

Ergonomic Methods to Improve Safety in the Construction Sector and Reduce Costs

A Senior Project presented to the Faculty of the
Industrial and Manufacturing Engineering Department
California Polytechnic State University, San Luis Obispo



Source: www.expainterviews.com

In Partial Fulfillment of the Requirements for the Degree
Industrial Engineering; Bachelor of Science

By:
Mona Barjasteh
June 2010

© 2010 **Mona Barjasteh**

Table of Contents

Abstract.....	1
Introduction.....	2
Background.....	4
Cost of Accidents.....	6
Workers' Compensation.....	7
Workers' Compensation Insurance.....	9
OSHA Regulations.....	9
Safety.....	12
"Green" Construction.....	12
Company XYZ.....	13
Most Common Injuries and Cost Association.....	14
Design.....	19
Lacerations.....	20
Lumbar Spine.....	21
Upper Extremities.....	22
Eyes.....	23
Methodology.....	24
Results.....	25
Conclusion.....	29
Bibliography.....	31
Appendix A: Small Construction Companies Ergonomic Improvement Manual.....	34

List of Figures

Figure 1: Fatalities classified according to industry	4
Figure 2: Distribution of Injuries for Construction versus all Other Industries.....	17
Figure 3: Distribution of Construction Injuries by Gender.....	17

List of Tables

Table 1: Distribution of Construction Injuries by Year	16
Table 2: Comparison of Frequency and Primary Care Medical Expenses for Injuries	18
Table 3: Distribution of Treatment Charges Exceeding \$10,000 by Nature of Injury	19
Table 4: Summary of cost for Lacerations.....	26
Table 5: Summary of cost for Lumbar Spine.....	27
Table 6: Summary of cost for Upper Extremities	28
Table 7: Summary of cost for Eyes.....	29

Abstract

Many small construction companies have difficulty providing a safe working environment for their employees because of their lack of resources. There is a need to provide a manual for small construction companies employing 10 or fewer workers with the best ergonomic solutions of the top most common injuries. Accidents in the construction field are very high with nearly 175,00 nonfatal injuries and 1,121 deaths in 2002. The nonfatal cases occur 7.1 times per 100 full time workers, while serious injuries occur 2.8 times per 100 full time workers. This information revealed the importance of focusing on minor injuries in order to reduce costs. Research provided that the most common injuries on the job site were lacerations, lumbar spine, upper extremities, and eye injuries. An analysis was done on the data found to calculate the total cost of each injury in order to determine the total cost of injury per year. Some examples of ergonomic alternatives to each injury was found and used in order to determine the total cost of protection. The cost of protection was determined through purchasing the right number of equipment for the individuals on the job site. After a cost analysis, a manual was created with the top most common injuries and the cost associated with each. The manual also provided companies with the steps to implement a safety plan, the benefits of protecting employees, and a summary of the OSHA regulations for the construction sector. A study was done on a small electrical engineering company in Los Angeles, XYZ. The company was researched prior to the creation of the manual in order to better understand the needs of small construction organizations. After the creation of the manual, the company was given a copy in order to provide critique and implementation information. The manual critique resulted in a few changes that would better help struggling companies with more explanations of injury protection benefits. The final edited manual was reviewed by the manager of the company and because of its value will be used in training seminars in the future.

Introduction

Construction is a field of work that is very physically demanding. The work can be performed at a variety of different sites ranging from buildings and highways to demolition sites and tunnel excavations. Individuals on the job operate a variety of tools making the job quite hands on. Many construction workers have to control machines, move heavy objects, repair equipment, as well as monitor processes. This job requires an individual who has great manual dexterity as well as the ability to think quickly and intelligently.

Since construction jobs are so demanding physically on a person's body, a variety of injuries can occur. Therefore it is important for employers to provide a safe environment for their construction workers. There are regulations set by the government in the form of OSHA guidelines in order to ensure that all businesses follow a certain baseline of safety. Many small construction companies, employing 10 or less individuals, have a difficult time providing a safe environment for their employees because they lack the resources of larger companies for new implementation techniques and the ability to keep up to date with all the regulations. Without the resources needed to determine the best solutions for the regulations, these small companies are at a disadvantage to larger ones. There is a need to provide a manual for small construction companies with the best-cost efficient solution. By providing a manual for small existing and newly starting construction companies, these organizations will be able to implement the necessary changes within a reasonable use of resources to be able to reduce the number of injuries and cost of workers compensation.

A professor at California Polytechnic University named Dr. Jose Macedo and a small construction company in Los Angeles brought about this project. After learning about this small company's safety method applications, it was easy to grasp the great disadvantage smaller organizations have in being able to properly comply and stay informed with all the OSHA regulations. Smaller companies are hindered because they employ fewer people and are not required to keep backlogs or get inspections from OSHA. In order to provide smaller companies with the necessary tools it was first important to research about the construction business, the common injuries and frequency of injuries, cost of injuries, common tools used, ergonomic factors, and the California regulations for construction businesses. The research provided the information to determine the top four most common injuries in order to find the best alternatives in preventing these injuries from occurring. The cost savings in medical bills justified the alternatives that were deemed the best.

The report it set up first providing the background information about the construction field and the injuries on the site. The design portion demonstrates the reasons why the top four most injuries occur and how the alternatives were chosen for each injury. The methods provide the feedback from a small construction company after reviewing the manual and the suggested adjustments. The results present the method used to calculate the cost reduction. Finally the paper will end with a conclusion summarizing the problem, objectives and the solutions found.

Background

The construction industry is one of the most dangerous fields in the United States. Often construction workers experience injuries and fatalities on the job. In 2002, the construction industry had 1,121 deaths, which gave it the top ranking of any line of work (Hatch, 2004). Figure 1 displays the distribution of fatalities according to industry.



Figure 1: Fatalities classified according to industry
Source: (Hatch, 2004)

Construction jobs have 50% more back injuries than any other field of work (National Institute for Occupational Safety and Health, 2007). A lot of the problems in

this field are associated with back, shoulder, neck, arm, and hand pains. Material handling incidents are 32% of the workers' compensation problems and have an average cost of \$9,240 per claim (National Institute for Occupational Safety and Health, 2007). It has been shown that 80% of all manual-handling results in lower back pain that 80% of the population experiences (Colling, 1990). It may seem hard to believe death should be a concern at work, but that was not the case for James Wilson. Mr. Wilson was a 40-year-old construction employee working on a church roof in downtown Philadelphia on October 13, 2009. The construction worker died after falling 125 feet from a lift that toppled and struck an apartment building. Although he was properly strapped into the bucket, the vehicle tipped over on the sidewalk killing Mr. Wilson while injuring three other individuals (New York Times, 2009). Cases like this are not uncommon among construction workers and happen regularly. This is why the necessary precautions are critical in this business.

Although there are a few pamphlets available to employers about simple solutions to common injuries, they do provide the cost savings associated with preventing the injuries with many of these suggestions. This manual provides the solutions to important OSHA regulations with the cost and savings associated with the program implementations. The manual is a simple and easy way for employers to quickly find the safety alternatives for the top most common injuries in the field of construction.

The choice of focusing on small construction companies was to capture a large part of the construction market. This sector is filled with many small businesses. There are 1,516,076 small companies that fit the category of less than 10 employees (Building & Construction Companies in United States, 2010). In the United States 68% of the

construction companies' employee fewer than five people and small contractors employ 12% of workers (Bureau of Labor Statistics, 2009). By focusing on the majority of the market the manual can provide the necessary benefits of its intentions.

Cost of Accidents

In the United States the cost of accidents annually equates to about \$800 billion. Within this cost, workplace accidents account for \$48 billion. Broken down even further, the lost wages accounts for \$38 billion, while medical expenses and insurance administration costs are \$24 billion and \$29 billion respectively. In the United States there are approximately 13,000 deaths associated with falling. There is also approximately 35 million hours of work lost in a given year due to accidents. The field of construction is the third highest-ranking industry on the basis of the number of deaths trailing behind mining and agriculture. The most frequent body parts injured are the back, legs, fingers, arms, trunk, and hands to name a few (Goetsch, 2003).

Since 1979 the total cost of accidental injuries has risen up from 6.5% to 15% (Everett, 1996). On the construction site it is difficult to calculate the total cost of injuries. The costs take into account the indirect as well as direct costs. The indirect cost includes costs associated with the loss of productivity of the crew and injured individuals, transportation costs to medical facilities, and the time taken to fill out forms. The direct costs are associated with the cost of worker's compensation. The ratio for indirect and direct costs is extremely variable depending on the experts' safety ratings. A study showed that the cost ratio for medical case injuries was 4.2, while lost workday injuries equaled to 20.3 (Appelgate, 1991). The study also showed that even minor injuries have

considerable costs. Many people do not take into consideration the indirect cost associated with injuries, but the study revealed that it is often a greater expense than the direct cost.

Workers' Compensation

Workers' Compensation was developed in order to allow employees injured on a job to become compensated appropriately by their employer. The main two aspects of workers' compensation are to reduce the costs for employees associated with workplace injuries and provide fairness to injured employees. The purpose of workers' compensation is to replace income, rehabilitate injured employees, prevent more accidents from occurring, and allocating the costs appropriate for each business. Income replacement is viewed as a ratio of two-thirds the future and current income (Goetsch, 1996). Rehabilitation is to provide the medical care that the patient needs at no cost till the individual is able to return to work. Accident prevention programs are incentives for employers to have because of the lower insurance premiums that result from fewer accidents. The allocation of workers' compensation costs is spread among the different business differently depending on the level of hazard associated with the particular job.

In findings from the Construction Industry Institute, it was learned that many contractors do not actively take part in the management of workers' compensation. The study showed that management could reduce the cost of workers' compensation by reducing the contractor's experience modification rate (EMR). The EMR rate is a ratio that is used by insurance companies to adjust the manual rates paid by the company (Hacher, 1997). Through surveys it was found that employers feel adequately about

educating employees about worker's compensation, but workers did not feel like they understood the system or were informed well enough (Hacher, 1997). Through the study it was also found that many contractor's view workers' compensation as overhead and do not allocate the responsibilities to specific managers (Hacher, 1997). It was found that employers should spend more time educating employees about workers' compensation as well as making sure that the needs of the injured victims are met. The injured employees can be placed in modified work programs that allow them to perform duties without exposing them to other coworkers that may result in further injury. Companies should also not use their EMR as the sole factor in evaluate the companies safety, but rather look at their safety program as a whole.

