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Engineer Manual 385 Effectiveness: A Study of Predictive Analytics

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ABSTRACT

Under the guidance of the United States Army Corps of Engineering Manual 385 (EM 385), the federal government has taken a stringent stance on construction safety. Using the mandated Occupational Safety and Health regulations and the 29 Code of Federal Regulation as a safety foundation, the EM 385 requires project-specific planning, continuous oversight and direct control of all safety activities. These mandates, required of every Department of Defense entity, focus on safety management not found within other federal agencies, in an attempt to reduce the number and severity of mishaps.

This study looks for causation between the use of the EM 385 and the number and the severity of mishaps using three multiple regression analysis. The research population studied included construction contractors who performed work within various federal government agencies. The data was compiled using 2008 data that was merged using the federal construction spending data with mishap rates obtained from the OSHA Data Initiative (ODI). The explanatory variables considered in this research were EM 385 use, contractor size, project size, construction sector, pricing structure, solicitation procedure, OSHA region, disadvantaged business status and type of federal set-aside. The three dependent variables included the total case rate (TCR), the days away, restricted, and transferred (DART) rate, and the days away from work (DAFWII) rate. Analysis of this data revealed that there were no conclusive results showing a causal relationship between the EM 385 and a reduction in the number and severity of mishaps.

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CHAPTER 1

INTRODUCTION

After an extensive review of all of the extant research and literature on the subject, it became apparent that there is a lack of quantitative research on the relationship between safety performance and the use of the Engineering Manual 385 (EM 385). The absence of this empirical evidence is perhaps why the EM 385 has not been more widely adopted within the federal government. The EM 385 is composed of extensive safety planning guidelines that have cost millions of dollars to develop and implement over its 73 year history. In an environment that over the past forty years has had a disproportionate number of mishaps as compared to other industries, this research has the potential to be a critical step forward in construction safety. Similar to other studies in construction safety, this research utilized post-accident analysis as a practical means of gauging the EM 385's effectiveness.

This research has assessed the causal link between the EM 385 and mishap reduction by isolating a variety of explanatory variables. The EM 385 has become a vital part of construction operations on all Department of Defense (DOD) construction projects, with the objective of creating a safer work environment. On March 1, 1941, the United States Army Corp of Engineers (USACE) published the first issue of the EM 385, four months after the Army Chief of Staff, General George Marshall, transferred all construction efforts from the

Quartermaster Department to the USACE. The EM 385 was created to reduce the number and severity of construction mishaps and was originally known as the *Safety Requirements for Excavation, Building, and Construction.* This guide originally took the form of a 60-page document that was produced by the War Department's Office, General Construction Division.

A historical perspective reveals the tremendous foresight went into the creation of the EM 385 as well as the urgency with which it was implemented. Over time the EM 385 has evolved in content and complexity as a result of proven advancements in mishap reduction regulation developed by the Occupational Safety and Health Administration (OSHA) and formal peer-reviewed research on construction safety. Based on the assumption that the number and severity of mishaps could be reduced by regulation and oversight, the safety planning principles contained in the EM 385 were intended to foster safer conditions for various construction projects.

Using the EM 385, the Department of Defense’s construction management agencies adhere to the mandated OSHA regulations as well as these additionally specified safety requirements. The “print architecture and nomenclature of the manual is similar to that of the OSHA regulations, with a few variations” (DeCoopman, 2011). These variations are in the specific safety planning processes that are mandated of construction contractors. A prime example of this is the Accident Prevention Plan (APP), a required preconstruction safety submittal. This plan is a safety and health policy, program document that interfaces with the contractor’s overall safety and health program and focuses on the specific project and its scope. The following project-specific information is addressed in the APP and is a required preconstruction submittal for those under the OSHA regulations:

- Project and company safety and health policies.
- Names, qualifications, responsibilities, and lines of authorities of project safety staff.
- Identification of subcontractor and supplier personnel and corresponding responsibilities.
- Safety training requirements of project staff.
- Required project-specific safety and health inspections.
- Specific accident reporting requirements.
- Project-specific safety and health expectations.
- Identification and route to medical support facilities, along with emergency action plans.
- Required scope-specific personal protective equipment that is mandated for use.
- Detailed safety plans for scope-specific hazards.

To assess the EM 385, this research examined three common safety metrics. These metrics are created, collected and actively tracked by OSHA. The metrics include the total number of recordable cases rate (TCR), the days away, restricted, and transferred (DART) rate, and the days away from work (DAFWII) rate. When combined, these three metrics make the number and severity of mishaps apparent and also provided a common measurement of safety for the purposes of the research at hand. For analysis, this research used a structural equation modeling technique, specifically multiple regression, to estimate and assess the number (TCR) and severity of mishaps (DART and DAFWII), in order to gauge the effectiveness of the EM 385 guidelines.

The study used randomly selected contractors from the OSHA Data Initiative (ODI) from the 2008 calendar year as its research population. The contractor mishap data obtained from ODI contained information on the three dependent variables that included the aforementioned TCR, DART, and DAFWII rates. These dependent variables were then merged with the 2008 federal spending data, which contained numerous explanatory variables. This data is broken down into primarily 5 separable influences. These influences include the safety protocol utilized, the project location by OSHA region, the size of the contractor by the number of employees, the type of business ownership and the project solicitation and pricing procedures.

Problem Statement

In 2011, the National Safety Council reported, "The most disabling workplace injuries and illnesses in 2007 amounted to more than $52 billion in direct workers' compensation costs, averaging more than 1 billion dollars per week according to the 2009 Liberty Mutual Safety Index" (Injury Facts, 2011). The report adds that "2006 to 2007 exhibited an 8.9% increase in the cost of the most disabling workplace injuries from $48.6 billion in 2006 to $53.0 billion in 2007" (Injury Facts, 2011). Over the 10-year period from 1998 to 2007, these costs grew to $53.0 billion from $37.1 billion, an increase of 42.8%. After adjusting for inflation, the one-year increase was 5.4% and the 10-year increase was 5.8%. In 2009 there were 3582 deaths, of which the construction industry accounted for 776 or 21.67% of all workplace fatalities. The construction industry has the fourth highest death rate per capita of all work environments. These statistics establish the need for decreases in construction mishaps and an increased awareness of construction safety. The research makes an attempt to determine the effect that the EM 385 has had on reducing the number and severity of mishaps.

Research Questions

The data, which was gathered from the OSHA Data Initiative, focused on general contractors conducting work within the federal government construction sector. The following two research questions were posed to determine if a relationship exists between the number and severity of mishaps and the use of the EM 385:

Research Question #1

What was the effect of the EM 385 on reducing the number of mishaps?

Research Question #2

What was the effect of the EM 385 on reducing the severity of mishaps?

Research Assumptions

Five assumptions are made in order to complete this research with the data available for analysis. These assumptions include:

- Contractors working on projects outside of Department of Defense do not use the EM 385 safety requirements, since it is not mandated for use by their respective federal agencies.
- The number (TCR) and severity of mishaps (DART and DAFWII) reflects the safety performance of contractors, since improved safety performance results in fewer and less severe mishaps.

- The contractor population obtained from ODI and collected in 2008 was randomly selected from high hazard industries, such as construction. Although sources publicly state that contractor selection by ODI is random, the exact methods of collection are withheld from the public in order for OSHA to perform their work of auditing contractors.
- The data self-reported to OSHA, thru ODI, is the most accurate and the only widely assessable data that can be used for research.
- Contractor working within specific federal government construction agencies operate in that sector almost exclusively due to the specialized nature of each federal agency and the qualification and certifications the contractor must possess.

Prior to this study, there has been no formal quantitative assessment of the EM 385, which is used by the DOD, one of the world's largest commissioners of construction contracts. Millions of dollars are spent annually on the safety precautions dictated by the EM385, and more importantly, the safety of millions of construction workers that depend on the effectiveness of these precautions. With 1 to 5 percent of DOD construction budgets being spent on construction safety, the costs incurred overall are significant. Therefore, the effectiveness of these safety efforts needed to be explored and quantified in order to justify the substantial cost of implementing the EM 385.

The objective of the EM 385 is to provide a work environment where fewer people get hurt and the severity of injuries is reduced. The reality is that mishaps will inevitably occur in construction, but a reduction in the number and severity of them is both monetarily and morally imperative. If a correlation between the use of the EM 385 and mishap reduction were established, then other federal agencies would be more likely to adopt the EM 385 as their standard.

The quantitative process utilized in this study can aid in assessing and determining the value that the EM 385 brings to project stakeholders. Prior to this study, the EM 385's effectiveness was quantitatively indeterminable due to the absence of empirical evidence within peer-reviewed literature. This research has the potential to generated new knowledge that can be used to move us toward a safer work environment. As with the 1971 OSHA regulations that brought safety standards and enforcement to the construction world, this research could potentially bring an additional contribution to construction safety through a set of established preconstruction safety submittals used across all construction sectors.

Research Limitations

Several limitations were evident with the collection process of the data, the data available for analysis, and the selected modeling techniques. It is expected that there was going to be inherent issues with working with large government historical datasets. This research compensates for these limitations via robust modeling development and statistical analysis. The research limitations included:

- The data collected contains only 2008 mishap data and no other data for any other year. As such, the results only reflected the number and severity of mishaps within the calendar year 2008.
- The data contains post-accident analysis rather than another safety metric that measures safety before a mishap occurs. This bases contractor safety by determining the number and severity of injuries and/or illnesses, after they have occurred. This

could potentially not reflect the actual safety practices on the jobsite, just the ones that result in mishaps.

- The data obtained from ODI contains errors based on contractor collection methods and/or complacency in gathering and reporting. This is glaringly evident in a thorough assessment of the data contained in the 2008 ODI dataset.
- The data could not be random, leaving the regression techniques utilized questionable.
- There is data omission that could skew the results of the regressions.
- There is a limited population of data from the randomized sampling conducted in 2008.
- The 2008 mishap data does not represent the 2014 mishap rates. 2008 data represents a recessionary collection period, while in 2014 there is an expansion of the economy.
- The EM 385 may enhance internal reporting requirements, but does not ensure the data reported to ODI is accurate. Since ODI data is not widely audited for accuracy, contractors could misrepresent their safety records, as reported to ODI. This is apparent in numerous explanatory variables that reported obviously erroneous information.

Background and History

Insurance costs are rising and workers are dying. That is the reality of the construction industry in America today, with between “1100 and 1300 workers killed per year” (Broderick and Murphy, 2001). Construction in the United States has consistently experienced higher fatality and injury/illness rates. Even with the significant reduction in mishaps over the past century, the construction industry remains to be one of the most dangerous places to work, based on the number and severity of mishaps that occur.

Few construction professionals would argue that worker safety is not a top moral and economic concern for businesses. These concerns are very practical considering the ties to worker compensation premiums. It however is a reality that worker safety is not a foolproof proposition. Safety is hindered by worker behavior, unknown contingencies and limited financial resources. In addition the dynamic nature of the construction workplace is perpetually changing.

The DOD uses the General Duty clause which states "the responsibility for safety management rests clearly on the employer" (USACE, 2008) invariably placing the responsibility of worker and workplace safety on the general contractor. For this reason the Department of Defense has mandated the use of the EM 385. With no direct EM 385 specific documented research, the government has created and used these construction safety guidelines to drive their project safety. These guidelines put significant effort into jobsite specific safety planning, which is different in format and use as compared to other federal agencies that perform construction.

The post-accident cost of safety is significant. Research utilizing 2004 mishap data reveals that disabling injuries had an annual cost of $15.64 billion (Rajendran, 2007). This fact clearly illustrates that worker safety effects business viability. Both productivity and the costs incurred resulting from worker injuries makes performing work safely a key characteristic of a profitable company. A study done in 2009 supports this idea that the more a firm spends on workplace safety, the lower its worker's compensation rates (Huang, 2009). From these findings it can be concluded that mishap reduction is possibly correlated to an increased focus on safety. This increased focus has tangible monetary incentives made real by higher insurance premiums and worker lost time on the project site.

In construction the general contractor bears the liability and responsibility for risks. This is outlined by the prime contracts that are authored by owners and agreed to by general contractors. One of the largest risks general contractors assume under a prime contracts is the responsibility and liability for worker safety. OSHA though the 29 Code of Federal Regulations, states that "In no case shall the prime contractor be relieved of overall responsibility for compliance with the requirements of this part for all work to be performed under the contract" (29 CFR 1926.16).

Historically, worker safety was not a primary concern until the United States turned to manufacturing, from an agricultural based economy. It was at this time that both state and federal governments began to regulate such industries as construction. In 1971 the federal government passed into law the Williams-Steiger Act, commonly known as the OSH Act. Recognizing the inability of legislators to create, monitor and enforce safety standards, congress created the Occupational Safety and Health Agency (OSHA), a federal agency that would perform these essential tasks. Since its inception in 1971, OSHA claims it has made a significant impact on reducing mishaps. OSHA based statistics show that 14,000 workers were killed on the job in 1970, while in 2009 that number fell significantly to approximately 4,340, in spite of the fact that the U.S. employment rate has doubled over that same time period (Occupational Safety and Health, n.d.). "Since the passage of the OSH Act, the rate of reported serious workplace injuries and illnesses has declined from 11 per 100 workers in 1972 to 3.6 per 100 workers in 2009" (Occupational Safety and Health, n.d.), a drop of nearly 68%.

Construction specifically remains to be one of the most danger workplaces, lagging behind almost all other industries while proportionately employing a smaller pool of workers. This can be attributed to many causes, some of which include work environment, complexity, worker behavior and culture. For these reasons, a significant amount of research has been dedicated to the study of construction worker safety. This research stretching from the early 1900's to present day and shows that worker safety would be increased by better project-based control. Since the publication of Heinrich's 1931 classic accident prevention text, it has been widely accepted that the most preventable injuries and illnesses are attributed to the actions of people. With the primary focus of most safety research on engineering controls, behavior based safety research lacks adequacy. For this reason this research could be critical to the construction industry at large.

Safety Mandates

Safety mandates in the United States have been developed and enforced by federal and state government agencies. The Occupational Safety and Health Administration (OSHA), a federal agency, has had a significant impact on mishap rates. From the number to the severity of mishaps, OSHA has reduced mishap rates using numerous engineering and behavior based controls. OSHA's safety mandates represent a key milestone in the history of worker safety. Despite the reduction in mishap rates, construction sites remain to be one of the most hazardous environments to work in. In the United States construction accidents remain a significant economic and social problem, with over 400,000 injuries and 1,200 deaths annually (BLS, 2010).

In a continued effort to increase construction safety, congressional bill HR 1063 proposes numerous changes to the OSH Act that created OSHA. These changes included many administrative and operational modifications that increased the influence and the authority of OSHA. H.R. 1063 was Congress' first major attempt to improve the OSH Act since it was established in an effort to create a safer construction industry, through additional safety mandates. The development of OSHA standards and the revisions contained in HR 1063 were preceded by the development of a safety manual in early part of the 20th century. This Army Corp of Engineers manual, known as the Engineering Manual 385 (EM 385) is used to manage safety on all Department of Defense construction projects.

In an effort to build a strong safety culture the EM 385 was developed by the Army Corp of Engineers (USACE) in March of 1941. This safety planning guide governs safety and health for Department of Defense projects. "While the OSHA standards say little about safety management, the EM 385 addresses this issue in some detail" (Rekus, 2003). Safety management as defined by the EM 385 takes the form of the accident prevention plan, which encompasses a detailed activity hazard analysis. It is important to understand that these safety management mechanisms are project and activity specific outlining the precautions necessary to mitigate the hazards that are inherent in every construction task.

The EM 385 "provides important management information through qualitative post-hazard analysis…This allows project participants to take precautions accordingly against eventual accident reoccurrence" (Wang, 2010). In the EM 385 it states that this manual supplements the safety and health standards (United States Army Corp of Engineers, 2008), outlined by the Code of Federal Regulations. The EM 385 safety planning requirements are meant to initiate and cultivate a safer construction safety and health program. In these guidelines, project specific safety planning is mandated, facilitating clear and concise direction to contractors in performance of construction work. The EM 385 was created to facilitate clear and concise safety guidance, through active safety planning as outlined in Appendix A of the EM 385. Use of the EM 385 serves as one of the key differentiator between Department of Defense construction projects and projects managed under all other federal agencies. Despite the lack of knowledge about accident causes in 1941, the EM 385 developed a mandate for organizational safety planning. The first section of the EM 385, in conjunction with the EM 385's Appendix A, outlines the requirement for safety planning through administrative controls, defined as the Accident Prevention Plan (APP). Through the APP, project specific hazards are identified and mitigating strategies are developed with the purpose of reducing the number and severity of mishaps associated with construction projects.

Safety Guidelines

"Teo et al. (2005) argued that insufficient safety knowledge of workers is one of the major causes of site accidents" (Wang, 2010). This fact supports the idea that safer project sites are ones that have a higher level of safety knowledge amongst the workforce and the project leadership. The APP serves as an essential piece of knowledge for contractors working under the EM 385. This plan ensures awareness, monitors and audits worker safety and outlines the guidelines that are needed to identify potential hazards and communicate them to the workforce. This concept of increased worker awareness resulting in better safety performance is a central tenet in the behavior based safety research that is currently available.

Given the content of behavioral based safety research it can be concluded that controlling behavior is essential to better safety performance. For this reason, development of safety programs, that institute pre-hazard assessment, is becoming more prominent in the construction industry. Making safety a critical dimension of business operations has shown to be an effective business model in construction. With worker compensation rates and the financial consequences following a fatality or serious injury, the cost incurred by a lack of safety can be reduced by modifying the safety culture on the project site. As a basis for guidance, the EM 385 provides contractors planning guidelines for mishap prevention. These guidelines have many safety planning requirements not evident in the OSHA regulations. These administrative items are outlined in Section 1 of the EM385, which gives specific guidance on safety program management.

The focus of safety guidelines should be on the greatest potential for losses. Emphasis on hazard elimination or mitigation is an essential aspect of an effective safety program. By eliminating or mitigating the greatest potential for losses, communication of safety guidelines becomes a key part of successful implementation. It is not a reasonable expectation that guidelines that are not communicated frequently, clearly and consistently will be followed. As with any initiative the implementation phase is where a program, such as safety, has the greatest potential for failure. “A program cannot be implemented if employees do not know the safety requirements” (Terrero, 1997).

With the dynamic nature of construction, the process of guiding workers to perform their work within the scope specific safety guidelines can be a difficult endeavor. Utilizing the EM 385, safety planning and management is directed to contractors, focusing on mishap prevention. Essentially the accident prevention plan creates a management strategy that construction managers utilize during the planning and execution phase of construction. From a safety perspective this document serves as the guide for performance of work with a zero mishap record. The accident prevention plan is "job-specific and will include work to be performed by subcontractors and measures to be taken by the Contractor to control hazards associated with materials, services, or equipment" (USACE, 2008, Section 401.A.11b). The accident prevention plan represents the safety management strategy mandated by the EM 385.

Project Specific Accident Prevention

Project specific accident prevention can be more effective the more specific it is. This requires involvement at the project level must occur with the stakeholders that have direct control of the work being performed. The process of preventing mishaps first begins with understanding why they occur. Once this is understood through qualitative and quantitative post-hazard analysis, on-site leadership can focus the project resources on the specific hazards that exist within each scope of work. This process allows project stakeholders to take precautions necessary for preventing accidents in the future. "Understanding the dependencies between project planning and construction safety is imperative to accident prevention" (Veteto, 1994). Development and use of project specific guideline for onsite safety management can be effective at reducing mishaps.

