The development of the safety program reflects the safety philosophy of the company. A statement of purpose or position developed by management is indicative of the attitude towards safety and assists in guiding the direction and goals to be set forth by the project safety manual. "Once the company managers have established a clear safety philosophy (preferably to minimize injuries), diligent efforts can then be expended to draft an effective safety program. The safety philosophy is very important, as it is at the core of the safety program" (Hinze, 1997).

The scope of the safety plan should encompass all activities that will occur on a particular construction project. General requirements may include company or governmental regulations that are designated for a specific project. "The safety plan for the construction site must be filled in with a set of information of a general nature on the characteristics of the building in context and with a list of minimum safety and health requisites that the Contractor must meet at the moment of organizing the work"

(Gottfried and Trani, 1999). The overall scope and content of the plan is dependent upon the nature, size, complexity, and location of the project being constructed. The scope analysis in many cases will be developed by a safety and health coordinator beginning with the acceptance of the general design of the project and concluding at final acceptance/ completion of construction (Alves Dias, 1996).

The elimination of potential hazards and unsafe conditions begins prior to the start of the construction process. Planned activities to be performed during the construction of the project should be examined and reviewed to ensure that necessary safety precautions have been taken to ensure a safe environment. In many cases the construction schedule may provide a good source for this review and can serve as a starting point for a safety checklist (Hinze, 1997).

In addition to the construction schedule, the continuous involvement and participation of employees and subcontractors is a resource that can assist in developing a comprehensive scope for the project safety plan. This resource provides not only physical content for the plan but can contribute to the communication of the safety philosophy as well. “By involving the employee in the safety process, more commitment is gained from the employee. This additional commitment may be attributable to the employee’s desire to execute something which he or she has developed or assisted in developing” (Harper and Koehn, 1998). Support, commitment and involvement by the various parties involved in the performance of the safety plan is important to its successful application on the jobsite. The establishment of the safety plans is indicative of the safety philosophy communicated on a jobsite. Safety practices on the jobsite should not be considered separate from other tasks performed on the job. Cooperation and coordination of the

safety plan is a mutual obligation of all employees on the job site (Hinze, 1997). Commitment and support of the safety plan to all parties involved on the project can be provided by several different methods. “In an effective program, management regards worker safety and health as a fundamental value of the organization and applies its commitment to safety and health protection with as much vigor as to other organizational goals” (U.S. Department of Labor, 1998).

In implementing a safety and health program, there are various ways to provide commitment and support by management and employees. Some recommended actions are described briefly as follows:

- State clearly a worksite policy on safe and healthful work and working conditions so that all personnel with a responsibility at the site (and personnel at other locations with responsibility for the site) fully understand the priority and importance of safety and health protection in the organization.
- Establish and communicate a clear goal for the safety and health program and define objectives for meeting that goal so that all members of the organization understand the results desired and the measures planned for achieving them.
- Provide visible top management involvement in implementing the program so that all employees understand that management’s commitment is serious.
- Arrange for and encourage employee involvement in the structure and operation of the program and in decisions that affect their safety and health so that they will commit their insight and energy to achieving the safety and health program’s goals and objectives.
- Assign and communicate responsibly for all aspects of the program so that managers, supervisors, and employees in all parts of the organization know what performance is expected of them.
- Provide adequate authority and resources to responsible parties so that assigned responsibilities can be met.
- Hold managers, supervisors and employees accountable for meeting their responsibilities so that essential tasks will be performed.
- Review program operations at least annually to evaluate their success in meeting the goals and objectives, so that deficiencies can be identified and the program and/or the objectives can be revised when they do not meet the goal of effective safety and health protection. (U.S. Department of Labor, 1998)

Safety Plan Content and Organization

The content and organization of the safety plan should be project specific. Because of this, the exact organization and content will vary from project to project based on the nature, size and complexity of the job (Diaz, 1996). “An effective occupational safety and health program will include the following four main elements: management commitment and employee involvement, worksite analysis, hazard prevention and control, and safety and health training” (U.S. Department of Labor, 1998). Within these general guidelines, specific aspects relative to both the project and the safety goals of the company and the program participants can be developed. An example of a safety plan format by Alves Dias (1996) suggests a three-part composition consisting of a plan resume, the project characterization, and hazard prevention measures. Each component in this proposed system contains items that are to be developed by the various project team participants within a particular time frame of the contract/construction process.

Table 2-1. Items to be included in the Safety and Health Plan. (Alves Dias, 1996)

Plan Resume	Project Characterization	Hazard Prevention Measures
Definition of Objectives	General Characteristics	Plans of Action With Regard to Site Conditions
Advance Information	Labor Quantities Table	Site Warning Sign and Traffic Plan
Applicable Regulations	Works Plan	Collective Protection Plan
Functional Organizational Chart	Work Time Chart	Individual Protection Plan
Working Hours	Site Project	Inspection and Safety Plan
Industrial Accident and Other Insurance	List of Especially Hazardous Works	Plan for the Use and Control of Site Equipment
Execution Stages	List of Especially Hazardous Materials	Workers’ Health Plan
Construction Methods		Accident Records and Statistics Plan
		Workers Training and Information Plan
		Visitors Plan
		Emergency Plan

The three phases comprising the above health and safety plan (HSP) are indicative of the phases in which the plan is to be implemented. The plan resume should define the objectives of the safety plan and the extent to which the safety and health plan will be implemented. The resume will additionally specify the general parameters by which the project will operate. During the design/bidding phase of the project, it is intended that the contractors take into consideration their proposed construction methods in relation to the requirements defined by the safety objectives (Alves Dias, 1996).

The project characterization phase of the safety program development process occurs during the contracting stage. “During the tender award phase, the successful contractor should submit all the details required to complete the safety and health plan presented during the previous phase to the Safety and Health Coordinator for his approval within a specified time period. Once these details have been incorporated into the Plan, the site can be set up and the works can commence” (Alves Dias, 1996). This phase of the safety plan development incorporates specific project attributes into the general requirements defined in the plan resume.

The hazard prevention phase of the plan will commence after the project specific details provided by the contractors in the project characterization phase have been approved by the safety coordinator and incorporated into the Plan (Alves Dias, 1996). “During the physical execution of the works and otherwise whenever necessary, the HSP shall be adapted to the actual construction conditions. Alterations to the project should be particularly subjected to prior analysis by the Safety and Health Coordinator in order to foresee any potential hazards associated therewith” (Alves Dias, 1996).

For a safety program to be effective, it must be clear in communicating the intent of the company and be applicable to all company projects and personnel (Hinze, 1997). In addition to the general safety plan developed by the company to define the safety philosophy/ position and other standard safety requirements and regulations, additional project-specific requirements are becoming more prevalent in contract requirements. “Many owners now require contractors to submit project-specific safety programs for approval (to be discussed at the preconstruction conference). Until the project safety program is approved, it is common for such an owner to refuse to process progress payments” (Hinze, 1997). The following items are generally not contained in the generic company safety program and are recommended for inclusion in the project-specific plan:

- Job number
- Job-site safety representative
- OSHA standards applicable to the work
- Description of safety orientation and training for all employees
- Days and times of regular weekly and monthly safety meetings
- First-aid facilities and procedures
- Outline of phases of work, potential hazards, and recommended safety precautions
- Emergency plans
- Written hazard communication program
- Schedule of regular job-site safety inspections
- Requirement of frequent safety inspections
- Procedures for reporting, investigating, and documenting injuries
- Signage for public safety
- MSDS information
- Safety committees
- Warning devices
- Subcontractor compliance (Hinze, 1997)

The project-specific requirement of the safety plan allows for the identification of potential hazards not identified by a generic plan. “Although compliance with the law, including specific OSHA standards, is an important objective, an effective program looks

beyond specific requirements of law to address all hazards. It seeks to prevent injuries and illnesses, whether or not compliance is an issue" (U.S. Department of Labor, 1998).

Job Safety Assessment (JSA)

An important element in the development of the project-specific safety plan is the job hazard analysis (JHA), more recently referred to as the job-site safety assessment or JSA. "To accomplish good safety performance, it is important to examine work procedures before they are used. That is, hazards and dangerous work methods must be anticipated" (Hinze, 1997). The process of identifying unsafe conditions on a job-site through a worksite analysis system such as a JSA identifies potential risks and assists in the success of the project safety plan. "Unawareness of a hazard stemming from failure to examine the worksite is a sign that safety and health policies are ineffective. Effective management actively analyzes the work and worksite to anticipate and prevent harmful occurrences" (U.S. Department of Labor, 1998).

Job safety assessments are typically performed prior to the commencement of construction. "A comprehensive JHA is performed in a team- based environment. It includes an assessment of safety hazards, including occupational health issues, and environmental impacts and aspects, and an assessment of associated risk; it then provides an organized listing of appropriate control measures to mitigate the risk" (Geronsin, 2001). A JSA interchangeably used instead of JHA, can be utilized at any point during the construction process to identify potential hazards associated with a particular task. "It is ideal to conduct job hazard analyses on projects to be constructed. It is possible, often advisable, to conduct subsequent job hazard analyses on a project that is well underway. Projects warranting such attention are those in which work to be performed is of an unusual or untried nature" (Hinze, 1997).

The development of the job safety analysis for a specific project can be derived using several methods depending on the specific nature of the tasks. In some cases, the general nature of the tasks will be apparent. In other cases, the construction schedule can provide a comprehensive resource to begin a JSA (Hinze, 1997). Information gathered from the JSA can be useful in planning activities, and educating and training workers involved in potentially hazardous tasks.

> The outcome of this process can be used to train new or transferred employees or to retain current staff after an inspection. The comprehensive JHA process quickly and efficiently shows workers the hazards present and the effect of control measures. …The team should meet with the affected employees to develop a level of understanding, acceptance, and agreement. Risk assessment should be analyzed and recommended control measures scrutinized until a consensus document is produced. (Geronsin, 2001)

Total Quality Management/ Safety Quality Management

Total Quality Management

"Total Quality Management (TQM) in the construction industry has emerged as the latest and most comprehensive vision of quality management" (Rwelamila and Smallwood, 1994). TQM is being utilized in the construction industry to align management practices with quality standards to reach a common goal. The process is designed to be a cyclical, proactive program for continuous improvement of both product quality and management practices through a central company goal or vision. "Total Quality Management (TQM) is an organization wide philosophy that links product and service quality to customer satisfaction by institutionalizing planned and continuous quality improvement. The purpose of TQM is to provide a common focus for all employees, so that individuals with different tasks, abilities and priorities are able to communicate in pursuit of a common organizational goal" (Cooper and Phillips, 1994).

In analyzing the complete management and quality process model, TQM focuses on the physical structure and organization as well as the attitudes and motivators affecting workers. The establishment of the TQM process within a company or management system involves ‘hard’ and ‘soft’ performance measurements.

> Within TQM, ‘hard’ aspects typically involve a range of production techniques such as statistical process control, Just in –time’ inventory control, changes in the lay out of work stations, design processes and procedures of the organization. These production techniques are generally analyzed by process flow-charting, tally charts, pareto analysis, scatter diagrams, histograms, control charts, and cause and effect analysis. …The ‘soft’ aspects of both TQM and safety management are largely concerned with attitudes, commitment and culture change within an organization. (Cooper and Phillips, 1994)

A central aspect to the successful performance of a TQM system is the development of clearly defined objectives and key performance indicators relative to those goals. In addition to defining objectives, communication and feedback must be provided. Communication and feedback offers immediate indicators of performance and direction in relation to the goals, results, and quality objectives defined during the previous stages of the TQM process (Cooper and Phillips, 1994).

Safety Quality Management

Integrating safety into the management and quality process using the principles defined by TQM can effectively relate management, quality, and safety into related attainable objectives. “Implementing a safety initiative in a company is no different than implementing a quality initiative. They are both aimed at changing the same thing, that is the behavior of people” (Sommerkamp and Lew, 1994). “The fundamental difference between the TQM approach to safety versus the traditional approach is the following. TQM approach is ‘proactive’ as compared to the reactive nature of the traditional approach. In a production setting, it involves solving production problems upstream

rather than inspecting for defects downstream" (Adrian, et al, 1994). To incorporate a safety quality management (SQM) policy effectively, regulatory-based compliance programs form the building blocks but a comprehensive safety process allows companies to better assess areas that require more attention (Geronsin, 2001). "Regulations are structured to control material, activities, and equipment that have, in the past, caused or been suspected to cause injuries. The key element of this statement is 'in the past.' Few companies will succeed by focusing efforts on what has already occurred" (Geronsin, 2001).

In a study conducted by the European Construction Institute, driving factors were identified from contractors as affecting the development of their safety programs. The derived list was as follows (in descending order of significance).

- Changes in Safety Legislation
- Total Project Management concepts
- Pressure from clients
- Better information available
- Increased insurance premiums
- Pressure from employees
- Pressure from employee Trade unions or Employee Organizations
- Pressure from the general public (Ayoade and Gibb, 1996).

Ayoade and Gibb describe a basic model for the integration of safety management into the quality management system. The quality, safety, and environment system (QS&E) is an SQM model that illustrates the integration of key processes within project management. The single integrated QS&E model promotes effective management by more closely representing the way companies do business, reducing administrative tasks, and promoting coordination (Ayoade and Gibb, 1996).

Within this particular SQM model, factors such as costs, legislation, total project management (TPM), and clients can promote integration. Perceived incompatibility of

standards, efforts aimed at pleasing pressure groups, project-specific requirements, and lack of commitment or understanding are potential influences inhibiting the integration of the QS&E system. These relationships of the QS&E model are illustrated in Figure 2-3.