Employers pay insurance companies through high premiums resulting in higher construction costs. The manual rates for construction companies are very high in many states. Certain groups have high economic interest in worker's compensation such as labor unions, insurers, trial attorneys, doctors, and employers. The interest becomes apparent in lawsuits. In order to improve worker's compensation law, the frequency and profitability of litigations must be reduced as well as returning injured workers as efficiently as possible back to their jobs (Hancher, 1991).

There are a few strategies that can be taken on in order to decrease worker's compensation costs. By having industry groups, safety programs and legislative reform, the costs may be reduced (Agarwal, 1997). The industry groups provide better credit worthiness for insurers while the safety groups establish continuous improvement. Legislative reform has proven to reduce the premiums assigned by insurance companies significantly.

Workers' Compensation Insurance

Many different issues can affect workers' compensation insurance rates which include the number of employees, risk associated with job performed, accident history of employer, possible future losses, profit of employer, quality of safety program, and actuary estimates (Goetsch, 2003). Insurance companies use different methods for determining the premium rates of organizations. Schedule rating is when the insurance company evaluates a business based on set baseline safety conditions. Manual rating is an established rate that is set up for the different professions. Experience rating is assigning managers a rate determined by a predicted value of average losses for that given company. Retrospective rating is specific rate that is set up for a given period of time. Premium discounting is discounts large companies receive for the size of their company. Combination method combines any of the previous stated methods in order to come up with the premium rates. An insurance company for a particular construction business can use any of these methods. Although the rate is variable by certain factors, it is of utmost importance for companies to keep low accident numbers to maintain decent rates.

OSHA Regulations

The Occupational Safety and Health Administration (OSHA) was created by the congress of the United States with the mission to prevent work-related injuries, illnesses, and fatalities. OSHA has certain federal regulations that an employer must follow in order to comply with workplace safety and health. Small organizations with ten or fewer employees are exempt from OSHA inspections and the requirement to maintain an injury

log (Goetsch, 2003). All businesses with one or more employees must adhere to the federal government agencies that follow OSHA guidelines or face fines and monetary damages. The four types of violations are other-than-serious violation, willful violation, repeat violation, and failure to correct previous violation (Goetsch, 2003). An other-than-serious violation is a violation that would not cause death or serious harm, but is still violating safety guidelines. A willful violation is one where the owner intentionally commits and makes no effort to eliminate it. A repeat violation is an infringement that had a prior similar violation. A failure to correct previous violation is failure to correct an earlier infraction resulting in a civil penalty.

The safety and health managers of a construction company need to make sure that certain aspects of the jobs are maintained to reduce hazardous activities. On the construction site it is very important to maintain lighting that illuminates the areas where the work takes place. The lighting is important in order to avoid trips and falls. Material handling and storage at a construction site is also very important. In order to prevent equipment failure from overuse and overload it is essential to check tools regularly for safety (Asfahl, 1999). Collapsing of stacked resources can also be prevented with standard inspections of the storage areas.

Protective equipment is essential on the construction sites. Hard hats are of top priority in order to protect the workers heads. Also many employees are exposed to long durations of loud damaging noises in which hearing protection would be crucial. Falling is probably one of the greatest hazards of construction work. In order to protect employees, although awkward, it is important to maintain the proper body harnesses for protection. The length and knot of the rope for harnessing is important in safety.

Furthermore to protect from accidental fires that result in property loss, it is vital to watch the quantities of flammable liquids on site. Construction workers use a wide range of tools on the site. Hand tools need to be paid close attention to for faulty handles and chips in the tool itself. Pneumatic tools should be checked for security to the hose in order to prevent accidental disconnection. The job sites construction workers often perform at are locations with poor conditions that can cause electrocutions. It is essential to have 15 and 20-ampere outlets that have ground fault circuit interrupter protection. Many construction companies work at high levels of elevation and often create their own ladders. Although these ladders are not illegal, the proper methodology of creating the ladder is crucial. A double cleat ladder is required for areas of work with more than 25 employees. Scaffolds are very technical and should be operated by a registered professional engineer. While on a scaffold, the safety belts should be tied to the building while making sure the floors of the scaffold are not loose (Asfahl, 1999). Although these are only a few of the adjustments that can be made on a construction site, these minor modifications can create a better job environment.

The OSHA Regulations for Construction Safety Management was read in order to gain a better understanding of the federal requirements. The sections that were focused upon were subpart A- General, subpart B- General Interpretations, subpart C- General Safety and Health Provisions, subpart D- Occupational Health and Environmental Controls, subpart E- Personal Protective and Life Saving Equipment, subpart I- Hand and Power Tools, subpart K- Electrical, subpart M- Fall protection, and subpart X- Stairways and Ladders. The important ideas of the OSHA regulations are summarized in the manual found in Appendix A.

Safety

Safety is clearly a necessary objective of the construction business. In a study done in Canada the information found showed that the extent a company follows policies influences the safety performance of the company as a whole. Safety performance was a lot better on projects where a safety officer worked fulltime. By having the safety officer coordinate safety meetings and monitor safety performance, it allowed for lower injury rates. Economic pressures also had a big impact on the safety performance. The results of the study showed that the safety officer's positions were viewed as an "expendable" job (Raboud, 1988). This meant that as times got rough, safety was not deemed a necessity and cutting out integral safety people resulted in more accidents. By taking safety issues seriously companies will be saving more in the long run.

"Green" Construction

Recently it has been a trend to have businesses look for green or sustainable methods of practice. Many companies will get Leadership in Energy and Environmental Design (LEED) certification in order to work in sustainable approaches. Although this may seem to have a more positive impact on the construction worker's safety and health, a recent study suggested that there was no evidence showing statistically significant difference in the green and non-green building projects (Rajendran, 2009). This would be an important aspect for newly starting construction companies to look at. New construction businesses can focus their start up costs for safer methods and programs rather than LEED certification.

Company XYZ

The small company that these methods were be applied to is company XYZ (fictitious name made to protect identity.) This company is a small electrical engineering construction company that was started in 1988 in southern California. The owner and manager of the company is Bob Bill (fictitious name made to protect identity.) The company works on a variety of different jobs that all involve construction within the electrical engineering sector. The company currently pays 8.16% of each employee's salary to insurance companies for workers compensation every quarter (Bill, 2010). XYZ Inc. currently has ten employees. The average salary per person per week is \$1,474. For a given quarter, XYZ pays \$1,443 per person to an insurance company for workers' compensation. This rate only applies to private jobs, which include smaller house or business jobs. The public jobs that the company works on are usually at schools or large businesses. These jobs usually have insurance provided in the form of OCIP insurance. OCIP is owner controlled insurance protection that the job initiator obtains for large jobs costing considerable amounts of money. The owner receives a discounted insurance rate of around 3% for the entire job. On these jobs, Mr. Bill does not have to directly pay insurance companies since the whole job is insured. Because of this XYZ's workers compensation pay is variable by job and difficult to determine the companies costs monthly for insurance. The jobs that XYZ is hired for depends on the bids that they win. In any given month there may be only smaller project requiring the company to pay worker's compensation or a big project where the fee is not Mr. Bill's responsibility.

At XYZ the company experiences a wide range of worker injuries. No particular injury is more common than another. The injuries are all related to over exertion or

accidents varying from back problems to falling off a scaffold. Within a given year the company experiences about 2-3 injuries. The injuries are usually minor. The last serious injury that occurred was in 2004 where an employee fell off a damaged, faulty ladder.

Since many construction companies work on both private and public jobs, it is essential to provide a manual that can minimize the risks regardless of the job environment. By providing a simple and easy manual for this company, they will be able to lower injury rates by practicing safer working methods.

Most Common Injuries and Cost Association

There are two types of categories for injuries minor or serious. The minor injuries take into account the injuries that do not result in lost time, while the serious injuries result in loss time or even death. Many of the serious injuries and fatalities get taken very seriously and OSHA makes significant changes to their standards. The minor injuries usually not the focus of research but have considerable suffering for the companies that have to take on these high medical costs. In 2002, The Bureau of Labor Statistics reported that nonfatal injuries occurred at a rate of 7.1 cases per 100 full time construction workers, while serious injuries occurred at 2.8 cases per 100 workers (Hinze, 2006). This data showed that the majority of injuries are minor injuries. This demonstrated that the best focusing point would be on minor injuries in order to reduce costs that go into these injuries. These injuries should be prevented with different measures. Although serious injuries are very important to consider as well, narrowing the scope down to minor injuries would better help smaller companies.

An article was found called *Construction Worker Injuries that do not Result in Lost Time*, which was deemed very beneficial to the project because it provided information about the top construction injuries along with the medical costs that would be involved with each injury. The research in this article was conducted by analyzing about 136,000 construction worker injuries in order to study the occurrences of injuries on the construction site as well as the cost associated with each injury. This article separated the injuries into 16 categories and this information provided the top most common injuries. From the medical costs associated with each injury the calculation of the benefits of reducing these injuries from occurring and the benefits of the alternatives was found.

The injury data found in this article was provided by Concentra Health services Inc, which is a full service medical system with 250 clinics across 34 states. The system tracks information on injuries for roughly 500,000 workers annually, which equates to about 7% of all OSHA recordable injuries. This satisfies the rate of 7.1 incidents for minor injures. The nature of the injury was categorized into 16 different groups accounting for different body parts like lacerations, lumber spine, and skin to name a few. Within the analysis of the construction industry injury distributions for men vs. women and younger vs. older workers was assessed. Table 1 shows the percentage of injury occurrences for various different years. From this table it is easy to see that only minor percentages changes occur from year to year. The most frequent injuries were lacerations, lumbar spine, upper extremity, and eye. These four categories were the top most common injuries that occurred accounting for about 59% of all injuries. With this information it was evident that these injuries needed to be addressed in order to provide a safe working environment.