There are many factors that attribute to accident prevention, through safety management. These include safety policy development, establishing safe working practice through safety training, conducting periodic safety meetings and providing routine safety inspections that serve to establish a hazard mitigation strategy to deal with the hazards that exist. With these elements evident, Department of Defense construction entities, including the Naval Facilities Command (NAVFAC) and the Army Corp of Engineers (USACE) mandated safety planning requirements through division one of the government standard construction specification, known as the Uniform Facility Guide Specification (UFGS). In this specification section, safety requirements are outlined, using the EM 385 as it source document. These safety specifications are only inclusive on federal construction projects and serve as management methods that are unique to Department of Defense funded projects.

Safety planning requirements were originally founded on the federal acquisition regulation clause 52.236-13(c), which states that "if this contract is for construction or dismantling, demolition or removal of improvements with any Department of Defense agency or component, the contractor shall comply with all pertinent provisions of the latest version U.S. Army Corps of Engineers Safety and Health Requirements Manual EM 385-1-1 in effect on the date of the solicitation." (Federal Acquisition Regulation, 1991). From this clause the EM 385 outlines safety planning requirements that are made project specific through formal administrative controls.

Research conducted by Vetoto in 1994 proved that the use of project planning reduces the frequency and severity of mishaps. It would be logical to conclude that a site-specific safety management plan that is a requirement on all Department of Defense construction projects will have the same effect of reducing mishaps. This safety plan requirement is not evident by content or methodology within other federal construction management agencies, since OSHA does not mandate or audit such a requirement. Although some informal and formal safety planning is utilized on projects within other federal agencies, the extensive planning mandates outlined in the EM 385 is not evident.

One key part of the EM 385 is the requirement for development of the Accident Prevention Plan. This project specific document is meant as a plan for contractors to use in order to prevent accident from occurring. “This requirement reflects a well-known safety axiom, that accidents just don't happen, they are caused and identifying and controlling these potential causes will prevent mishaps from occurring” (Rekus, 2003). By definition the project specific accident prevention plan is not a generic document, but a detailed safety plan outlining the management processes that will be used to prevent accidents from occurring.

It is evident from the content requirements of the EM 385, that this guideline is explicit. A contractor must develop and utilize project specific plans for every project, taking the site-specific hazards into account and outlining a plan on how a constructor will build a project safely and methodically. The use of the EM 385 attempts to bridge the gap left from the lengthy safety mandates and the actual construction that takes place on the jobsite. Essentially the EM 385 defines the planning processes that will be used to prevent mishaps, ensure compliance and accountability, in an attempt to foster a positive safety culture. The difference between OSHA regulations and the EM 385 is that OSHA develops the rules for safety and the EM 385 implements them through on-site safety management.

The most important aspect of the EM 385 is the safety planning requirements. The EM 385 requires names and qualifications to be assigned to each construction management position, outlining the safety planning responsibility for jobsite management. The degree of specificity mandated by the EM 385 requires a plan to contend with each and every potential hazard an employee could be exposed to. A fully developed accident prevention plan is by definition over 100 pages of safety planning, due to the content requirements mandated by Appendix A of the EM 385.

"All construction projects, whether large or small, should be preceded by a thorough analysis of the potential health or physical hazards that may be encountered" (Broderick and Murphy, 2001). This analysis is known as the activity hazard analysis by the definition of the EM385. In section 10 of the accident prevention plan the activity hazard analysis is outlined. Section 01.A.09 of the EM 385 states that activity hazard analysis shall be prepared by the contractors performing the work for each definable work activity. It further stipulates that the analysis will define the scope of work, the project specific hazards and the mechanisms used to eliminate or control the hazards that exist. In Appendix B of this document a standard form of activity hazard analysis (AHA) is shown. The AHA shows the project specific nature the EM 385 uses to control safety hazards.

CHAPTER 2

REVIEW OF LITERATURE

Construction safety has historically had a disproportionate number of mishaps. This fact can be attributed to the inherent tendency of human nature to choose productivity over safety. Given this reality, this literature review will take a broad based assessment of safety using the expectancy and domino theory and its application to the construction industry. This theoretical framework links human behavior to accident causation.

The expectancy theory relates to a person's need to maximize pleasure and/or minimize pain (Vroom, 1964). Essentially the expectancy theory states that a person estimates how likely a given behavior will lead to a desired outcome. This theory fueled an argument made by two researchers named William Maloney and James McFillen. Maloney and McFillen (1983) argued that the need for empirical evidence on worker motivation, within the construction industry, was warranted. With this need apparent, subsequent construction safety research focused on behavior-based safety management techniques. This behavior-based safety management research affirmed that improved safety performance is tied to the principles contained in the EM 385. These principles included such behavior-based concepts such as enforcement of safety standards, orientation of new workers, job specific safety planning, safety accountability and safety inspections.

Through research on behavior-based theories it became apparent that fewer and less severe mishaps can be associated with safety practices that emphasize human behavior. This concept was built upon Heinrich's Domino Theory. In his 1930 research, Heinrich established the theory that accident causation consisted of five elements (Heinrich, 1930). These elements were sequential in nature and moved from the social environment workers occupy to the accidents that occur. The central claim in this theory was that worker behavior is the primary cause of accidents. Further research by Rook, Altman, and Swain in 1966, Recht in 1970, Petersen in 1982, and finally Reason in 1990 attempted to not only define human errors that lead to accidents, but also to categorize them for analysis.

Both the expectancy and domino theories helped anchor this research because they revealed that human behavior affects the number and severity of mishaps. Subsequently, this insight led to 40 years of research that has tied safety performance to pre-hazard and pre-accident behavior. The results uncovered by this research have directly influenced the content of the current EM 385. Putting these research findings to practical use, this study has attempted to determine their combined value by assessing the effectiveness of the EM 385.

Safety

Workplace safety has been driven by the 1970 Occupational Safety and Health Act. This legislation was enacted to mitigate a trend of mishap occurrences that have plagued almost every industry in America. Two years after the OSH Act was enacted, the first retrospective case study analysis was done by Dr. Michael Hon Dong. This research tested the OSHA's center-periphery model and looked at multiple counties in California in order to analyze the OSHA's enforcement program (Dong, 1974). The objective of this research was to determine whether or not there was a behavior-based correlation between the number of safety inspections and the number of accidents. No correlation was found by the researchers, who drew upon data from interviews, post-accident analysis and a time series study. This regional industry-wide research did, however, show that there was a probable correlation between safety enforcement and mishap reduction in the construction industry (Dong, 1974). This foundational research showed that within the construction industry mishap reduction could potentially be achieved through the creation and implementation of safety guidelines. 30 years had passed between the creation of the EM 385 and Dong's research, and it was apparent that the EM 385 needed revisions and would soon be affected by Dong's study and by other safety-based research that had occurred since the 1970s, when interest in this area began to grow in quantity and quality.

Technology Management and Safety

Technology management is defined by the Association of Technology, Management, and Applied Engineering (ATMAE) as "the field concerned with the supervision of personnel across the technical spectrum and a wide variety of complex technological systems" (ATMAE, n.d.). A fundamental requirement of technology management programs taught at universities across the nation is instruction in safety and health issues. Construction management falls under the umbrella of technology in most colleges or departments across America's post-secondary educational system.

As subsets of technology management, construction and manufacturing have historically had a disproportionate amount of mishaps in both number and severity. In the safety literature research in manufacturing and construction has been significant to both academics and practitioners. This could be attributed to worker exposure and the historical need for safety in these industries. Technology management is “concerned with the supervision of personnel” (ATMAE, n.d.) and this link to worker safety is an integral piece of supervision from a fiscal and humanitarian perspective.

Safety in Construction

Statistically, construction has been and continues to be one of the most dangerous industries for workers. Because of this, construction has been the focus of numerous studies since the enactment of the 1970 OSH Act. Most of these studies have focused on the physical facet of safety, while fewer have studied the behavioral aspect. These studies have both concentrated on post-hazard and post-accident analysis. In a 2008 study it was found that most safety management programs were being applied in an informal fashion rather than using a safety management model (Hallowell, 2008). Looking at ways to learn from mishaps that have occurred, construction research has attempted to study precautionary techniques to mitigate hazards and prevent accidents.

The EM 385 content has grown in content from 60 to 1045 pages over its 73-year history. This growth in content can be attributed to the safety research and the viable principles that this research has uncovered. The causation between hazard mitigation and accident prevention techniques and the post-hazard and post-accident results is the basis of many safety management principles. This is supported by a 2006 study in which safety management was linked to improved safety performance (Bradbury, 2006). In that same year, other research revealed that selection and incorporation of safety requirements into prime contracts influenced the contractor’s project safety performance. The following sections of this literature review will explore the research findings that correspond to principles utilized in the EM 385. These principles will be paired with the Accident Prevention Plan (APP) content, since implementation of safety standards is the key objective of the EM 385.

Past Research on the EM 385 Principles

Section 1 of the APP is focused on accountability. This section mandates that the major stakeholders in the project, approve and/or concur with the safety plan. The foundation for safety accountability was the research conducted by Dr. Jimmie Hinze in 1976. In this research Hinze (1976) studied the effect of middle management on construction safety. Middle management, as identified by Dr. Hinze, was the project superintendent. Interestingly enough this research also discovered the effects that top management had on project safety. The research findings formed many best practices in safety management; with regard to accountability, however this research discovered that top management’s influence on middle management was significant. The emphasis on safety by top and middle management resulted in a higher concern for safety on the project site. In section 1 of the APP there is a mandate for accountability from both top and middle management. It is not by chance that this plan, which focuses on safety implementation, starts with mandating approval and concurrence by both middle and top management.

Section 2 of the APP contains information on both the project and the organization performing the work. This background information is an important factor to consider prior to commencing construction. This was apparent in a 1997 study done on prequalification and bid evaluations of contractors (Hatush and Skitmore, 1997). This research revealed that financially successful construction companies have a successful history of safety. While the APP is focused on work performance, it is important to analyze the processes and procedures that an organization plans on using. This same section outlines the project description by definable features of work. This information is used in the risk management section of the APP, making the ability to analyze hazards by scope of work critical to risk mitigation.

Section 3 of the APP contains an organization's safety and health policy. Studies completed in 2005 established the positive effect of safety policies on jobsite safety in construction (Teo, Ling, and Chong, 2005). By laying out an organization's safety and health policy, this study revealed that project safety starts with a vision about how an organization views safety. In addition this research also revealed that having a policy in place results in more funds being allocated for safety and better focus on site safety. Similarly this research also revealed that having a project-specific safety policy could be heavily influenced by the project management staff.

Section 4 of the APP requires project safety roles and responsibilities to be outlined. This requirement can be traced back to research that shows causation between mishap reduction and personnel qualifications (Wong, Holt and Cooper, 2000). This research revealed that past experience and qualifications are essential factors in a project's safety and health program. A 2004 research study concluded that the key to a successful safety program is to have a dedicated safety professional that is trained and is active in the project organization (Findley, 2004). This can be attributed to focus, experience and the safety competency that a dedicated safety representative can bring to an organization.

Section 5 of the APP is directed at managing subcontractors. The foundation for this section lies in the theory that management focus on safety drives safety performance (Huang and Hinze, 2006). This reality was attributed to management using time and monetary resources to drive their safety program. The use of these resources pointed to a few specific management actions that led to improved safety performance. These included management talks on safety, making safety equipment readily available and mandating trained safety staff on the project site.

The content in section 6 of the APP can be tied to the foundational research done by Tam (1998). This research showed a strong correlation between safety training and improved safety performance. Tam's study concluded that a focus on safety training within the workforce was the underlying reason for decreases in mishaps. The increased awareness and understanding of accepted methods and the expectation of the organization with regard to safety clearly showed that safety training can reduce mishaps. This was later supported by a 2005 study that linked accidents to a lack of worker training (Teo, 2005).

Research has shown that section 7 of the APP, which details inspection processes, is effective at reducing mishaps. A 2008 study examined the effectiveness of providing workers' compensation premium discounts to safety committees that implemented a mishap prevention program that included workplace inspections (Liu, 2008). This research concluded that the effectiveness of safety inspections on reducing mishaps is apparent in the change in attitude toward safety that these events bring to an organization. Safety tends to be less of a focus when there is no regular enforcement, and this observation is supported by numerous studies. It has been discovered, through research, that safety inspections have a strong correlation to mishap reduction.

Section 8 of the APP addresses accident reporting. Accident reporting has been proven to be an essential part of accident prevention. This section of the APP requires the contractor to outline the means and methods of accident reporting and tracking. While there is nothing that can be done after an accident has occurred, understanding the reason behind an incident is essential to preventing a reoccurrence. In this way, post-accident analysis provides valuable data that can help mitigate the hazards that might lead to a similar mishap. Keeping project-level records, as the EM 385 requires, has also been proven, through post-accident analysis, to reduce the number and severity of mishaps (Garza, Hancher and Decker, 1998). This can be attributed to the accountability associated with measuring the safety performance of project staff and placing more emphasis on specific safety concerns.

Scope-specific safety planning is required under section 9 of the APP. In a foundational safety study on middle management's effect on safety, Hinze (1976) concluded that middle management's effect on safety is a greater emphasis on the importance of planning. Hinze found that including safety in project planning can attribute to fewer and less severe mishaps. Dr. Benner reaffirmed these finding 8 years later when he found that the most effective way to reduce mishaps is to regulate safety through mandated requirements (Benner, 1983). While OSHA has found this to be true, effective implementation and enforcement of these regulations is key to their success. For this reason section 9 of the APP focuses on scope-specific planning to mitigate hazards and avoid mishaps.

The last section of the APP is the most crucial in light of the abundant amount of research available. Section 10 of the APP focuses on risk management processes. Being able to predict mishaps can help make existing safety programs more effective. This fact is the central concept behind activity hazard analysis (AHA). Defining the hazards that exist in each definable feature of work is the objective of each AHA. Research done throughout the 1990s investigated the integration of safety and health activities into project schedules. This research found that having safety merged with the project schedule resulted in precautionary methods that could prevent accidents. AHAs accomplish that by linking schedule activities with definable features of work that are assessed for hazards and then developing a plan to contend with those hazards.

This proactive approach to safety management focuses on implementation of safety standards to reduce the number and severity of mishaps. Adding substance to this research, Garza, Hancher and Decker (1998) uncovered that project safety is improved at the project level (Garza, Hancher and Decker, 1998). This bottom-up approach informed the risk management process that the EM 385 utilizes in its safety program implementation. The focus on a process for identifying, analyzing, and reviewing risks and then implementing plans to minimize those risks is critical to mishap reduction. Another study done in 2008 further supported this assertion by acknowledging that "activity-based quantification of safety risks" (Hallowell, 2008) results in fewer mishaps. It is a common belief in the literature that safety performance is tied to project-level safety management due primarily to the ability to define hazards more specifically. Through qualitative post-hazard and post-accident analysis, workers can take precautions to mitigate and hopefully eliminate accident reoccurrence (Wang, 2010).

Safety Variables

With the link established between safety research and the EM 385, this study had to contend with numerous dependent and explanatory variables that needed to be quantified in order for this analysis to be valid. Causation between the EM 385 and a reduction in mishap quantity and severity was this research's objective, while considering other explanatory variables that could affect this predictive model. The following sections tie safety research to the variable selection utilized in this study. It was through this review of the literature that the dependent and explanatory variables were uncovered and quantified for statistical analysis. Using multiple regression analysis as the statistical technique, this methodical selection allowed for evaluation of each key explanatory and dependent variable.

Safety Metrics

The Paperwork Reduction Act of 1995 forced many organizations within the federal government to rethink the methods and metrics utilized in the way they collected data. OSHA decided that streamlining the way that data was collected while still keeping the quality of measurement accurate was essential to complying with this 1995 act. This requirement for data collection was mandated under the 29 CFR Part 1904, Recording and Reporting Occupational Injuries and Illnesses. To simplify and standardize collection, OSHA decided that the number and severity of mishaps were key factors in the assessment of safety standards.

The TCR, DART and DAFWII rates were founded on a theoretical basis known as the Parkinson Law (Cyril, 1955). Simply stated this law acknowledges that expectations are the key to establishing performance. So by establishing these standard metrics and publishing the averages each year, standards are set for the industry to manage procurement, assess performance and dictate changes. Using these principles, research conducted in 1998 showed that there was a correlation between mishap reduction and keeping records on incident rates (Garza, Hancher and Decker, 1998). It was discovered that upper management awareness of safety performance on a project-specific basis resulted in a tool that management could utilize to analyze, assess and take action. These safety metrics enable OSHA, individual organizations and specific projects to compare, target and provide support to its workers.

Safety by Region

In a 2008 survey of occupational injuries and illnesses, 22 states were found to have a higher number of mishaps than national average, with 14 states experiencing lower than national average rates (BLS, 2011). It is with this reality that the region where the work takes place must be considered as a factor in the assessment of mishap rates. Past research has shown this trend to be true by linking region to safety performance. From a pure statistical perspective, ODI surveys have shown that there are regional variations in safety performance. This has to do with numerous factors, including variation in climate, culture, worker knowledge and most importantly organized labor.

Safety by Size

The size of the project is the primary factor that companies use to determine the necessary crew size that would be required to complete the job. Foundational research done with project superintendents has revealed that smaller organizations in construction tend to have better communication (Hinze, 1976). Through this improved communication, safety becomes much more vital to the crew, project and/or company. The close-knit dynamics of smaller organizations tend to result in fewer mishaps, even when there is an absence of a project and/or organizational safety program. Other research has pointed to the fact that safety has a higher return on investment for smaller projects than larger projects (Jasontek, 2006). While no research has decisively concluded that size is the reason for decreased mishaps, the size of revenue, crew and project was a key variable that this research needed to consider in order to properly assess the EM 385's effectiveness.

Safety by Industry

In each annual report by the BLS, incidence rates are published by industry, sector, and sub-sector. The annual reports are subdivided by these categories due to the effect each sector has on the number and severity of mishaps. In the 2008 Bureau of Labor and Statistics report (BLS, 2008) the sectors that had the highest annual average employment were contained in the building construction sector. This sector was then subdivided into residential and commercial for analysis. The 2008 report showed that by the normalized number and severity of mishaps, commercial construction was a more hazardous industry than residential construction. With this in mind it was essential to this research that the construction sector be considered.

Safety by Contract Type

In studies that focused on pre-project peer reviews (Mcleod, 2012) and management of construction contracts, safety assessment by contract type was a key factor in risk mitigation. Shifting of risk liability from the owner to the contractor through different contract mechanisms resulted in lower risks for owners and higher risks for contractors. The motives behind contractors working under lump-sum and unit-price contracts varied greatly. Contractors working under a lump-sum contract were driven by higher profitability to complete the project more quickly, which resulted in less general requirement costs. Inversely unit-price contracts were driven by the time and cost that were incurred. These contract methods can drive contractors working under lump-sum contracts to assume more safety risks, since the faster a project gets completed, the fewer project overhead costs are incurred. More risk can equate to more mishaps, and for that reason contract type was considered as a variable in this research.

Safety by Solicitation Procedures

Bid prequalification focuses on many aspects of an organization's record of performance. Arguably the most important aspect of any company is the company's safety record. In an article on prequalification importance in a tough economy, Douglas Mcleod stated that in a tough economy such as the one in 2008, lowest bid procurement in the competitive bid world could result in working with contractors with poor safety performance (Mcleod, 2012). Under the negotiated solicitation model, safety can be a key factor in selection, since selection can be based on intangibles, such as past safety performance, rather than on the lowest price. On the other hand, competition could breed better safety performance. An understanding of this variation in safety performance resulted in this research utilizing solicitation procedures as one of its explanatory variables.