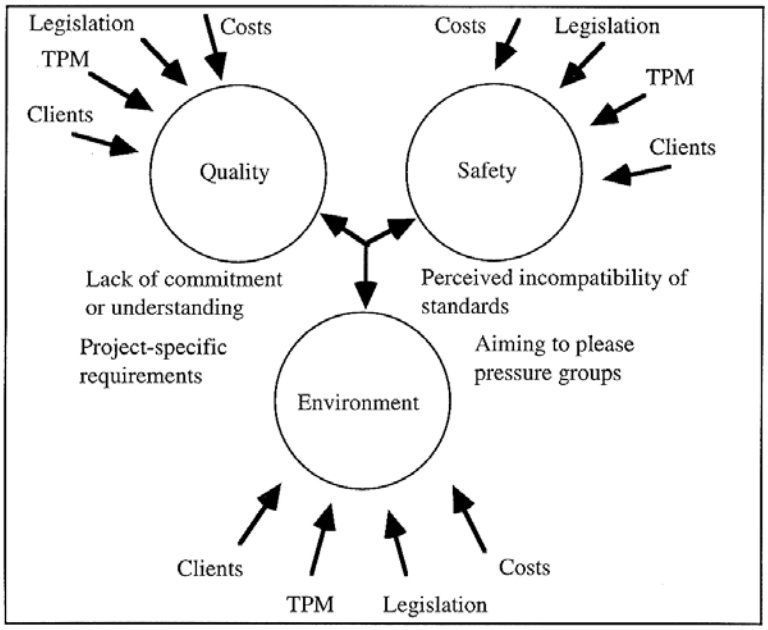

Figure 2-3. Competing pressures causing change in the integration of QS&E systems. (Ayoade and Gibb, 1996)

This model illustrates the impacts of an integrated safety management system and some of the impacts affecting its application. Ayoade and Gibb note that the ideal QS&E model facilitates a balance of the influences illustrated in Figure 2-3. Increased integration within the QS&E system is clearly beneficial. Total integration is both impossible and undesirable (Ayoade and Gibb, 1996).

Avoiding potential pitfalls associated with addressing safety, quality, and performance within the context of the SQM system involves understanding the system and its function in accomplishing the objectives defined by management. Cooper and Phillips (1994) identified five common failures of SQM systems resulting from both individual and cumulative factors.

- A failure to appreciate the time scale involved
- Not recognizing the full implications of TQM and the impact upon the business as a whole
- Lack of senior management commitment to the quality process
- Resistance to change, which may be overt or covert in nature, at both the individual and organizational level
- Uncertainty about how to implement a quality improvement programme (Cooper and Phillips, 1994)

Addressing safety management from a TQM perspective encourages the incorporation of safety, management, and quality within the defined performance objectives of the company. “The integration of safety dimensions with quality management systems can empower the capabilities of TQM and help enhance the performance with regard to safety concerns, and strengthen safe operation practices in an organization” (Pun and Hui, 2002).

“ In construction companies safety management can be included in the sphere of quality management, if a TQM approach is adopted, comprising requirements from all the relevant stakeholders, not only the customers. Specific project requirements, as well as regulatory impositions, may in some cases preclude the realisation of the full potential of such integration” (Alves Dias and Curado, 1996). “Within the context of TQM, in the long run, there is a necessity for the introduction of both quality systems and a quality culture to facilitate the quality process” (Cooper and Phillips, 1994). An effective system should balance the requirements of both the internal and external project clients by approaching the implementation of the SQM program in a systematic manner. These requirements include the following:

- Set project mission

- Develop project plans to meet clients requirements
- Carry out an analysis of the objectives of the project
- Define initial strategies to introduce TQM
- Carry out training and education (when necessary). (Rwelamila and Smallwood, 1994)

"A formal organization structure, clearly defined responsibility and authorization, effective communication, people training, education, involvement and job satisfaction all contribute to the success of SQM implementation" (Pun and Hui, 2002).

Technology and Safety

The increased role of computers and computer-based technologies has greatly impacted the construction industry. "Starting in the 1970's, computer scientists have learned to program computers with experts' knowledge to match patterns and draw inferences for diagnosis, planning, and other 'intelligent tasks.' This 'expert system' technology which is already widely used in the financial sector (e.g., for approving charge card expenditures or loan requests) is now finding its way into engineering and construction management applications" (Levitt and Samelson, 1993).

The influence of increased use of technology in the construction field is becoming increasingly evident at even the field level of the building process. In a study by Elliot (2000), on-site trade foremen were surveyed to determine their usage of technology in the scheduling communication process. It was determined that the majority (84%) of the foremen did not use a computer to perform any part of their job tasks. However, it was found that general attitudes towards computers were positive. "The computer literacy rate of the foremen in this study is higher than initially expected. …Computer use on the job (16%) is also higher than expected for foremen. Experience with computerized devices is

common as well; about one-third use some type of electronic organizer, typically for phone numbers and addresses" (Elliot, 2000).

Training

Project specific training and new worker orientation is good practice and in some cases required for the communication of safety and hazard awareness on a jobsite. "Training is an essential component of an effective safety and health program. Training helps identify the safety and health responsibilities of both management and employees at the site. Training is often most effective when incorporated into other education or performance requirements and job practices" (U.S. DEPARTMENT OF LABOR, 1998).

To increase its impact on safety performance, training should be specific to the project or task and be cost effective. Technology currently available in the construction field can be utilized to create and implement custom training modules and bring safety management to a new level (Coble and Elliot, 2000). The use of computer technology can assist management to increase hazard awareness and improve safety planning among both staff and workers. Additionally, computers can assist by facilitating access, expediting, and organizing extensive amounts of safety related information.

> To improve safety management, a more proactive approach that integrates safety with other project management functions is needed. Such approach would involve more people in the safety management process, would ensure timely availability of safety information and would utilize safety knowledge in design and in the selection of construction methods. For this proactive approach to be effective, computer-based systems that effectively manage safety information are needed. (Elzarka, Minkarah, and Pulikal, 1999)

"Employee training programs should be designed to ensure that all employees understand and are aware of the hazards to which they may be exposed and the proper methods for avoiding such hazards" (U.S. Department of Labor, 1998). The use of computers and technology can be utilized in a variety of ways to assist management in

efficiently communicating safety hazards and best practices to employees. “Multimedia courseware authoring technologies being developed…will allow employers to easily assemble diagrams, pictures, sound, video clips, and interactive computer programs into multimedia training modules…appropriate for use in construction safety orientation and training” (Levitt and Samelson, 1993).

Identification and Documentation of Hazards

“Hazard exposure may occur at the beginning, middle, or end of a job. It is imperative to have training in place before exposure occurs. Well before exposure, management must prepare a plan to deal with the exposure” (Coble and Elliot, 2000). “Some hazards will be readily apparent from an understanding of the general nature of the projects to be undertaken. Others may be identified only after consideration has been given to the specific methods to be employed in accomplishing the work. A schedule of activities that accurately reflects the activities to be undertaken can serve as a good resource for this analysis” (Hinze, 1997). Once potential hazards have been identified, project specific worker training can be implemented.

“Common safety concerns are applicable to many tasks. Training, hazard recognition, and personal protective equipment, for example, would be appropriate safety concerns for many activities. In order to be useful for field supervisors, however, information must be provided that is specific for individual work tasks” (Coble and Elliot, 2000).

Computer technology can be utilized to assist in identifying hazards and safety concerns. Several prototype programs have been developed to accomplish this task using various means of obtaining and organizing safety-related information. One such prototype is a set of integrated programs known as Safety Base and Safety Net. The

purpose of this specific software application is to create a “knowledge-intensive database system that can be used as a stand alone system or in conjunction with current CPM programs by construction mangers, superintendents, and foremen” (Kartam, 1995). Safety Base and Safety Net uses computer technology to expedite the processes for accessing safety related information and applying that information to specific tasks occurring on a particular project. “The goal is to have a dynamic, proactive, interactive tool for identifying safety requirements according to OSHA, ANSI, ACI, etc. and safety recommendations according to safe work practices during the early planning phase as well as the construction phase of a project” (Kartam, 1995).

An important aspect in the development of Safety Base and Safety Net is the ability to transfer and integrate information with other software applications. This relates not only to the technical aspect of compatibility in the programming language, but also the type, categorization, and format of the information to be integrated. “The use of a common coding system improves consistency and information flow between Safety Base and other computer-based construction systems allowing for better integration of organizational efforts. With such standard coding system, basic computer operations such as information storage and retrieval are much more efficient” (Kartam, 1995).

SuperBase is a safety-oriented database program designed to organize and access large amounts of information. The user interface is important in both inputing and retrieving information. The technical or information aspect of the program is designed such that information within the system coordinates with data fields common to other construction related programs for easier integration with common database information.

Knowledge that has been represented by CSI classification is implemented into the system using the SuperBase database system running on IBM-PC or compatible

> computers. SuperBase allows alternative means of accessing information as well as a potential for integration with other computer-based construction systems. Also, SuperBase can be linked to scheduling software such as Primavera and MS- Project making it possible for automatic transferring of safety information to project specific activities in a CPM schedule based on the MASTERFORMAT coding system [CSI divisions 1-16]. (Kartam, 1995).

The visual user interface is developed to easily obtain both general and specific data from the user based on the required output desired. Input of required information is obtained through user-friendly pop-up menu selections. “Although menu selection has greater flexibility in the base program the proper use of data selection allows for structuring the program to be downloaded into the CPM system” (Kartam, 1995). The ability to link safety database information to CPM project schedules allows for the identification of relevant safety information to identified hazards within the schedule. This application utilizes computer technology to more efficiently manage specific safety requirements. “Project mangers can use the system to identify and delegate appropriate safety performance standards during project execution. The system can also help identifying unanticipated requirements when conditions and/or methods change” (Kartam, 1995). This researchers review of the SafetyBase and Safety Net prototype revealed that while the aims and objectives were quite progressive, the actual development of the software was never completed. Thus, this software was never implemented or tested on an actual project site.

Another method for identifying and addressing safety issues on a jobsite is through the use of checklists. Checklists can be used to provide basic guidance on identified safety concerns during a job hazard analysis. “The benefits gained from utilizing checklists to perform jobsite safety inspections have led to an increase in their use. Users of checklists have begun to examine both the content of the checklists and their

implementation" (Gambatese and Hinze, 1996). The development of safety checklists during the assembly of the job specific safety program can be helpful in assisting project management or safety personnel in both safety planning and safety inspections. "The checklists should be customized for the types of projects typically undertaken by a firm. Some of the checklists may be sufficiently generic to need little or no modification from one project to another: For example, the checklist for sanitation and the checklist for personal protective and lifesaving equipment may have such general utility. Other checklists may vary considerably between projects" (Hinze, 1997). Use of both applicable generic and customized checklists in a consistent format additionally provide documentation for addressing and responding to safety concerns.

> Preprinted checklists can simplify record keeping. They may also help ensure that a predetermined set of jobsite conditions are examined in each inspection. If the same type of report is used consistently over a period of time, a baseline measure can be established. From that, management can quickly ascertain whether the safety conditions on a project are below par for the firm's projects. (Hinze, 1997)

The development of safety checklists can play a beneficial role for project management and safety personnel in identifying, implementing, and documenting project-specific elements of safety programs.

Computer technology can additionally assist project management in the application of checklists to address safety issues within the scope of project tasks and requirements. Specifically, checklists can be useful as a guide in the completion of weekly or monthly safety inspections performed by project management or an appointed safety committee. Jobsite safety committees are usually comprised of workers from various trades on the project. "The objective of the safety committee is to serve as a second pair of eyes for management in identifying areas of safety that warrant attention" (Hinze, 1997). The committee members offer a valuable perspective in addressing hazards yet may have

inconsistent levels of formal training in safety. “Safety inspectors and committees using generic checklists can have difficulty in efficiently performing a thorough safety inspection. Perhaps one way to alleviate these problems is to create a tool which produces project-specific safety checklists applicable to the work at hand” (Gambatese and Hinze, 1996). To assist in communicating task specific safety issues and increasing awareness of hazard identification, a computer program called Construction Inspection Guide has been developed.

The Construction Safety Guide “incorporates OSHA’s safety and health regulations for the Construction Industry into a format designed for performing customized job site safety inspections” (Coble and Elliot, 2000). The program takes advantage of the computers ability to store, access, and retrieve large amounts of information and present this information in an organized format easily navigated by the user. Safety related regulations and guidelines are divided into four main categories: general requirements, work phases, temporary structures, and construction materials. Within each category group, information is further subdivided into a more focused group of activities. When selecting a topic from this list, specific checklist titles are displayed in the view window (Figure 2-4).

Figure 2-4 illustrates the selection process to locate a checklist for requirements for cast in place concrete. The user first selects construction materials. The construction materials category contains a more focused group of activities including concrete, masonry, steel, wood, and toxic and hazardous substances. Upon selection of concrete from the list, a series of checklist topics are displayed relating to the use of concrete.

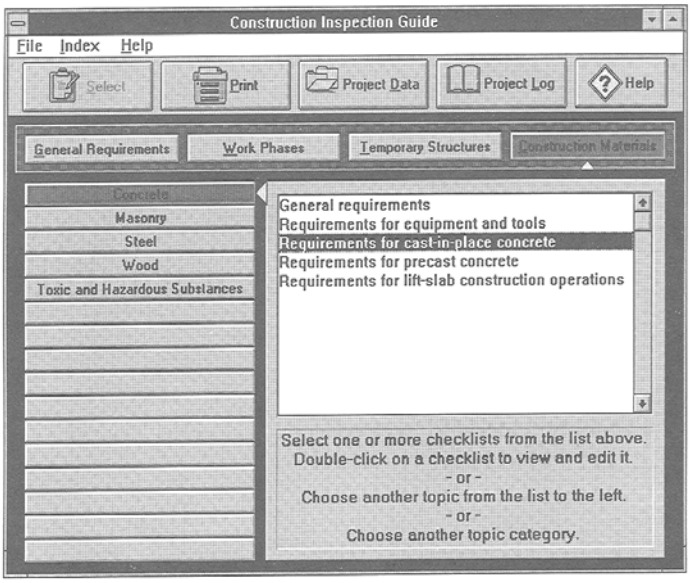

Figure 2-4. Construction inspection guide: concrete checklist. (Gambatese and Hinze, 1996)

The ability of the program to efficiently direct users to specific safety-related information can be an invaluable tool for the identification of potential hazards on the jobsite. “The ability to focus on various project characteristics and to create project specific checklists provides a powerful tool in addressing safety hazards. The checklists provide safety inspectors and committees with a valuable resource in a concise, easy-to-read format which allows safety inspections to be conducted in a reliable, efficient manner” (Gambatese and Hinze, 1996).