Table 1: Distribution of Construction Injuries by Year
Source: (Hinze, 2006)

Nature of injury	2001 (%)	2002 (%)	2003 (%)	Total (%)
Lacerations	23.8	23.8	24.0	23.9
Lumbar spine	12.6	12.8	12.9	12.8
Upper extremity	11.5	11.7	11.0	11.4
Eye	11.2	10.8	10.8	10.9
Ankle/foot	6.2	6.1	6.0	6.1
Soft tissue injuries	6.3	6.0	5.8	6.0
Knee	5.4	5.7	5.6	5.5
Shoulder/humerus	4.3	4.6	4.5	4.5
Fractures	4.2	4.3	4.4	4.3
Skin	3.7	3.6	3.7	3.7
Cervical spine	1.8	1.9	2.2	2.0
Non-Occ/NOC	2.0	1.8	2.0	1.9
Other/traumatic	1.8	1.8	1.9	1.8
Head/neck	1.7	1.7	1.9	1.8
Thoracic spine	1.8	1.9	1.7	1.8
Other/nontraumatic	1.8	1.6	1.7	1.7
Total	43,897	45,957	46,144	135,998

The lacerations category encompassed cuts mostly on fingers and hands; while the lumbar spine was general sprains and non-specific back pains. The upper extremity injuries consisted of contusions in the fingers and hands, sprains in the wrist and fingers, pain in the joint, and crushing injuries. The eye injuries were normally just inflammation, abrasions, or scratches from foreign objects. Figure 2 shows the injuries of construction workers as well as other industries. A cross-tab chi-square analysis was done that showed

there was statistical significance at a .001 level that that construction and other industries showed differences for the top four construction injuries.

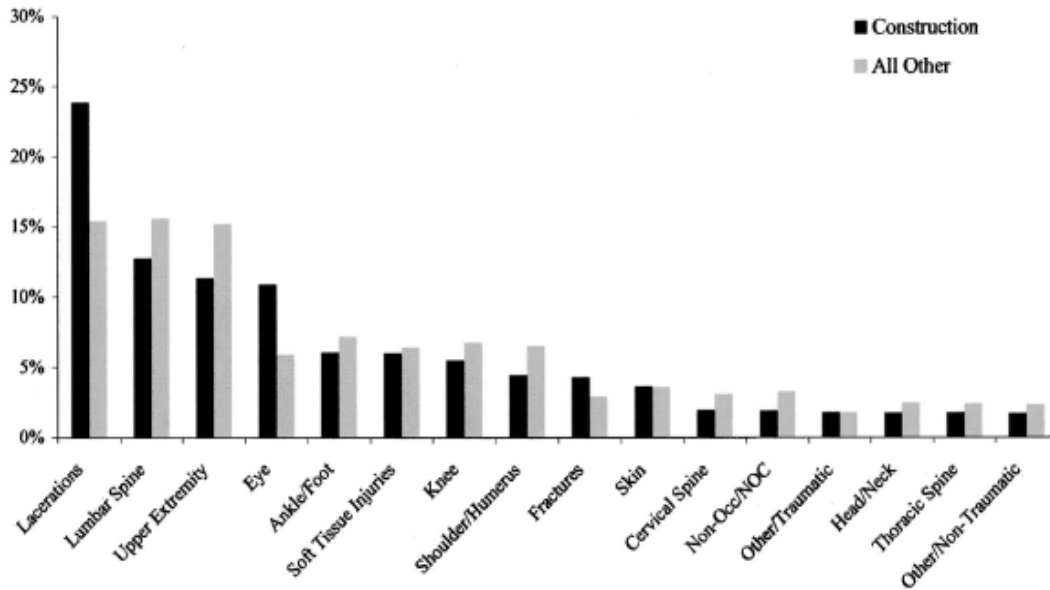


Figure 2: Distribution of Injuries for Construction versus all Other Industries
Source: (Hinze, 2006)

Figure 3 shows the distribution difference between genders in the construction field.

Women were more likely to have upper extremity and lumbar spine issues. The average age for individuals used in this data were men at 35.7 and for women it was 38.6.

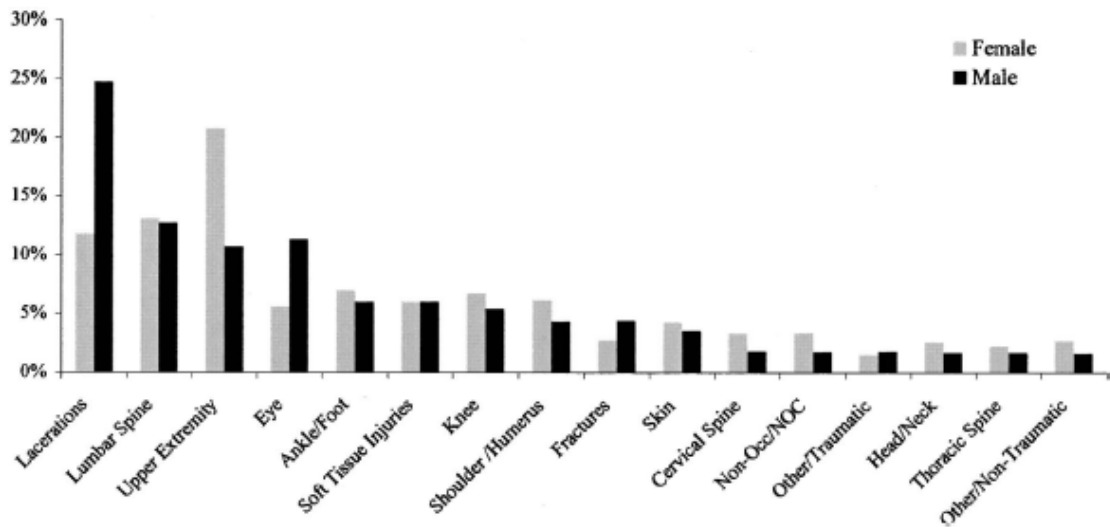


Figure 3: Distribution of Construction Injuries by Gender
Source: (Hinze, 2006)

Table 2 shows the cost associated with the injuries. Although lacerations were not very costly they did have a large frequency of occurrence.

Source: (Hinze, 2006)

Table 2. Comparison of Frequency and Primary Care Medical Expenses for Injuries

Nature of injury	Number of patients	Total patients (%)	Total medical charges (\$)	Total charges (%)	Average charge/patient (\$)	Rank average charges/patient
Lacerations	32,459	23.9	13,654,972.50	17.8	420.68	11
Lumbar Spine	17,342	12.8	15,399,391.19	20.0	887.98	2
Upper Extremity	15,466	11.4	9,368,597.82	12.2	605.75	8
Eye	14,880	10.9	3,773,156.96	4.9	253.57	16
Ankle/Foot	8,268	6.1	5,139,688.14	6.7	621.64	7
Soft Tissue Injuries	8,205	6.0	4,180,020.52	5.4	509.45	9
Knee	7,546	5.5	6,174,063.51	8.0	818.19	4
Shoulder /Humerus	6,096	4.5	5,692,319.42	7.4	933.78	1
Fractures	5,883	4.3	4,402,321.96	5.7	748.31	5
Skin	4,974	3.7	1,740,718.00	2.3	349.96	12
Cervical Spine	2,680	2.0	2,321,141.29	3.0	866.10	3
Non-Occ/NOC	2,622	1.9	872,394.61	1.1	332.72	14
Other/Traumatic	2,463	1.8	633,173.35	0.8	257.07	15
Head/Neck	2,412	1.8	1,092,072.51	1.4	452.77	10
Thoracic Spine	2,396	1.8	1,662,740.12	2.2	693.96	6
Other/Non-Traumatic	2,306	1.7	773,370.56	1.0	335.37	13
Total	135,998	100.0	76,880,142.46	100.0	565.30	

Note: Costs represent primary care medical charges (including physical medicine) from large Occupational Health Care Provider Group only and do not include any additional medical treatment provided by specialists, other primary care providers, diagnostic services, inpatient and other ambulatory facility charges, etc.

The shoulder injuries did have a higher cost than all other injuries, because they had a higher likely hood for surgery than any other injury. The most costly injuries were shoulder and humorous injuries displayed in table 3, which proposed a particular concern.

Source: (Hinze, 2006)

Table 3. Distribution of Treatment Charges Exceeding \$10,000 by Nature of Injury

Nature of injury	Distribution of all injuries (%)	Distribution of injuries exceeding \$10,000 (%)
Lacerations	23.9	4.2
Lumbar spine	12.8	12.5
Upper extremity	11.4	16.6
Eye	10.9	0
Ankle/foot	6.1	0
Soft tissue injuries	6.0	4.2
Knee	5.5	12.5
Shoulder/humerus	4.5	37.5
Fractures	4.3	12.5
Skin	3.7	0
Cervical spine	2.0	0
Non-Occ/NOC	1.9	0
Other/traumatic	1.8	0
Head/neck	1.8	0
Thoracic spine	1.8	0
Other/nontraumatic	1.7	0
Total	100.0	100.0

The information found in this article gave insight into the cost of injuries. The research provided the necessary steps toward determining the injuries to be focused on in the manual.

Design

The information researched about construction injuries provided the areas of focus that could be used in the manual. The four most occurring injuries were used as the basis of the manual in order to reduce the costs associated with these injuries. The manual was structured around these injuries and examples of alternatives were selected that could reduce the occurrence of these injuries. The best example alternatives for lacerations, lumbar spine, eye, and upper extremity injuries were chosen in order to help employees

have a safer work environment. The alternatives were not chosen for cost, because it was important to choose the best-suited tool rather than the lowest cost item. The costs of the device were taken into account in the cost analysis and the payback period, but were not a determining factor in the selection process. Once the alternatives were chosen for each particular injury, a cost analysis was completed in order to determine the total cost of protection in a small company as well as the total cost of injury in a year. After the economic analysis was complete, a manual was created focusing on the injuries, the alternatives, and some steps a small company should take in order to provide the safe working environment. This section of the paper discusses the injuries in the manual, the alternatives chosen, as well as the benefits of the solutions.

Lacerations

Lacerations were one of the most frequently occurring accidents at the workplace and although it may seem like a simple fix, it is essential to purchase the right equipment to provide safety. The two alternatives chosen were gloves and cutters. Two types of the most appropriate gloves were found for the worksite. The 360-degree coverage and palm and finger gloves were the best alternatives. These two gloves both have level 5 cut resistance in order to prevent cuts and deep tears from occurring. The difference between the two gloves is that the 360-degree coverage glove has the cut resistance over the entire hand with a liquid resistant finish, while the palm and finger glove only has resistance on the palm and palm side of the fingertips. The palm and finger glove allows for better dexterity and comfort making it more appropriate for jobs that entail rigorous hand activity in small places. The best type of cutters for the construction environment would be ones with

automatic relock spring and guard protection from the blade. It would also be important to make sure that the cutters are for both right and left handed individuals in order to accommodate employees that are left handed. These solutions will help reduce the amount of lacerations on the site from careless activity.