Safety by Business Type

Disadvantaged business entities (DBE) under Federal acquisition regulations (FAR, 1991) are required to set aside work for performance in almost every procurement sector. Construction is particularly affected by this requirement due to the large volumes of money involved in the work. Whether these disadvantaged businesses operate as a prime or as a subcontractor, the procurement rules are still applicable. These mandated procurement processes and their effect on DBEs was the focus of research conducted in 2001 (Wilson, 2001). Although this research did not directly address safety performance, it was apparent that federal policies and procedures can affect DBE performance. For that reason this research considered DBEs and the set-asides they were given as a factor in its statistical assessment of the EM 385 and its contribution to a reduction in mishaps.

Summary

This research conducted by numerous peer reviewed studies cited in this literature review, makes the construction sector-wide analysis of the EM 385 a logical step in construction safety research. Keeping with the central concepts of the previous research, this study evaluated an existing and longstanding safety implementation tool directly and quantitatively. This research assessed the effectiveness of this tool, the EM 385, on mishap reduction. Previous peer-reviewed literature showed that specific safety approaches contained in the EM 385 had been proven effective. With that in mind, a sector-wide quantitative assessment of the direct effectiveness of the EM 385 appeared to be warranted. If this research were able to prove quantitatively that the EM 385 indeed enhanced safety, then a case could be made that a wider spread use of the EM 385 processes, whether in part or in total, is warranted. Conversely, this analysis could point to weaknesses in the current system that might suggest other managerial and/or policy adjustments.

CHAPTER 3

METHODOLOGY

The primary objective of this research is to assess whether a quantitative relationship can be determined between the use of the Engineering Manual 385 processes and mishap rates. In the following text the approaches used for data collection and analysis are identified, along with a description of the research protocol utilized.

The Problem

Listed below is the research questions posed by this research:

Research Question #1

What was the effect of the EM 385 on reducing the number of mishaps?

Research Question #2

What was the effect of the EM 385 on reducing the severity of mishaps?

The Model

The following structural equations estimate the causation between the number and severity of mishaps and the use of the EM 385, while partitioning several other key explanatory variables. The predictive analytics dictate the following:

$$Y_i = \beta_0 + \beta_j (EM\ 385_j) + \beta_k(REGION_k) + \beta_l(REV_l) + \beta_m(EMPL_m) + \beta_n(SIZE_n) + \beta_p(PTYPE_p) + \beta_q(CTYPE_q) + \beta_r(SOLIC_r) + \beta_s(DIS_s) + \beta_t(SET_t) + \varepsilon_0$$

Where:

$Y_{i=1}$ = TCR – Total Case Rate

$Y_{i=2}$ = DART – Days Away, Restricted or Transferred

$Y_{i=3}$ = DAFWII – Days Away From Work

β_0 = Intercept

$EM385_{j=1}$ = EM385 - Major Funding Agency Category

$EM385_{j=2}$ = EM385 - Major Agency Category of Contract

$REGION_{k=1}$ = Place of Performance - OSHA Regions 1

(Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, Vermont)

$REGION_{k=2}$ = Place of Performance - OSHA Regions 2

(New Jersey, New York, Puerto Rico, Virgin Islands)

$REGION_{k=3}$ = Place of Performance - OSHA Region 3

(District of Columbia, Delaware, Maryland, Pennsylvania, Virginia, West Virginia)

$REGION_{k=4}$ = Place of Performance - OSHA Region 4

(Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee)

$REGION_{k=5}$= Place of Performance - OSHA Region 5

(Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin)

$REGION_{k=6}$= Place of Performance - OSHA Region 6

(Arkansas, Louisiana, New Mexico, Oklahoma, Texas)

$REGION_{k=7}$= Place of Performance - OSHA Region 7

(Iowa, Kansas, Missouri, Nebraska)

$REGION_{k=8}$= Place of Performance - OSHA Region 8

(Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming)

$REGION_{k=9}$= Place of Performance - OSHA Region 9

(Oakland, San Diego, Phoenix, Honolulu, Las Vegas)

$REGION_{k=10}$= Place of Performance - OSHA Region 10

(Alaska, Idaho, Oregon, Washington)

REV_l= Contractor Size by Revenue ($)

$EMPL_m$= Contractor Size by Employees (#)

$SIZE_n$ = Project Size ($)

$PTYPE_{p=1}$ = Project Type (Residential)

$PTYPE_{p=2}$ = Project Type (Commercial)

$CTYPE_{q=1}$ = Contract Type (Unit Price)

$CTYPE_{q=2}$ = Contract Type (Lump Sum)

$SOLIC_{r=1}$ = Solicitation Procedures (Negotiated)

$SOLIC_{r=2}$ = Solicitation Procedures (Competitive Bid)

$DIS_{s=1}$ = Disadvantaged Business

$DIS_{s=2}$ = Non-Disadvantaged Business

$SET_{t=1}$ = Set-Aside Used

$SET_{t=2}$ = Set-Aside Not Used

ε_0 = Error

Variable Definitions:

TCR - Total number of recordable mishaps as indicated on the OSHA 300A Form. The more mishaps the greater the TCR.

DART - Days away, restricted, and transferred as indicated on the OSHA 300A Form. The more severe the mishap, the greater the DART.

DAFWII - Days away from work as indicated on the OSHA 300A Form. The more severe the mishap, the greater the DAFWII.

EM385 - Major Funding Agency Category: Federal Department that funds & manages construction work (i.e. Department of the Army).

EM385 - Major Agency Category of Contract: Federal Agency that obtains the construction funding from congress (i.e. Department of Defense).

OSHA Region: Occupational Safety and Health Agency region by project location (10 Regions).

Contractor Size by Revenue: Contractor size by the annual company gross revenue in U.S. Dollars.

Contractor Size by Employees: Contractor size by the number of employees employed.

Project Size: Project by U.S. dollar value of awarded contract.

Project Type: Construction sector of project (Residential or Commercial).

Contract Type: Method of procurement by contract type (Lump Sum or Unit Price).

Solicitation Procedures: The number of contractors that bid a construction project (Negotiated (1) or Competitive Bid (>1).

Disadvantaged Business: The disadvantaged business status of contractor performing the construction work.

Set-Aside: The type of limited procurement method used by the federal government to obtain a construction contract (i.e. Minority-Owned, Veteran-Owned, etc…).

The Data

The EM 385 was developed and implemented by the United States Army Corp of Engineers with the objective of reducing mishaps. In the following years, all other Department of Defense agencies adopted the use of EM 385 with this same objective. This research collected data from Government databases that track and record construction related mishaps. This database is an assembly of data obtained from the OSHA Data Initiative. Due to an absence of explanatory variables, more data was needed in order to properly partition explanatory variables within the regression model. This data for these explanatory variables was obtained from the Federal Spending database. These two databases were then merged for calendar year 2008, since that year OSHA targeted the construction industry for assessment.

The OSHA Data Initiative (ODI) gathers data annually from randomly selected contractors within targeted industries, such as construction, due to its high frequency of mishaps (IN.gov, 2013). For this research, the metric of safety performance was the central tenet of concern. The data that this research utilized provided the basis for assessing the effectiveness of the EM 385, from a quantitative perspective, within the 2008 calendar year. The research merged data from two independent sources. This merger utilized common data types between the two databases for use in answering the research questions posed. The common data contained in both databases was contractor name and address. The dependent variables that were obtained to answer the research questions include: the total case rate of mishaps (TCR), the days away, restricted, and transferred (DART) and the days away from work (DAFWII). The TCR reflects the number of mishaps, while DART and DAFWII reflect the severity of those mishaps. Data for TCR, DART and DAFWII were available by contractor name and address in the ODI database.

Listed below are several definitions to further explain these three dependent variables:

Case rates: These "represent the number of injuries and illnesses per 100 full-time workers and were calculated as: (N / EH) X 200,000 where

N = number of injuries and illnesses

EH = total hours worked by all employees during the calendar year

200,000 = Base for 100 full-time equivalent workers (working 40 hours per week, 50 weeks per year). Days away from work cases include those that result in days away from work with or without job transfer or restriction" (Bureau of Labor and Statistics, 2010).

Injury or illness: “An injury or illness is an abnormal condition or disorder. Injuries include cases such as, but not limited to, a cut, fracture, sprain, or amputation. Illness includes both acute and chronic illnesses, such as, but not limited to, a skin disease, respiratory disorder, or poisoning” (1960.2 Occupational Safety and Health, 2012).

A correlation matrix was examined for the explanatory variable to assess multicollinearity issues, as shown in Appendix C of this document. Once this was completed a multiple regression analysis was performed using SPSS. Using a multiple regression analysis allowed the research to assess the significance of key explanatory variables possibly contributing to the mishap rates that can predict the behaviors related to the frequency and severity of mishaps.

Target Population

Historically construction has been one of the most dangerous work environments. This can be attributed to the worker hazard exposure, lack of training and numerous other safety related issues. In this research the safety records of contractors is assessed by utilizing post-accident analysis. The targeted population utilized in this research was construction contractors that operated within the federal construction arena. By utilizing a post-accident analysis, this research used the ODI randomly selected populations to assess the effectiveness of the EM385.

Accessible Population

For the purpose of this study, a random sample of data from the OSHA Data Initiative (ODI) was used. ODI through its yearly collection process targeted the construction industry in 2008 for analysis. This was due to the disproportion number and severity of mishaps that have historically plagued construction. Within this targeted industry, construction contractors were then randomly selected. Due to a lack of explanatory variables available in the ODI database, gathering of additional data was necessary in order to perform this research. This additional data was collected using the Federal Spending database, which contained contractor and project specific demographics data. ODI's data represents the only large scale collection of mishap data available at the present time. Annually ODI attempts to collect 80,000 samples of data, randomly selected in targeted high-hazard industries. In 2008, the year this research data was collected, ODI targeted the construction industry by randomly selecting 190 construction contractors, performing work on over three thousand federal projects. This summary of data represents the most accurate and only large scale data collection of contractor safety data currently available.

Database Assembly

A multiple regression analysis was used to test the effectiveness of the EM385 on the number and severity of mishaps. To begin the analysis, the ODI database for NAICS 236220, 236210,236116, 236115 was collected from the 2008 OSHA Data Initiative. This information contained the Contractor Name, Contractor address, TCR, DART and DAFWII for contractors in both the residential (236115 & 236116) and commercial (236220 & 236210) construction sectors. This information was then merged with every project each contractor on the ODI list performed.

At this point the database contained all project for contractors performing work in any year within the past decade. From this dataset, the projects from 2008 were extracted, since the dependent variables obtained were from ODI data collection for calendar year 2008. In this 2008 project database, every project was then grouped by construction contractor. Where variations occurred in the research data, an assumption was made based on the quantity of data given. From this database a proxy for the EM385 needed to be identified. The EM385 proxy is a key variable to this research that requires special care and consideration. The EM 385 proxy is generated from two variables within the merged database.

The first variable is the federal contracting agency and the second being the funding agency. The federal government can issue contracts through one agency (i.e. Department of Transportation), while using a different agency to provide the funds for that contract (i.e. Department of Army). In these cases, the agency that issues the contract is the contracting agency, while the agency that provided the funding is the funding agency. Both the contracting and funding agency's data was utilized for the proxy since the United States Federal Acquisition Regulation states that "If this contract is for construction or dismantling, demolition or removal of improvements with any Department of Defense agency or component, the Contractor shall comply with all pertinent provisions of the latest version of U.S. Army Corps of Engineers Safety and Health Requirements Manual, EM 385–1–1, in effect on the date of the solicitation" (FAR 52.236-13).

In order to conduct this research the contracting and funding agency data needed to be merged to accurately reflect use of the EM 385. The contracting and the funding agency merger were each given a dummy variable of 1 to any data source with any direct affiliation with the Department of Defense or any entity thereof. This includes the DOD, Army, Navy and Air Force. If these departments are included in either the contracting or funding field, the EM 385 is used as mandated by the Federal Acquisition Regulation. If neither the contracting agency nor the funding agency reflected DOD or a DOD entity, the database was given a dummy variable of 0.

Data Preparation

In order to conduct a statistical analysis of the data, numerous explanatory variables had to be transformed into dummy variables, meaning variables having 2 categories. This initial process was necessary in order to take the raw data and analyze it mathematically. It appears after initial analysis that significance in the R Square could be an issue, given the extensive use of dummy variables. In order to mitigate this issue statistically quantifiable data was utilized for all variables that were numerical and dummy variables were used for all non-numerical data. In addition all large numbers were reduced by a fraction.

Data Analysis

The data analysis was a quantitative study that took randomly selected contractors from the 2008 calendar year, via an OSHA randomized methodology used for industry review, to determine whether there is a relationship between the EM 385 and the reduction in mishaps. "The Agency uses this data to calculate establishment-specific injury/illness rates, and in combination with other data sources, to target enforcement and compliance assistance activities" (OSHA, 2013). Identification and creation of a clear and concise data set was the first step taken in the data analysis for this research. These research factors allowed the data to be partitioned by the factors that affected the number and severity of mishaps. The use of a combination of original and converted data allowed for the evaluation of the explanatory variables. A correlation matrix was completed on all variables to determine if any variables had a high linear relationship. The process of identifying the multicollinearity of variables allows for proper variable selection, since highly correlated variables can cause a lack of validity of the variables within the research model. The sensitivity of highly correlated variables can cause individual variables to act erratically within the model and misrepresent their influence on the dependent variables. For these reasons highly correlated variables were identified and one of the variables was retained in the model, while the others were removed. Finally a series of multiple regressions was performed to assess the explanatory variables' impact on the three dependent variables.

Data Issues

As discussed previously, the data from ODI was merged with the federal spending database that utilized both the contractors name and address and associated it with each explanatory variable identified in the research model. This resulted in the creation of a database that combined the dependent variables with the explanatory variables by project. To complete the data set for the analysis the datasets were combined by contractor, since the explanatory and dependent variables were associated with the contractor and not by project. From this process discrepancies became apparent. These discrepancies were addressed by assessing the explanatory variable and determining the correct variable that should be used for each contractor. The example in Table 1 illustrates this issue and the means by which this research determined the data to utilize in this statistical analysis.

Table 1

Data Merger Discrepancy Sample

Contractor Name	Project Data				
	Contractor # of Employees in Hundreds	NAICS Dummy Variable	Solicitation Procedures - Dummy Variable	Type of Setaside - Dummy Variable	SBA Certified Small Disadvantaged Business
A & K CONSTRUCTION INC	0	0	0	1	0
A & K CONSTRUCTION INC	0	0	0	1	0
A & K CONSTRUCTION INC	0.04	1	1	0	1
A & K CONSTRUCTION INC	0	1	0	-	0
A & K CONSTRUCTION INC	0	0	0	1	0
A & K CONSTRUCTION INC	0	0	0	1	0
A & K CONSTRUCTION INC	0	0	0	1	0
A & K CONSTRUCTION INC	2.34	1	0	1	1
A & K CONSTRUCTION, INC	0	1	0	1	0
A & K CONSTRUCTION, INC	0.04	1	1	1	1
A & K CONSTRUCTION, INC	0.04	1	1	1	1
Conclusions about Contractor's IV	**0.04**	**1**	**0**	**1**	**0**

As shown in Table 1, each of the A&K Construction Inc's explanatory variables was assessed, resulting in conclusions being drawn from the discrepancies between projects as reported by the Federal Spending database. Data that was retained in the final database was based on the quantity of data available that indicated the value of the explanatory variable, since a contractor cannot have more than one characteristic in each explanatory variable. So in the explanatory variable solicitation procedures, there are three "1" values and eight "0" values. It is a reasonable assumption, based on the quantity of the values associated with the contractor, that the contractor operates under the "0" value, rather than the "1" value. The 0 value represents a contractor that negotiates his bids, rather than competitively bids them. Retention of discrepancies data was necessary after removal of discrepancies showed a substantial decrease in degrees of freedom, resulting in findings that lacked significance and validity.

The accuracy of data entry was validated manually through an examination of descriptive values. Missing data was classified as a non-response. Missing data may have the potential to skew the study results, so a close examination of this data was necessary. “If less than 5% of data points are missing in a random pattern from a large data set, the problems are less serious and almost any procedure for handling missing values yields similar results” (Tabachnick and Fidell, 2007). With the percentage of non-responsive data being less than 5% in all explanatory variables used in the final research model (See Table 2), deletion of these contractors will not enhance the results from the data analysis, so the data available was retained in the model. With no evident pattern of non-response data in the explanatory variables, there is no potential for violating the assumption of independence.

Table 2

Missing Data

		TCR	DART	DAFWII	EM385 Proxy	Contractor # of Employees	Solicitation Procedures	OSHA Region 1	OSHA Region 2	OSHA Region 3	OSHA Region 4	OSHA Region 5	OSHA Region 6	OSHA Region 7	OSHA Region 8	OSHA Region 9	OSHA Region 10	Disadvantaged Business
N	Valid	190	190	190	190	190	190	184	184	184	184	184	184	184	184	184	184	190
	Missing	0	0	0	0	0	0	6	6	6	6	6	6	6	6	6	6	0

Validity of Instrument

The research data and the instruments used in the collection of this data were based on the methodology utilized by OSHA. Mishap data from ODI was obtained from the OSHA mandated 300A document that is required to be maintained and submitted by every business entity. With a concern about the validity of this approach, data was gathered from two reliable government sources, that were randomly sampled by the OSHA Data Initiative. This ODI data was then merged with federal spending data that reflected the numerous explanatory variables needed for this research.

Validity addresses how accurately and reliably this research truly reflects reality. In order to improve the internal validity of this research, identification and mitigation of potential bias of the researcher was completed by using an unbiased external data collection process and the regression resulted being verified by an independent statistical expert. All of these methods were employed during the course of this study. For full disclosure, the researcher conducting this research owns a consulting company that actively utilizes the EM 385 for its product development. It was through this for-profit endeavor that the researcher began to question the effectiveness of the EM 385 mandates that were created as a requirement for Department of Defense construction projects. It is with this background that the researcher became interested in whether or not there existed causation between the EM 385 and mishap reduction.

The Methods

The research process is the means by which this research collected, analyzed and applied the data to the research questions posed. Listed below is the sequence the research utilized to determine if a quantifiable causation existed between the dependent and explanatory variables:

1. Stated a substantive research question:

Research Question #1

What was the effect of the EM 385 on reducing the number of mishaps?

Research Question #2

What was the effect of the EM 385 on reducing the severity of mishaps?

2. Stated a null and alternate hypothesis:

Null Hypothesis: The use of the EM 385 does not reduce mishap rates.

Alternate Hypothesis: The use of EM 385 does reduce mishap rates.

If H0 is rejected, there is a significant linear relationship between the dependent and explanatory variables. However if H0 is not rejected, either there is no evidence that a linear relationship between the dependent and explanatory variables or the data from 2008 provides insufficient evidence to conclude a relationship does indeed exist of any kind, positive or negative.

3. Set alpha (Type I error) and described why it was selected: An initial alpha was set at .05 percent as this is often standard practice. A two tailed methodology was employed as some of the explanatory variables have unknown positive or negative impacts on the ODI safety metrics.

4. Stated the statistical technique(s) that will be used: A structural multiple regression equation modeling the effects on the three dependent variables was used.

5. Discuss and describe important assumptions, limitations, and threats to validity related to the specific statistical technique: This is addressed in literature review under the assumptions section.

6. Describe the population, sample and the sampling procedure: The research population comes from a data set where contractors were randomly selected within targeted industries such as construction. The sampling of contractors occurred during 2008 through the OSHA Data Initiative (ODI). While the exact process is confidential, ODI's methodology for collection is focused on a large-scale industry review in order to assess compliance and safety in high hazard industries such as construction. OSHA uses this data to calculate typical injury/illness rates, assist in target enforcement and ensure compliance assistance activities. Using four industry sector codes focused on residential and commercial general contractors, data was extracted from the ODI database. This data reflected general contractors working in construction. Due to a lack of explanatory variables in the ODI database, the contractor data was then merged with the federal spending database to identify contractors working in the federal construction sector. This merger process required contractor data to be extracted from project data that occurred during calendar year 2008. From this process the merger was completed and the database reflected general contractors working on federal projects, with all the associated dependent and explanatory variable necessary to conduct this research.