A prototype program containing similarities to Safety Base, Safety Net, and Construction Inspection Guide is a program currently in development and funded by NIOSH through The Center To Protect Workers’ Rights. Salus CPM, like Safety Base and Safety Net integrates safety with the construction project schedule. Utilizing a database of safety-based information, an integrator plug-in is used to insert safety checklists directly into the project schedule and link checklists to specified tasks. The

result is a project schedule that incorporates specific links to task-specific checklists within the environment of the scheduling software. The integration of these checklists into the project assists project management in addressing safety guidelines and requirements for the development of a project-specific safety plan. If safety items are associated with scheduled activities, it is more likely that the activity will be performed without injuries (Nelson and Hinze, 2001).

Salus CPM is comprised of two parts: a database and a safety integrator. The database program organizes information obtained from safety experts and construction firms into a list of guidelines. For ease in application and accessibility, these guidelines are organized into a series of checklists related to a certain type of construction activity (Nelson and Hinze, 2001).

The safety integrator is set up as a plug-in to existing scheduling software platforms such as Primavera SureTrak (to include P3 and Microsoft Project in further development). The integrator utilizes a floating toolbar to the SureTrak menu that allows the user to add safety checklists to the construction schedule or view checklists that have already been added (Nelson and Hinze, 2001). Checklists added using the safety integrator are shown as a line item beneath the relevant schedule activity in the activity description column. The visual notation of an added safety checklist within the schedule bar chart is an orange diamond. A relationship arrow connected to the start of the linked activity to the orange diamond indicates that the checklist is to precede the start of the activity (Figure 2-5).

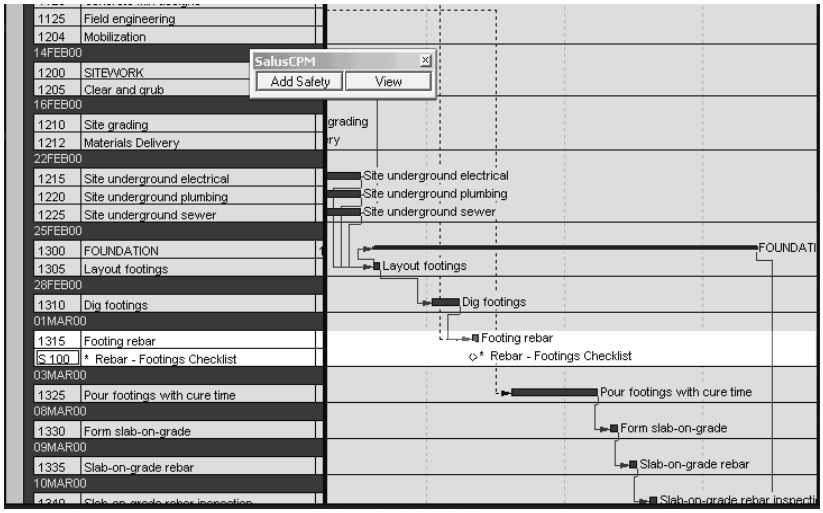

Figure 2-5. Safety checklist linked to SureTrak schedule. (Nelson and Hinze, 2001)

After being successfully linked to the schedule, it is then possible to view and print the safety checklist from the Salus CPM viewer located in the floating toolbox.

Because the project schedule lists the sequential tasks to be performed to complete a project, it drives and influences the management decisions regarding construction activities (Nelson and Hinze, 2001). The construction schedule specifically addresses the tasks to be performed during the construction process. “Research results show striking evidence that project coordination and safety performance are closely related. …This coordination applies to schedules related to the overall project duration and also to the short interval schedules which typically focus on a two or three week period” (Hinze, 1994). Using the construction schedule to link safety checklists and guidelines can help project management to anticipate safety problems and play a central role in developing a site-specific safety plan (Nelson and Hinze, 2001).

Communication of Safety

One of the many advantages of computer-based training modules is the ability to communicate a wide variety of information in an interactive, accessible, and visually

comprehensive format. A prototype program, HAZCOM Interactive, has been developed as a tool to interactively communicate safety-related information and training modules based on an electronic hazardous chemical database. The database was developed from information contained in the International Chemical Safety Card (ICSC) to assist in the communication and training of the hazard communication standard (HCS) (Jones, 2000).

Project-specific safety hazard communication can be a difficult to communicate on a construction site because of the amount of information required, literacy issues, and language barriers present within much of the workforce.

> Construction foremen have different needs than management. In addition, construction foremen usually have different education levels than management. Obviously this requires training software to be needs sensitive. As a result, software may need to be designed for some semiliterate or illiterate users. In addition, it must be enjoyable. (Coble and Elliot, 2000)

To simplify the communication of chemical hazard information, the program utilizes various media formats linked through a visual user interface. “The interface was designed to quickly and easily communicate ICSC information in a way that addresses the language and literacy requirements of its users (specifically through a combination of graphics, multi-language audio and multi-language text). It is a simple point and click interface with a variety of supplemental navigational features” (Jones, 2000). The user interface system uses pictographs to link both supplemental information and hazard training modules in various formats (Figure 2-6). As illustrated in figure 2-6, links to subsequent information is linked through standard universal symbols representative of the linked data. Because HAZCOM Interactive relies heavily on graphics as a source of information and as a link between the database and targeted training modules, the meanings of the symbols is an important aspect of communication and navigation (Jones,

2000). Games are also utilized within the software to reinforce graphic symbols and presented information.

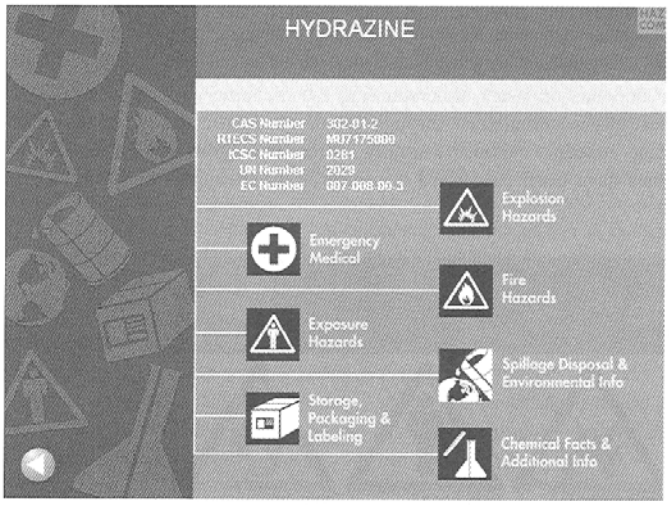

Figure 2-6. HAZCOM Interactive: Screen for accessing information on Hydrazine. (Jones, 2000)

HAZCOM Interactive utilizes a database of chemical safety information that can be used interactively for information or to assist in worker training. The program utilizes the ability of the computer to store, access and present large amounts of information in various formats to assist in the communication of safety hazards associated with chemical hazards.

> The system's navigational schemes are intended to allow users to find specific information quickly (and in a non-linear fashion). The use of graphics and audio files is targeted to expanding access to semi-literate users. The print-on-demand capabilities are intended to expand the impact into the physical workplace. The system also creates a broad foundation on which training programs can be developed in an environment where a critical mass of information can be found. (Jones, 2000)

The use of a database program to store and access information creates advantages for field personnel. "By conceptually recreating Hazard Communications Standard (HCS) programs as integrated electronic databases of information for use on field office PC's,

many of the inconveniences and inefficiencies of the current system could be greatly reduced. In addition to compact storage, an electronic database makes loading and retrieving specific information easier” (Jones, 2000).

CHAPTER 3
RESEARCH METHODOLOGY

Introduction

The purpose of this research study was to identify general trends within the construction industry concerning the use of technology and technology-based applications in the development and implementation of project-specific safety plans. Software and computer-based applications for project management, scheduling, cost control and analysis have been available in some form and to various degrees of implementation for many years. The application and functionality of their use have become more complex as the development, use, and reliance of technology in the construction environment has increased. Computer-based applications directed specifically towards the creation and performance of job specific safety programs is a relatively new concept. Some prototype applications have been developed, however research on their application within the contracting environment has not been extensively conducted. This study was designed to obtain information from general contractors and construction managers of various sizes within the commercial construction market.

Geographic Focus of Research

Florida contains a wide variety of commercial contractors in regards to market specialty, size, and management practices. To research general trends regarding the use of technology-based safety applications, the geographical focus of the study was limited to commercial contractors operating within the state of Florida.

Questionnaire Development

To obtain information from Florida contractors, a questionnaire was developed to determine the current uses of technology and the use of computer-based applications in developing and implementing project-specific safety programs. Because of the varying degrees of familiarity and exposure of construction personnel to technology-based applications and their use within the construction environment, a survey was developed to be applicable to all respondents regardless of their knowledge of computer programs. The questionnaire was designed to obtain information from knowledgeable respondents by allowing for expanded comments and feedback. Some of the questions were open ended to allow the respondents to elaborate in their answers regardless of their experiences concerning the use of technology. The survey was set up in two parts; the development of project specific safety plans within the respondent's company and personal preferences in computer related technology applications. Respondents were also presented with a self-running demonstration of Salus CPM as a precursor to the questions included in the second part of the survey. The demonstration CD-ROM was provided to serve as a specific example of a particular application of technology for the development of project-specific safety programs. The demonstration was not intended as a wholistic solution to integrating technology into safety management, but rather as an example of one approach to the subject addressed in this research. The format of the questionnaire was designed to allow respondents to provide information concerning project-specific safety plans within their company and personal experiences regarding the use of computer technology for the performance of their work.

The questionnaire was developed by the researcher following a thorough literature study to gain a base of knowledge concerning issues relating to technology and the

development of project-specific safety plans. A pilot study was performed through an initial questionnaire developed and presented to several practitioners in the form of an interview and software demonstration on a laptop computer. Based on the comments from three individuals, a revised questionnaire format was developed to eliminate ambiguities and to better focus the overall scope. The content and format of the survey was modified during subsequent revisions to facilitate a postal questionnaire. The revised and final format of the questionnaire contained both qualitative and quantitative questions divided into two parts. Additionally, a self-running software demonstration was included with the questionnaire. The respondents were instructed to view the demonstration CD prior to answering the questions in part two. The questionnaire contained twenty-six questions. Sixteen of the questions were open-ended (short answer), five that asked for a yes or no response, and five solicited a multiple choice reply.

Identifying Research Participants

The focus of this study was to collect information on the use of technology in the development and implementation of safety programs within the commercial construction environment. The questionnaire asked for information related to the procedures and tools involved with developing job-specific safety programs. It is most likely that knowledge regarding the development and application of job-specific safety plans would be more thorough at the management level. The respondents were therefore intended to be at a management level with experience relating to jobsite safety practices within the company. The researcher intended to develop a sample that was both diverse and broad. Because of their responsibility for the overall safety techniques to be implemented for the entire project, research was limited to commercial general contractors. The contacts for the questionnaire were generated from the directory of the Florida members of the

Associated Builders and Contractors filtered for general contractors. Potential questionnaire respondents were chosen by selecting every fourth company from the list.

It was assumed by the researcher that the respondents were familiar in varying degrees with both computer-based technology and project specific safety planning. Additionally, it was assumed that the respondents were familiar with safety planning within their company and able to respond to the questions with regard to the applications within their company.

Questionnaire Distribution

The distribution of the questionnaire was conducted by mailing or hand-delivering 105 questionnaires and CD ROM's to project managers, superintendents, and safety personnel from the companies identified during the selection process. The questionnaire included a cover letter explaining the background of the study as well as instructions regarding the completion of the survey and the start-up procedure of the CD ROM demonstration. Additionally, the objectives of the research were noted and respondents were instructed to only respond to questions they felt comfortable in answering. Respondents were instructed to return the questionnaire to the researcher via facsimile or mail.

Sample Size

The desired sample size was determined to be a minimum of ten respondents. Ten companies completed and returned the questionnaire. The response rate for this study was determined to be 9.5%. The intent of this study was to obtain general trends of companies in the use of technology and its implications for the use and development of project specific safety plans, i.e., insights as opposed to statistical rigor were sought in this

research. Individual detailed responses to the questions were deemed to be indicative of possible broad trends within the industry.

Data Analysis

The data collected from the survey questionnaire were analyzed with emphasis on the role of computer technology for the development and implementation of job specific safety programs within the participants' companies. The data were examined to determine general trends in the use of computer-based safety functions among Florida commercial contractors and the preferences of individual respondents towards software applications. Questions that solicited multiple choice and yes-no responses were organized to summarize the information provided. Open-ended responses were examined to understand further comments by the survey participants. Where applicable, open-ended responses were stratified or otherwise grouped to show any trends among the responses.

CHAPTER 4
RESULTS

A total of ten construction management professionals in the commercial construction field participated in the research survey. Information provided by the participants was analyzed to identify general trends in project-specific safety plan development and technology. The companies participating in the survey consisted of a broad range consisting of small, medium, and large companies. For the purpose of comparison, participating companies were identified by the letters A through J from smallest to largest, based on annual volume. When the results are presented, the data will represent the responses of the ten participants unless this is specifically noted as otherwise, i.e., it will be noted if results are based on only some of the respondents.

Nine of the ten respondents provided information on total annual volume. The combined total annual volume of eight of the research participants (excluding the firm with the highest volume) was approximately $700 million. The annual volume of the companies ranged in size from $3 million to over $10 billion dollars (see Table 4-1). The median total annual volume of the research participants was $40 Million.

Respondents were asked if project-specific safety plans were currently developed for their company. Most (70%) of the respondents indicated that project specific safety plans were required by their company (Figure 4-1). Company "I," indicating that project specific plans are not currently developed, provided additional comments stating "a generic safety plan is used with the job specific [plan] if required."

Table 4-1. Annual company volume.