Lumbar Spine

The next most common injury was lumbar spine injuries. These injuries would be very important to address because of the large number of accidents that occur from material handling. The example solutions for this particular category were bit extension shaft, kneeling creeper, and stand-up screw gun. The bit extension shaft can be bought in many different sizes in order to screw hard to reach places. It helps reduce stress on the arm, neck, shoulder, and back. This tool allows for the arms to be closer to the side of the body, while using the bicep muscles instead of the shoulder. Although the bit extension reduces stress, the action of looking up can still provide neck strain to the individual. The extension shaft allows for a variety of unique drilling and easy reach of inaccessible screws making it a perfect tool for the job site. The next solution that would reduce back stress is the kneeling creeper. The kneeling creeper is a seat as well as a knee placement to work on ground level activities comfortably. The foam kneepads allow for a more comfortable working environment, while the seat provides secure seating. The kneeling creeper detaches easily for convenient storage and travel to different locations. The last solution is a stand up screw gun. The stand up screw gun allows for reduction of lower back injuries because of the standing ability. It also provides a consistent screw depth without wobbling. Another tool that was used in comparison with the stand up screw gun

was the powder actuated fastening tool. This tool is fast efficient and can be used in any weather condition. Although the powder actuated fastening tool is very effective, it requires hearing protection and is not ideal for small jobs. Only for companies that drill extensively, would this tool be a good investment. These alternatives provide some solutions to lumbar spine problems.

Upper Extremities

Another common construction site accident was upper extremities. These accidents could be reduced with tools such as spring assisted drywall-finishing tools, extension poles for powder-actuated tools, and rebar tying tools. The spring-assisted drywall-finishing tool provides about 75% of the force needed to push the compound on the wall (National Institute for Occupational Safety and Health, 2007). It reduces the chance of muscle or joint injury. The spring assisted finishing tool cuts down the strain associated with pushing in corners as well as flat areas. This tool would be ideal for small companies. This alternative was better for smaller companies than the pneumatic drywall finishing system. Even though the pneumatic system allowed for less pain and a faster finish, it was restrictive to movement while working and was not practical for small finishing jobs. The pneumatic drywall finishing system would cost a lot of money and would not be as efficient for smaller companies who do not drywall on a regular basis. Another solution is the extension tool for powder-actuated tools. The extension tool reduces the risk of hand, arm, and shoulder injury. It also allows for less recoil shock and lower noise exposure. The extension pole has less setup time since ladders and scaffolds are not needed. The adjustable height of the pole allows it to conform to any job site for

convince. Finally the last tool is the rebar-tying tool. This tool is good for companies that are mostly creating foundations with concrete. This tool lowers the risk of hand and wrist injuries. It allows for quick rebar tying and easy change of tool direction. The tool can tie rebar in about 1.6 seconds. All in all these tools are a few solution methods that a small company can take in order to improve upper extremity injuries.

Eyes

The last injury is the eyes. The eyes are a very delicate part of the body and need to be treated with great care. The examples of alternatives that would best fit construction companies were goggles and face shield. The goggles need to have full side protection that seals out dust and airborne particles with high impact requirements. It should also protect against UV rays as well as prevent fogging. By purchasing the proper type of goggles that are against the face, it can prevent any objects from hitting the employee's eyes. Since these goggles are hugging the face it will eliminate slippage and carelessness of the eye protection. The face shields should follow class 6A requirements. This requirement states that the face shield should have impact, piercing, splash, head, and glare protection. By following these guidelines the eyes will not become a major injury at the job site.

The solutions found would be very helpful in lowering the amount of accidents on the job site and providing a better working environment for employees. Although these solutions are not the only methods to reduce accidents, these examples are ways that small companies can provide a healthier work environment. Even though all these

solutions will not apply to every construction industry, these examples give companies options of ways to improve their current methods.

Methodology

In order to provide small companies with the information analyzed, a manual was created and can be found in Appendix A. The manual was created and after feedback from company XYZ was revised. The first written draft contained the basic structure, which was information about each individual injury, the alternative solutions, as well as the cost associated. The first manual differed with the final manual in that it did not contain the introduction about the importance of reducing injuries and the steps toward creating a safety plan. The set up of each page of the first manual was to fit all the information on one page. The feedback from company XYZ showed the importance of spacing out the information for easy readability and the importance of expressing why safety should be priority at any company. After revising the first manual and implementing the feedback, it also became apparent that it would be important to include a safety implementation plan and the summarization of the OSHA regulations conducted in the research of the project. The safety implementation plan allowed companies to look at a quick checklist of the steps necessary to start a safety plan at the company. The addition of the summarized points of the OSHA regulations provided the reader a quick guide to important necessities to the safety plan. Once the final manual was created, it was once again given to company XYZ for final feedback. The response came back positive and the manual was thought of as a good tool for small construction companies. The company said that this manual would be discussed in their next training meeting in order to make employees aware of the information.

Results

The purpose of the manual is to provide safe alternative to costly injuries. In order to be able to determine whether the solutions were cost effective, it was important to first find out the annual cost of the injuries. Once this was analyzed, the cost of protection could be determined. For each injury an analysis was done on the probability of the injury occurring per year, the amount of workers injured in that year, the expected cost of the injury in a year, the cost of protection, and the payback period.

The analysis was done for each injury in the manner below. This example is on Lacerations:

Total number of construction injuries studied in 2002: 135,998

(total number of people studied in the research done through Concentra Health)

Laceration number of patients: 32,459

(total number of injured patients in this category)

Probability of injury per year: *(total number injured in category/ total number studied)*

$$32,459 / 135,998 = 0.2387 \approx 0.24$$

Amount of workers injured in a year: *(# workers in small businesses * probability of injury)*

$$(10 * 0.24) = 2.39$$

Expected cost of injury in a year: *(cost of injury * number of individuals injured in a year)*

$$\$420.68 * 2.39 = \$1004.05$$

Cost of Protection: *(varies by type of tool and amount of tool purchased)*

$$(\$30 * 10) + (\$4 * 10) = \$340$$

Payback Period: < 1 Year

This analysis was done on each injury in the manual in order to provide the costs associated with benefits that safety provides. For the lacerations table 4 shows the summary of the costs. The cost of protection was determined from purchasing ten gloves and ten cutters for each employee. The gloves cost \$30 per pair and the cutter was \$4 each. This gave the total cost of \$340, which was far below the expected cost of injury per year.

Table 4: Summary of cost for Lacerations

Probability of injury per year	0.24
Amount of workers injured in a year	2.39
Expected cost of injury in a year	\$1004.05
Cost of Protection	\$340
Payback Period	< 1 Year

The lumbar spine analysis is provided in table 5. The cost of protection was determined by purchasing seven bit extensions, five kneeling creepers, and three stand up screw guns. The amount was determined through analysis of company XYZ predicted usage on three different job sites. The cost of each tool was about \$25 for the bit extension, \$160 for the kneeling creeper, and \$330 for the stand up screw gun. This gave a grand total of \$1,965. Although this cost was more than the expected cost of injury in a year, these tools would not need to be purchased every year. With good care and maintenance of the tools, these tools can have a long lifetime making the payback period of two years reasonable.

Table 5: Summary of cost for Lumbar Spine

Probability of injury per year	0.13
Amount of workers injured in a year	1.3
Expected cost of injury in a year	\$1132.32
Cost of Protection	\$1,965
Payback Period	1.7 Years

The upper extremity analysis is provided in Table 6. The total cost of protection was determined by purchasing two spring assisted drywall-finishing tools, three extension poles for powder-actuated tools, and two rebar tying tools. The purchasing cost

of each tool is \$1,150 for the spring-assisted drywall-finishing tool, \$350 for the extension pole, and \$1,300 for the rebar tying tool. The drywall-finishing tool set consists of two flat boxes, one handle, one pump, and one box filter. The total cost of protection exceeds the cost of injury and requires a nine-year payback period. Although this may seem unreasonable for purchasing safety equipment, it must be kept in mind that not all companies would require these tools. These alternatives are only solutions that may not be applied to every construction company. Many companies may not require the rebar tying tool or the drywall-finishing tool. The company's needs should be taken into consideration for determining the protection equipment resulting in a different protection cost.

Table 6: Summary of cost for Upper Extremity

Probability of injury per year	0.11
Amount of workers injured in a year	1.14
Expected cost of injury in a year	\$688.87
Cost of Protection	\$5,950
Payback Period	8.6 Years

The eye injury cost analysis is provided in Table 7. The cost of protection for eye injuries accounts for ten goggles and ten face shields giving a total cost of \$210. This cost is below the total cost of the injury and requires less than a year for payback. The

equipment for eye protection should be purchased yearly in order to protect employees from faulty goggles and face shields. It is important to make sure that the equipment is kept in good condition before use.

Table 7: Summary of cost for Eyes

Probability of injury per year	0.11
Amount of workers injured in a year	1.09
Expected cost of injury in a year	\$277.44
Cost of Protection	\$210
Payback Period	< 1 Year

These solutions provide small companies a way to measure and justify the cost of protection equipment for each part of the body. It should always be kept in mind that some equipment may require a large initial investment that can provide long-term benefits.

Conclusion

Small companies have a difficult time being able to keep up with all the new regulations as well as the proper safety equipment. Without designated safety personnel, it can become difficult to keep up training and education. This manual can provide small companies a few alternatives to particular injuries and the guidance necessary to implement an efficient safety plan. By providing a safe working environment,

construction managers will be able to increase company health, moral, and build a strong supporting team.

The most important thing for small companies is to become aware of the most frequent injuries: lacerations, lumbar spine, upper extremities, and eyes. The analysis showed that in a year roughly about one to three injuries could occur in any of the top most frequent categories. The cost of each injury demonstrated the large sums that companies can incur. The frequency of injuries also increases insurance rates forcing employers to pay well above the cost of the injury. This provided the evidence necessary to validate the importance of protection equipment. The companies should take the provided information associated with cost of injury and look at the plausibility of using any of the provided alternatives in their businesses.