<u>7. Identify the variables:</u>

Dependent Variables: Number of recordable mishaps (TCR)
Severity of mishaps (DART & DAFWII)

Explanatory Variable: EM 385
Contractor Size by Revenue
Contractor Size by Employees
Project Size
Project Type (Residential or Commercial)
Contract Type
Solicitation Procedures
Place of Performance OSHA Region
Disadvantaged Business
Set-Aside Used

<u>8. Describe the data:</u> The data for this research was acquired from two sources. The first source was data from the OSHA Data Initiative (ODI). This data contained contractor name, address, TCR, DART, DAFWII and year the data was collected. Given an initial lack of explanatory variables found within the ODI database, another source of data was obtained. This data was collected and disseminated by the Federal Spending database. The data from each database was sorted by contractor and then merged. With the two databases a search for data by contractor name and address was then conducted. From this process the data from the federal spending database was then merged with the data from ODI. Data for over three thousand observations, from randomly selected contractors under ODI, were then found within the Federal Spending database. This data merger process combined the three dependent, with ten explanatory variables into one database.

9. Data Preparation:

The data listed below required no preparation for statistical analysis:

Total case rate (TCR)

The days away, restricted, and transfer (DART)

The days away from work (DAFWII)

Contractor Size by Revenue

Contractor Size by Employees

Project Size

The data listed below required preparation for statistical analysis. Dummy Variables were used as follows:

Use of the EM 385: 1=EM385 Use, 0= EM385 Non-Use _=Not Identified

Project Type: 1=Commercial Construction, 0=Residential, _= Not Identified

Contract Type: 1=Fixed Price, 0=Variable Cost, _= Not Identified

Solicitation: 1= Competitive Bid (<1 Bidder),0=Negotiated (1 Bidder), _= Not Identified

Disadvantaged Business:1=DBE Used, 0=No DBE Used, _No DBE identified

In addition to this data preparation, Place of Performance is grouped by OSHA region.

These regions are listed below and were grouped for analysis:

OSHA Regions 1
(Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, Vermont)

OSHA Regions 2
(New Jersey, New York, Puerto Rico, Virgin Islands)

OSHA Region 3
(District of Columbia, Delaware, Maryland, Pennsylvania, Virginia, West Virginia)

OSHA Region 4
(Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee)

OSHA Region 5
(Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin)

OSHA Region 6
(Arkansas, Louisiana, New Mexico, Oklahoma, Texas)

OSHA Region 7
(Iowa, Kansas, Missouri, Nebraska)

OSHA Region 8
(Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming)

OSHA Region 9
(Oakland, San Diego, Phoenix, Honolulu, Las Vegas)

OSHA Region 10
(Alaska, Idaho, Oregon, Washington)

10. Calculate and interpret the results: Multiple regression was utilized to test the causation between the 3 dependent and 10 explanatory variables.

Multiple Regression – Assessment of the causal relationship between explanatory and dependent variable.

Correlation – Assessment of correlation of explanatory variable using a correlation matrix.

11. Display the results of the statistical tests used: This information is contained in the research findings (Chapter 4) of this study.

<u>12. State whether or not the null hypothesis was rejected:</u> This information is contained in the research findings (Chapter 4) of this study.

<u>13. Interpret the results in terms of the substantive question and provided recommendations for future research:</u> This information is contained in the Conclusion section (Chapter 5) of this research, showing the data that has been analyzed and conclusions from data have been developed.

CHAPTER 4

RESULTS

Chapter four discusses the findings of this research. This study was designed to quantitatively assess the effectiveness of the EM385. In this chapter there are several sub-sections that review the data, model and research questions posed, describe the research populations within the research model, test the hypothesis, and offer descriptive statistics along with data analysis and interpretation. The following section presents the findings of this study addressing each research question.

The Final Model

The following is the final structural equation that estimate the causation between the number and severity of mishaps and the use of the EM 385 and other explanatory variables that are significant and/or essential to this research. The final model is as follows:

$$Y_i = \beta_0 + \beta_j (EM\ 385_j) + \beta_k(REGION_k) + \beta_m(EMPL_m) + \beta_r(SOLIC_r) + \beta_s(DIS_s) + \varepsilon_0$$

Where:

$Y_{i=1}$ = TCR – Total Case Rate

$Y_{i=2}$ = DART – Days Away, Restricted or Transferred

$Y_{i=3}$ = DAFWII – Days Away From Work

β_0 = Intercept

$EM385_{j=1}$ = EM385 - Major Funding Agency Category

$EM385_{j=2}$ = EM385 - Major Agency Category of Contract

$REGION_{k=1}$ = Place of Performance - OSHA Regions 1

(Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, Vermont)

$REGION_{k=2}$ = Place of Performance - OSHA Regions 2

(New Jersey, New York, Puerto Rico, Virgin Islands)

$REGION_{k=3}$ = Place of Performance - OSHA Region 3

(District of Columbia, Delaware, Maryland, Pennsylvania, Virginia, West Virginia)

$REGION_{k=4}$ = Place of Performance - OSHA Region 4

(Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee)

$REGION_{k=5}$ = Place of Performance - OSHA Region 5

(Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin)

$REGION_{k=6}$= Place of Performance - OSHA Region 6

(Arkansas, Louisiana, New Mexico, Oklahoma, Texas)

$REGION_{k=7}$= Place of Performance - OSHA Region 7

(Iowa, Kansas, Missouri, Nebraska)

$REGION_{k=8}$= Place of Performance - OSHA Region 8

(Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming)

$REGION_{k=9}$= Place of Performance - OSHA Region 9

(Oakland, San Diego, Phoenix, Honolulu, Las Vegas)

$REGION_{k=10}$= Place of Performance - OSHA Region 10

(Alaska, Idaho, Oregon, Washington)

$EMPL_{m}$= Contractor Size by Employees (#)

$SOLIC_{r=1}$ = Solicitation Procedures (Negotiated)

$SOLIC_{r=2}$ = Solicitation Procedures (Competitive Bid)

$DIS_{s=1}$ = Disadvantaged Business

$DIS_{s=2}$ = Non-Disadvantaged Business

ε_0 = Error

In analysis of the explanatory variables for the final structural equation the p-value significance was assessed. A p-value shows the level of significance, so a low p-value (>.10) shows the probability of occurrence by chance is relatively high. If an explanatory variable did not display a p-value less than .10, the variable could be removed from the model, provided it was not necessary for consideration in the research model. Following several stepwise regression analysis of the explanatory variables, the revised research model became apparent, retaining both explanatory variables with a significant p-value and variables key to answering the research questions posed. Several key explanatory variables in the model had an insignificant p-value (>.10), but were retained due to the importance of the variable in the final regression model.

The following variables were retained in the final research model, due to a significant p-value and/or being essential to assessment of the effectiveness of the EM385:

Dependent Variables (Necessary to assess the number and severity of mishaps):

TCR: Total number of recordable mishaps as indicated on the OSHA 300A form. The more mishaps, the greater the TCR.

DART: Days away, restricted, and transferred as indicated on the OSHA 300A form. The more severe the mishap, the greater the DART.

DAFWII: Days away from work as indicated on the OSHA 300A form. The more severe the mishap, the greater the DAFWII.

Explanatory Variables (Necessary to construct the model to assess the regression results of this research):

EM385 Proxy: Merger of major funding agency category and major agency category of contract.

Major funding agency: Federal department that funds and manages construction work (i.e. Department of the Army).

Major agency category of contract: Federal agency that obtains the construction funding from congress (i.e. Department of Defense). This explanatory variable was retained because the EM385 is the essential variable that is being studied as part of this research.

OSHA Region: OSHA regions by project location (10 Regions). All 10 regions are necessary to assess the differences in location and its effect on safety.

Contractor Size by Employees: Contractor size as determined by the number of employees employed. Even though this is not statistically significant in the final model, the fact remains that considering the size of the contractor is imperative to the number and severity of mishaps. Given a choice between the revenue and employees to quantify the size of the contractor, the data in the number of employees is more accurately based on the data availability and accuracy, meaning that there are more data points on the number of employees that appear to be valid.

Solicitation Procedures: The number of contractors that bid a construction project (Negotiated (1) or Competitive Bid (>1). Even though statistically the results show that the solicitation procedures are insignificant, considering the effect of procurement methods on mishap rates is a key part of this study and should be considered in the final research model.

Disadvantaged Business: This variable represents the disadvantaged business status of contractors that perform the construction work. After assessing numerous explanatory variables, related to disadvantaged businesses, it was decided to assess disadvantaged businesses as a whole, rather than the individual categories. This explanatory variable encompasses numerous categories of disadvantaged business status to include the following:

Historically Underutilized Business Zones (HUBZONE)

Small disadvantaged business

SBA certified small disadvantaged business

Women owned

Veteran owned

Service-Disable veteran owned business

Minority owned business

Women owned small business

Joint venture women owned small business

Small businesses certified as socially and economically disadvantaged

After assessing all of these disadvantaged business categories individually, these 10 variables were combined into one explanatory variable to allow this research to assess the affect disadvantaged businesses had on increasing or decreasing mishap rates. The effect disadvantaged businesses status had on mishap rates was the objective of keeping this variable within the research model.

Explanatory Variables

After a series of statistical analysis, the following final explanatory variables proved to be statistically significant and/or essential to the assessment of the EM 385 effectiveness:

- EM385 Proxy – Explanatory variable to assert the use or non-use of the EM385.
- OSHA Region - Place of performance by project location.
- Contractor Size by Employees - Contractor size by the number of employees.
- Solicitation Procedures - The method used to procure construction projects.
- Disadvantaged Business - The disadvantaged business status of contractors.

Through a systematic process of including 33 variables in the original research model, it is possible that an explanatory variable was omitted. This variable could affect the behavior related to the number and severity of mishaps. While this variable could be essential to this research it is not available given the current data collection model utilized by the federal government. With this in mind, the 5 explanatory variables listed above reflect, and represent, the key data areas needed for this research to be conducted, while considering the significance of the data given by both the ODI and federal spending databases. Shown below in Table 3 through 14 the descriptive statistics of the explanatory variables retained in the final research model:

Table 3

Descriptive Statistics: EM385 Proxy

EM385 Proxy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – Do not use EM385	16	8.4	8.4	8.4
	1 – Use the EM385	174	91.6	91.6	100.0
	Total	190	100.0	100.0	

Table 4

Descriptive Statistics: Contractor # of Employees

Contractor # of Employees					
	Number of Employees Per Hundred	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	30	15.8	15.8	15.8
	.01 - .10	109	58.3	58.3	74.2
	1.01 – 2.00	13	6.7	6.7	78.9
	2.01 – 3.00	6	3	3	81.6
	3.01 – 4.00	4	2	2	83.7
	4.01 – 5.00	1	.5	.5	82.1
	5.01 – 10.00	12	6.1	6.1	88.9
	10.01 – 20.00	6	3	3	94.2
	20.01 – 50.00	3	1.6	1.6	95.8
	50.01 -100.00	4	2.1	2.1	97.9
	100.01 - 500.00	2	1	1	98.9
	501.00 – 1000.00	1	.5	.5	99.5
	1000.00 – 2013.66	1	.5	.5	100.0
	Total	190	100.0	100.0	

Table 5

Descriptive Statistics: Solicitation Procedures

Solicitation Procedures

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – Negotiated Bidding	47	24.7	24.7	24.7
	1 – Competitive Bidding	143	75.3	75.3	100.0
	Total	190	100.0	100.0	

Table 6

OSHA Region 1

OSHA Region 1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – Not OSHA Region 1	177	93.2	96.2	96.2
	1 – Region 1	7	3.7	3.8	100.0
	Total	184	96.8	100.0	
Missing	System	6	3.2		
Total		190	100.0		

Table 7

OSHA Region 2

OSHA Region 2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – Not OSHA Region 2	174	91.6	94.6	94.6
	1 – Region 2	10	5.3	5.4	100.0
	Total	184	96.8	100.0	
Missing	System	6	3.2		
Total		190	100.0		

Table 8

OSHA Region 3

OSHA Region 3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – Not OSHA Region 3	162	85.3	88.0	88.0
	1 – Region 3	22	11.6	12.0	100.0
	Total	184	96.8	100.0	
Missing	System	6	3.2		
Total		190	100.0		

Table 9

OSHA Region 4

OSHA Region 4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – Not OSHA Region 4	139	73.2	75.5	75.5
	1 – Region 4	45	23.7	24.5	100.0
	Total	184	96.8	100.0	
Missing	System	6	3.2		
Total		190	100.0		

Table 10

OSHA Region 5

OSHA Region 5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – Not OSHA Region 5	160	84.2	87.0	87.0
	1 – Region 5	24	12.6	13.0	100.0
	Total	184	96.8	100.0	
Missing	System	6	3.2		
Total		190	100.0		

Table 11

OSHA Region 6

OSHA Region 6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – Not OSHA Region 6	145	76.3	78.8	78.8
	1 – Region 6	39	20.5	21.2	100.0
	Total	184	96.8	100.0	
Missing	System	6	3.2		
Total		190	100.0		

Table 12

OSHA Region 7

OSHA Region 7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – Not OSHA Region 7	172	90.5	93.5	93.5
	1 – Region 7	12	6.3	6.5	100.0
	Total	184	96.8	100.0	
Missing	System	6	3.2		
Total		190	100.0		

Table 13

OSHA Region 8

OSHA Region 8

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – Not OSHA Region 8	172	90.5	93.5	93.5
	1 – Region 8	12	6.3	6.5	100.0
	Total	184	96.8	100.0	
Missing	System	6	3.2		
Total		190	100.0		

Table 14

OSHA Region 9

OSHA Region 9

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 – Not OSHA Region 9	173	91.1	94.0	94.0
	1 – Region 9	11	5.8	6.0	100.0
	Total	184	96.8	100.0	
Missing	System	6	3.2		
Total		190	100.0		

Multicollinearity Analysis

The data analysis began with development of the correlation matrix. With 3 dependent and 14 explanatory variables, multiple correlations were identified as a potential issue. For this reason, a correlation matrix was examined for multicollinearity issues. In the initial research model explanatory variables with a Pearson Correlation of <.60 were assessed. After this assessment the highly correlated explanatory variables were analyzed individually. The explanatory variables that were highly correlated were not retained in the final research model; in fact the model was specifically structured to only include one explanatory variable for each area of behavior.

Highly correlated explanatory variables are highlighted in the correlation matrix shown in Appendix C. The highly correlated variables contained in the initial model are tied to the categories of disadvantaged business entities. With the creation of the disadvantaged business explanatory variable that identified any and all types of disadvantaged business entities, this multicollinearity issue was resolved. In addition federal set-aside projects were highly correlated with a Pearson correlation of .642 with disadvantaged businesses, since set-asides are aimed at providing disadvantaged business entities with exclusive opportunities to win and perform federal projects. In the final model the set-aside variable was removed, while retaining the disadvantaged business variables, which is a compilation of the disadvantaged categories outlined in the explanation of the explanatory variables in the final regression model.

Multiple Regression Analysis

Once identifying and resolving all multicollinearity issues, the multiple regression analysis began. This process analyzed the causation between explanatory variables and dependent variables. Multiple uses of dependent and explanatory variable combinations were regressed in an effort to retain variables that showed causation, with a significant p-value. In addition it was necessary to retain the EM385 proxy, project location, contractor size and method of bid solicitation, regardless of their p-values. This variable selection process was completed in an attempt to develop a research model containing both significant explanatory variables and those that were necessary to assess the effectiveness of the EM385. This process was then repeated by an independent statistics professional to verify these research results.

The R Square from this model was 0.22 for the TCR estimation (see Table 15), 0.13 for DART estimation (see Table 16), and a 0.12 for DAFWII estimation (see Table 17). In these final regression models the explanatory variables have the ability to predict the value of Y, which is the number and severity of mishaps based on the percentage of estimation. These percentages show the variation in the dependent variables that are attributable to the explanatory variables used in this model. The R Square reveals that very little of the variation of the dependent variables is attributable to the explanatory variables due to missing observations, little variation in the data, and behavioral issues with respect to reporting. As revealed in the coefficient analysis in Table 18, 19 and 20, these types of issues has resulted in a low R Square.

Table 15

TCR Model Summary

TCR Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.472[a]	.223	.163	5.30296

Table 16

DART Model Summary

DART Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.363[a]	.132	.065	3.43742

Table 17

DAFWII Model Summary

DAFWII Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.355[a]	.126	.059	2.23218

Table 18

Multiple Regression TCR Coefficient Tables

TCR Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2.044	1.796		1.138	.257
	EM385 Proxy	1.203	1.491	.057	.807	.421
	Contractor # of Employees	-.001	.003	-.031	-.446	.656
	OSHA Region 1	6.232	2.211	.206	2.818	.005
	OSHA Region 2	-.691	1.889	-.027	-.366	.715
	OSHA Region 3	-1.417	1.416	-.080	-1.001	.318
	OSHA Region 4	-1.309	1.167	-.097	-1.122	.263
	OSHA Region 5	1.907	1.385	.111	1.377	.170
	OSHA Region 7	1.141	1.778	.049	.642	.522
	OSHA Region 8	6.620	1.753	.283	3.777	.000
	OSHA Region 9	-.911	1.819	-.037	-.501	.617
	OSHA Region 10	9.707	3.857	.174	2.517	.013
	Solicitation Procedures	.511	.937	.038	.545	.587
	Disadvantaged Business	1.962	.829	.166	2.367	.019

Table 19

Multiple Regression DART Coefficient Table

DART Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.093	1.164		.939	.349
	EM385 Proxy	.761	.967	.059	.787	.432
	Contractor # of Employees	.000	.002	-.009	-.118	.906
	OSHA Region 1	2.675	1.433	.144	1.866	.064
	OSHA Region 2	.048	1.224	.003	.039	.969
	OSHA Region 3	-1.170	.918	-.107	-1.275	.204
	OSHA Region 4	-1.166	.756	-.141	-1.542	.125
	OSHA Region 5	.576	.898	.055	.642	.522
	OSHA Region 7	.067	1.153	.005	.058	.954
	OSHA Region 8	2.380	1.136	.166	2.095	.038
	OSHA Region 9	-1.096	1.179	-.073	-.929	.354
	OSHA Region 10	-2.679	2.500	-.078	-1.071	.286
	Solicitation Procedures	.448	.607	.054	.738	.461
	Disadvantaged Business	1.203	.537	.166	2.238	.027

Table 20

Multiple Regression DAFII Coefficient Table

DAFWII Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.016	.756		.021	.983
	EM385 Proxy	.648	.628	.077	1.033	.303
	Contractor # of Employees	.000	.001	-.027	-.369	.713
	OSHA Region 1	2.249	.931	.187	2.417	.017
	OSHA Region 2	1.431	.795	.141	1.800	.074
	OSHA Region 3	-.184	.596	-.026	-.309	.758
	OSHA Region 4	-.302	.491	-.057	-.614	.540
	OSHA Region 5	.688	.583	.101	1.180	.240
	OSHA Region 7	.334	.748	.036	.446	.656
	OSHA Region 8	.563	.738	.061	.764	.446
	OSHA Region 9	-.663	.766	-.068	-.866	.388
	OSHA Region 10	-1.301	1.624	-.059	-.801	.424
	Solicitation Procedures	.251	.394	.047	.637	.525
	Disadvantaged Business	1.023	.349	.219	2.932	.004

Listed below is an evaluation of the coefficients used in the final research model for the three structural equation models as seen in Table 18, 19 and 20:

EM385 Proxy – The EM385 proxy coefficient is expected to be negative, there should be fewer mishaps, not more. This however is not the result determined in the regression results for all three structural equation models, which is reflected in a positive sign on the coefficient. A positive sign on the coefficient reflects that mishaps increase in all three dependent variable (TCR, DART and DAFWII), when considering the affect the EM385 has on the number and severity of mishaps. The opposite was the expected result, contrary to the hypothesis, which stated that EM385 use would result in a reduction in the number and severity of mishaps, resulting in a negative coefficient. It is important, however, to realize that the p-value lacks significance, so the coefficient result lacks validity.