Company	Annual Volume FY 2002
A	N/A
B	$3 Million
C	$6 Million
D	$8 Million
E	$30 Million
F	$40 Million
G	$120 Million
H	$160 Million
I	$300 Million
J	Over 10 Billion

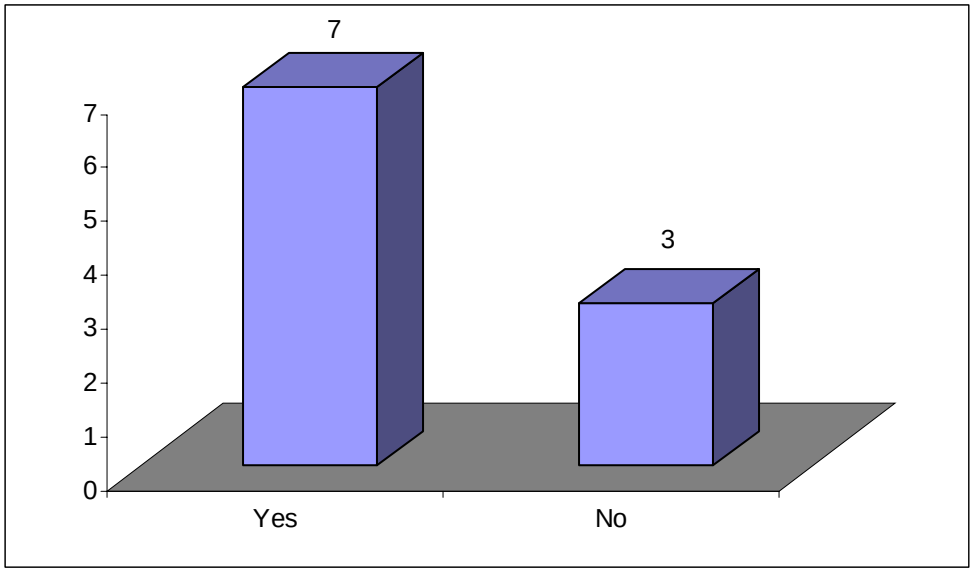

Figure 4-1. Do firms require project-specific safety programs (n=10)?

A cross tabulation was then performed to compare company volume and the use of project specific safety plans (Table 4-2). Participants were asked who prepares the project safety plan. Five possible selections were provided: safety representative, superintendent, project manager, outside consultant, and other. Respondents were to select all of the categories that were applicable. Fourteen total responses were given. Of the total responses, the safety representative and project manager were represented four times in each category, three respondents indicated “other.” Two participants indicated

that the superintendent was responsible for the development of the safety plan. One company did not respond to this question. There were no selections of "outside consultant" for safety program development (Figure 4-2). Additional information was provided for the three "other" responses. The additional comments indicated that the following personnel were responsible for developing project safety plans: project staff, a quality control officer, and "a company-wide safety plan developed only by a safety director."

Table 4-2. Cross tabulation of annual volume and use of project specific safety plans.

Company	Annual Volume	Project Specific Safety Plan Developed?
A	N/A	Yes
B	$3 Million	Yes
C	$6 Million	Yes
D	$8 Million	No
E	$30 Million	Yes
F	$40 Million	Yes
G	$120 Million	No
H	$160 Million	Yes
I	$300 Million	No
J	Over $10 Billion	Yes

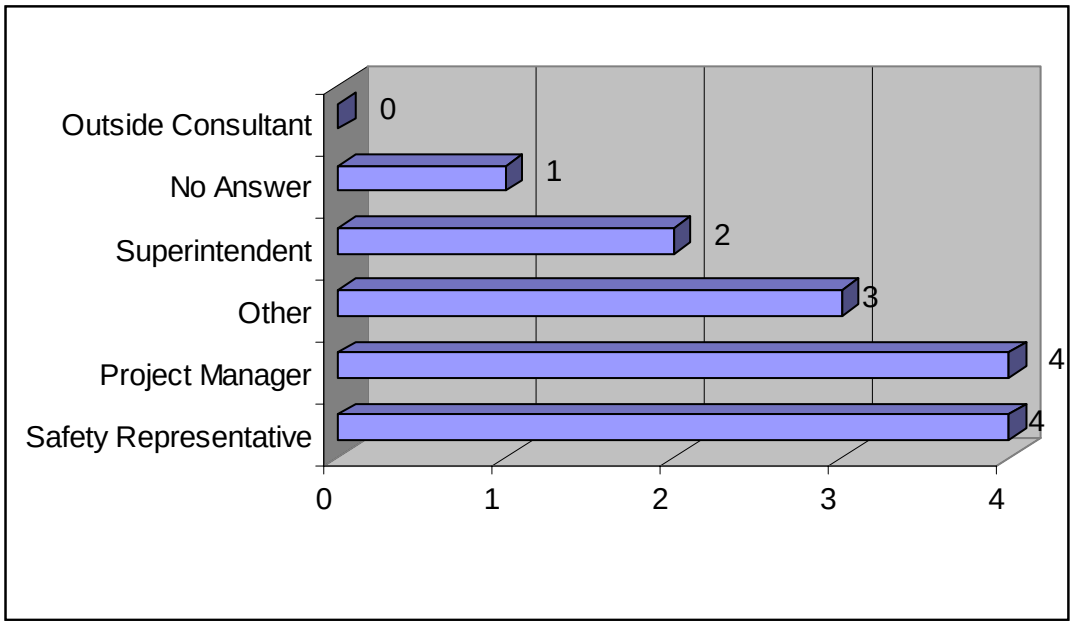

Figure 4-2. Who develops the safety plan?

Respondents were asked when the safety plan is developed. Three selections were provided: after contract execution (before construction), after contract execution (after construction begins, and "other." There were ten responses (including two "n/a" responses). Half (five) of the respondents indicated that safety plans were developed after the contract execution (before construction begins), three indicated "other," and two did not respond. "Other" responses (three) provided additional information on when safety plans were developed. The responses specified that safety plans were developed during the pre-bid phase, as part of the proposal, and "generic plans are used with a job specific [plan] developed if required."

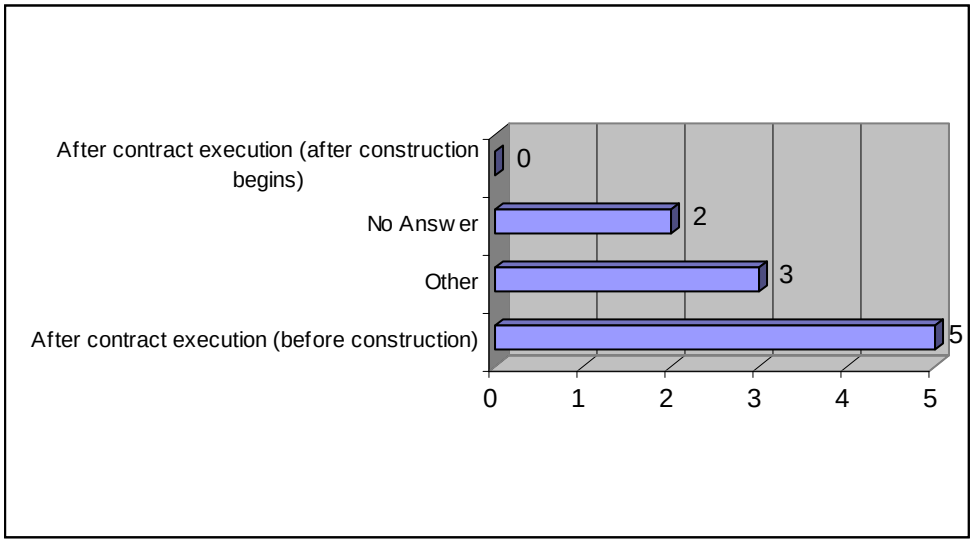

Figure 4-3. When is the project safety plan developed?

Next, the participants were asked how they determined what was to be included in a project specific safety plan. A brief description of the steps involved was also requested. The question requested as an open-ended response to allow for more detailed and or varied responses. Procedures noted by the respondents included the following:

- The contents of the safety plan were derived through an ongoing checklist that is developed from previous and current construction projects.

- The safety plan is developed with the use of general safety guidelines as a base, and then the specifics of the individual project are added.
- Generally, the project manager thinks through the construction process and tries to identify specific tasks. Each new plan is a modification of the previous – adjusted to fit the new project.
- Review project documents before bidding, during project scheduling, and during the preconstruction meeting.
- The safety plan for a specific project begins in preconstruction and is based upon the scope of work.
- The plan is developed by performing a review of the project specifications.
- Safety plans are based on the potential hazards at the site (i.e. chemical, biological, physical, etc.).
- It employs or includes a generic outline coupled with unique or specific area or trade requirements – especially unique safety applications. The main focus is on unusual and/or rare safety concerns.
- Content requirements of the project specific safety plan and steps of development are pre-determined by company policy. The content requirements of the site-specific safety plan are identified within the company Safety Management Manual. During the preconstruction phase, a Risk Register is created to establish key performance indicators. This document provides a measurement tool for initial and subsequent safety reviews during the construction phases of the project. The plan is reviewed on a monthly basis by the on-site project team to ensure any necessary revisions are documented

Participants were asked to describe the extent of the scope within the typical safety plan. Two participants did not answer this question. The question was open-ended to allow for more detailed responses by research participants. The researcher divided the information given by the respondents into four categories: basic, moderate, extensive, and no answer. Three participants had moderate safety plans, three participants had extensive safety plans, and two had basic plans (see Figure 4-4). A cross tabulation was performed to compare annual volume of the company and the extent of the of the project safety plan (Table 4-3).

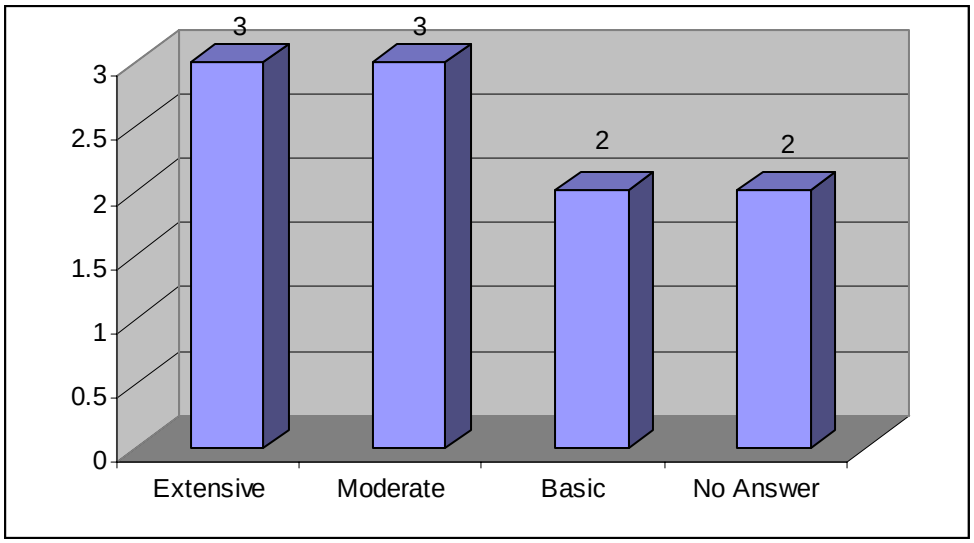

Figure 4-4. How extensive is the scope of a typical safety plan?

Table 4-3. Annual volume and extent of the scope of the safety plan.

Company	Annual Volume	Scope of Safety Plan
A	N/A	N/A
B	$3 Million	Moderate
C	$6 Million	Moderate
D	$8 Million	Basic
E	$30 Million	Extensive
F	$40 Million	Moderate
G	$120 Million	N/A
H	$160 Million	Basic
I	$300 Million	Extensive
J	Over $10 Billion	Extensive

Detailed responses were given by each of the participants.

- The scope of the project safety plan is based upon the project.
- The range is within 30 to 60 pages.
- The extent of the safety plan is moderate; we identify as many specific tasks as possible but do not break them down to a minute detail.
- Basic
- Very extensive – includes software, policies, checklists, etc.

- A hazard analysis and safe work practice guide is developed for all hazardous operations.
- The scope of the safety plan is “designed to meet minimum standards; OSHA 29CFR 1910.120, haz waste site operations.
- The scope includes management participation down through field operations, inclusive of monitoring safety of operations/subcontractor activities. Plan includes development and implementation of emergency procedures, accident investigations, safety training and direct employee involvement.
- Site-specific project requirements designated by pre-set company policies are established prior to the start of construction. Every trade is reviewed by scope of work and hazards are documented and incorporated into the project specific safety plan. The plan establishes safe work practices for work to be performed on the job, safety orientation for all new personnel on the project (including subcontractors) and weekly project safety meetings.

Next, respondents were asked what is involved in implementing a project-specific safety program on a project (how does the written information get put into action). Company “A” stated that safety plans are implemented during the preconstruction meetings. Implementation of the safety plan by company “B” is performed by providing safety manuals to subcontractors who sign that they have received, read, and agree to comply. Weekly tailgate meetings with sign-in required are held after the start of the project. Company “C” stated, “it is the responsibility of each project superintendent to implement the plan.” Company “D” responded that the project superintendent and/or general superintendent is responsible for the implementation of the safety plan. The safety plan is implemented in company “E” by the company safety manager. The company safety manager then directs the plan to two regional safety coordinators. The plan is then directed to the project managers, followed by the project superintendents and subcontractors. Company “F” stated that safety plans are implemented through “weekly meetings held on general safety. Preparatory meetings are held prior to the start of each activity, when specific safety issues are reviewed. Company “G” did not answer this

question. Company "H" stated that the safety plan "is prepared by a manager or staff member. It is then reviewed by the project staff who sign off and acknowledge with a signature." Company "I" responded "the basic responsibility falls on the director of safety to publish and follow up on requirements. Follow-up is accomplished via field audits and/or directly reporting safety requirements and training." Company "J" implements the safety plan through "pre-construction meetings and weekly safety audits. Safety meetings are held once a week."

The modification of project-specific safety plans allows the plan to adapt to the changes or new hazards identified during construction. Participants were asked what kind of changes might be made to the project safety plan during construction (after the plan has been put into effect). Changes addressed by the respondents included the following:

- Changes made to the plans included emergency action and egress plans.
- Specific changes or additions to the safety plan (if required) are made at weekly tailgate meetings.
- Once the plan is in place, it is generally not revisited unless there is a problem (i.e. an accident).
- Unforeseen conditions are reviewed during project meetings. Plans for these changes are then developed and implemented.
- Changes made to the project safety plan are made due to modifications in the scope of the project and/or project site conditions.
- Plans for specific work activities are developed as needed. Lifting plans and fall protection is usually amended on the site. When a plan is added, it is reviewed and signed off with applicable crews.
- Changes to the project safety plan are addressed during the weekly safety meetings. Project safety plans "can and almost always do change."
- Changes are implemented to accommodate new or revised operations on the project. "Most changes are affected via directives such as safety manual changes or

company ‘safety grams.’ Some modifications are difficult to implement if they involve changes to a “long-time” procedure, e.g. “old habits being hard to break.”