Bibliography

- "11" Flexible Extension Shaft, Drivers & Bits, Power Tool Accessories - McFeely's ."
McFeely's Square Drive Screws - Screws, Fasteners, Festool Power Tools and more . N.p., n.d. Web. 1 May 2010.
<<http://www.mcfeelys.com/product/FBX-0011/11quot-Flexible-Extension-Shaft>>.
- Agarwal, Pankaj. "Strategies for Construction Contractors to Reduce Workers' Compensation Costs." *Journal of Management in Engineering* 13.5 (1997): 70-75. EBSCO. Web. 3 Feb. 2010.
<<http://ejournals.ebsco.com/direct.asp?ArticleID=E17L0LRQTP7XFQR7RCVV>>
- Appelgate, Lisa L., and Jimmie Hinze. "Costs of Construction Injuries." *Journal of Construction Engineering and Management* 117.3 (1991): 537-50. EBSCO. Web. 5 Feb. 2010.
<<http://ejournals.ebsco.com/direct.asp?ArticleID=4A0885CC32F8817A3000>>.
- Asfahl, C. Ray. *Industrial Safety and Health Management*. 4th ed. New Jersey: Prentice Hall, 1999. Print.
- Bill, Bob. "XYZ Inc." Telephone interview. 2 Feb. 2010.
- "Building & Construction Companies in United States." *Company Profiles & Company Information on Manta*. N.p., n.d. Web. 8 May 2010.
<http://www.manta.com/mb_33_E0_000/building_construction?refine_company_emp=E01&refine_company_emp=E02>.
- Bureau of Labor Statistics, U.S. Department of Labor, *Career Guide to Industries, 2010-11 Edition*, Construction, 17 Dec. 2009. Web. 8 May 2010
<http://www.bls.gov/oco/cg/cgs003.htm>
- Colling, David A. *Industrial Safety Management and Technology*. New Jersey: Prentice Hall, 1990. Print.
- Everett, John G. "Costs of Accidents and Injuries to the Construction Industry." *Journal of Construction Engineering and Management* 122.2 (1996): 158-64. EBSCO. Web. 27 Jan. 2010.
<<http://ejournals.ebsco.com/direct.asp?ArticleID=PHRU6N6XVAUV6AJXNM06>>.
- "Face Shield - Lab Safety Supply." *Lab Safety Supply - Safety Products, Material Handling, Industrial Supply, Respirators, Safety Glasses and More!* . N.p., n.d. Web. 21 Apr. 2010.
<<http://www.labsafety.com/search/Face+Shield&x=22&y=15/>>.

- "Gloves Online: General Purpose & Work, Construction Gloves." *Gloves Online: GO Gloves, your source for gloves since 1996*. N.p., n.d. Web. 15 Apr. 2010. <<http://www.gloves-online.com/products.php?cat=81>>.
- Goetsch, David L. *Occupational Safety and Health*. 2nd ed. New Jersey: Prentice Hall, 1996. Print.
- Goetsch, David L. *Construction Safety and Health*. New Jersey: Prentice Hall, 2003. Print.
- Hancher, Donn E. "Improving Workers' Compensation Management in Construction." *Journal of Construction Engineering and Management* 123.3 (1997): 285-91. EBSCO. Web. 1 Feb. 2010. <<http://ejournals.ebsco.com/direct.asp?ArticleID=BTX48JVC42J4MR1LG11>>.
- Hancher, Donn E., and Kevin D. Newman. "Workers' Compensation Issues in Construction." *Journal of Professional Issues in Engineering Education and Practice* 117.3 (1991): 228-44. EBSCO. Web. 15 Jan. 2010. <<http://ejournals.ebsco.com/direct.asp?ArticleID=430386C7DA97F7C04854>>.
- Hatch, David. "Worker Safety." *CQ Researcher*. 21 May 2004. Web. 22 Jan. 2010. <<http://library.cqpress.com/cqresearcher/cqresre2004052100>>.
- Hinze, Jimmie, Jenny Devenport, and Geneva Giang. "2006." *Journal of Construction Engineering and Management* 132.3 (2006): 321-326. American Society of Civil Engineers. Web. 5 Apr. 2010.
- Martin, Sam. "Control experience modification factor, before it controls you." *Insurance Journal - Property Casualty Insurance News*. N.p., n.d. Web. 30 Apr. 2010. <<http://www.insurancejournal.com/magazines/southcentral/2007/07/23/features/82444.htm>>.
- National Institute for Occupational Safety and Health. *Simple Solutions Ergonomics for Construction Workers*. Cincinnati: National Institute for Occupational Safety and Health, 2007. Print.
- "OSHA Safety Regulations in the Construction Site - free!." EHSO – Environmental Health & Safety Online - Free EHS Guidance Contents Page. N.p., n.d. Web. 3 Apr. 2010. <<http://www.ehso.com/oshacConstruction.htm>>.
- "Pennsylvania: Worker Dies After Crane Topples." *New York Times* 13 Oct. 2009, Late edition ed., sec. A: 23-23. *New York Times*. New York Times Company, 13 Oct. 2009. Web. 20 Jan. 2010. <<http://proquest.umi.com/pqdweb?did=1877985941&sid=1&Fmt=3&clientId=17878&RQT=309&VName=PQD>>.

- Raboud, Paul, and Jimmie Hinze. "Safety on Large Building Construction Projects." *Journal of Construction Engineering and Management* 114.2 (1988): 286-93. Web. 21 Jan. 2010. <<http://ejournals.ebsco.com/direct.asp?ArticleID=493FA5DF1B38AC6A53EC>>.
- "Racatac Kneeling Sitting Creeper ." *Automotive Tools and Equipment - Everything you need repair todays vehicles* . N.p., n.d. Web. 16 Apr. 2010. <<http://www.etoocart.com/racatac-kneeling-sitting-creeper-rct01rac3.aspx>>.
- Rajendran, Sathyanarayanan, John A. Gambatese, and Michael G. Behm. "Impact of Green Building Design and Construction on Worker Safety and Health." *Journal of Construction Engineering and Management* 135.10 (2009): 1058-066. EBSCO. Web. 30 Jan. 2010. <<http://ejournals.ebsco.com/direct.asp?ArticleID=4A119E59AE41B3E4C2D7>>.
- "Ramset Powder Tools." *ConstructionFastening.com*. N.p., n.d. Web. 1 May 2010. <<http://www.constructionfastening.com/powder.html>>.
- "RSC-432 Raze Disposable Safety Cutter. Pacific Handy Cutter.." *SafeCutting.com! Klever Kutter, Klever Konzept, Olfa, Martor, Lewis, Olo and more!*. N.p., n.d. Web. 2 May 2010. <<http://www.safecutting.com/rsc432.htm>>.
- "Stand-up Screw Gun - Easy Installation of Mezzanine Floors with Collated Screws ." *RESINDEK mezzanine floor panels* . N.p., n.d. Web. 21 Apr. 2010. <<http://www.resindek.com/Mezzanine-Floors/standup-screw-gun.aspx>>.
- "V2G - Stylish goggle keeps dust and airborne particles out: IndustrialSafetyGear.com." *IndustrialSafetyGear.com*. N.p., n.d. Web. 17 Apr. 2010. <<http://industrialsavings.com/hard-hats/-v2g.html>>.

Small Construction Companies Ergonomic Improvement Manual

Mona Barjasteh
June 2010

Table of Contents

Cost of Injuries.....	1
Lacerations.....	2
Upper Extremities.....	4
Lumbar Spine.....	6
Eye.....	9
Steps to Formulate a Safety Plan.....	11
Bibliography.....	12
Appendix A: OSHA Regulations for Construction Safety Management.....	13

Cost of Injuries

Why are injuries important to care about?

Injuries prevention is very important especially in the construction industry. Construction work is ranked at the top with some of the highest accidents of all the industries. In the construction business there are roughly 50% more back injuries than any other job. While material handling incidents are about 32% of worker's compensation problems. Manual handling on the job site results in lower back pain 80% of the time. In 2002, the total number of deaths came out to 1,121 in construction work as well as 175,000 nonfatal injuries that resulted in days away from work. With such high statistics of injuries in the construction industry it is important to try and reduce the numbers through accident prevention methods.

Even with the high statistics of injuries it is also beneficial for companies to reduce their worker injuries in order to save money in worker's compensation costs. Insurance companies rely on a modification factor in order to predict future losses that a given company will have. Meaning that if a company has had injuries in the past, they will have an increased modification factor resulting in higher workers compensation costs. The insurance companies determine that companies with prior injuries will likely have more accidents in the future. The employer because of this is not actually insuring injuries rather financing them. The employer in the end will have to pay for their injuries and then some because of the increased modification factor. Employers need to inform their employees that insurance is not the basis for accidents. The increase of accidents can deter money away from the business that could have been used for bonuses. These reasons make it essential to find ways to prevent accident and injuries from occurring.

What are the most common injuries and are there ways to reduce accidents?

The most common injuries in the workplace are lacerations, lumbar spine, upper extremity, and eye injuries. In this manual it provides information about these most common injuries as well as some examples of tools that can be used to prevent them.

Lacerations

What are lacerations?

Lacerations are cuts or deep tears in the skin. In the construction sector lacerations occur mostly on fingers and hands. This can become an enormous problem on the site slowing down workers and creating a messy situation. Lacerations are the most frequent injuries that occur in construction. Although these injuries may seem minor, it actually costs employers thousands of dollars a year. Without the proper safety equipment employees can become badly injured.

What to do?

In order to prevent laceration injuries on the job site it is necessary to have employees wearing the right gloves and carrying the right cutting equipment. With gloves that are cut resistant, it will prevent deep tares from occurring. Choosing between 360 coverage gloves versus only palm and finger coverage gloves, companies can determine the best options depending on the job being done. The 360-coverage glove allows for level 5 cut resistance over the entire hand, but the liquid resistant finish makes the gloves less flexible. The palm and finger coverage gloves allow for the same cut resistance only on the palms and fingers, but allows for dexterity and comfort. These gloves are the best choice because of their protective ability.



360-coverage gloves



Palm and finger coverage gloves

Construction workers need cutting tools to perform various activities on the job site. In order to have a safe cutter, the workforce should be using cutters that have an automatic relock spring as well as guard protection from the blade. These cutters would be best if they were able to be used by either hand making it easier for workers that are left handed.



Cutters

What is the cost?

The cost of purchasing the safer equipment would only cost around \$34 per employee. It would cost \$30 for 350 coverage gloves (or \$24 for palm and finger coverage gloves) and \$4 for cutters. The chart below shows the total cost of the protection versus the total cost of injury. By purchasing ten gloves and ten cutters the total would cost \$340. It is clear to see that the cost of the protection is below the cost of injuries occurring in a year. This cost will likely become an annual cost because of the necessity to make sure that the equipment being used is properly providing the right protection. Since gloves and cutter can deteriorate with extended use, it would be safer to throw out old equipment each year.

Laceration cost comparison

Probability of injury per year	0.24
Amount of workers injured in a year	2.39
Expected cost of injury in a year	\$1004.05
Cost of Protection	\$340
Payback Period	< 1 Year

Upper Extremity

What are upper extremity injuries?