This result could be due to missing observations, little variation in the data, and behavioral issues with respect to reporting. The limited sample size, the fact this data is only from one calendar year, only a few non-EM385 data points, possible misspecification of the explanatory variable and any omitted variable problems are all possible explanations for the incorrect sign and lack of significance. While the EM385 intent is to reduce mishaps, it may just encourage proper reporting, while businesses outside the control of the EM385 could be underreporting and/or misreporting, whether intentional or not. This could explain the contradictory and erroneous information within the database, as identified during the data merger process. The most likely result is not that the EM385 is causing more mishaps than the control group, but that the data is skewed by a behavior or the data is a misrepresentation of the population as a whole.

This is mathematically concluded by the lack of significance in the p-value, within a series of regression results using data contained in multiple regression models. Given that the coefficients are incorrectly signed and insignificant, nothing can be said about the impact and importance of the EM385 on safety. The EM385 effectiveness on reducing the number and severity of mishaps is inconclusive. If a lack of effectiveness was the result, it could be tied to the behavior of the workers and/or supervisors. This is based on the fact that while the EM 385 encompasses numerous administrative requirements, the planning does not find its way into the daily operations of the workers on site. While extensive safety planning is required under the EM 385, and a formal submittal approval process is necessary, these research results do not quantitatively conclude that safety planning does or does not lead to fewer and less severe mishaps. Given the FAR regulation mandates and the assignment of government representatives to monitor safety, the safety requirements mandated by the EM 385 could or could not be enacted at the worker level. While inspections of safety requirements occur at the government level, the primary daily oversight is left to on-site representatives that are employed by the prime contractor.

With production being a prime focus of general contractors, the perception of safety performance by the workers in the field is that safety is secondary to progress. While general contractors may publicly say safety is their number 1 priority, the reality could be that people are hired and fired based on the timely performance of the work, and not the safety record they possess. There are obviously extremes to this since a gross violation in a high hazard area may be grounds for termination, the vast majority of violations committed are not going to end in termination. However, the focus on timely project completion is imperative to project success due to numerous financial motives. The focus on production over safety translates into tangible consequences when contractors are punished via liquidated damages for not completing a project on time, while safety records are perceived as less important to project success, unless a mishap actually occurs. The focus of the low-bid environment the government utilizes for procurement makes safety a non-factor in performance grading by the government. Correspondingly this lack of grading results in a low importance to the contractor, given the fact future project work is focused more on timely completion and quality, rather than safety.

Contractor Size by Employees: The contractor size coefficient is expected to be negative, however the regression result reflects a positive sign on the severity of mishap coefficients

(DART and DAFWII), while there is a negative sign on the number of mishaps (TCR). A positive sign mathematically would result in the DART and DAFWII to increase because of more employees; however, a negative sign on the TCR would result in the number of mishaps decreasing because of an increase in contractor size by employees. DART and DAFWII coefficient results are contrary to the original hypothesis that an increase in contractor size by employee would result in less severe mishaps, mathematically showing a negative coefficient.

TCR's negative coefficient shows the research assumption could possibly be correct, that the number of mishaps decreases by an increase in contractor size. The incorrect sign on the severity of mishap could be due to the lack of accurate reporting by contractors. Contrary to this premise is that there is possibility that contractors are safer with fewer employees. While this is contrary to what was originally theorized, this is a possibility. The contractor size is a key variable to consider since the more employees, results in more resources that can be attributed to safety. Larger contractors have formal safety policies and procedures, along with designated safety professionals to oversee and monitor safety.

Along that same thought process, smaller contractors have fewer resources to dedicate to safety, so they should have more mishaps that are of greater severity. The research results however show that indeed smaller contractors have more mishaps, however smaller contractor have a greater severity. These conclusions however lack significance in the p-value, so in the end this analysis becomes irrelevant. It is however imperative that this explanatory variable be factored into the final research model, due to its potential effect on the number and severity of mishaps. It appears we can draw no conclusions on the impact of contactor size on the dependent variables of TCR, DART and DAFWII.

OSHA Region – The OSHA Regions coefficients are expected to be half negative and half positive, which is a reflection of the mathematics associated with regression techniques used. The population as a whole is represented, so one-half has fewer mishaps than the other half. A negative sign mathematically would result in the three dependent variables to be reduced because of the place of performance region. The conclusive results reflect that OSHA regions 1 and 8 have more mishaps that are more severe, while OSHA region 10 has a fewer number of mishaps. All other coefficient results by region lack significance in the p-value.

OSHA Region 1 represents projects in the Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island and Vermont areas. This region represents the Northeast portion of America and is heavily unionized in the construction trades. It might be theorized that safety would be improved by the use of organized labor, since safety training through apprenticeships are widely utilized. This however is not represented in the results of this data, with the coefficients being positive. A positive coefficient means that there are more mishaps in this region than the control. With a p-value that is significant the results show that given this data, in calendar year 2008, the heavily unionized northeast region had more mishaps. This could perhaps be attributable to the stringent reporting requirements of unions, not evident in non-unionized areas.

OSHA Region 2 represents projects in New Jersey, New York, Puerto Rico and the Virgin Islands areas. This region represents a diversity of locations since geographically they are not connected. With a mix of unionized and non-unionized labor in the construction trades, this region was difficult to categorize. The data analysis shows that the coefficients are positive for the number of mishaps and negative for the severity of mishaps. A negative coefficient means that there are fewer mishaps in this region, while a positive would mean more mishaps. By interpreting the coefficients it appears that there are more mishaps, but the severity is less. These results are tempered however by the fact that the p-value is only significant on the severity of mishaps. It can be concluded then that given this data, this OSHA region has perhaps less severe mishaps, as compared to the OSHA control region, Region 6.

OSHA Region 3 represents projects in District of Columbia, Delaware, Maryland, Pennsylvania, Virginia and West Virginia. This region is diverse in the labor pools it draws from. Even though these regions are geographically connected, the labor represents a mix of unionized and non-unionized labor. The data analysis shows that the coefficients are negative on both the number and severity of mishaps. A negative coefficient means that there are fewer mishaps in this region. These results are statistically insignificant though, with a p-value greater than .10. As a result no affirmative conclusion can be drawn about this region.

OSHA Region 4 represents projects in the Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina and Tennessee areas. This region represents the southeast portion of America and is not heavily unionized within the construction trades. Using the theory that safety would decline by the use of non-organized labor, due to less safety training, the coefficients would be expected to be positive. This however is not represented in the results of this data, with the coefficients being negative. A negative coefficient means that there are fewer mishaps in this region. With a p-value that is greater than .10 the results however are inconclusive.

OSHA Region 5 represents projects in the Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin areas. This region represents an area of America that is predominantly unionized in the construction trades. It is theorized that safety would be improved by the use of organized labor, because of the safety training requirements of unions and the positive culture unions create around safety. This however is not represented in the results of this data, with the coefficients being positive. A positive coefficient means that there are more mishaps in this region, which is contrary to the theory about union safety training decreases mishaps. However with a p-value that is insignificant the results are not reliable, meaning the results are inconclusive between working in this region and safety performance.

OSHA Region 6 represents projects in the Arkansas, Louisiana, New Mexico, Oklahoma, and Texas areas. This region represents the southwestern areas of America and is not heavily unionized in the construction trades. Using the theory that mishaps would increase by the use of non-organized labor, the coefficients would be expected to be positive. This variable however was excluded from the model because of multicollinearity issues. OSHA Region 6 represents the control for this research on OSHA regions.

OSHA Region 7 represents projects in the Iowa, Kansas, Missouri, and Nebraska areas. This region represents America’s west and is not unionized in the construction trades. Using the theory that mishaps increase by using non-organized labor, the coefficients would be expected to be positive. This is represented in the results of this data, with the coefficients being all positive. A positive coefficient means that there are perhaps more mishaps in this region. In the end, no conclusion can be draw since the p-value lacks significance in all three dependent variables.

OSHA Region 8 represents projects in the Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming areas. This region represents America's northern mid-west region and is not unionized in the construction trades. Using the theory that mishaps increase in areas where non-organized labor is used, the coefficients would be expected to be positive. This is represented in the results of this data, with the coefficients all being positive. A positive coefficient means that there are more mishaps in this region, as compared to other regions. With a p-value significant in the number of mishaps it could be concluded that perhaps this region has a higher number of mishaps. On the severity of mishaps, the DART has a significant p-value, while the DAFWII is insignificant. This contrary data could possibly indicate errors in data reporting, since it is logical that the days away from work would be in line with the days away restricted and transferred. Because of this issue with conflicting data a conclusion cannot be drawn on the severity of mishaps.

OSHA Region 9 represents projects in the Oakland, San Diego, Phoenix, Honolulu, and Las Vegas areas. This region represents the west coast areas and does not have unionized construction trades. The theory that safety declines in areas where non-organized labor is used would result in a coefficient being positive. This is not represented in the number and severity of mishaps, with all the coefficients being negative. A negative coefficient means that there are fewer mishaps in this region and the severity is also lower. With a p-value being insignificant for all three coefficients, no conclusion can be drawn from these research results.

OSHA Region 10 represents projects in the Alaska, Idaho, Oregon, and Washington areas. This region represents the northwestern areas of America, which are not primarily unionized in the construction trades. The theory that safety declines in areas of non-organized labor the coefficients would be expected to be positive. This is represented in the number of mishaps, but not in the severity of mishaps, with the TCR coefficients being positive and the DART and DAFWII being negative. A positive coefficient means that there are more mishaps in this region, but the severity is less. With a p-value significant in the number of mishaps it could be concluded that this region has more mishaps. On the other hand in the severity of mishaps, both coefficients have insignificant p-values. The conclusion that can be drawn about this is that the number of mishaps is perhaps greater in this region.

In summary, OSHA regions effect on safety can be attributed to multiple issues, however this research focused on the union and non-union aspect. This is attributed to the research that has shown safety having a causal link to safety education, worker knowledge, management focus and training. With organized labor focus on apprenticeships, having dedicated safety personnel on the project site and continuous safety training and oversight, the focus on unions in this research is warranted.

Solicitation Procedures: The solicitation procedures coefficient is expected to be negative; however the regression results reflect a positive coefficient. A positive sign on the coefficient would result in the three dependent variables to increase, meaning the number and severity of mishaps would increase. This is contrary to the original hypothesis that stated that more bidders would result in fewer mishaps, resulting in a negative coefficient.

The theory behind the hypothesis is that competition breeds better results, in this case fewer and less severe mishaps. While the results did not show this theory to be true, the sample size and validity of the dependent variables could be questionable. These results, however, lack significance with a p-value greater than .10, so the solicitation procedures used by the government could not be a factor that affects mishap rates. The fact is that data could misrepresent the research population is a more likely conclusion given the lack of significance.

Disadvantaged Business: Disadvantaged Business' coefficient is expected to be positive. This is due to the fact that disadvantaged businesses tend to be smaller, have less experience and lack the professional knowledge gained through experience and formal education. This is shown in the regression results reflecting a positive coefficient. A positive sign on the coefficient would result in the three dependent variables to increase because of the disadvantaged businesses type. This is what the hypothesis expected to see. The hypothesis theorized that disadvantaged businesses have more mishaps with a greater severity, showing a positive coefficient. In all three dependent variables the p-value is significant, so the coefficient results reflect this explanatory variable increase in the number and severity of mishaps.

The EM385 Extraction Model

The following structural equation removed the EM385 explanatory variable from the research model. This was done so a comparative analysis of causation could be assessed between the number and severity of mishaps and the explanatory variables that are significant and/or essential to this research, minus the EM385 variable. This model dictates the following structural equation:

$$Y_i = \beta_0 + \beta_k(REGION_k) + \beta_m(EMPL_m) + \beta_r(SOLIC_r) + \beta_s(DIS_s) + \varepsilon_0$$

Where:

$Y_{i=1}$ = TCR – Total Case Rate

$Y_{i=2}$ = DART – Days Away, Restricted or Transferred

$Y_{i=3}$ = DAFWII – Days Away From Work

β_0 = Intercept

$REGION_{k=1}$ = Place of Performance - OSHA Regions 1

(Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, Vermont)

$REGION_{k=2}$ = Place of Performance - OSHA Regions 2

(New Jersey, New York, Puerto Rico, Virgin Islands)

$REGION_{k=3}$ = Place of Performance - OSHA Region 3

(District of Columbia, Delaware, Maryland, Pennsylvania, Virginia, West Virginia)

$REGION_{k=4}$ = Place of Performance - OSHA Region 4

(Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee)

$REGION_{k=5}$ = Place of Performance - OSHA Region 5

(Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin)

$REGION_{k=6}$= Place of Performance - OSHA Region 6

(Arkansas, Louisiana, New Mexico, Oklahoma, Texas)

$REGION_{k=7}$= Place of Performance - OSHA Region 7

(Iowa, Kansas, Missouri, Nebraska)

$REGION_{k=8}$= Place of Performance - OSHA Region 8

(Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming)

$REGION_{k=9}$= Place of Performance - OSHA Region 9

(Oakland, San Diego, Phoenix, Honolulu, Las Vegas)

$REGION_{k=10}$= Place of Performance - OSHA Region 10

(Alaska, Idaho, Oregon, Washington)

$EMPL_m$= Contractor Size by Employees (#)

$SOLIC_{r=1}$ = Solicitation Procedures (Negotiated)

$SOLIC_{r=2}$ = Solicitation Procedures (Competitive Bid)

$DIS_{s=1}$ = Disadvantaged Business

$DIS_{s=2}$ = Non-Disadvantaged Business

ε_0 = Error

Extraction Model Results

After removing the EM385 from the research model the results reflect that the EM 385's effect on the number and severity of mishaps is inconclusive as seen in Table 21 through 26. This assertion was made after examining the effect that the EM385 variable had on the number and severity of mishaps when retained in the model (Table 21, 22 and 23), and then removed from the model (Table 24, 25 and 26). This attempt to show causation, essentially reviewed the coefficients of all the explanatory variables looking for a change in p-values, R Square, and importance when the EM385 was extracted from the model. As we can see EM 385 removal results are similar and thus the use of the EM385 explanatory variable remains inconclusive.

Table 21

Final Research TCR Model Summary

TCR Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.472[a]	.223	.163	5.30296

Table 22

Final Research DART Model Summary

DART Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.363[a]	.132	.065	3.43742

Table 23

Final Research DAFWII Model Summary

DAFWII Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.355[a]	.126	.059	2.23218

Table 24

EM385 Extracted TCR Model Summary

TCR Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.469[a]	.220	.165	5.29754

Table 25

EM385 Extracted DART Model Summary

DART Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.359[a]	.129	.067	3.43359

Table 26

EM385 Extracted DAFWII Model Summary

DAFWII Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.347[a]	.121	.059	2.23262

In summary the R Square from comparing the final research model to EM385 extracted model shows R Squares that are nearly identical in both models. The R Square in both regression models indicates that the explanatory variables have the ability to predict the value of Y, which is the number and severity of mishaps based on a percentage estimation of 0.22 for the TCR estimation, 0.13 for the DART estimation and 0.12 for the DAFWII estimation. The R Square from both models, with the EM385 Proxy and without, show almost no variation, so it is logical to conclude that the EM385 contribution to the model is indeed insignificant and/or inconclusive. Essentially there is no change with or without the EM385 in the model.

Table 27

Final Research TCR Model Coefficient Table

TCR Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.044	1.796		1.138	.257
	EM385 Proxy	1.203	1.491	.057	.807	.421
	Contractor # of Employees	-.001	.003	-.031	-.446	.656
	OSHA Region 1	6.232	2.211	.206	2.818	.005
	OSHA Region 2	-.691	1.889	-.027	-.366	.715
	OSHA Region 3	-1.417	1.416	-.080	-1.001	.318
	OSHA Region 4	-1.309	1.167	-.097	-1.122	.263
	OSHA Region 5	1.907	1.385	.111	1.377	.170
	OSHA Region 7	1.141	1.778	.049	.642	.522
	OSHA Region 8	6.620	1.753	.283	3.777	.000
	OSHA Region 9	-.911	1.819	-.037	-.501	.617
	OSHA Region 10	9.707	3.857	.174	2.517	.013
	Solicitation Procedures	.511	.937	.038	.545	.587
	Disadvantaged Business	1.962	.829	.166	2.367	.019

Table 28

Final Research DART Model Coefficient Table

DART Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.093	1.164		.939	.349
	EM385 Proxy	.761	.967	.059	.787	.432
	Contractor # of Employees	.000	.002	-.009	-.118	.906
	OSHA Region 1	2.675	1.433	.144	1.866	.064
	OSHA Region 2	.048	1.224	.003	.039	.969
	OSHA Region 3	-1.170	.918	-.107	-1.275	.204
	OSHA Region 4	-1.166	.756	-.141	-1.542	.125
	OSHA Region 5	.576	.898	.055	.642	.522
	OSHA Region 7	.067	1.153	.005	.058	.954
	OSHA Region 8	2.380	1.136	.166	2.095	.038
	OSHA Region 9	-1.096	1.179	-.073	-.929	.354
	OSHA Region 10	-2.679	2.500	-.078	-1.071	.286
	Solicitation Procedures	.448	.607	.054	.738	.461
	Disadvantaged Business	1.203	.537	.166	2.238	.027

Table 29

Final Research DAFWII Model Coefficient Table

DAFWII Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.016	.756		.021	.983
	EM385 Proxy	.648	.628	.077	1.033	.303
	Contractor # of Employees	.000	.001	-.027	-.369	.713
	OSHA Region 1	2.249	.931	.187	2.417	.017
	OSHA Region 2	1.431	.795	.141	1.800	.074
	OSHA Region 3	-.184	.596	-.026	-.309	.758
	OSHA Region 4	-.302	.491	-.057	-.614	.540
	OSHA Region 5	.688	.583	.101	1.180	.240
	OSHA Region 7	.334	.748	.036	.446	.656
	OSHA Region 8	.563	.738	.061	.764	.446
	OSHA Region 9	-.663	.766	-.068	-.866	.388
	OSHA Region 10	-1.301	1.624	-.059	-.801	.424
	Solicitation Procedures	.251	.394	.047	.637	.525
	Disadvantaged Business	1.023	.349	.219	2.932	.004

Table 30

EM385 Extracted TCR Model Coefficient Table

TCR Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	3.133	1.185		2.645	.009
	Contractor # of Employees	-.001	.003	-.030	-.440	.660
	OSHA Region 1	5.977	2.186	.198	2.734	.007
	OSHA Region 2	-.577	1.881	-.023	-.307	.759
	OSHA Region 3	-1.460	1.413	-.082	-1.033	.303
	OSHA Region 4	-1.293	1.166	-.096	-1.109	.269
	OSHA Region 5	1.982	1.380	.115	1.435	.153
	OSHA Region 7	1.288	1.767	.055	.729	.467
	OSHA Region 8	6.654	1.750	.284	3.802	.000
	OSHA Region 9	-.806	1.812	-.033	-.445	.657
	OSHA Region 10	9.854	3.849	.177	2.560	.011
	Solicitation Procedures	.560	.934	.042	.599	.550
	Disadvantaged Business	1.849	.816	.157	2.265	.025

Table 31

EM385 Extracted DART Model Coefficient Table

DART Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.781	.768		2.320	.022
	Contractor # of Employees	.000	.002	-.008	-.112	.911
	OSHA Region 1	2.514	1.417	.136	1.774	.078
	OSHA Region 2	.120	1.219	.008	.099	.922
	OSHA Region 3	-1.197	.916	-.110	-1.307	.193
	OSHA Region 4	-1.156	.755	-.140	-1.530	.128
	OSHA Region 5	.624	.895	.059	.697	.487
	OSHA Region 7	.160	1.145	.011	.140	.889
	OSHA Region 8	2.402	1.134	.167	2.117	.036
	OSHA Region 9	-1.029	1.175	-.069	-.876	.382
	OSHA Region 10	-2.586	2.495	-.076	-1.037	.301
	Solicitation Procedures	.479	.605	.058	.792	.429
	Disadvantaged Business	1.131	.529	.156	2.137	.034

Table 32

EM385 Extracted DAFWII Model Coefficient Table

DAFWII Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.603	.499		1.207	.229
	Contractor # of Employees	.000	.001	-.026	-.361	.719
	OSHA Region 1	2.112	.921	.176	2.292	.023
	OSHA Region 2	1.493	.793	.147	1.883	.061
	OSHA Region 3	-.208	.596	-.029	-.348	.728
	OSHA Region 4	-.293	.491	-.055	-.596	.552
	OSHA Region 5	.728	.582	.107	1.252	.212
	OSHA Region 7	.413	.745	.044	.554	.580
	OSHA Region 8	.582	.738	.063	.789	.431
	OSHA Region 9	-.606	.764	-.063	-.793	.429
	OSHA Region 10	-1.222	1.622	-.055	-.753	.452
	Solicitation Procedures	.278	.394	.052	.706	.481
	Disadvantaged Business	.962	.344	.205	2.796	.006

After comparing the final regression model's explanatory coefficients (Table 27, 28 and 29) to the coefficients where the EM385 was extracted from the model (Table 30, 31 and 32), it was apparent that the EM385 retained or extracted from the model had little to no effect on the other explanatory variables. In all cases the variation was less than a few percent in significance, while all the coefficient signs remained the same. This again confirms the fact that the EM385 contribution to the research model is inconclusive.