- Changes are made to the implemented project safety plan as changes occur or are identified on the job site.

Computers are a tool that can be used for the efficient storage, retrieval, and presentation of large amounts of information. As computer literacy has increased within the construction industry, their role in the performance of job-related tasks has become more common. Respondents were asked the extent to which computers are used to develop their project safety plans. The question was open ended to allow the participants to provide detailed responses. The researcher divided the information provided by the participants on the use of computers for the development of project safety plans into four main categories: basic, moderate, extensive, and no answer. The replies show that 50% of the participating companies use computers on a basic level for the development of their project safety programs (Figure 4-5). Moderate and extensive use of computers for safety plan development was indicated by two respondents. One company did not respond. A cross tabulation was performed to compare annual volume of the participants and the extent that computers are used for the development of project safety plans (Table 4-4).

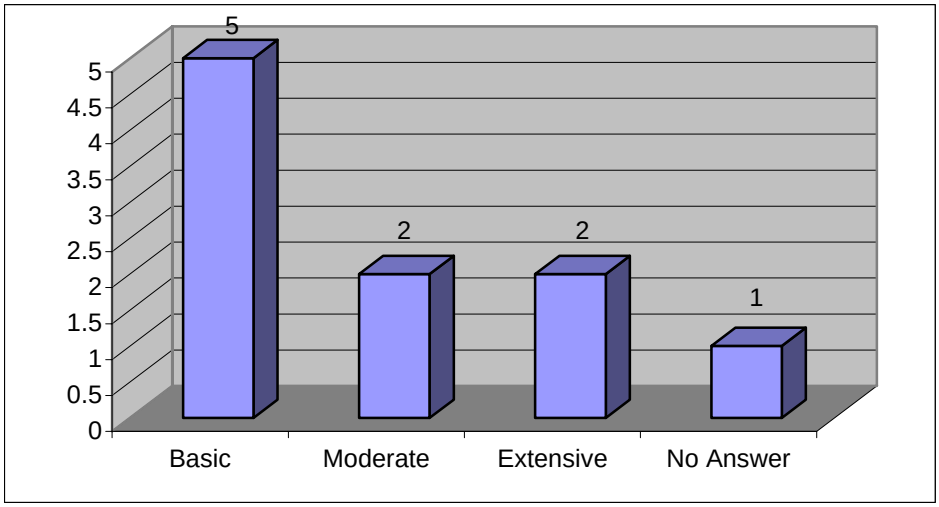

Figure 4-5. Extent of computer use in the development of project safety plans.

Table 4-4. Annual volume and the extent of computer use for the development of project safety plans.

Company	Annual Volume	Computer Use for Developing Safety Plans
A	N/A	Basic
B	$3 Million	Basic
C	$6 Million	Basic
D	$8 Million	Basic
E	$30 Million	Moderate
F	$40 Million	Moderate
G	$120 Million	N/A
H	$160 Million	Extensive
I	$300 Million	Basic
J	Over $10 Billion	Extensive

Detailed responses were provided by the survey participants describing the extent that computers are used to develop their project safety plans. Computers were used for the following purposes:

- To record data.
- For the formulation of plans only.
- Only in the development.
- Very Little.
- All corporate documents are issued from our CPM software.
- All text is on the computer; drawings and diagrams are copied and added.
- Computers are used for training and tracking, generation of written plans, e.g., word processing.
- Currently, used only by the director of safety. It would be very beneficial to have on-site computers.
- Word processing and excel spreadsheets, the entire plan is generated via a computer.

In addition to the development of project specific safety plans, many safety-related tasks have the potential of being streamlined through the use of computer technology. Respondents were asked if computers were used in the performance of safety-related

functions other than the safety plan. Eight choices were provided: safety audit, job safety analysis, accident investigation, tracking injury rates, safety training, safety meetings, pretask planning, and other. Respondents were to select all applicable categories. Twenty-five selections were marked from seven respondents (Figure 4-6). Three companies did not respond to this question. Four respondents selected training, safety audits, accident investigations, and safety meetings. Tracking injury rates was selected by three respondents. Pretask analysis, job safety analysis, and other were selected by two respondents.

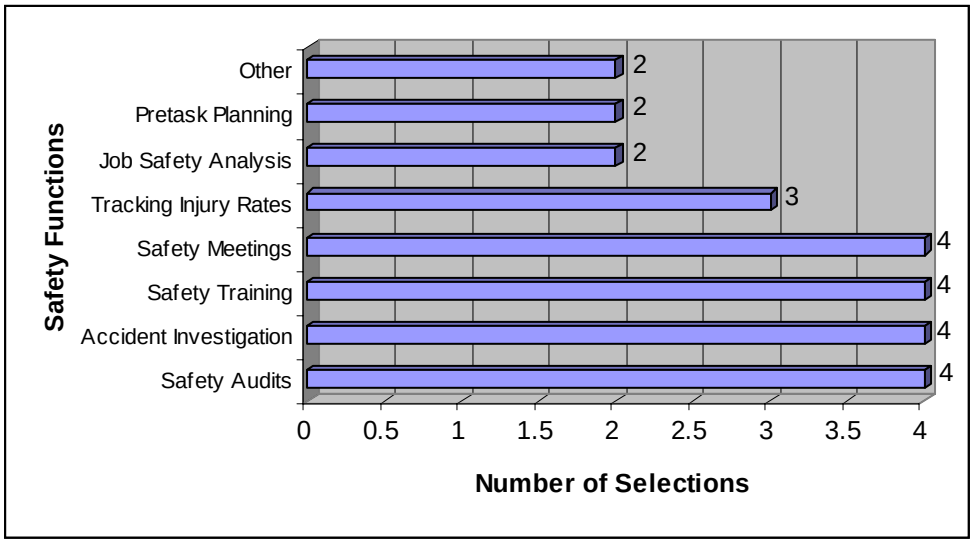

Figure 4-6. With exception of the safety plan, are computers used for other safety-related functions?

Both respondents that selected “other” provided additional information. One respondent stated that computers are not used for additional safety-related functions. The second comment reported that computers were used to develop quality control reports.

Respondents were asked if computer programs used to record and track information obtained through monitoring efforts and to track different aspects of safety. The question was open-ended to allow for a more detailed response. Half of the respondents stated they

do not use computers to record and track information related to other aspects of safety (Figure 4-7). Four respondents stated that their company does use computers to record and track information to monitor other aspects of safety. One company did not respond.

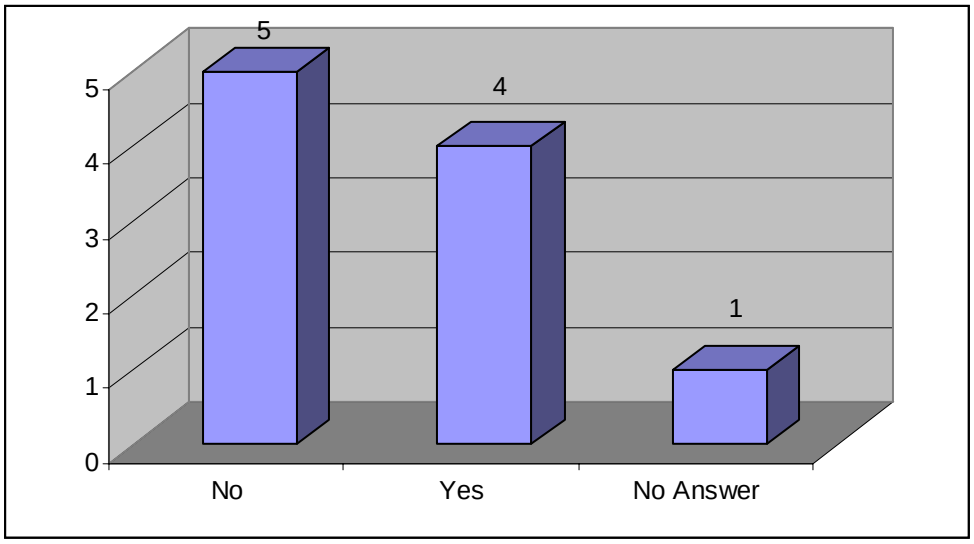

Figure 4-7. Are computer programs used to record and track information obtained for other aspects of safety?

Three participants provided detailed responses. Company "C" stated that the use computer programs to record and track other aspects of safety were not used at this time. It was additionally noted "if there was a comprehensive program that incorporated the OSHA requirements as they applied to a small contractor, we would be interested." Company "F" stated that a QC report tracks safe workdays and any incident or directive given regarding safety. Company "I" indicated that they utilize computer programs to establish trends and survey information.

Participants were asked if computers were used for the development of large-scale project-specific applications. Five choices were provided: detailed safety investigations, project safety training, accident investigation, pretask planning, and other. Respondents were to mark all applicable selections. Twenty-two selections were given by ten

respondents. Five selected project safety training and five selected “other” (Figure 4-8). Detailed safety audits, accident investigations, and pretask planning were each selected by four respondents.

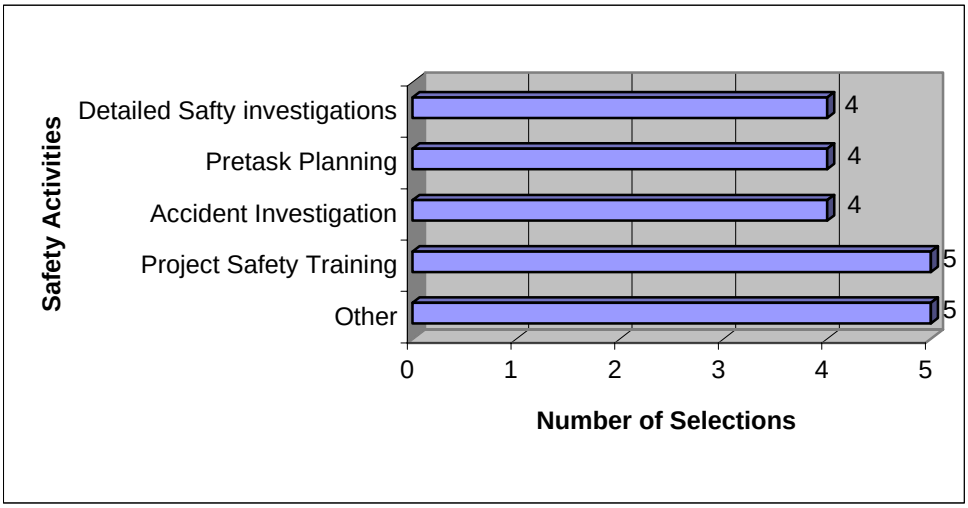

Figure 4-8. How are computers used in the development of large-scale project-specific activities?

The four respondents selecting “other” provided additional detailed information. Company “B” stated that Microsoft Project was used for scheduling, Company “C” used computer applications for the development of the job safety analysis, Company “E” utilized computers to develop drug and alcohol policies, and Company “G” did not use computers to track large-scale project-specific activities.

The increase in computer use and applications in the construction industry has helped to contribute to the rise in computer literacy and computer related technologies. Participants were asked if any on-site personnel, such as the field engineer, superintendent, or foreman, used mobile technology devices (palm pilots or PDA’s) to perform their jobs? Four of the respondents stated that mobile technology devices (palm

pilots, PDA's) were used in varying capacities on their projects to perform job-related tasks (see Figure 4-9).

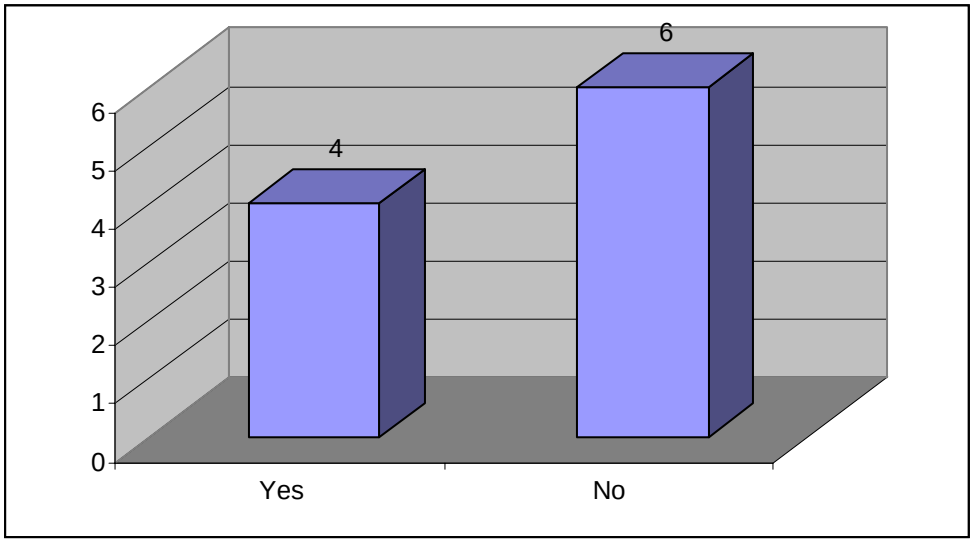

Figure 4-9. Do field personnel use mobile technology devices to perform their job?

Additional comments were provided by four of the ten respondents. Company "C" stated that although they do not currently use mobile technology devices, "we have discussed bringing them into use at a later date – providing that the company will benefit by increased production, better record keeping or other similar needs." Company "E" stated "some use their own equipment. Superintendents receive laptops." Company "H" used mobile technology devices to a limited extent only. Company "I" did not use PDA's, but "there are plans to adapt the use of hand held devices."

Participants were asked if they see the use of computers as a tool for making their job easier within their company? Eight of the respondents viewed computers as making their jobs easier within their company (Figure 4-10). One respondent disagreed, and one company did not answer this question. Company "E" noted additionally that computers are seen as a tool for office use but not in the field. For the purpose of the comparison illustrated in Figure 4-10, the researcher categorized this response as "yes."