An upper extremity injury consists of a few types of injuries. These injuries include contusions on hands and fingers, sprains in wrist and fingers, pain in joints, and crushing injuries. Although this injury category contains a variety of different types of injuries mainly to hands and fingers, it can easily be controlled with the right measures.

What to do?

To prevent upper extremity injuries on the job site it is necessary to buy the right materials for employees. Many contractors use flat and corner mudboxes in order to finish drywalls, but these tools require a lot of force and strength. This force causes fatigue as well as injuries in wrists and arms. By using a spring assisted finishing tool, it will eliminate most of the force and pushing employees have to do. It cuts down the strain significantly reducing the number of injuries.



Spring assisted drywall finishing tool



Extension pole

Many employees have to reach in high places in order to use powder-actuated tools. The reaching can cause injuries to hands, arms, and shoulders. By having an extension pole for the powder actuated tools it will reduce the risk of injuries as well as reduce the recoil shock. The extension pole will lower noise exposure as well have less set up time associated with ladders and scaffolds. The adjustable height of the pole allows it to be perfect match for any job.

Tying rebar is a very hand intensive job. It requires fast hand movements as well as being bent at stooped positions. This increases wrist and hand problems in construction workers. By using a rebar-tying tool it reduces the risk of injuries and removes the quick hand movements that are necessary. It also allows for easy change of tool direction

making it easier to get into hard to reach places. The rebar-tying tool is a great addition on the job site to get fast rebar ties.



Rebar tying tool

What is the cost?

The total cost of purchasing the equipment would cost \$5,950 for the whole company. The tools would cost \$1,150 for the spring-assisted drywall-finishing tool, \$350 for the extension poles for the powder-actuated tools, and \$1300 for the rebar-tying tool. For the cost of protection analysis two spring assisted drywall-finishing tools were analyzed along with three extension poles and two rebar tying tools. These numbers were used in order to provided the right amount of equipment if various different jobs were being conducted at the same time. The chart below shows the cost of the protection versus the cost of an injury. The total cost of the tools is above the yearly cost of an injury of this type. Although the payback period is nine years, it is dependent on the type of construction business. The equipment cost can vary depending on the amount of tools necessary for a particular business. An employer may not need to purchase a tool like the rebar-tying tool if the company does not work with rebar. Also every worker will not have to be supplied individually with this equipment. With great care and maintenance of the tools a long lifetime can be expected with these tools and will not need to be purchased often.

Upper extremity cost comparison

Probability of injury per year	0.11
Amount of workers injured in a year	1.14
Expected cost of injury in a year	\$688.87
Cost of Protection	\$5,950
Payback Period	8.6 Years

Lumbar Spine

What are lumbar spine injuries?

A lumbar spine injury consists of general sprains and non-specific back pains. Many positions like bending, stooping, kneeling, or squatting are required in the construction job and can cause pain in the lower back. Ligaments can become stretched and discs can get squeezed. It is important to pay close attention to the twisting that the body must conduct in order to reduce back stress.

What to do?

To decrease the chances of having workers become injured in this category, it is important to purchase the right equipment to provide the best safety. One such tool is a bit extension shaft. This tool attaches to a drill in order to allow for a variety of unique drilling and easy accessibility to hard to reach screws. This extension shaft permits the arms to stay closer to the side and allows for the use of the bicep muscle instead of the shoulder. The reduction in stress on the arm, neck, shoulder and back is essential in injury reduction. Although the strain of looking up can become harmful to the neck, it should be done carefully in order to not bring about this problem.



Bit Extension Shaft

Another tool that reduces lower back stress is the kneeling creeper. The kneeling creeper has two uses, one as a seat and another as a knee placement for low groundwork. The foam kneepads allow for comfort when working in low areas. It also provides convenient detachability for storage as well as travel to different sites.



Kneeling Creeper



Stand-Up Screw Gun

The stand up screw gun is another alternative to reducing lower back injuries. The stand up ability allows for the reduction in lower back injuries. This tool allows for consistent screw depth and strength to provide steady screws each time.

What is the cost?

The total cost of equipment protection would cost \$1,965. The cost of equipment includes seven bit extensions, five kneeling creepers, and three stand up screw guns. The cost of each tool is \$25 for the bit extension, \$160 for the kneeling creeper, and \$330 for the stand up screw gun. The number of equipment to purchase was determined by the potential of having different jobs at the same time and the equipment necessary at the particular job sites. Although the pay back period is about two years, this can vary by business depending on the amount of equipment purchased. These tools also do not need to be purchased every year if maintained and kept well.

Lumbar spine cost comparison

Probability of injury per year	0.13
Amount of workers injured in a year	1.3
Expected cost of injury in a year	\$1132.32
Cost of Protection	\$1,965
Payback Period	1.7 Years

Eyes

What are eye injuries?

Eye injuries are very serious and can cause great damage to the worker. Eye injuries include inflammation, abrasion, or scratches from foreign objects. Because of the sensitivity of the eyes, it is very important to make sure that the proper protection gear is used at all times.

What to do?

In order to protect the eyes from injuries it is important to maintain full coverage from any kind of object. The two kinds of alternatives could be goggles and face shields. The goggles should have full side protection and hug the employee's face. The seal will keep out dust and airborne particles from entering into the employee's eyes. The goggles should also protect against UV rays as well as prevent fogging. By purchasing goggles with high impact requirements it can be easier to reduce injuries. The face shield that should be purchased should follow class 6A guidelines. This would mean that the face shield has high impact, piercing, splash, head, and glare protection. By purchasing these two types of protection equipment for workers, it will greatly reduce injuries if used properly and consistently.



Goggles



Face shield

What is the cost?

The cost of eye protection comes to a total of \$210. This accounts for ten pairs of goggles and ten face shields. The goggles cost around \$7, while the face shields cost about \$14. The payback period for this injury is less than one year, since the total cost of protection is below the expected cost of injury. This protection equipment will need to be

purchased every year in order to ensure full safety. The wear and tare of the goggles after a year can cause the goggles to become less impact resistant. Therefore it would be important to make sure that the goggles and face shields used are appropriate in providing safety and replaced when damaged.

Eye cost comparison

Probability of injury per year	0.11
Amount of workers injured in a year	1.09
Expected cost of injury in a year	\$277.44
Cost of Protection	\$210
Payback Period	< 1 Year

Steps to Formulate a Safety Plan

- Designate a qualified safety person to make regular safety inspections and enforce the use of safety equipment.
 - Enforce and create safety rules as well as make sure the safety person knows the proper methods for handling accidents.
- Make sure that the rules and safety procedures are understood by every employee and are visibly up at a certain location on every job site.
 - Make sure employees know what hazardous materials are and the proper removal and disposal of these materials
- Provide on going safety training either daily for a few minutes prior to employee starting their job or weekly at the company meetings.
 - Safety training should include accident prevention, injury severity prevention, and probability of accident occurring.
- Records and safety inspections logs should be kept in order to provide company proof.
- Personal protective equipment should be made available to every employee and should be checked regularly for damages and faults. The damage equipment should be identified and replaced immediately to prevent injuries.
- Provide a clean job environment and make sure that clean up of rubbish and debris is done regularly everyday.
- No equipment should be used without the proper training.
- Make sure to keep up to date with new OSHA regulations that are passed as well as comply with all regulations

Bibliography

- "11" Flexible Extension Shaft, Drivers & Bits, Power Tool Accessories - McFeely's . " *McFeely's Square Drive Screws - Screws, Fasteners, Festool Power Tools and more* . N.p., n.d. Web. 1 May 2010. <<http://www.mcfeelys.com/product/FBX-0011/11quot-Flexible-Extension-Shaft>>.
- Bureau of Labor Statistics, U.S. Department of Labor, *Career Guide to Industries, 2010-11 Edition*, Construction, on the Internet at <http://www.bls.gov/oco/cg/cgs003.htm> (visited May 08, 2010)
- "Face Shield - Lab Safety Supply." *Lab Safety Supply - Safety Products, Material Handling, Industrial Supply, Respirators, Safety Glasses and More!* . N.p., n.d. Web. 21 Apr. 2010. <<http://www.labsafety.com/search/Face+Shield&x=22&y=15/>>.
- "Gloves Online: General Purpose & Work, Construction Gloves." *Gloves Online: GO Gloves, your source for gloves since 1996*. N.p., n.d. Web. 15 Apr. 2010. <<http://www.gloves-online.com/products.php?cat=81>>.
- Hatch, David. "Worker Safety." *CQ Researcher*. 21 May 2004. Web. 22 Jan. 2010. <<http://library.cqpress.com/cqresearcher/cqresrre2004052100>>.
- Hinze, Jimmie, Jenny Devenport, and Geneva Giang. "2006." *Journal of Construction Engineering and Management* 132.3 (2006): 321-326. American Society of Civil Engineers. Web. 5 Apr. 2010.
- Martin, Sam. "Control experience modification factor, before it controls you." *Insurance Journal - Property Casualty Insurance News*. N.p., n.d. Web. 30 Apr. 2010. <<http://www.insurancejournal.com/magazines/southcentral/2007/07/23/features/82444.htm>>.
- National Institute for Occupational Safety and Health. *Simple Solutions Ergonomics for Construction Workers*. Cincinnati: National Institute for Occupational Safety and Health, 2007. Print.
- "OSHA Safety Regulations in the Construction Site " EHSO – Environmental Health & Safety Online - Free EHS Guidance Contents Page. N.p., n.d. Web. 3 Apr. 2010. <<http://www.ehso.com/oshacConstruction.htm>>.
- "RSC-432 Raze Disposable Safety Cutter. Pacific Handy Cutter.." *SafeCutting.com! Klever Kutter, Klever Konzept, Olfa, Martor, Lewis, Olo and more!*. N.p., n.d. Web. 2 May 2010. <<http://www.safecutting.com/rsc432.htm>>.
- "Racatac Kneeling Sitting Creeper ." *Automotive Tools and Equipment - Everything you need repair todays vehicles* . N.p., n.d. Web. 16 Apr. 2010. <<http://www.etoocart.com/racatac-kneeling-sitting-creeper-rct01rac3.aspx>>.
- "Ramset Powder Tools." *ConstructionFastening.com*. N.p., n.d. Web. 1 May 2010. <<http://www.constructionfastening.com/powder.html>>.
- " Stand-up Screw Gun - Easy Installation of Mezzanine Floors with Collated Screws ." *RESINDEK mezzanine floor panels* . N.p., n.d. Web. 21 Apr. 2010. <<http://www.resindek.com/Mezzanine-Floors/standup-screw-gun.aspx>>.
- "V2G - Stylish goggle keeps dust and airborne particles out: IndustrialSafetyGear.com." *IndustrialSafetyGear.com*. N.p., n.d. Web. 17 Apr. 2010. <<http://industrialsavings.com/hard-hats/v2g.html>>.