Model Strength, Weaknesses and Limitations

A weakness in this research was the discrepancies in the data and the data merger process from project to contractor. Due to this, the research data quality and quantity is questionable. A lack of robustness in the data collection processes performed by the federal spending database calls into question the validity of the data used. The major weakness of this research model is the fact that the data obtained is contradictory in many cases. Take for example the annual revenue by company. In many cases the revenue is $0. This cannot be accurate because when a project is awarded by the federal government the result would be a revenue stream to the contractor.

Mathematically several key items were considered. First the R Square was evaluated since this value predicts the amount of variance accounted for in this model by the explanatory variables used. The R Square represent the ability of our model to accurately represent the variation of the dependent safety variables. Thus, a weakness of the model is its inability to have any useful predictive power. This is a potential weakness of this model, since the R Square is below 0.22 for TCR estimation, 0.13 for DART estimation and 0.12 for DAFWII estimation, in the final regressions performed.

Another key mathematical issue is the p-value needed to be assessed using each explanatory variable. Using the p-values level of less than .10, the final regression model retained 14 variables of the 33 original explanatory variables available, due to the p-values associated with each explanatory variable and the needs of the research to assess each key factor. The removal of 19 explanatory variables could show a weakness in the data.

Finally the degrees of freedom must be considered. In the final regression model, the degrees of freedom are the constant plus the explanatory variables in the equation minus 1. In the residual, known as the error, the degrees of freedom are the sample size minus the constant plus the explanatory variable in the equation. The database used had relatively low degrees of freedom, considering the vast amount of data that was originally available for analysis. This limitation in the degrees of freedom could potentially adversely skew the research results. This is due to the limited sampling size from 2008 and the merger of over 3000 projects into 190 contractors.

In the mathematical assessments listed above, the data appears to be the main issue, with apparent discrepancies, omitted variable bias, possible misspecification within the model and errors contained within the data. The original model considered the major aspects that affect safety, the final model did not allow for all these variables to be used due to the accuracy and significance of the data present in the dataset and the correlation of the explanatory variables. The lack of contractors working outside of the EM385 realm of control is limited in this model, which is the largest concern since it could skew the regression results and conclusions drawn from the analysis.

In this research the original volume of data was a strength. With such a large collection of data available, the potential for valuable analysis is substantial. However the strength was tempered by the accuracy of the data gathered. This could point to a potential weakness if not properly handled during the collection and analysis process. The tendency to analyze data while not considering the issues with data collection is a concern. This is a key concern with the movement of the government to collect more data, utilizing an online data collection system.

With the variety of data used in this model, the need to have structure is important. OSHA has done this well with the development of TCR, DART and DAFWII. This data normalizes the data for ease of interpretation. The federal spending database also structures the data in a readily usable way. By collecting data and structuring it properly, the federal government data is readily categorized into metrics that are regularly reported. While this is a strength, the merger of the data collected is a weakness. With different agencies collecting different data with no process to merge that data makes this weakness difficult to overcome.

The robustness of the data is the main issue with this research. The quality and accuracy of the data collected by the federal government is not audited, hence the data validity is questionable. This is apparent in the obvious erroneous data contained in the multiple datasets used in this research. With the value of the data being collected being imperative to this study and future studies like it, the accuracy of the data is of paramount importance. While the data available from the federal government could be used to help reduce the number and severity of mishaps, the current model of collection and handling is flawed. This is a weakness in this research, while the variety, volume and value are a strength.

Summary

In chapter 4, the model results were presented. This chapter was completed to provide evidence for answering the two research questions posed. Out of the 33 explanatory variables available for analysis, 4 were considered significant. Ten additional variables were retained since they were essential to the behavioral model regardless of their p-value. The domino and expectancy theories establish that safety performance is tied to worker behavior and worker behavior is driven toward production, not safety. Based on this theoretical basis, this study tested the effect each explanatory variable had on each dependent variable that is linked to worker behavior. The study findings indicate that it cannot be determined that there is or is not causation between EM385 and the reduction in the number and severity of mishaps, so the null hypothesis is not rejected.

In an attempt to verify these inconclusive results the EM385 proxy was extracted from the model. When the EM385 proxy was extracted, the variable significance, coefficient value and sign did not change between the final and extracted model. This however cannot serve as substantial proof that the EM385 has no causation to fewer and less severe mishaps.

Chapter 5 will explore the reason for the results that were uncovered in this research. An explanation of why this research did not reject the null hypotheses will be discussed while adding supporting information. The research hypothesis states that there exists a significant and positive causation between the EM385 and the TCR, DART and DAFWII. Issues with the variability of the data put into question the inconclusive research findings. In Chapter 5 an analysis and interpretation of the findings detailed in this chapter will be examined. Lastly, recommendations for further investigation into the issue of construction safety will be provided, in addition to the implications for future policy actions and/or changes.

CHAPTER 5

CONCLUSIONS

Quantitative Conclusions

Quantitative conclusions are the primary objective of this chapter, attempting to draw upon the research results that provide a contribution to the body of knowledge and recommend future research within this research area. The ultimate objective of this research was to determine the impact the EM 385 has on reducing the number and severity of mishaps. The research hypotheses theorized that the EM 385 can reduce the number and severity of mishaps, which is based on the theoretical foundation developed from past research and the current EM385 use across all Department of Defense projects. As indicated in Chapter 4 of this research, the multiple regression analysis indicate four potential conclusions:

- The EM 385 is not effective at reducing the number and severity of mishaps.
- The ODI data utilized does not accurately reflect the number and severity of mishaps.
- The model is misspecified and does not properly represent the behavior of workers within the construction industry.
- The control group used in this research is more effective at reducing the number and severity of mishaps.

The first potential conclusion drawn from the research result is that the EM385 is not effective at reducing the number and severity of mishaps. This could be because of the lack of enforcement, use and/or the effectiveness of the guidelines outlined in the EM 385. While the EM385 does specify many administrative requirements, it does not mandate any significant changes to the OSHA regulations that are prominent in other construction sectors. Essentially the EM385 mandates the project management staff to go through many administrative requirements that are precautionary in nature. These precautionary requirements may not be enforced, lack application to all levels of the project staff and/or are not correctly utilized or specified.

If indeed the EM385 is not effective at reducing mishaps, the application rather than the content of the guide is the most likely cause of this occurrence. As outlined in the literature review that is part of this research, the EM 385 principle and practices are backed by peer reviewed research, and historical mishap reductions through OSHA mandates. For these reasons it is possible that if indeed the EM385 lacks effectiveness the reason for this is most likely caused by the behavior of workers, not the standards that govern them. While this conclusion is a possibility this research does not support the conclusion that the EM385 is or is not effective. The EM385's effectiveness on the number and severity of mishaps is inconclusive based on these research results.

The second conclusion drawn from the research results is that the data collected from ODI and the Federal Spending Database is inaccurate, thus affecting the final regression model and the data analysis process. This is due to contradictory data and omissions within the data. This can be attributed to the behavior of companies to accurately report and/or underreport the number and severity of mishaps, along with the misrepresentation of other explanatory variables. So the logical question is why does this occur? One possible reason is that the reporting of data is not audited, so misreporting and/or underreporting is not scrutinized through verification. While reporting is essential and mandated, the accuracy of reporting is not verified, nor audited. The fact that this information is not verified or audited can make organizations unwilling and/or unconcerned about the accuracy of the data reporting.

When reporting the key mishap metrics to ODI (TCR, DART and DAFWII), the contractor behavior is motivated to only report what is documented on the OSHA 300A form. The contractor will have a tendency to only report what is documented, not what actually occurred. It is also important to note that the ODI data contained within ODI is used by OSHA to target companies for further inquiry and investigation. So the Contractor behavior may be dictated by the incentive to misreport and/or underreport mishaps, since the consequences for accurately reporting are outweighed by the incentive to report inaccurately. As far as the reporting of descriptive data to the Federal Spending database, the Contractor behavior of misreporting is more about fulfilling the requirement for reporting, rather than accurately reporting. At all levels in the chain of information transfer, the focus on compiling the data is the essential, rather than on the accuracy of the data. Since data is transferred several times before final compilation and reporting errors can occur from the contractor to the final data entry by the government personnel. This can most likely be attributed to the lack of importance on accuracy, and the primary focus on reporting.

The third conclusion drawn from the research results is that the research model used does not properly predict a reduction in the number and severity of mishaps. Having a correctly specified research model is important since explanatory variables influence the response of dependent variables. While a thorough analysis and review of past research went into the factors that affect the number and severity of mishaps, the model developed as part of this research could be flawed. For this reason this research could misrepresent the EM385's effectiveness.

Before concluding the model is appropriate to use in assessing the effectiveness of the EM 385, it is important to analyze the R Square and the adjusted R Square. The R Square in this model indicates 22% and 13% for the number and severity of mishaps, respectively. The model predicts that the explanatory variables used in the model accounts for less than ¼ of the total effect of reducing mishaps. While the R Square indicates the amount of variance attributable to the model, in this model only a small amount of the variance is shown. Using numerous explanatory variables that were inserted and extracted from the model, it appears no conclusion can be drawn about the EM 385 effectiveness on reducing the number and severity of mishaps. However, the R Square was reduced significantly by extracting numerous explanatory variables that lacked significant p-values, leaving only a quarter of the model attributable to the variance predicted by this model.

To develop an optimum model given the available data, the explanatory variables that remained in the final multiple regression model reflected significant p-values of less than .10 or are key indicators for this research. This was done even if the coefficient sign was as originally theorized. In addition the adjusted R Square shows that shrinkage can be expected by considering the number of observations and the number of predictor variables. Adjusted R Square takes into account the sample size and in this case the adjusted R Square indicates that the data is accounting for 16% and 6%, respectively, for the number and severity of mishaps. This variance predicted by the model indicates a potential that the combination of explanatory variables chosen in this research do not represent causation between the explanatory and dependent variables.

Each explanatory variable was selected based on their behavior attributable to reduce the number and severity of mishaps. Worker and supervisor behavior is the foundation for each explanatory variable and is the reason these variables were included in the research model. Multiple regression is an effective tool to consider the effect of multiple variables simultaneously, however this statistical tool makes assessing the EM385 not a clear cut proposition. This is due to the combined effect that the chosen explanatory variables have on reflecting the effectiveness of the EM385. In addition it is also important also to consider the fact that the coefficient on the number and severity of mishaps is positive, not negative. As discussed in the results section of this research a positive sign on the coefficient shows that use of the EM385 increases mishaps. This is contrary to the research hypothesis that is based on past research and basic logic. Based on this model, causation between the EM385 and the reduction in number and severity of mishaps cannot be determined, primarily due to the lack of significance of the EM385 coefficient.

The last potential conclusion drawn from the research results is that the control group is more effective at reducing the number and severity of mishaps. The control group contractors work for federal agencies not involved in Department of Defense projects or any entity thereof. While each agency utilizes the same basic OSHA standards, organization and implementation is performed in different ways. It is important to recognize that the control group operates under the same basic mandates as the research group, and the results show that the behavior is not altered by the use of the EM385.

The EM 385 may be a redundant requirement that is unnecessary in reducing the number and severity of mishaps. On the other hand the EM385 does force reporting requirements, which could be attributable to the control group being documented as safer. From a statistical perspective this conclusion is not apparent, since there is no negative coefficient on the EM 385 variable in any of the regressions performed. This could be driven by a small control of contractors working outside the EM385. The lack of contractor data could skew the conclusions drawn from this research. This conclusion is also indeterminable because the EM385 is not significant.

Quantitative Summary

The quantitative model presented did not show that the EM 385 use resulted in fewer and less severe mishaps. These findings do not confirm past research results by the Dong (1974), Bradbury (2006), Hinze (1976) and Findley (2004) that show a causal relationship between the principles and practices used throughout the EM 385. However, the results did not conclude that the EM 385 is not of any value. This is largely due to the problems discussed above with data, sample, population, and variance in the explanatory variables. On the surface the results tend to lead the reader to believe that the EM385 is not effective. While that may or may not be true, we can prove neither quantitatively.

Implications

Safety is the paramount concern on every construction project. Whether driven by monetary or moral concerns, construction safety should be a key aspect of today's construction world. As a basis for reducing mishaps, the Army Corps of Engineers uses the EM 385. The EM 385 is a tactical guide that takes many of the research based theories on safety and applies it to jobsite management. This research started with the premise that if one can quantitatively show that the use of the EM 385 reduces mishaps, then it could be argued that it should be utilized across other construction sectors, segments and industries to reduce mishaps. If the contrary was true then the efficiency of the EM 385 would come into question and require further research before action is taken to revise and/or replace the EM 385.

Policy Conclusions

This work also provided a platform for suggesting policy changes to assist in future research and provide for safer work sites in the construction industry. These conclusions are in fact a necessity in that the data appears to show us nothing about the impact of the EM385. This issue should be corrected in further review and/or enhanced data collection. These policy conclusions are listed below.

Policy Change #1

The data provided by ODI lacks key descriptive data necessary to conduct quantitative research that could potentially help researchers reach quantitative conclusions that would help reduce the number and severity of mishaps. This research was possible through a laborious process of manually linking mishap data with the federal spending database. It is this researches' recommendation that OSHA change its policy on data collection to encompass descriptive data within the OSHA 300A form. This will allow future research and further studies to target trends by contractor and/or project, while considering the effects of descriptive variables.

Policy Change #2

ODI needs to collect additional contractor mishap data from contractors. With the use of modern day technology this requirement can be achievable and can reduce the time commitment for contractors that are selected to submit their OSHA 300A form. More data will assist in better targeting of contractors by ODI and allow for more comprehensive quantitative research results within the construction industry.

Policy Change #3

OSHA, through the use of the ODI, needs to audit the data ODI collects. The quality of the mishap data that is collected is a concern and may be the reason the use of the EM 385 lacked any causation within this research model. The quality of the federal spending data is also a concern given that many pieces of data were omitted or obviously erroneous. This was apparent in descriptive data like contractor gross annual sales equaling $0 for many of the observations. The quality and accuracy of the data was a major concern as our underlying model has strong theoretical basis and none of the regressions during the process, nor in the final result provided for any definitive and significant quantitative conclusions.

Policy Change #4

Safety administrative requirements need to be examined to determine whether or not the behavior matches the objective. The Army Corps of Engineers needs to examine the EM 385 content to match the behavior of the workers to the desired outcomes. Given that the quantitative results are inconclusive, there may be a disconnect between the management of safety and worker safety. Why this is occurring would require a thorough review of the EM 385 in its entirety to ensure that the objective of creating a safer worksite is achieved through various safety management controls outlined in the EM 385. This could result in fewer and/or additional EM385 planning and documentation requirements that could affect the content and the implementation of the EM 385.

Policy Change #5

Workers Compensation claims (EMR data) should be cross-referenced to the data submitted to ODI. This would require a policy change by OSHA to ensure the OSHA 300A matches the claims submitted to workers compensation insurers. The results of this research call into question the quality of the data. Only through the process of verifying the data through an audit and cross-referencing this data, can ODI's collection process provide useful quantitative research results and management outcomes. Accurate data collection procedures and data auditing are paramount to outcomes assessment.

Further Research Recommendations

Given the inconclusive quantitative research results the following additional research is recommended.

Recommendation #1

This research recommends a follow-up study on the effectiveness of the EM385. The follow-up study could be a case study analysis using multiple projects that do and do not use the EM385. The research conducted in this dissertation represents a broad quantitative assessment of the EM385. Further studies should address this research using smaller projects where perhaps many descriptive variables can be controlled. This study did not have that luxury, due to the large dataset analysis completed. A smaller focused study could perhaps correct data control issues and provide a more realistic and quantitative results.

Recommendation #2

When ODI conducts another targeted sampling of the construction industry, this research should be reconstructed. At this point these research results are inconclusive, failing to prove or disapprove quantitatively that causation exists between the EM385 and reducing the number and severity of mishaps. Additional research in different calendar years where ODI targets the construction industry could perhaps provide significant research results. Until this occurs, a definitive recommendation to very specific changes in the EM385 may be premature.

Recommendation #3

Research conducted on the accident prevention plan (APP) would be the next logical research step, following quantifiable research results by a subsequent study as outlined in recommendation #2. Specific research of the APP may help describe the relationship between the EM385 and lower mishaps rates. The APP represented the implementation tool utilized by the principles and practices of the EM385. Within the APP, identifying the key ingredients that will lead to lower and less severe mishaps is important to future implementation.

Recommendation #4

Additional quantitative studies on the EM 385 effectiveness should be conducted with special attention paid to the connection between jobsite behaviors, safety management tools, and data collection. This future course of study could also help identify the issues that are not clear through quantitative study. Since any reduction of mishaps is founded on behaviorally based issues, a qualitative study regarding the behavior aspect of the EM385 would bring greater insight into the EM385's effectiveness. It is through this future research that the variables that affect safety performance can be better assessed.

Recommendation #5

The federal government should conduct a broad based data-oriented and specific analysis of the effectiveness of the EM 385. This could include broader descriptive data collection, perhaps as well as more robust and alternative mishap data collection. The collection of more contractor mishap rates, with descriptive data, could be mandated under the Federal Acquisition Regulation. By conducting this broad based analysis, not only will assessment of the EM385 be possible, but many other descriptive data analyses would be feasible. This descriptive data should focus on contractor and project size, construction sector, business type and ownership and bidding and solicitation procedures. This same descriptive data is currently collected and compiled by the federal spending database.

Currently no broad based assessment of this type is being conducted as only regional districts collect and analyze mishap data.

Summary

In summary, this research has, through detailed analysis, revealed that the EM 385 modeling presented does not quantitatively prove or disapprove the EM385's effectiveness at reducing mishaps. It is important to frame this assertion by realizing that this is based on only 2008 data, using two databases of questionable and un-provable quality. It should be noted as well, that this research does not and cannot suggest that the EM385 is effective. The quantitative results of this study are inconclusive.