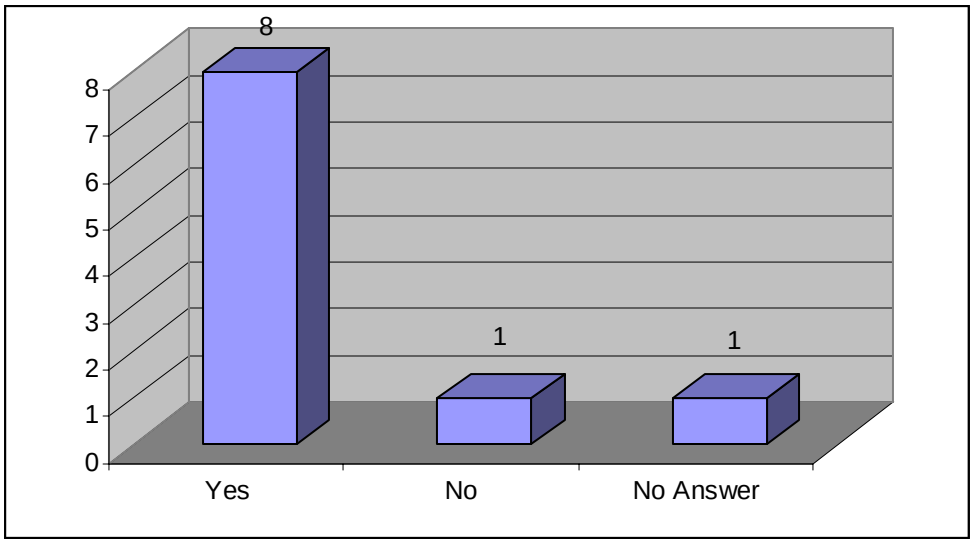

Figure 4-10. In your company, do you see the use of computers as a tool for making your job easier?

The level of literacy and exposure to computers and computer programs can affect their acceptance and use to perform job-related tasks. Participants were asked if they had a personal computer at home. All of the participants stated yes. They were then asked how much time they spent using computers at home. The researcher stratified the responses into four categories based on weekly usage: less than one hour, one to five hours, five to ten hours, and greater than ten hours per week. Six respondents spent one to five hours per week using a home computer (Figure 4-11) Two respondents used home computers less than one hour per week. One respondent used a home computer from five to ten hours a week, and another used a home computer more than ten hours per week. The average amount of time spent by the respondents using home computers was hours per week (Figure 4-12).

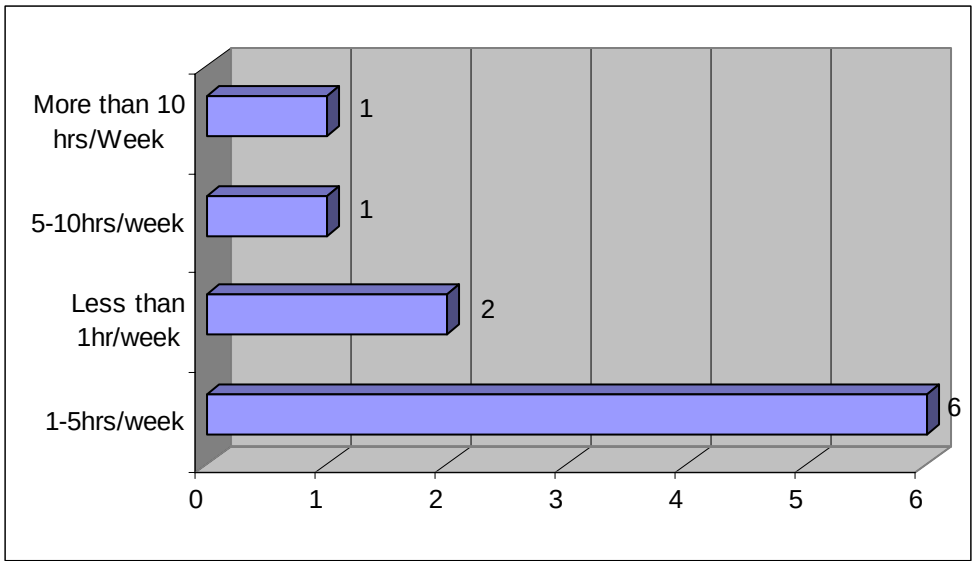

Figure 4-11. How much time do you spend on a computer at home?

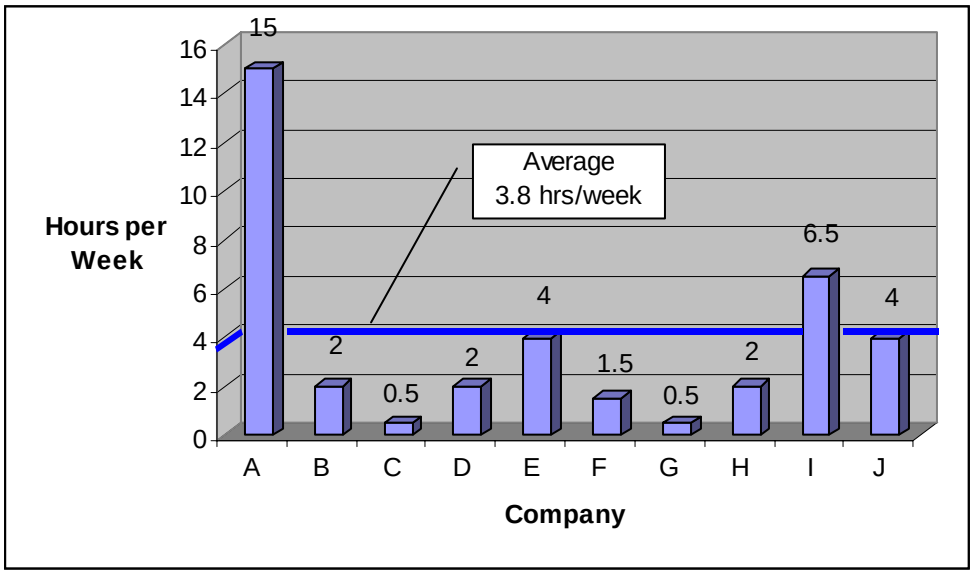

Figure 4-12. Average amount of time spent on computers at home.

Participants were asked if they personally used a computer to perform job-related tasks. Eight of the respondents indicated that they personally used a computer at work to perform job related tasks (Figure 4-13).

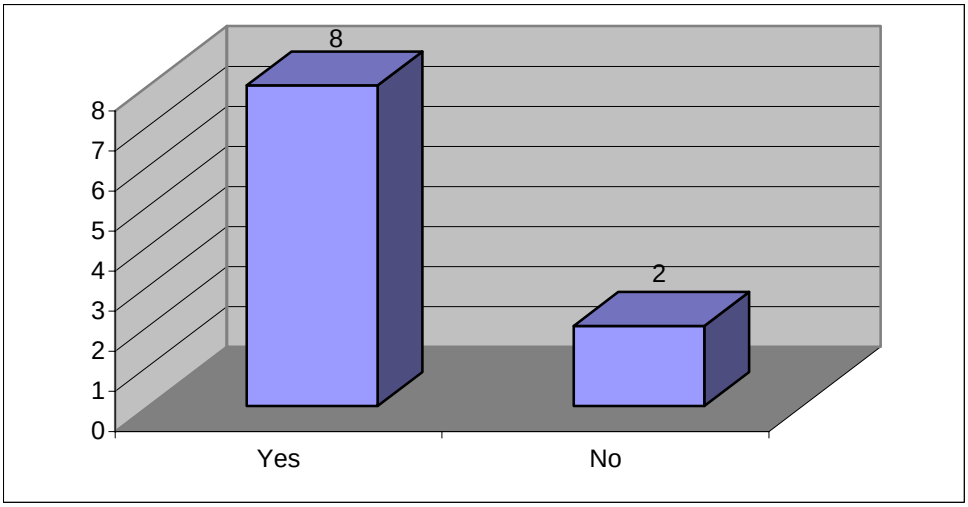

Figure 4-13. Frequency of respondents that use a computer for any job related functions?

Respondents were asked what tasks they performed on their computers. Five choices were provided: email, spreadsheets, word processing, letters/correspondence, and scheduling. All categories that applied were to be selected. A total of thirty-five selections were made by nine participants. One respondent did not answer this question. Of the thirty-five total selections, eight included e-mail and letters/correspondence (Figure 4-14). Seven respondents used them with spreadsheets and word-processing. Scheduling was selected by five respondents.

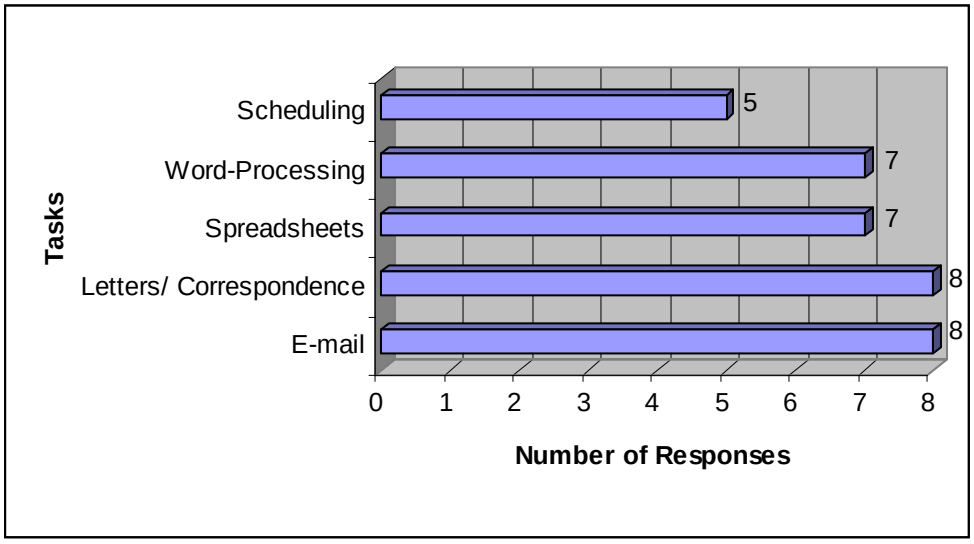

Figure 4-14. What type of tasks do you perform on the computer?

Today, many companies employ staff to assist in technology and computer related issues within the organization. Respondents were asked if their company had a designated technology person to assist with computer technology and software related issues. All participating companies stated that technology/computer personnel were available within their company. Two respondents noted additional comments. One company has an IT division to perform computer assistance. The second stated that IT assistance functions were outsourced to a consultant.

Participants were asked if they had ever acquired software that looked good but later decided not to use it because it was not user friendly. Six respondents stated they had stopped using software because it was not easy to use (Figure 4-15).

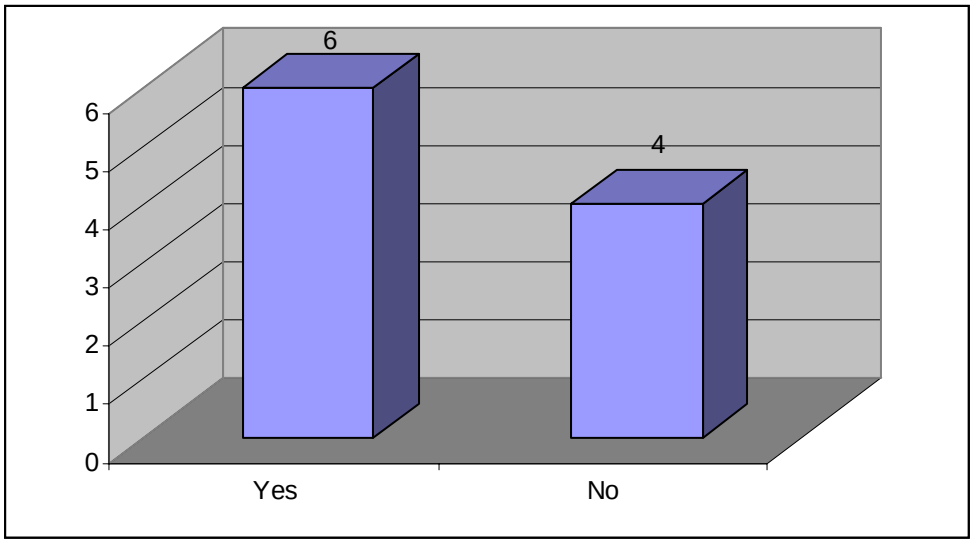

Figure 4-15. Have you ever decided not to use software because it was not user friendly?

Participants were asked how much time they would put into a software program to learn it. The researcher stratified the data into three categories: minimal, moderate, and extensive. Five respondents would put an extensive amount of effort into learning new

software (Figure 4-16). Three would invest a minimal effort, and two would expend a moderate effort to learn new software.

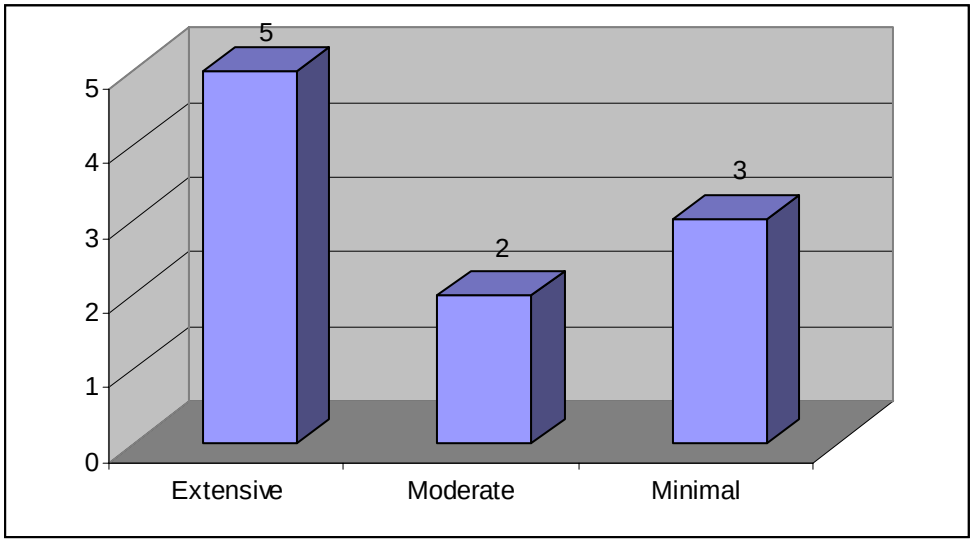

Figure 4-16. How much effort will you put into learning new software?