OSHA Regulations for Construction Safety Management

(This information was gathered from Title 29 of the Code of Federal Regulations Part 1926)

Subpart A- General

Any authorized representative has a right of entry to any site to inspect safety standards as well as investigate. (1926.3)

Subpart B- General Interpretations

Davis-Bacon Act limits minimum wage protection to laborers on job sites. (1926.13)

No subcontractor can require any laborer to work in an environment that is unsanitary, hazardous, or dangerous to the individual's health. (1926.13)

A subcontractor is a person who agrees to perform any part of the labor requirements of a contract for a construction site. (1926.13)

"... If the goods or materials in question are ordinarily sold to other customers from regular inventory, the supplier is not a "subcontractor." Generally, the furnishing of prestressed concrete beams and prestressed structural steel would be considered manufacturing; therefore a supplier of such materials would not be considered a "subcontractor."" (1926.13)

"...Service Contract Act of 1965 requires as a condition of every Federal contract (and bid specification therefore) exceeding \$2,500, the "principal purpose" of which is to furnish services to the United States through the use of "service employees," that certain safety and health standards be met. See 29 CFR Part 1925, which contains the Department rules concerning these standards." (1926.15)

Subpart C- General Safety and Health Provisions

It is the employer's responsibility to initiate and maintain accident prevention responsibilities with frequent and regular inspections of the jobsite. (1926.20)

Employer should only permit qualified and trained employees to operate machinery. (1926.20)

The employer should instruct each employee of unsafe conditions and regulations in his work environment to eliminate injury. (1926.21)

Employees handling hazardous material should be instructed on the potential hazards, first aid procedures, and how to avoid injury. (1926.21)

Employees using flammable liquids and gases must be instructed of safe handling of the materials. (1926.21)

Employees entering in a confined space should be instructed of the hazards involved and the precautions as well as emergency equipment required. (1926.21)

The employer should make first aid services available for every employee that needs it. (1926.23)

The employer is responsible for developing an effective fire protection program at the job site. (1926.24)

At the construction site scrap lumber, protruding nails, and other debris should be clear of the work areas. (1926.25)

Containers should be available to separate wastes such as hazardous material or used rags. (1926.25)

Construction areas should be light naturally or artificially. (1926.26)

The employer is responsible for requiring employees to wear the appropriate protective equipment at all times in operations. (1926.28)

Every building should have exits arranged in order to provide a free and unobstructed egress from all parts of the building. (1926.34)

Subpart D- Occupational health and Environmental Controls

The employer must ensure the availability of medical personnel for advice and consultation. (1926.50a)

Prior to the start of the project the employer should make provisions about serious injuries. (1926.50b)

In the absence of hospitals or physicians an equivalent person should be made available to the worksite to render first aid. (1926.50c)

First aid supplies should be easily accessible. (1926.50d)

The employer must provide prompt and proper equipment for transportation of injured persons to hospitals or physicians. (1926.50e)

The proper medical numbers should be posted clearly. (1926.50f)

There should be suitable facilities for quick flushing of the eyes and body if employees are exposed to injurious corrosive materials. (1926.50g)

An adequate supply of water shall be provided in all places of employment and containers of drinking water shall be marked clearly. (1926.51a)

Common drinking cups are prohibited and service cups are supplied in a sanitary container for unused cups. (1926.51a)

Bathrooms shall be provided with 1 toilet seat for up to 20 employees, 1 toilet seat for 20 or more as well as 1 urinal per 40 workers, and with 200 and more employees must have 1 toilet seat and 1 urinal per 50 workers. (1926.51c)

General washing facilities shall be kept in sanitary conditions. (1926.51f)

Protection against noise exposure following the table below (1926.52a&b):

**TABLE D-2
Permissible Noise Exposures**

Duration per Day, Hours	Sound Level dBA Slow Response
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or less	115

The daily noise exposure of two or more periods should be considered with their combined effects through the following computation methods:

$$F_e = (T_1 / L_1) + (T_2 / L_2) + \dots + (T_n / L_n) \text{ where:}$$

F_e = The equivalent noise exposure factor.

T = The period of noise exposure at any essentially constant level.

L = The duration of the permissible noise exposure at the constant level (from Table D-2).

If the value of F_e exceeds unity (1) the exposure exceeds permissible levels. (1926.52d)

Only employees trained and qualified shall work on laser equipment and proof should be available at all times. (1926.54a&b)

Eye protection should be made available when working in areas with light greater than 0.005 watts. (1926.54c)

Warning placards should be made available for areas in which lasers are present. (1926.54d)

Beam shutters shall be turned off with the laser transmission is not required for substantial periods of time. (1926.54e)

When it is raining, snowing, foggy, or dusty the operations of the laser systems must be prohibited. (1926.54h)

Laser unit should be set up above the employee's heads. (1926.54k)

Exposure to inhalations of substance concentrations above the "Threshold Limit Values of Airborne Contaminants for 1970" must be avoided from appendix A. (1926.55a)

Construction areas shall be lighted with the minimum illumination listed in Table D-3. (1926.56a)

Subpart E- Personal Protective and Life Saving Equipment

Protective equipment shall be provided for eyes, face, and head and maintained sanitary and reliable. (1926.95a)

Employer shall be responsible that employees that provide their own equipment have adequate and proper maintenance of equipment. (1926.95b)

Footwear of all employees shall meet requirements and specifications of American National Standard for Men's Safety-Toe Footwear. (1926.96)

Protective helmets must be worn in areas where there is possible danger of head injuries. (1926.100a)

Helmets must meet the impact of falling objects as well as high voltage shock specified in American National Standards Institute. (1926.100b&c)

Ear protective devices shall be provided to insert in the ear and plain cotton is not acceptable as protective device. (1926.101)

Employees shall be provided with eye and face protection equipment. (1926.102a)

Employees with corrective spectacles shall be protected with goggles that provide optical correction, goggles that can be worn over spectacles, or goggles that have corrective lenses mounted behind the protective lenses. (1926.102a3)

Face and eye protection must be kept in clean and good condition. (1926.100a4)

Protectors should be protective, comfortable, snug enough to not interfere with movements, durable, cleanable, disinfected, and protect against radiant energy. (1926.100a6&8)

Proper respiratory protective devices shall be provided that protect against the concentration levels of the hazardous materials. (1926.103b)

Employees required to use respiratory protective equipment should be trained thoroughly in its use, inspect and maintain the equipment regularly, as well as clean and disinfect after each use. (1926.103c)

Written standards of operation procedures governing the selection and use of respirators shall be established as well as respirators selected based on the hazards the worker is exposed to. (1926.103e)

Regular inspection and evaluation of the continued effectiveness of the program must be implemented. (1926.103e)

A program for the maintenance and care of respirators shall be implemented with a log kept of all the inspection dates and findings. (1926.103h)

“Lifelines, safety belts, and lanyards shall be used only for employee safeguarding. Any lifeline, safety belt, or lanyard actually subjected to in-service loading, as distinguished from static load testing, shall be immediately removed from service and shall not be used again for employee safeguarding.” (1926.104a)

“Lifelines used on rock-scaling operations, or in areas where the lifeline may be subjected to cutting or abrasion, shall be a minimum of 7/8-inch wire core manila rope. For all other lifeline applications, a minimum of 3/4-inch manila or equivalent, with a minimum breaking strength of 5,400 pounds, shall be used.” (1926.104c)

Subpart I- Tools-Hand and Power

All hand and power tools should be kept in safe condition and have accommodating guards. (1926.300a&b)

Belts, gears, shafts, pulleys, and other rotating or moving parts shall be guarded from exposure to employee contact. (1926.300b)

The point of operation of the machines shall be guarded in order to prevent the operator from having any body parts in the danger zone. (1926.300b)

Special hand tools for removing and easy handling of material should be provided. (1926.300b)

“The maximum angular exposure above the horizontal plane of the wheel spindle ... shall never be exceeded, and the distance between the wheel periphery and the adjustable tongue or the end of the peripheral member at the top shall never exceed 1/4 inch (0.635 cm).” (1926.300b)

“The angular exposure of the grinding wheel periphery and sides for safety guards used on machines known as bench and floor stands should not exceed 90 deg. or one-fourth of the periphery. This exposure shall begin at a point not more than 65 deg. above the horizontal plane of the wheel spindle.” (1926.300b)

“The maximum angular exposure of the grinding wheel periphery and sides for safety guards used on cylindrical grinding machines shall not exceed 180 deg. This exposure shall begin at a point not more than 65 deg. above the horizontal plane of the wheel spindle.” (1926.300b)

Employees using hand and power tools should be provided protective equipment to protect them from hazards. (1926.300c)

Hand-held powered grinder with a 2-inch diameter or less can have only a positive “on-off” control. (1926.300d)

Hand-held powered drills, tappers, fastener drivers, and angle grinders with wheels of 2 inches in diameter or greater should have a momentary contact “on-off” control and may have a lock-on control that off can be accomplished with a single motion of the same finger. (1926.300d)

All other hand-help powered tools shall be equipped with constant pressure switches that will shutoff power when the pressure is released. (1926.300d)

Employers shall not issue unsafe handling of tools. Wrenches and adjustable tools shall not be used when the jaws are sprung enough that slippage occurs. Impact tools shall be kept free of mushroomed heads. Wooden handles of tools shall be kept splinter free. (1926.301a,b,c,&d)

Electric power operated tools should have double insulated or grounded. (1926.302a)

Pneumatic power tools shall be secured to the hose to prevent accidental disconnect as well as have safety clips. (1926.302a&b)

Pneumatic driven mailers or staplers with more than 100psi must have a safety device on the muzzle to prevent tool from ejecting. (1926.302b)

Manufactured safe operating pressures should not be exceeded. (1926.302b)

Blast cleaning nozzles should have an operating valve that must be held manually and a support for the nozzle should be mounted for when not in use. (1926.302b)

Only trained employees on the particular tools shall be allowed to operate the tool. (1926.302e)

The tools should be tested each day before loading to make sure the devices are in proper working conditions. (1926.302e)

Loaded tools should never be left unattended as well as not used in explosive and flammable environment. (1926.302e)

Woodworking tools should be guarded and meet all the requirements of the American National Standards Institute. (1926.304)