While this research has not exhausted the efforts to prove the effect the EM 385 has on reducing mishaps, it does however serve as a start in identifying an issue where future research and policy changes that can help determine the effectiveness of the EM385. With the time, money and resources used by the federal government to utilize this safety guide, it is worth additional evaluation to continue the research in this subject area. The question on whether or not the EM385 provides any value for project safety is critical to the construction industry at large. The EM385 represents a collection of proven safety techniques and practices. In theory these practices and principles will lead to fewer and less severe mishaps, however in this research these results were not apparent.

This research has attempted through historical data analysis to assess causation between a wide variety of explanatory variables and mishap rates. It is that recommended future research utilize alternate data sources that could provide evidence of causation. Using the same research model, with different data sources and theoretical basis, may provide useful results, however changing the model also could be a logical step forward for research on the EM385 effectiveness. Only through these additional steps and continued the research could a conclusive determination be possible.

All of the results point to one conclusion and that is the ability to determine a quantitative relationship between mishap rates and the EM 385 at this point in time, with the available data at hand, is indeterminate. That said, the model originally presented has a strong theoretical basis and changes in data collection and auditing policies may be able to correct the inability of this model to define a significant quantitative relationship.

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APPENDIX A: OSHA 300A FORM

OSHA's Form 300 (Rev. 01/2004)

Log of Work-Related Injuries and Illnesses

Attention: This form contains information relating to employee health and must be used in a manner that protects the confidentiality of employees to the extent possible while the information is being used for occupational safety and health purposes.

Year 20__ __

U.S. Department of Labor
Occupational Safety and Health Administration

Form approved OMB no. 1218-0176

You must record information about every work-related death and about every work-related injury or illness that involves loss of consciousness, restricted work activity or job transfer, days away from work, or medical treatment beyond first aid. You must also record significant work-related injuries and illnesses that are diagnosed by a physician or licensed health care professional. You must also record work-related injuries and illnesses that meet any of the specific recording criteria listed in 29 CFR Part 1904.8 through 1904.12. Feel free to use two lines for a single case if you need to. You must complete an Injury and Illness Incident Report (OSHA Form 301) or equivalent form for each injury or illness recorded on this form. If you're not sure whether a case is recordable, call your local OSHA office for help.

Establishment name ________________

City ____________ State ______

Identify the person			**Describe the case**			**Classify the case** CHECK ONLY ONE box for each case based on the most serious outcome for that case:				**Enter the number of days the injured or ill worker was:**		**Check the "Injury" column or choose one type of illness:** (M)					
								Remained at Work									
(A) Case no.	(B) Employee's name	(C) Job title (e.g., *Welder*)	(D) Date of injury or onset of illness	(E) Where the event occurred (e.g., *Loading dock north end*)	(F) Describe injury or illness, parts of body affected, and object/substance that directly injured or made person ill (e.g., *Second degree burns on right forearm from acetylene torch*)	(G) Death	(H) Days away from work	(I) Job transfer or restriction	(J) Other recordable cases	(K) Away from work	(L) On job transfer or restriction	(1) Injury	(2) Skin disorder	(3) Respiratory condition	(4) Poisoning	(5) Hearing loss	(6) All other illnesses
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					Page totals ➤	___	___	___	___	___	___	___	___	___	___	___	___
												(1) Injury	(2) Skin disorder	(3) Respiratory condition	(4) Poisoning	(5) Hearing loss	(6) All other illnesses

Be sure to transfer these totals to the Summary page (Form 300A) before you post it.

Page __ of __

OSHA's Form 300A (Rev. 01/2004)

Summary of Work-Related Injuries and Illnesses

Year 20__ __

U.S. Department of Labor
Occupational Safety and Health Administration

Form approved OMB no. 1218-0176

All establishments covered by Part 1904 must complete this Summary page, even if no work-related injuries or illnesses occurred during the year. Remember to review the Log to verify that the entries are complete and accurate before completing this summary.

Using the Log, count the individual entries you made for each category. Then write the totals below, making sure you've added the entries from every page of the Log. If you had no cases, write "0."

Employees, former employees, and their representatives have the right to review the OSHA Form 300 in its entirety. They also have limited access to the OSHA Form 301 or its equivalent. See 29 CFR Part 1904.35, in OSHA's recordkeeping rule, for further details on the access provisions for these forms.

Number of Cases

Total number of deaths	Total number of cases with days away from work	Total number of cases with job transfer or restriction	Total number of other recordable cases
______	______	______	______
(G)	(H)	(I)	(J)

Number of Days

Total number of days away from work	Total number of days of job transfer or restriction
______	______
(K)	(L)

Injury and Illness Types

Total number of . . .
(M)

(1) Injuries	____	(4) Poisonings	____
		(5) Hearing loss	____
(2) Skin disorders	____	(6) All other illnesses	____
(3) Respiratory conditions	____		

Post this Summary page from February 1 to April 30 of the year following the year covered by the form.

Public reporting burden for this collection of information is estimated to average 58 minutes per response, including time to review the instructions, search and gather the data needed, and complete and review the collection of information. Persons are not required to respond to the collection of information unless it displays a currently valid OMB control number. If you have any comments about these estimates or any other aspects of this data collection, contact: US Department of Labor, OSHA Office of Statistical Analysis, Room N-3644, 200 Constitution Avenue, NW, Washington, DC 20210. Do not send the completed forms to this office.

Establishment information

Your establishment name ______________________

Street ______________________

City ______________ State ____ ZIP ______

Industry description (*e.g., Manufacture of motor truck trailers*)

____

Standard Industrial Classification (SIC), if known (*e.g., 3715*)

__ __ __ __

OR

North American Industrial Classification (NAICS), if known (*e.g., 336212*)

__ __ __ __ __ __

Employment information (*If you don't have these figures, see the Worksheet on the back of this page to estimate.*)

Annual average number of employees ________

Total hours worked by all employees last year ________

Sign here

Knowingly falsifying this document may result in a fine.

I certify that I have examined this document and that to the best of my knowledge the entries are true, accurate, and complete.

______________________ Company executive ______ Title

(___) ______________ Phone ___/___/___ Date

APPENDIX B: ACTIVITY HAZARD ANALYSIS

Activity Hazard Analysis (AHA)

Activity/Work Task:	Overall Risk Assessment Code (RAC) (Use highest code) ____
Project Location:	**Risk Assessment Code (RAC) Matrix**
Contract Number:	
Date Prepared:	
Prepared by (Name/Title):	
Reviewed by (Name/Title): Josh Fritzgerald (SSHO)	
Notes: (Field Notes, Review Comments, etc.)	

Severity	Probability				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	E	E	H	H	M
Critical	E	H	H	M	L
Marginal	H	M	M	L	L
Negligible	M	L	L	L	L

Step 1: Review each "Hazard" with identified safety "Controls" and determine RAC (See above)

"**Probability**" is the likelihood to cause an incident, near miss, or accident and identified as: Frequent, Likely, Occasional, Seldom or Unlikely.

"**Severity**" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible

Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.

RAC Chart
E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Job Steps	Hazards	Controls	RAC

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements

The AHA shall be reviewed and modified as necessary to address changing site conditions, operations, or change of competent/qualified person's

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01.A.13 Contractor-Required AHA. Before beginning each work activity involving a type of work presenting hazards not experienced in previous project operations or where a new work crew or subcontractor is to perform the work, the Contractor(s) performing that work activity shall prepare an AHA. > See Figure 1-2 for an outline of an AHA. An electronic version AHA may be found on the HQUSACE Safety Office Website.

a. AHAs shall define the activities being performed and identify the work sequences, the specific anticipated hazards, site conditions, equipment, materials, and the control measures to be implemented to eliminate or reduce each hazard to an acceptable level of risk.

b. Work shall not begin until the AHA for the work activity has been accepted by the GDA and discussed with all engaged in the activity, including the Contractor, subcontractor(s), and Government on-site representatives at preparatory and initial control phase meetings.

c. The names of the Competent/Qualified Person(s) required for a particular activity (for example, excavations, scaffolding, fall protection, other activities as specified by OSHA and this manual) shall be identified and included in the AHA. Proof of their competency/qualification shall be submitted to the GDA for acceptance prior to the start of that work activity.

d. The AHA shall be reviewed and modified as necessary to address changing site conditions, operations, or change of competent/qualified person(s).

(1) If more than one Competent/Qualified Person is used on the AHA activity, a list of names shall be submitted as an attachment to the AHA. Those listed must be Competent/Qualified for the type of work involved in the AHA and familiar with current site safety issues.

(2) If a new Competent/Qualified Person (not on the original list) is added, the list shall be updated (an administrative action not requiring an updated AHA). T he new person shall acknowledge in writing that he or she has reviewed the AHA and is familiar with current site safety issues.

APPENDIX C: CORRELATION MATRIX

		TCR	DART	DAFWII	EM385 Proxy	Contractor Annual Revenue	Contractor # of Employees	NAICS	Type of Contract Pricing	Solicitation Procedures	Set-Aside	OSHA Region 1	OSHA Region 2	OSHA Region 3	OSHA Region 4	OSHA Region 5	OSHA Region 6	OSHA Region 7	OSHA Region 8	OSHA Region 9	OSHA Region 10
TCR	Pearson Correlation	1	.773**	.616**	.027	-.048	-.057	-.004	.046	.013	.153*	.173*	-.055	-.123	-.185*	.105	-.045	.037	.288**	-.067	.170*
	Sig. (2-tailed)		.000	.000	.707	.509	.438	.960	.530	.860	.041	.019	.458	.096	.012	.158	.546	.618	.000	.366	.021
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
DART	Pearson Correlation	.773**	1	.820**	.028	-.018	-.032	.036	.049	.038	.162*	.137	.010	-.103	-.162*	.097	.027	.024	.199**	-.070	-.072
	Sig. (2-tailed)	.000		.000	.704	.804	.663	.635	.499	.601	.030	.064	.895	.164	.028	.192	.717	.751	.007	.348	.333
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
DAFWII	Pearson Correlation	.616**	.820**	1	.039	-.049	-.049	.033	.043	.015	.249**	.149*	.126	-.056	-.121	.105	-.036	.031	.058	-.097	-.062
	Sig. (2-tailed)	.000	.000		.589	.502	.498	.657	.554	.833	.001	.043	.088	.447	.102	.158	.632	.677	.433	.190	.400
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
EM385 Proxy	Pearson Correlation	.027	.028	.039	1	.039	.033	.040	-.022	.090	-.125	-.148*	.071	-.074	-.015	.056	-.040	.079	-.002	.075	.031
	Sig. (2-tailed)	.707	.704	.589		.591	.651	.599	.763	.218	.097	.044	.335	.319	.836	.447	.591	.288	.981	.311	.674
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Contractor Annual Revenue	Pearson Correlation	-.048	-.018	-.049	.039	1	.123	.082	.019	-.015	-.156*	-.050	-.002	-.044	.045	.002	.026	-.042	-.056	.086	-.027
	Sig. (2-tailed)	.509	.804	.502	.591		.091	.275	.789	.834	.037	.499	.979	.557	.540	.984	.725	.573	.447	.244	.717
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Contractor # of Employees	Pearson Correlation	-.057	-.032	-.049	.033	.123	1	.042	-.007	.052	-.097	-.027	-.016	-.045	.110	.060	-.055	-.035	-.027	-.020	-.014
	Sig. (2-tailed)	.438	.663	.498	.651	.091		.581	.923	.477	.198	.718	.831	.540	.138	.421	.462	.633	.718	.792	.851
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
NAICS	Pearson Correlation	-.004	.036	.033	.040	.082	.042	1	-.024	-.089	.070	-.031	.082	.054	.001	-.092	-.059	.086	.006	-.001	.036
	Sig. (2-tailed)	.960	.635	.657	.599	.275	.581		.747	.234	.370	.688	.285	.482	.986	.228	.438	.260	.933	.985	.641
	N	179	179	179	179	179	179	179	179	179	168	173	173	173	173	173	173	173	173	173	173
Type of Contract Pricing	Pearson Correlation	.046	.049	.043	-.022	.019	-.007	-.024	1	-.042	-.092	.015	.018	.027	.042	-.191**	.038	.020	.020	.019	.008
	Sig. (2-tailed)	.530	.499	.554	.763	.789	.923	.747		.568	.221	.843	.811	.714	.571	.009	.605	.792	.792	.802	.917
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Solicitation Procedures	Pearson Correlation	.013	.038	.015	.090	-.015	.052	-.089	-.042	1	-.172*	.047	-.031	.054	-.029	.070	.017	-.157*	-.003	.037	-.062
	Sig. (2-tailed)	.860	.601	.833	.218	.834	.477	.234	.568		.022	.526	.677	.468	.693	.344	.823	.033	.964	.620	.401
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Set-Aside	Pearson Correlation	.153*	.162*	.249**	-.125	-.156*	-.097	.070	-.092	-.172*	1	.002	-.029	-.032	.003	-.049	.054	.013	.033	-.016	.024
	Sig. (2-tailed)	.041	.030	.001	.097	.037	.198	.370	.221	.022		.974	.708	.677	.972	.521	.481	.863	.668	.838	.757
	N	178	178	178	178	178	178	168	178	178	178	173	173	173	173	173	173	173	173	173	173
OSHA Region 1	Pearson Correlation	.173*	.137	.149*	-.148*	-.050	-.027	-.031	.015	.047	.002	1	-.048	-.073	-.113	-.077	-.103	-.053	-.053	-.050	-.021
	Sig. (2-tailed)	.019	.064	.043	.044	.499	.718	.688	.843	.526	.974		.520	.323	.126	.299	.164	.479	.479	.499	.779
	N	184	184	184	184	184	184	173	184	184	173	184	184	184	184	184	184	184	184	184	184
OSHA Region 2	Pearson Correlation	-.055	.010	.126	.071	-.002	-.016	.082	.018	-.031	-.029	-.048	1	-.088	-.136	-.093	-.124	-.063	-.063	-.060	-.025
	Sig. (2-tailed)	.458	.895	.088	.335	.979	.831	.285	.811	.677	.708	.520		.233	.065	.210	.093	.393	.393	.415	.735
	N	184	184	184	184	184	184	173	184	184	173	184	184	184	184	184	184	184	184	184	184
OSHA Region 3	Pearson Correlation	-.123	-.103	-.056	-.074	-.044	-.045	.054	.027	.054	-.032	-.073	-.088	1	-.210**	-.143	-.191**	-.097	-.097	-.093	-.039
	Sig. (2-tailed)	.096	.164	.447	.319	.557	.540	.482	.714	.468	.677	.323	.233		.004	.053	.009	.189	.189	.210	.603
	N	184	184	184	184	184	184	173	184	184	173	184	184	184	184	184	184	184	184	184	184
OSHA Region 4	Pearson Correlation	-.185*	-.162*	-.121	-.015	.045	.110	.001	.042	-.029	.003	-.113	-.136	-.210**	1	-.220**	-.295**	-.150*	-.150*	-.143	-.060
	Sig. (2-tailed)	.012	.028	.102	.836	.540	.138	.986	.571	.693	.972	.126	.065	.004		.003	.000	.042	.042	.052	.421
	N	184	184	184	184	184	184	173	184	184	173	184	184	184	184	184	184	184	184	184	184
OSHA Region 5	Pearson Correlation	.105	.097	.105	.056	.002	.060	-.092	-.191**	.070	-.049	-.077	-.093	-.143	-.220**	1	-.201**	-.102	-.102	-.098	-.041
	Sig. (2-tailed)	.158	.192	.158	.447	.984	.421	.228	.009	.344	.521	.299	.210	.053	.003		.006	.167	.167	.187	.584
	N	184	184	184	184	184	184	173	184	184	173	184	184	184	184	184	184	184	184	184	184
OSHA Region 6	Pearson Correlation	-.045	.027	-.036	-.040	.026	-.055	-.059	.038	.017	.054	-.103	-.124	-.191**	-.295**	-.201**	1	-.137	-.137	-.131	-.054
	Sig. (2-tailed)	.546	.717	.632	.591	.725	.462	.438	.605	.823	.481	.164	.093	.009	.000	.006		.064	.064	.077	.464
	N	184	184	184	184	184	184	173	184	184	173	184	184	184	184	184	184	184	184	184	184
OSHA Region 7	Pearson Correlation	.037	.024	.031	.079	-.042	-.035	.086	.020	-.157*	.013	-.053	-.063	-.097	-.150*	-.102	-.137	1	-.070	-.067	-.028
	Sig. (2-tailed)	.618	.751	.677	.288	.573	.633	.260	.792	.033	.863	.479	.393	.189	.042	.167	.064		.347	.369	.709
	N	184	184	184	184	184	184	173	184	184	173	184	184	184	184	184	184	184	184	184	184
OSHA Region 8	Pearson Correlation	.288**	.199**	.058	-.002	-.056	-.027	.006	.020	-.003	.033	-.053	-.063	-.097	-.150*	-.102	-.137	-.070	1	-.067	-.028
	Sig. (2-tailed)	.000	.007	.433	.981	.447	.718	.933	.792	.964	.668	.479	.393	.189	.042	.167	.064	.347		.369	.709
	N	184	184	184	184	184	184	173	184	184	173	184	184	184	184	184	184	184	184	184	184
OSHA Region 9	Pearson Correlation	-.067	-.070	-.097	.075	.086	-.020	-.001	.019	.037	-.016	-.050	-.060	-.093	-.143	-.098	-.131	-.067	-.067	1	-.026
	Sig. (2-tailed)	.366	.348	.190	.311	.244	.792	.985	.802	.620	.838	.499	.415	.210	.052	.187	.077	.369	.369		.722
	N	184	184	184	184	184	184	173	184	184	173	184	184	184	184	184	184	184	184	184	184
OSHA Region 10	Pearson Correlation	.170*	-.072	-.062	.031	-.027	-.014	.036	.008	-.062	.024	-.021	-.025	-.039	-.060	-.041	-.054	-.028	-.028	-.026	1
	Sig. (2-tailed)	.021	.333	.400	.674	.717	.851	.641	.917	.401	.757	.779	.735	.603	.421	.584	.464	.709	.709	.722	
	N	184	184	184	184	184	184	173	184	184	173	184	184	184	184	184	184	184	184	184	184
Disadvantaged Business	Pearson Correlation	.150*	.135	.169*	-.174*	-.174*	-.098	.114	.060	-.123	.642**	-.105	-.050	.005	-.003	.044	.009	.053	.053	-.067	.021
	Sig. (2-tailed)	.039	.064	.020	.016	.017	.178	.130	.411	.091	.000	.155	.501	.944	.973	.550	.908	.477	.477	.369	.778
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Hubzone	Pearson Correlation	.004	.074	.097	-.081	-.080	-.045	.040	.025	-.082	.364**	-.065	.002	-.009	.153*	-.019	-.036	-.087	-.087	-.006	.142
	Sig. (2-tailed)	.960	.308	.184	.265	.273	.534	.596	.733	.263	.000	.377	.981	.908	.038	.799	.623	.240	.240	.937	.055
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
SDB	Pearson Correlation	-.007	.044	.077	.013	-.125	-.066	.071	.037	-.192**	.484**	-.098	.003	-.013	.070	.053	-.055	-.019	.036	-.009	-.052
	Sig. (2-tailed)	.918	.546	.291	.855	.086	.364	.343	.613	.008	.000	.185	.972	.863	.345	.474	.461	.795	.626	.906	.486
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
SBA Certified SDB	Pearson Correlation	.091	.103	.147*	-.085	-.024	-.064	.020	.036	-.110	.472**	-.026	-.118	.029	-.026	.012	-.021	.147*	-.019	-.009	.080
	Sig. (2-tailed)	.211	.156	.042	.242	.747	.378	.791	.618	.132	.000	.721	.110	.692	.730	.868	.776	.046	.795	.906	.278
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Women Owned Business	Pearson Correlation	.084	.093	.051	-.087	-.015	-.019	-.004	.018	-.015	.220**	.070	-.060	-.093	.123	-.030	-.019	.026	-.067	.033	-.026
	Sig. (2-tailed)	.248	.203	.482	.232	.839	.792	.956	.805	.842	.003	.347	.415	.210	.096	.690	.802	.724	.369	.656	.722
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Veteran Owned Business	Pearson Correlation	-.022	.002	.018	-.263**	-.073	-.036	.098	.021	-.013	.249**	-.055	.121	.029	-.009	.019	-.039	.013	.013	-.070	-.029
	Sig. (2-tailed)	.767	.979	.805	.000	.316	.625	.192	.771	.858	.001	.460	.102	.695	.905	.796	.597	.860	.860	.348	.697
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Service Disabled Veteran Owned Business	Pearson Correlation	-.025	.000	.006	-.183*	-.062	-.028	.079	.017	.081	.200**	-.048	.154*	-.014	-.025	.050	-.066	.034	.034	-.060	-.025
	Sig. (2-tailed)	.734	.999	.939	.011	.396	.702	.294	.814	.270	.007	.520	.037	.846	.738	.504	.376	.649	.649	.415	.735
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Minority Owned Small Business	Pearson Correlation	.180*	.119	.098	-.122	-.053	-.064	.174*	.038	-.093	.304**	-.101	-.004	.019	-.040	.002	-.035	.246**	.028	-.129	.076
	Sig. (2-tailed)	.013	.103	.178	.093	.464	.383	.020	.607	.202	.000	.171	.959	.799	.586	.981	.641	.001	.702	.082	.305
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Women Owned Small Business	Pearson Correlation	.242**	.211**	.135	-.240**	-.020	-.010	.024	.005	.042	.092	.372**	-.018	-.027	-.042	-.029	-.038	-.020	-.020	-.019	-.008
	Sig. (2-tailed)	.001	.003	.063	.001	.784	.892	.747	.942	.568	.221	.000	.811	.714	.571	.700	.605	.792	.792	.802	.917
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Joint Venture Women Owned Small Business	Pearson Correlation	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]
	Sig. (2-tailed)																				
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Subchapter S-Corporation	Pearson Correlation	.012	-.020	-.016	-.125	-.014	-.022	-.022	.015	.059	.045	.097	.066	.004	.065	-.003	-.111	.052	-.056	-.054	-.022
	Sig. (2-tailed)	.867	.788	.829	.085	.850	.766	.768	.835	.415	.553	.191	.370	.962	.383	.963	.135	.486	.448	.469	.763
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Limited Liability Company	Pearson Correlation	-.001	-.010	-.007	-.041	-.028	-.025	.065	.014	.047	.248**	-.040	.078	.014	-.047	.092	-.034	.063	-.053	-.050	-.021
	Sig. (2-tailed)	.984	.886	.920	.572	.697	.731	.385	.846	.516	.001	.594	.295	.847	.526	.216	.650	.399	.479	.499	.779
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Foreign Owned and Located	Pearson Correlation	-.035	-.017	-.031	.022	-.007	-.009	.024	.005	.042	-.061	-.015	-.018	-.027	.130	-.029	-.038	-.020	-.020	-.019	-.008
	Sig. (2-tailed)	.631	.813	.673	.763	.920	.899	.747	.942	.568	.417	.843	.811	.714	.079	.700	.605	.792	.792	.802	.917
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Corporate Entity	Pearson Correlation	.032	.022	-.010	-.181*	-.061	.276**	.035	.022	.086	.025	.039	-.074	-.054	.049	-.005	-.018	-.003	.075	.004	-.032
	Sig. (2-tailed)	.657	.765	.896	.012	.402	.000	.645	.763	.238	.743	.595	.318	.464	.511	.947	.804	.964	.313	.962	.663
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Partnership or LLC Partnership	Pearson Correlation	-.012	-.023	.017	.075	.082	-.023	.083	.018	-.015	.124	-.050	.041	-.022	.070	-.030	-.075	.026	-.067	.130	-.026
	Sig. (2-tailed)	.864	.748	.815	.303	.261	.750	.270	.805	.842	.098	.499	.584	.764	.346	.690	.314	.724	.369	.079	.722
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Sole Proprietorship	Pearson Correlation	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]
	Sig. (2-tailed)																				
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184
Subcontractor Plan Required	Pearson Correlation	-.165*	-.145	-.177*	.080	.053	.082	.011	-.083	.081	-.005	.047	.017	.119	-.063	-.010	-.056	-.028	-.122	.140	.083
	Sig. (2-tailed)	.031	.058	.021	.298	.491	.284	.890	.282	.293	.949	.547	.829	.127	.422	.903	.474	.720	.120	.074	.286
	N	171	171	171	171	171	171	163	171	171	160	165	165	165	165	165	165	165	165	165	165
8A Contractor	Pearson Correlation	-.079	-.070	-.069	-.051	-.038	-.058	.157*	.035	-.074	.261**	-.093	-.050	.002	-.002	-.013	.070	.106	-.009	-.058	-.049
	Sig. (2-tailed)	.280	.336	.347	.481	.599	.428	.036	.636	.312	.000	.209	.504	.974	.975	.863	.348	.152	.906	.433	.509
	N	190	190	190	190	190	190	179	190	190	178	184	184	184	184	184	184	184	184	184	184