The respondents that would expend extensive time in learning new software added comments such as “as long as it takes,” “as needed to train all users,” “as much time as needed to get the desired output,” and “as much time as required, noting that I, personally, am not as computer literate as I might like.” Respondents that stated that moderate time was spent in learning new software included “forty hours per year,” and “basic knowledge within a week, continued training based on the usefulness of the program.” Respondents stating that a minimal effort would be invested to learn new software stated that minimal efforts were made, “initially one day of immersion-type training, thereafter, minimal; mostly to look up information on as-needed basis.”

Respondents were asked if the familiarity of the visual organization (or basic navigation) of a new software package affects the potential usage. Eight of the participants indicated that that the visual organization affects potential usage. One added “absolutely” and another said “ I believe it is critical for those with limited computer

knowledge." One noted that it did not affect their usage and one participant had no opinion. Additional comments noted by two of the respondents. Many business computer systems and software packages utilize a Microsoft Windows operating system. The respondents were asked if they preferred a Windows-based or another standard system format. Of the respondents, nine preferred Windows-based formats. One indicated that another system was preferred and one respondent indicating a preference to a Windows-based format noted, "I have no other experience."

Many programs operate with the parameters of other software packages, e.g., MS Word, Primavera P3, Microsoft Excel, etc.. Respondents were asked if consideration were given to a new software package, would the interface (visual organization) be important for the development or facilitation of procedures that address safety practices. The researcher organized the responses into four categories: yes, no, other, and no answer. Of the respondents, seven indicated the interface of the software was important for the development of procedures that address safety. One of the respondents did not find the software user interface to be important (Figure 4-17). One respondent stated the user interface of the software "could be" important. One company did not respond to this question. Additional notation stated "any safety input would be secondary to the prime program objective (schedule, budget, etc.) since safety is normally addressed separately." Another additional comment noted that it is "much easier to work with applications that are similar to ones that you are familiar with."

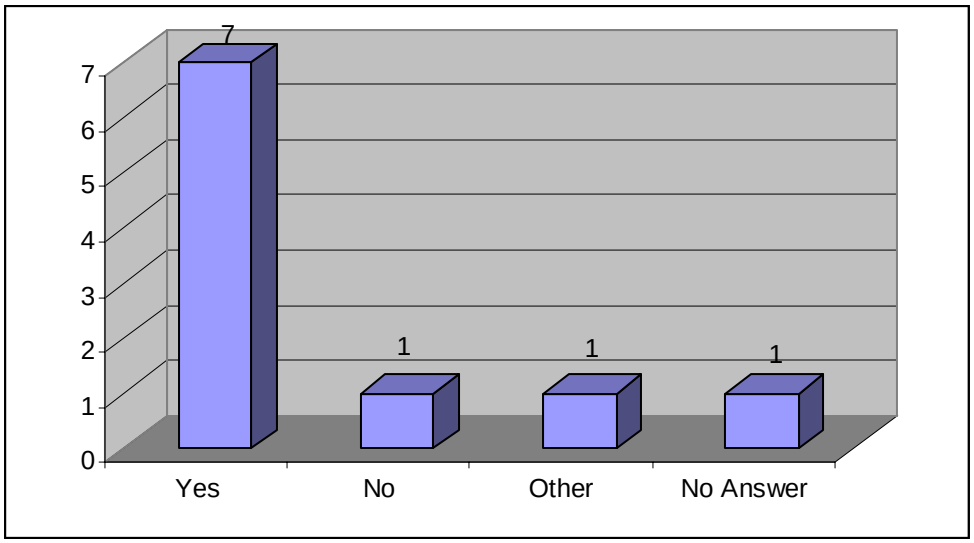

Figure 4-17. Is the software user interface important for the development or facilitation of procedures that address safety?

Respondents were asked if job-specific safety software would help in the development of safety plans for company projects. The responses were divided into three categories by the researcher: yes, no, and other. Seven of the respondents indicated that job-specific safety software would help in developing safety plans within their company (Figure 4-18).Two respondents indicated job-specific safety software would not benefit their company for the development of safety plans. One response, categorized as “other” stated “there are currently several on the market, however relatively expensive.” Additional comment s noted by participants included the following:

- An additional application should be adopted to permit some development of a “job hazard analysis” through the same software. A JHA is an excellent guide for field personnel.
- MSDS
- Currently, we utilize MS Word and develop each plan on an as-needed basis.

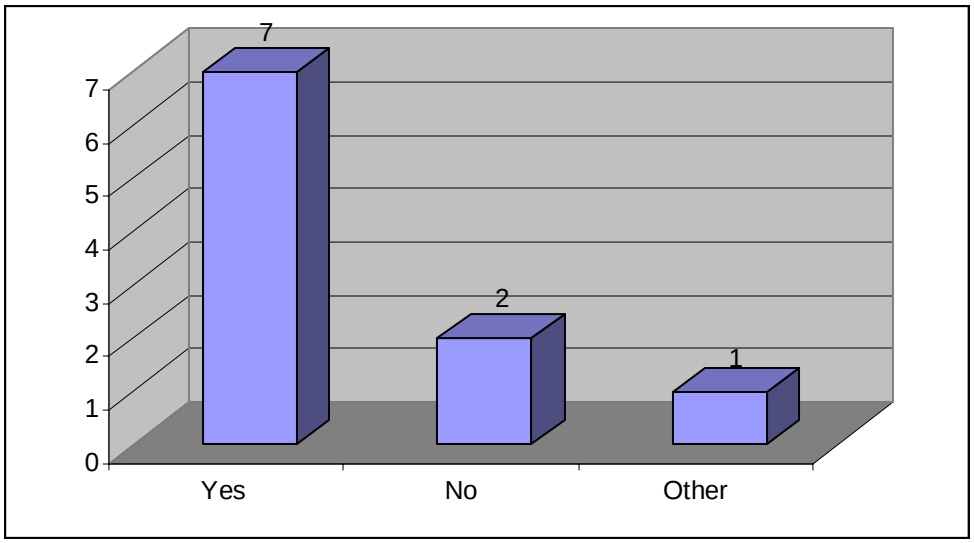

Figure 4-18. Would job specific safety software help in developing safety plans for your company's projects?

Participants were asked if software to create project specific safety programs had the ability to work within the current procedures for safety plan development. Of the responses, nine indicated that project-specific safety programs could work within the current safety plan development procedures of their company. One company indicated that project-specific safety software would not assist current safety plan development procedures. Respondents indicating that project-specific safety software applications had the ability to work within the current program development within their company were asked to identify features or parameters that would benefit this procedure. Comments provided by the respondents include the following:

- Scheduling
- I believe it would save time in developing site-specific safety plans. A feature that allows a selection from multiple choices would be advantageous! Additionally, a reference to the corresponding paragraph in the CFR's would be a plus.
- Plan Development

- The idea that [a site specific safety program] will be compatible with Microsoft project will enable the project manager and/or superintendent to take a more active role in our safety plan.

- The addition of checklists would help in the precon phase. Our typical CPM [program] tracks submittals. The checklists would fit in after submittal approval and prior to the start of a work activity.

- Include other relevant topics associated with construction management, e.g., materials testing. Each/many phases of construction require materials to be tested, adding a prompt for soil density and concrete testing would be as nice as the safety topics.

- Ability to thoroughly develop, modify, and incorporate unique checklists and training facilities for both my company (the GC) as well as the subcontractor.

CHAPTER 5
SUMMARY

The second phase of this study was designed to identify general trends among participating construction firms regarding the role of technology for developing project-specific safety programs. Additionally, the survey attempted to determine the extent to which companies utilize computer technology and software to improve safety performance on their job sites.

Development of Project-Specific Safety Plans

The overall findings of the survey indicated that safety programs are developed within all of the participating companies in varying degrees. Of the respondents seven indicated the safety programs used on their job-sites were required to be project-specific. Furthermore, there seems to be no relationship evident in the requirement of project-specific safety plans and annual volume of the company (Table 4-2).

Survey results indicated that the responsibility of preparing the project safety plan was typically performed by management-level personnel. In many cases, safety plans were developed by the project manager or a company safety director within the firm. In other cases, the development of the safety plan was performed by either the project staff or a quality control officer, followed by project superintendents. Four respondents indicated that this task was performed by multiple positions as listed above. In these cases the selections were recorded by the researcher as an individual response and included in the listed percentages.

The scope and specific content of the safety program for a project can be affected by safety planning in relation to the construction schedule. Companies seem to recognize the importance of implementing safety policies prior to the start of construction activities. The development of safety procedures in conjunction with other project –specific planning activities, such as scheduling which can assist in integrating safety into the total quality management process. Five respondents indicated the safety plan was developed between contract execution and the beginning of construction. Three respondents indicated that the project safety plan was developed prior to the execution of the contract (during the pre-bid period or during the project proposal phase).

Defining the scope and content is an important element in the overall application and performance of the safety program on a jobsite. The identification of potential jobsite hazards prior to the performance of work has been identified in recent articles as an important element of a safe jobsite. This pretask analysis is partially indicative of an industry-wide trend towards a more proactive approach towards project safety. Nine of the respondents indicated that some type of pretask analysis was performed to develop the content of their safety programs. Some of the pretask activities noted in the survey results included the use of checklists from other projects, scope of work, and project specifications review, and pre-set company content requirements. In general, survey results indicated that the scope of the safety plans was more extensive in larger companies (Table 4-4).

Following the development of the safety plan, the implementation process allows for the communication of the hazards identified during the development phase. Putting the written information into action on the jobsite is important for communicating

practices for the safe completion of activities to be performed and establishing the company's commitment to safety on the project. The majority of the respondents address the communication of the safety plan on the jobsite. In most cases, the superintendent or the on-site project staff was responsible in varying degrees for the initial execution of the safety plan. Four respondents stated specifically that jobsite meetings were used to communicate safety policies and information to workers. Two companies noted that a "review and sign" procedure was used to ensure that project staff had read the project safety plan.

The ability of the safety plan to adjust to changing conditions during the construction phase of the project can impact safety performance on the jobsite. The increasing awareness of the impacts of injuries on personnel, costs, and schedule has made many construction companies more proactive in response to safety issues on the jobsite. Survey findings indicate that seven of the participating companies reviewed safety concerns during weekly safety or tailgate meetings to determine if changes to the jobsite safety plan were necessary. One company addressed specific safety changes through specific safety directives. Other changes in the safety plan were implemented through mandatory project specific safety requirements such as fall protection and lifting plans to be developed on the jobsite. Of the ten respondents, one company indicated that the project safety plan was "usually not revisited unless there is an accident." Findings seem to indicate that changes to the project safety plans are more extensive in larger companies.

Computers and Safety Related Tasks

In recent decades, technology in the workplace has substantially increased. Because of their ability to efficiently store, process, and retrieve large amounts of

information, computers have become an indispensable tool for the performance of business related tasks. Computer usage and literacy in the construction industry can vary between the office and field activities. Many construction companies now use computer technology for estimating, scheduling, and project management activities. In many instances specific software applications are used to perform these tasks. The majority of the respondents indicated that computers are used only on a basic level to develop and implement project-specific safety plans. Survey findings indicate that larger companies utilize computers more extensively for this purpose.

Safety-related activities on the jobsite require clear communications, training, and documentation. Information gathered during the performance of these activities can assist in the continuous development of the project safety plan. The survey indicates that half of the participants do not use a dedicated computer program to record or track safety information. In more basic software applications however, eight of the respondents used other general-purpose programs for safety related tasks. Results indicate that computer use for safety activities is more common among larger companies. Of the participants, the majority of computer usage for safety related tasks is to document accident investigations, safety meetings, and safety audits. Minimal computer use was indicated for the performance of job safety analyses and pretask planning.

As computer technology has developed over the past few decades, there has been a growing trend towards mobility. The increase in mobile technology has progressed from the personal computer to laptop computers. Most recently, handheld technology devices have been developed with increasing sophistication. Many of these devices utilize graphics, touch screen input, and information synchronization capabilities to mimic PC

formats and applications. Handheld technology has the ability to influence the way technology is used to perform designated tasks. Personal digital assistants (PDA's) such as 3COM's Palm Pilot and Hewlett Packard's IPAQ offer a operating platform and program availability that mimics many standard programs available on standard PC's including Microsoft Word, Excel, and Meridian's Prolog. On construction sites, the potential exists for the use of this technology by field personnel for the performance of project tasks. Of the survey respondents, six did not use PDA's on the jobsite. Additional comments indicate that among companies that do not use PDA's, there is moderate interest for implementing their use in the future.

Computer Usage

Construction projects involve a range of workers with varying skills and job functions. Exposure to computers at home and in the performance of job-related tasks can affect the literacy and acceptance of computer applications for both new and experienced users. Survey results show that home computer usage between one to five hours per week for most participants. For work related functions, eight of the survey participants use a computer. The majority of this use is for e-mail and letters/correspondence. Results seem to indicate that the majority of computer use is for communication purposes.

Software Development and Organization

Computer literacy within a company can vary based on the type of work, level of training, and exposure to technology of its employees. It is important that new software communicate information effectively and efficiently to its intended users. The design and user interface of a software package can influence its use. Survey results indicate that user interface affected software use. Of those surveyed, six respondents had stopped using a software program because it was not user friendly. The amount of time dedicated

to learning new software, however was high. Five respondents indicated that extensive efforts are put into learning new software, especially in larger companies.

The familiarity of new software to other common program formats can contribute to its acceptance and use. Time, effort, and resources dedicated to implementation can potentially be reduced. Eight participants indicated that familiarity with the visual interface or navigation was a factor in its use. The majority of business and home computers are PC's (IBM Compatible). In addition, many of these machines utilize a Microsoft Windows operating system. Other operating systems such as Mac X, and Linux are also available. Nine participants preferred a Microsoft Windows format for new software packages. One respondent noted, "I have no other experience."

Some applications are designed to operate within existing software rather than as an independent program. The extensiveness and function of these "piggyback" programs can vary depending on its intended use. Additionally, the visual format and user interface of the piggyback program in relationship to the parent program, e.g., Primavera P3, MS Word, etc., can affect its use. For the purpose of developing and facilitating procedures that address safety, eight respondents indicated that the interface/visual organization of this type of software is important. Two respondents noted that similarities in the programs would make the applications "easier to work with" and "reduce the learning curve." Nine respondents were receptive to safety-based software applications to assist in the existing company procedures for safety plan development. One respondent, however, noted cost as a deterrent for utilizing safety software.