Subpart K- Electrical

There are four divisions involved in construction work. Installation safety requirements including electrical power and light, safety-related work practices covering the hazards that arise from the use of electricity at jobsites, safety-related maintenance and environmental considerations, and safety requirements for special equipment. (1926.400)

All electrical conductors and equipment shall be approved and the employer shall ensure that the electrical equipment is free from causing serious harm or death. (1926.403a&b)

The protections provided must be durable and contain electrical insulation to prevent overheating with extended use. (1926.403b)

Equipment that is used to break current should have a sufficient amount of voltage to interrupt the current. (1926.403c)

Electrical equipment should be mounted firmly to the surface, allow for ventilation and cooling of the equipment, all joints and splices shall be covered with insulation, and shall be isolated from all combustible material. (1926.403d&f)

Conductor used as a grounded conductor should be identifiable and distinguishable from all other conductors. (1926.404a)

A grounding terminal or grounding-type receptacle shall not be used for any other purpose than grounding. (1926.404a)

The employer shall only use approved ground fault circuit interrupters for all 120 volt, single-phase 15 and 20-ampere receptacle outlets. (1926.404b)

The employer shall have grounding conductor programs on the site in order to have all the cords covers that are not part of the buildings with the requirements of a written descriptions of the program available for inspections, one or more persons to implement the program, and any equipment connected by cord and plug are fixed and not exposed to damage. (1926.404b)

All grounding conductors should be tested for continuity and each receptacle shall be tested for correct attachment. (1926.404b)

All required tests should be done before the first use, before equipment is returned to service, before used after any incident, and not exceeding intervals of 3 months. (1926.404b)

Outlet devices should not have an ampere rating less than the load with a single receptacles not having an ampere rating less than that of the branch circuit, or with two or more receptacles conforming to the values in table K-4. (1926.404b)

**TABLE K-4. - Receptacle Ratings
for Various Size Circuits**

Circuit rating amperes	Receptacle rating amperes
15	Not over 15.
20	15 or 20.
30	30.
40	40 or 50.
50	50.

“Conductors shall have a clearance of at least 3 feet (914 mm) from windows, doors, fire escapes, or similar locations. Conductors run above the top level of a window are considered to be out of reach from that window and, therefore, do not have to be 3 feet (914 mm) away.” (1926.404c)

Conductors above a roof space should have a clearance from the highest point of the roof surface of not less than 8 feet vertical for insulated conductors and not less than 10 feet vertical or diagonal for covered conductors except when the roof is

accessible to vehicles where it should be no less than 18 feet or if it is not usually accessible to employees on foot where the vertical clearance should not be less than 3 feet. (1926.404c)

Lamps for outdoor lighting shall be located below electrical equipment unless it is controlled by a way to disconnect unless there is a safeguard for re lamping operations. (1926.404d)

Service-entrance conductors that are installed with open wires should only be available to qualified persons. (1926.404d)

Warning signs of high voltage should be posted in places where unauthorized employees may come into contact. (1926.404d)

Over currents of 600 volts or less should not be in a place that is a hazard to employees. (1926.404e)

Circuit breakers should have a clear on and off position and if used as a 120 volt it should be marked as "SWD". (1926.404e)

Feeders and branch circuits that are over 600 volts must have protection from short-circuits. (1926.404e)

DC systems with 3 wires should have neutral conductor grounded. (1926.404f)

DC systems over 500 volts and between 300 volts should be grounded unless from an AC system that should be grounded. (1926.404f)

Portable generators need not be grounded and can be a grounded electrode for a system supplied by a generator. (1926.404f)

The path to ground should be permanent and continuous. (1926.404f)

Electrical equipment is considered grounded effectively if it is secured to a metal rack or a structure that is grounded properly for noncurrent carrying metal parts. (1926.404f)

Wiring system should not be installed in ducts that are used for transporting dust, flammable vapors, or vapor removal. (1926.405a)

Temporary wiring should be removed upon completion off the construction project. (1926.405a)

All lamps should be protected from accidental breakage and temporary lights should not be suspended by the electric cord unless designed for being suspended by the cord. (1926.405a)

Sharp corners and projections should be avoided. (1926.405a)

Qualified personnel should place switchboards that are exposed in areas that are dry and only accessible. (1926.405a)

Flexible cords that pass through holes should be protected by bushings. (1926.405a)

No employee should be working in an area with electrical power circuits unless the employee is protected against electric shock by deenergizing and grounding the circuit. (1926.416a)

Barriers should be set up in order to make sure that an area where electrical equipment is used would not be used as a passageway during periods of energizing of parts. (1926.416b)

Worn electrical cords should not be used and extension cords must be fastened with staples. (1926.416e)

Controls that are being deactivated should be tagged and shown as inoperative. (1926.417)

No conductors should be operating in damp/wet locations, in a gas and fume environment, and excessive temperatures. (1926.432a)

Subpart M- Fall Protection

The employer should make sure that the walking and working surfaces that the employees are working on has the strength and structural support for employee safety. (1926.501a)

A safety net or guardrail system should be provided in areas where there was an unprotected side or edge with 6 feet or more above a lower level. (1926.501b)

Employees in hoist areas should be protected from falling 6 feet or more by a personal fall arrest system or any other system. (1926.501b)

Employees working on surfaces should be protected from falling through holes, tripping in or stepping into holes, and objects falling through holes more than 6 feet above lower levels. (1926.501b)

Employees on ramps or other walkways must be protected from falling 6 feet or more to lower levels. (1926.501b)

Employees less than 6 feet above dangerous equipment should be protected from falling into dangerous equipment. (1926.501b)

Employees on roofs with unprotected sides and edges of 6 feet or more should be protected with a guardrail system. (1926.501b)

The employer has the burden of establishing a fall protection system that is feasible and will not create a greater hazard upon implementation. (1926.501b)

Employees walking in areas exposed to falling objects should be protected and enforced to wear a hard hat by the employer. (1926.501c)

The guardrail system should have a height of 42 inches \pm 3 inches above the walking level. (1926.502b)

Midrails should be installed at a height midway between the top edges of the rail to the walking level. (1926.502b)

Guardrails shall be surfaced in order to prevent injuries to employees. (1926.502b)

Guardrail system used around holes as points of access should be provided with a gate or offset in order for the person to walk directly into the hole. (1926.502b)

Lanyards and vertical lifelines should have a minimum breaking strength of 5,000 pounds and should be protected from being abraded. (1926.502d)

Harnesses for the body and body belts should be made of synthetic fibers. (1926.502d)

Fall systems that are subject to impact loading shall be immediately removed from service and not used again until inspected for protection. (1926.502d)

The employer shall provide prompt rescue of employees in the event of a fall. (1926.502d)

Body belts shall be at least 1 5/8 inches wide. (1926.502d)

Positioning devices should be in a way that the employee cannot fall from more than 2 feet. (1926.502e)

Body belts and harnesses shall be used only for employee protection. (1926.502e)

When control lines are used it should be erected no less than 6 feet and no more than 25 feet. (1926.502g)

Each line should be clearly marked at no more than 6 foot. (1926.502g)

Each line shall have a minimum breaking strength of 200 pounds. (1926.502g)

No materials or equipment except masonry shall be stored within 4 feet of the working edge. (1926.502j)

The fall protection plan should be prepared by a qualified person and developed specifically for the site where the work is being performed. (1926.502k)

A copy of the fall protection plan should be maintained at the job site at all time and the implementation should be under the supervision of a qualified person. (1926.502k)

The fall protection plan should include a statement providing the names of each employee designated to work in the controlled access zones. (1926.502k)

The employer should provide a training program for each employee who might be exposed to fall hazards. (1926.503a)

The latest training certification shall be maintained and when an employer see that an employee does not have the understanding and training that is required, the employee should be retrained. (1926.503c)

Subpart X- Stairways and Ladders

Stairs or ladder should be provided where there is an elevation break of 19 inches or more. (1926.1051a)

When a ladder is to serve, as a two-way traffic way then there should be two more separate ladders or a double-cleated ladder. (1926.1051a)

There must be a point of access that must always be kept clear for free passage for employees or another point of access must be created. (1926.1051a)

Stairways that are created just during the construction work of the building and is not permanent should have landings of no less than 30 inches, extend to at least 22 inches every 12 feet or less. (1926.1052a)

Stairs should be installed at around 30 to 50 degrees from the horizontal. (1926.1052a)

Riser height and tread depth shall be uniform within each flight of stairs and variations should not exceed $\frac{1}{4}$ of an inch. (1926.1052a)

A platform should be provided when a door or gate open directly onto a stairway. The swing of the door would not reduce the width of the platform any less than 20 inches. (1926.1052a)

Stairways should be free of hazardous protrusions as well as slipper conditions. (1926.1052a)

Stairways having four or more risers or rising more than 30 inches must have at least one handrail and one stair rail system. (1926.1052c)

Handrails and top rails should be able to withstand a force of up to 200 pounds applied within 2 inches from the top edge without failing. (1926.1052c)

Handrails and stair rails must be surfaced to prevent injuries to employees. (1926.1052a)

Handrails that will not be permanent should have at least a minimum of 3-inch clearance between the handrail and the walls or other objects. (1926.1052c)

A self-supporting portable ladder should be able to support at least four times the intended load unless it is an extra-heavy -duty type metal or plastic which would be able to sustain at least 3.3 times the maximum load. (1926.1053a)

Fixed ladders should be able to withstand at least two loads of 250 pounds concentrated between any two consecutive attachments. (1926.1053a)

Ladder rungs should be parallel and uniformly spaced when the ladder is set up in position. (1926.1053a)

Steps of a portable ladder and fixed ladders should be spaced no less than 10 inches apart and no more than 14 inches apart. (1926.1053a)

The minimum distance between the sides of the rungs on a ladder should be at least 16 inches. (1926.1053a)

Ladder components shall be surfaced to prevent injury to employees. (1926.1053a)

Wood ladder should not be coated with opaque coverings except to identify warning labels. (1926.1053a)

Ladders should be free of oil and should not be loaded beyond the maximum intended load. (1926.1053b)

The area of the top and bottom rungs of the ladder should be kept clear. (1926.1053b)

A ladder should not be moved when being used. (1926.1053b)

A competent person should inspect the ladders for visible defects. (1926.1053b)

Each employee should have at least one hand grasp on the ladder when moving up and down the ladder. (1926.1053b)

The employer should provide a training program for each employee to recognize hazards. (1926.1060a)

Retraining should be provided to employees in order to make sure the understanding and knowledge is maintained. (1926.1060b)