		Disadvantaged Business	Hubzone	SDB	SBA Certified SDB	Women Owned Business	Veteran Owned Business	Service Disabled Veteran Owned Business	Minority Owned Small Business	Women Owned Small Business	Joint Venture Women Owned Small Business	Subchapter S-Corporation	Limited Liability Company	Foreign Owned and Located	Corporate Entity	Partnership or LLC Partnership	Sole Proprietorship	Subcontractor Plan Required	8A Contractor
TCR	Pearson Correlation	.150*	.004	-.007	.091	.084	-.022	-.025	.180*	.242**	.c	.012	-.001	-.035	.032	-.012	.c	-.165*	-.079
	Sig. (2-tailed)	.039	.960	.918	.211	.248	.767	.734	.013	.001		.867	.984	.631	.657	.864		.031	.280
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
DART	Pearson Correlation	.135	.074	.044	.103	.093	.002	.000	.119	.211**	.c	-.020	-.010	-.017	.022	-.023	.c	-.145	-.070
	Sig. (2-tailed)	.064	.308	.546	.156	.203	.979	.999	.103	.003		.788	.886	.813	.765	.748		.058	.336
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
DAFWII	Pearson Correlation	.169*	.097	.077	.147*	.051	.018	.006	.098	.135	.c	-.016	-.007	-.031	-.010	.017	.c	-.177*	-.069
	Sig. (2-tailed)	.020	.184	.291	.042	.482	.805	.939	.178	.063		.829	.920	.673	.896	.815		.021	.347
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
EM385 Proxy	Pearson Correlation	-.174*	-.081	.013	-.085	-.087	-.263**	-.183*	-.122	-.240**	.c	-.125	-.041	.022	-.181*	.075	.c	.080	-.051
	Sig. (2-tailed)	.016	.265	.855	.242	.232	.000	.011	.093	.001		.085	.572	.763	.012	.303		.298	.481
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Contractor Annual Revenue	Pearson Correlation	-.174*	-.080	-.125	-.024	-.015	-.073	-.062	-.053	-.020	.c	-.014	-.028	-.007	-.061	.082	.c	.053	-.038
	Sig. (2-tailed)	.017	.273	.086	.747	.839	.316	.396	.464	.784		.850	.697	.920	.402	.261		.491	.599
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Contractor # of Employees	Pearson Correlation	-.098	-.045	-.066	-.064	-.019	-.036	-.028	-.064	-.010	.c	-.022	-.025	-.009	.276**	-.023	.c	.082	-.058
	Sig. (2-tailed)	.178	.534	.364	.378	.792	.625	.702	.383	.892		.766	.731	.899	.000	.750		.284	.428
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
NAICS	Pearson Correlation	.114	.040	.071	.020	-.004	.098	.079	.174*	.024	.c	-.022	.065	.024	.035	.083	.c	.011	.157*
	Sig. (2-tailed)	.130	.596	.343	.791	.956	.192	.294	.020	.747		.768	.385	.747	.645	.270		.890	.036
	N	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	163	179
Type of Contract Pricing	Pearson Correlation	.060	.025	.037	.036	.018	.021	.017	.038	.005	.c	.015	.014	.005	.022	.018	.c	-.083	.035
	Sig. (2-tailed)	.411	.733	.613	.618	.805	.771	.814	.607	.942		.835	.846	.942	.763	.805		.282	.636
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Solicitation Procedures	Pearson Correlation	-.123	-.082	-.192**	-.110	-.015	-.013	.081	-.093	.042	.c	.059	.047	.042	.086	-.015	.c	.081	-.074
	Sig. (2-tailed)	.091	.263	.008	.132	.842	.858	.270	.202	.568		.415	.516	.568	.238	.842		.293	.312
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Set-Aside	Pearson Correlation	.642**	.364**	.484**	.472**	.220**	.249**	.200**	.304**	.092	.c	.045	.248**	-.061	.025	.124	.c	-.005	.261**
	Sig. (2-tailed)	.000	.000	.000	.000	.003	.001	.007	.000	.221		.553	.001	.417	.743	.098		.949	.000
	N	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	160	178
OSHA Region 1	Pearson Correlation	-.105	-.065	-.098	-.026	.070	-.055	-.048	-.101	.372**	.c	.097	-.040	-.015	.039	-.050	.c	.047	-.093
	Sig. (2-tailed)	.155	.377	.185	.721	.347	.460	.520	.171	.000		.191	.594	.843	.595	.499		.547	.209
	N	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	165	184
OSHA Region 2	Pearson Correlation	-.050	.002	.003	-.118	-.060	.121	.154*	-.004	-.018	.c	.066	.078	-.018	-.074	.041	.c	.017	-.050
	Sig. (2-tailed)	.501	.981	.972	.110	.415	.102	.037	.959	.811		.370	.295	.811	.318	.584		.829	.504
	N	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	165	184
OSHA Region 3	Pearson Correlation	.005	-.009	-.013	.029	-.093	.029	-.014	.019	-.027	.c	.004	.014	-.027	-.054	-.022	.c	.119	.002
	Sig. (2-tailed)	.944	.908	.863	.692	.210	.695	.846	.799	.714		.962	.847	.714	.464	.764		.127	.974
	N	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	165	184
OSHA Region 4	Pearson Correlation	-.003	.153*	.070	-.026	.123	-.009	-.025	-.040	-.042	.c	.065	-.047	.130	.049	.070	.c	-.063	-.002
	Sig. (2-tailed)	.973	.038	.345	.730	.096	.905	.738	.586	.571		.383	.526	.079	.511	.346		.422	.975
	N	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	165	184
OSHA Region 5	Pearson Correlation	.044	-.019	.053	.012	-.030	.019	.050	.002	-.029	.c	-.003	.092	-.029	-.005	-.030	.c	-.010	-.013
	Sig. (2-tailed)	.550	.799	.474	.868	.690	.796	.504	.981	.700		.963	.216	.700	.947	.690		.903	.863
	N	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	165	184
OSHA Region 6	Pearson Correlation	.009	-.036	-.055	-.021	-.019	-.039	-.066	-.035	-.038	.c	-.111	-.034	-.038	-.018	-.075	.c	-.056	.070
	Sig. (2-tailed)	.908	.623	.461	.776	.802	.597	.376	.641	.605		.135	.650	.605	.804	.314		.474	.348
	N	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	165	184
OSHA Region 7	Pearson Correlation	.053	-.087	-.019	.147*	.026	.013	.034	.246**	-.020	.c	.052	.063	-.020	-.003	.026	.c	-.028	.106
	Sig. (2-tailed)	.477	.240	.795	.046	.724	.860	.649	.001	.792		.486	.399	.792	.964	.724		.720	.152
	N	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	165	184
OSHA Region 8	Pearson Correlation	.053	-.087	.036	-.019	-.067	.013	.034	.028	-.020	.c	-.056	-.053	-.020	.075	-.067	.c	-.122	-.009
	Sig. (2-tailed)	.477	.240	.626	.795	.369	.860	.649	.702	.792		.448	.479	.792	.313	.369		.120	.906
	N	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	165	184
OSHA Region 9	Pearson Correlation	-.067	-.006	-.009	-.009	.033	-.070	-.060	-.129	-.019	.c	-.054	-.050	-.019	.004	.130	.c	.140	-.058
	Sig. (2-tailed)	.369	.937	.906	.906	.656	.348	.415	.082	.802		.469	.499	.802	.962	.079		.074	.433
	N	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	165	184
OSHA Region 10	Pearson Correlation	.021	.142	-.052	.080	-.026	-.029	-.025	.076	-.008	.c	-.022	-.021	-.008	-.032	-.026	.c	.083	-.049
	Sig. (2-tailed)	.778	.055	.486	.278	.722	.697	.735	.305	.917		.763	.779	.917	.663	.722		.286	.509
	N	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	165	184
Disadvantaged Business	Pearson Correlation	1	.346**	.589**	.391**	.300**	.315**	.286**	.415**	.088	.c	.094	.237**	-.060	.136	.163*	.c	-.093	.354**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000	.000	.227		.198	.001	.411	.062	.025		.228	.000
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Hubzone	Pearson Correlation	.346**	1	.420**	.300**	.062	.090	-.004	.159*	-.025	.c	.013	.115	-.025	-.104	-.085	.c	-.073	.235**
	Sig. (2-tailed)	.000		.000	.000	.397	.215	.956	.028	.733		.854	.114	.733	.153	.243		.345	.001
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
SDB	Pearson Correlation	.589**	.420**	1	.495**	.265**	.141	.055	.217**	-.037	.c	.088	.108	-.037	.081	-.014	.c	-.138	.263**
	Sig. (2-tailed)	.000	.000		.000	.000	.052	.449	.003	.613		.227	.138	.613	.269	.844		.071	.000
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
SBA Certified SDB	Pearson Correlation	.391**	.300**	.495**	1	.270**	.146*	.000	.161*	.145*	.c	.026	.042	-.036	-.009	.101	.c	-.021	.170*
	Sig. (2-tailed)	.000	.000	.000		.000	.044	1.000	.026	.045		.720	.566	.618	.897	.164		.787	.019
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Women Owned Business	Pearson Correlation	.300**	.062	.265**	.270**	1	-.073	-.058	-.017	.293**	.c	.172*	-.048	-.018	.168*	.035	.c	.019	-.002
	Sig. (2-tailed)	.000	.397	.000	.000		.320	.423	.811	.000		.017	.507	.805	.020	.631		.805	.983
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Veteran Owned Business	Pearson Correlation	.315**	.090	.141	.146*	-.073	1	.805**	.328**	-.021	.c	.036	.254**	-.021	.192**	.178*	.c	-.039	.113
	Sig. (2-tailed)	.000	.215	.052	.044	.320		.000	.000	.771		.624	.000	.771	.008	.014		.617	.122
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Service Disabled Veteran Owned Business	Pearson Correlation	.286**	-.004	.055	.000	-.058	.805**	1	.283**	-.017	.c	.068	.329**	-.017	.268**	.143*	.c	-.031	.070
	Sig. (2-tailed)	.000	.956	.449	1.000	.423	.000		.000	.814		.352	.000	.814	.000	.048		.687	.334
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Minority Owned Small Business	Pearson Correlation	.415**	.159*	.217**	.161*	-.017	.328**	.283**	1	-.038	.c	.020	.036	-.038	.122	.093	.c	-.060	.720**
	Sig. (2-tailed)	.000	.028	.003	.026	.811	.000	.000		.607		.781	.621	.607	.093	.201		.438	.000
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Women Owned Small Business	Pearson Correlation	.088	-.025	-.037	.145*	.293**	-.021	-.017	-.038	1	.c	.347**	-.014	-.005	.240**	-.018	.c	-.071	-.035
	Sig. (2-tailed)	.227	.733	.613	.045	.000	.771	.814	.607			.000	.846	.942	.001	.805		.356	.636
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Joint Venture Women Owned Small Business	Pearson Correlation	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c
	Sig. (2-tailed)																		
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Subchapter S-Corporation	Pearson Correlation	.094	.013	.088	.026	.172*	.036	.068	.020	.347**	.c	1	-.041	-.015	.314**	.060	.c	-.132	.036
	Sig. (2-tailed)	.198	.854	.227	.720	.017	.624	.352	.781	.000			.574	.835	.000	.409		.085	.626
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Limited Liability Company	Pearson Correlation	.237**	.115	.108	.042	-.048	.254**	.329**	.036	-.014	.c	-.041	1	-.014	-.059	-.048	.c	-.014	-.021
	Sig. (2-tailed)	.001	.114	.138	.566	.507	.000	.000	.621	.846		.574		.846	.416	.507		.857	.775
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Foreign Owned and Located	Pearson Correlation	-.060	-.025	-.037	-.036	-.018	-.021	-.017	-.038	-.005	.c	-.015	-.014	1	-.022	-.018	.c	.083	-.035
	Sig. (2-tailed)	.411	.733	.613	.618	.805	.771	.814	.607	.942		.835	.846		.763	.805		.282	.636
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Corporate Entity	Pearson Correlation	.136	-.104	.081	-.009	.168*	.192**	.268**	.122	.240**	.c	.314**	-.059	-.022	1	-.075	.c	-.020	.100
	Sig. (2-tailed)	.062	.153	.269	.897	.020	.008	.000	.093	.001		.000	.416	.763		.303		.795	.168
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Partnership or LLC Partnership	Pearson Correlation	.163*	-.085	-.014	.101	.035	.178*	.143*	.093	-.018	.c	.060	-.048	-.018	-.075	1	.c	.044	-.060
	Sig. (2-tailed)	.025	.243	.844	.164	.631	.014	.048	.201	.805		.409	.507	.805	.303			.569	.414
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Sole Proprietorship	Pearson Correlation	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c	.c
	Sig. (2-tailed)																		
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190
Subcontractor Plan Required	Pearson Correlation	-.093	-.073	-.138	-.021	.019	-.039	-.031	-.060	-.071	.c	-.132	-.014	.083	-.020	.044	.c	1	-.096
	Sig. (2-tailed)	.228	.345	.071	.787	.805	.617	.687	.438	.356		.085	.857	.282	.795	.569			.209
	N	171	171	171	171	171	171	171	171	171	171	171	171	171	171	171	171	171	171
8A Contractor	Pearson Correlation	.354**	.235**	.263**	.170*	-.002	.113	.070	.720**	-.035	.c	.036	-.021	-.035	.100	-.060	.c	-.096	1
	Sig. (2-tailed)	.000	.001	.000	.019	.983	.122	.334	.000	.636		.626	.775	.636	.168	.414		.209	
	N	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	171	190

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c. Cannot be computed because at least one of the variables is constant.

VITA

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EDUCATION

MBM Thomas Edison State College, Trenton, NJ, Project Management, 2008.

BS Thomas Edison State College, Trenton, Business Management, 2005.

AS Thomas Edison State College, Trenton, Business Management, 2002.

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PROFESSIONAL EXPERIENCE

2008 – Present Eastern Kentucky University, Richmond, KY
Duties: Instructor of Construction Management

2008 – Present ACE Consulting Company, Nicholasville, KY
Duties: Project Management Consultant

2006-2008 Mason and Hanger, Lexington, KY
Duties: Director of Design-Build Construction

2005-2006 ETS-Lindgren, Glendale Heights, IL
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Project Management Professional (PSP) *Certified by AACE*