CHAPTER 6
CONCLUSIONS AND RECCOMENDATIONS

Conclusions

The purpose of this research was to identify general trends in the use of computers and computer-related technology for the development and implementation of project-specific safety programs in the construction industry. The conclusions of this study are based on responses of ten participants. Because of the small sample size, the findings of this research cannot be regarded as being supported by statistical rigor. As a result, the conclusions are related to general trends that appear to exist in the construction industry. It was intended that the results of this study would provide valued information for those considering the development of software and computer applications for project specific safety programs.

Software applications specifically designed for safety management on construction sites have the ability to contribute to the overall total quality management process. Integrating computer-based safety management tools both in the field and in the office can assist in communication, documentation, and integration of the safety program to all aspects of the construction process. Computers have become a necessity in many business environments over the past decade. Because of the hands-on nature of their work, many construction companies do not fully utilize computer technology equally in both field and office environments. The current and future role of computers in the construction industry for project management functions creates a potential for computer-based safety plan integration. Computer-based job-specific safety software could assist

project staff in addressing the changing safety requirements necessary to maintain a safe project. Developing software programs such as HAZCOM Interactive utilize the storage, retrieval, and communication benefits of computer technology. The generation and documentation of safety functions such as job hazard analyses, pre-task checklists, and safety audits/inspections could be performed with greater efficiency and contribute to a more proactive project safety program.

This study determined the extent to which computers are used to develop and implement job-specific safety plans. Safety-specific software is a relatively new application compared to other project management software. As safety becomes a larger factor in the overall total quality management process on construction sites it is expected that software that contributes to this purpose will be more prevalent. Project-specific safety plans are prevalent for the performance of construction projects at the site level. In most cases, management-level personnel are responsible for the development of these plans. In the past decade, computers have taken a more prevalent role in the performance of construction management tasks with the greatest impacts evident in larger companies. The familiarity with the software format and user interface strongly influences the acceptance of new programs. Microsoft windows-based software formats are predominant on most computers and are preferred for new software. Various levels of computer literacy, however, have affected the type and amount of use of computer software and technology for safety-related tasks. The development and implementation of project-specific safety plans on both computers and portable electronic devices is performed only to a limited extent. While various aspects of safety related information are created, tracked, and communicated through the use of computers, no comprehensive

computer-based safety program is currently utilized. Despite limited computer use, basic computer literacy within the industry presents the potential for the introduction of various safety-related software applications. In addition, construction firms are receptive to computer-based applications for assisting in the development of their project safety programs.

Recommendations

The widespread use of computer technology is relatively new to the construction industry. As computers have become more common in the management of projects, their applications and use for daily activities has increased. Computer technology is developing continuously. Specific software packages are currently utilized by many construction companies that assist in establishing a comprehensive approach to the management of project related information. The prototype software noted in this research explores both independent and integrated approaches to computer-based project specific safety applications. This research study identified preferences in format and user interface in the introduction of new software. Additionally, further exploration into the applications of safety software based on popular or familiar platforms such as Microsoft Windows, Primavera's SureTrak, Timberline, etc. could assist in the acceptance of new programs. It is recommended that software developers consider these research findings when developing computer applications in the area of construction safety. The development of software for computer safety applications should consider these factors. A recommendation for future research would be to conduct a comprehensive study that would reflect the views of a larger population within the construction industry.

Computer technology and applications are changing constantly. It is recommended that software developers address the safety needs of contractors and understand the

specific roles of their application. Additionally, it is recommended that contractors take proactive measures to identify and research computer software and their applications for improve safety on their jobsite.

APPENDIX A
SURVEY QUESTIONNAIRE

Survey on Technology and the Implementation of Project-Specific Safety Programs

Part 1

1. What is the approximate annual volume of your company? _____

2. Are project specific safety plans currently developed for your companies' projects?

☐ Yes ☐ No

3. Who prepares the safety plan?

☐ Safety Rep ☐ Superintendent ☐ Project Manager ☐ Outside Consultant

☐ Other _____

4. When is the safety plan developed for a project?

☐ After contract execution (before construction)

☐ After contract execution (after construction begins)

☐ Other

5. How do you decide what needs to be included in a project specific safety plan? Can you describe the steps of the development?

6. How extensive is the scope of a typical safety plan?

7. What is involved in implementing a project specific safety program on a project? (How does the written material get put into action?)

8. During construction (after the plan has been put into effect), what kind of changes might be made to project specific safety plans? How easy is it to make these kinds of changes?

9. To what extent are computers used to develop these plans?

10. In other aspects of safety (safety audits, job safety analysis, accident investigations, tracking injury rates, safety training, safety meetings), are computers used for any of these functions?

☐ Safety audit ☐ Job safety analysis ☐ Accident

☐ Tracking injury rates ☐ Safety Training ☐ Safety meetings

☐ Pretask planning ☐ Other _____

11. To monitor the different aspects of safety, is a computer program used to record and track the information?

12. Are Computers used in the development of large-scale project specific applications (i.e. job safety analysis, pretask planning, safety training, detailed inspections, etc)?

☐ Detailed safety ☐ Project safety training ☐ Accident

☐ Pretask planning ☐ Other _____

13. Do any site personnel such as the field engineer, superintendent, or foreman use mobile technology devices (like Palm Pilots / PDA's) to perform their job?

14. In your company, do you see the use of computers as a tool for making your job easier?

☐ Yes ☐ No

At this time, please insert the Salus CPM demonstration CD provided. The demonstration is self- starting/ running. If the Salus CPM demonstration does not start, please follow this path to begin: Salus_CPM(CD Rom drive)/bin/clickme. (From the desktop, double click on “My Computer,” double click on the CD drive, open the “bin” folder, and double click on “clickme”)

The Salus CPM demonstration is provided to you for two purposes; to present information regarding current and potential developments in technology-based safety applications, and as a precursor to the questions contained in part 2 of this study. The Salus CPM demonstration is intended as an example of a developing technology-based application for project-specific safety management. It is not presented as wholistic solution to incorporating technology into safety management, but rather an example of one particular approach related to the subject addressed in this research.

Part 2

15. Do you have a computer at home? ☐Yes ☐No

16. How much time do you spend on a computer at home? _____hrs/ wk

17. Do you personally use the computer for any job related functions?

☐Yes ☐No

18. What tasks do you do on the computer?

☐ E-Mail ☐ Spreadsheets ☐ Word Processing ☐ Letters/ correspondance
☐ Scheduling

19. Does your company have a technology person to help you with computer and software problems?

20. Have you ever acquired software that looked good but then decided not to use it because it was not user friendly?

☐Yes ☐No

21. How much time/ effort will you put into a software program to learn it?

22. Does the familiarity of the visual organization (or basic navigation) of a new software package affect the potential usage?

23. Do you prefer a windows-based (or other standard program) based format?

24.Many programs work within the parameters of other software packages (MS word, P3, excel, etc.). If you were to consider a software package, is the interface (visual organization) important for the development or facilitation of procedures that address safety practices?

25. Would job specific safety software help in developing safety plans for your company's projects?

25. Do you think that software that helps to create project specific safety programs has the ability to work with your current safety plan development procedures? What features or parameters would be most beneficial to your company?

Optional: A summary of this research will be compiled and presented in a report. If you would like a complimentary copy, include your name and address below. Your company identity be used only to deliver a report to you. Thank you for your participation.

Name:_____

Firm:_____

Address:_____

City:_____ State:_____ Zip:_____

LIST OF REFERENCES

Adrian, James J., Farzad Schahbodaghlou, Douglas J. Adrian. "Reducing Accidents on Construction Sites: Safety Using TQM Alternative," Proceedings of the Fifth Annual Rinker International Conference Focusing on Construction Safety and Loss Control, ed. Raymond Issa, Richard J. Coble, Brent R. Elliot. University of Florida: Gainesville: 1994, 443-460.

Al-Mufti, M. A.. "Promotion of Health and Safety Culture Through Accident Cost Awareness," Implementation of Safety and Health on Construction Sites, ed. Amarjit Singh, Jimmie Hinze, and Richard Coble. A.A. Balkema, Rotterdam: 1999.

Alves Dias, Luis M.. "The Safety and Health Plan in the Construction Industry." Implementation of Safety and Health on Construction Sites, ed. Luis M. Alves Dias and Richard J. Coble. A.A. Balkema, Rotterdam: 1996.

Alves Dias, Luis M. and Miguel Torres Curado. "Integration of Quality and Safety in Construction Companies." Implementation of Safety and Health on Construction Sites, ed. Luis M. Alves Dias and Richard J. Coble. A.A. Balkema, Rotterdam: 1996.

Ayoade, Aubrey I., Alistair G. F. Gibb. "Integration of Quality, Safety and Environmental Systems." Implementation of Safety and Health on Construction Sites, ed. Luis M. Alves Dias and Richard J. Coble. A.A. Balkema, Rotterdam: 1996.

Coble, Richard J. and Brent R. Elliot. "Scheduling for Construction Safety." Construction Safety and Health Management, ed. Richard Coble, Jimmie Hinze, and Theo C. Haupt. Prentice Hall, Upper Saddle River; 2000, 43-57.

Cooper, M.D., R.A. Phillips. "Achieving the Objectives of Total Quality Management by Focusing Upon Safety Management." Proceedings of the Fifth Annual Rinker International Conference Focusing on Construction Safety and Loss Control, ed. Raymond Issa, Richard J. Coble, Brent R. Elliot. University of Florida: Gainesville: 1994, 371-381.

Elliot, Brent R.. "Investigation of the Construction Scheduling Communication Process: Problems, Foreman's Role, Means of Improvement, and Use of Information Technology." Ph.D dissertation, University of Florida, 2000.

Elzarka, H. M., I. A. Minkarah, and R. Pulikal. "A Knowledge-Based Approach For Automating Construction Safety Management." Implementation of Safety and Health on Construction Sites, ed. Amarjit Singh, Jimmie Hinze, and Richard Coble. A.A. Balkema, Rotterdam: 1999.

Eubanks, Francis M.. "Elements Of a Construction Safety Management Program." Proceedings of the Fifth Annual Rinker International Conference Focusing on Construction Safety and Loss Control, ed. Raymond Issa, Richard J. Coble, Brent R. Elliot. University of Florida: Gainesville: 1994, 325-338.

Gambatese, John A., and Jimmie Hinze. "A Guide for Safety Inspections." Implementation of Safety and Health on Construction Sites, ed. Luis M. Alves Dias and Richard J. Coble. A.A. Balkema, Rotterdam: 1996.

Geronsin, Rolin. "Job Hazard Assessment: A Comprehensive Approach." Professional Safety. December, 2001. 23-31.

Gottfried, Arie and Marco L. Trani. "Safety and Health Design Management on the Construction Site: Guidelines for Roles and Application Tools." Implementation of Safety and Health on Construction Sites, ed. Amarjit Singh, Jimmie Hinze, and Richard Coble. A.A. Balkema, Rotterdam: 1999.

Harper, Randall S. and Enno Koehn. "Managing Industrial Safety in Southwest Texas," Journal of Construction Engineering and Management. November/ December 1998.

Hinze, Jimmie. Construction Safety. Prentice Hall, Upper Saddle River: 1997.

Hinze, Jimmie. "Incurring the Costs of Injuries Versus Investing in Safety." Construction Safety and Health Management, ed. Richard Coble, Jimmie Hinze, and Theo C. Haupt. Prentice Hall, Upper Saddle River: 2000, 23-42.

Hinze, Jimmie. "The Role of Project Coordination in Construction Safety." Proceedings of the Fifth Annual Rinker International Conference Focusing on Construction Safety and Loss Control, ed. Raymond Issa, Richard J. Coble, Brent R. Elliot. University of Florida, Gainesville: 1994, 357-370.

Jones, Pierce. "Hazard Communications Using Interactive Computer Based Training Techniques." The Management of Construction Safety and Health, ed. Richard J. Coble, Theo C. Haupt, and Jimmie Hinze. A.A. Balkema, Rotterdam: 2000.

Kartam, Nabil. "Integrating Construction Safety and Health Performance Into CPM." Construction Congress: Proceedings from the 1995 Conference, ed. C. William Ibbs. American Society of Civil Engineers, New York: 1995, 456-462.

Levitt, Raymond Elliot and Nancy Morse Samelson. Construction Safety Management. John Wiley and Sons, Inc., New York: 1993.

Nelson, Jeff, and Jimmie Hinze. Salus CPM: An Introduction. [CD ROM].Conceptual Arts, 2001.

Pun, Kit-Fai and Ip Kee Hui. "Integrating the Safety Dimension into Quality Management Systems: A Process Model." Total Quality Management. May 2002, 373-391.

Rwelamila, P. D. and J. J. Smallwood. "Total Quality Management (TQM) Without Safety Management?" Proceedings of the Fifth Annual Rinker International Conference Focusing on Construction Safety and Loss Control, ed. Raymond Issa, Richard J. Coble, Brent R. Elliot. University of Florida, Gainesville: 1994, 391-408.

Sommerkamp, John and Jeffrey J. Yew. "Safety Quality Management." Proceedings of the Fifth Annual Rinker International Conference Focusing on Construction Safety and Loss Control, ed. Raymond Issa, Richard J. Coble, Brent R. Elliot. University of Florida, Gainesville: 1994, 349-355.

U.S Department of Labor. "Safer Construction Workplaces Evident During the Early 1990's" Summary 95-3, Bureau of Labor Statistics. http://stats.bls.gov/iif/oshwc/ossm0004.pdf. August 17, 2003.

U.S. Department of Labor. Construction Industry Digest. Occupational Safety and Health Administration. OSHA 2202: 1998.

BIOGRAPHICAL SKETCH

Casey R. Lewis was born outside of Atlanta, GA. He received a bachelor's degree in interior design from the University of Georgia. Prior to entering the graduate school at the University of Florida, he worked in commercial interior design in Atlanta, GA, and Jacksonville, FL. Casey will have completed the requirements for his Master of Science in Building Construction degree in August 2004 and will be employed as a project engineer in Charlotte, NC.