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Comparison of costs of personal protective equipment for all workers to avoid costs of fall accidents

Sultan Noori Al-karawi

COMPARISON OF COSTS OF PERSONAL PROTECTIVE EQUIPMENT FOR ALL WORKERS TO AVOID COSTS OF FALL ACCIDENTS

by

SULTAN NOORI AL-KARAWI

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Approved by:

W. Eric Showalter, Advisor
Stuart Baur
Suzanna Long

ABSTRACT

The construction industry is one of the most important industries in the United States. It is the biggest contributor in the growth of the U.S. economy. Despite the great achievements and prominent role for this sector in the U.S. economy, the construction industry is suffering from neglect and dereliction by related government institutions and private companies. This neglect led to formation of a negative image about the construction industry that has caused a deep impact in productivity and economic growth. One of the reasons is a high percentage of accidents that occur within the construction industry which leads to injuries and fatalities. The construction industry consists of about 5% of the U.S.A work force, and accounts for some 20% of the work fatalities and 12% of disabling injuries. The largest percentages of fatalities or injuries in the construction industry were the result of a fall. The falling fatality rate was about 33.3% of the total attributed most common accidents in this sector at 2010 (CPWR, 2013), and this percentage increased in 2012 as the number of fatalities due to falls was to 280 out of 775 people killed in industrial constructions (United States Department of Labor, 2012).

This thesis is a comparison between the total cost of fall accidents and costs of protective programs to reduce a fall accidents. The lack of accurate information about costs is one of the main reasons that employers show little interest in supporting the protective systems to avoid a fall hazards. The mechanism that was used in this thesis is a realistic comparison between costs that may occur as a result of fall accident in the construction industry, and costs of use of Personal Protective Equipment (PPE).

ACKNOWLEDGEMENTS

I am very grateful to my thesis advisor, Dr. Eric Showalter, for his guidance and encouragement. His expertise in Construction Engineering improved my research skills and prepared me for future challenges, thanks for his support. I thank my other committee members, Dr. Stuart Baur, and Dr. Suzanna Long, for their helpful suggestions and comments during my study. Dr. Suzanna Long, I would like to say I am very pleased when ‘’I was in your class (Management for Engineers & Scientists)’’. I would like to extend my thanks to the faculty & staff of the Department of Civil Engineering at Missouri University of Science & Technology.

I would like take this opportunity to present this modest effort to several people who made this endeavor possible. First and foremost, dedicate this effort to the memory of my father who has been deceased since I was nine years old. I also dedicate this effort to my mother, who helped me with her prayer and kindness, and she was as my father and mother in my life. To the faithfulness in my wife and her love, I dedicate my respect and love for her. Thanks to my brothers and sisters who wish to me always a better Life. Thanks to my colleagues. Thanks to Iraqi students in Rolla city. Thanks to Staff and Faculty of Diyala University. Lastly, I would like of my heart to present my master degree to my dear son "Mokhalad". I am asking God to keep him for us, and make to him a better future.

TABLE OF CONTENTS

Page

LIST OF ILLUSTRATIONS

Page

LIST OF TABLES

Page

1. INTRODUCTION

The construction industry in the United States is a huge and diverse industry to a great extent. Ranging from small residential and commercial projects, to complex projects such as dams, bridges, and highway. All of which are managed by engineering and construction companies. Generally, the construction industry is divided into three major of sub-sectors. First, companies or institutions directly responsible for the construction of buildings, it may be the work done includes a new work, alteration, additions and modification or demolition of any structure or building. As well as other specialized business those are involved in other types of structures, such as electricians, and plumbers. Second, heavy and civil engineering construction “nonresidential building” (e.g. highways, dams, road, and other "infrastructure" building). Third, specialty trade contractors that are within the main construction (e.g., pouring concrete, plumbing, site preparation, electrical work and painting) involved in building work or acts and other activities that are similar for all construction, but these activities are not responsible for the entire project.

Construction is one of the most important industries in the United States in particular and in the rest of the world in general, so as to by a large contribution in the Gross Domestic Product (GDP) for the majority of the world countries, and the Gross National Product (GNP).The importance of this sector is not only for its size or number of employees in this area, but for large importance in the economic growth of the countries. The construction industry has an important role in the economy of all nations, its importance in achieving the goals of economic and social development of national, and providing shelter, employment, and infrastructure. It is clear also that sector has a direct impact on all aspects of the economy. The table below shows statistics on the size, and annual revenue of the construction industry in the United States (US Census Bureau, 2012). Table 1.1 shows statistics on the size, and annual revenue of the construction industry

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Table 1.1- Statistics on the Size, and Annual Revenue of the Construction Industry in the United States.

Construction Industry Statistics		**Annual Revenue**
US Construction industry annual revenue		**$1.731 Trillion**
Number of construction companies in the US		729,345
Number of construction company employees in the US		7,316,240
Average construction company employee salary		$45,200.00
Construction Company Type Statistics	**Number of Companies**	**Value of Annual Business**
Construction of Buildings	211,956	$748 Billion
Heavy and civil engineering construction	39,439	$260 Billion
Specialty trade contractors	477,950	$722 Billion

From these statistics we find the construction employment is greater than 5% of the rest of the other industrial sectors, but responsible for 20% of the accidents. Thus construction is about 4 times more hazardous than other industries (U.S. Department of Commerce, 2012). Table 1.2 shows percent of employment for industry

Table 1.2 - Percent of Employment for Industry.

Industry	Percent of Employment
Steel	1.1%
Auto	1.0%
Agriculture	4.5%
Construction	5.0%

Unfortunately, in spite of the significant role played by industrial construction in economic growth on various areas within the United States as well as the achievements of this sector in recent years which are established by large-scale projects such as The Gateway Arch in St. Louis, the Sears Tower in Chicago, the Golden Gate Bridge in San Francisco and the Cable Stayed Bridge in Alton, Illinois. This broad sector suffers from neglect and dereliction in many ways by related companies and institutions, which led to the formation of a negative image about the sector that caused the faltering economic growth, and reduced productivity during the last decade compared with the past 50 years. One of these reasons is a high percentage of accidents that occur within this sector which leads to injuries and fatalities. Figure 1.1 shows annual Construction as % of Gross Domestic Product (GDP) (U.S. Department of commerce, 2012).

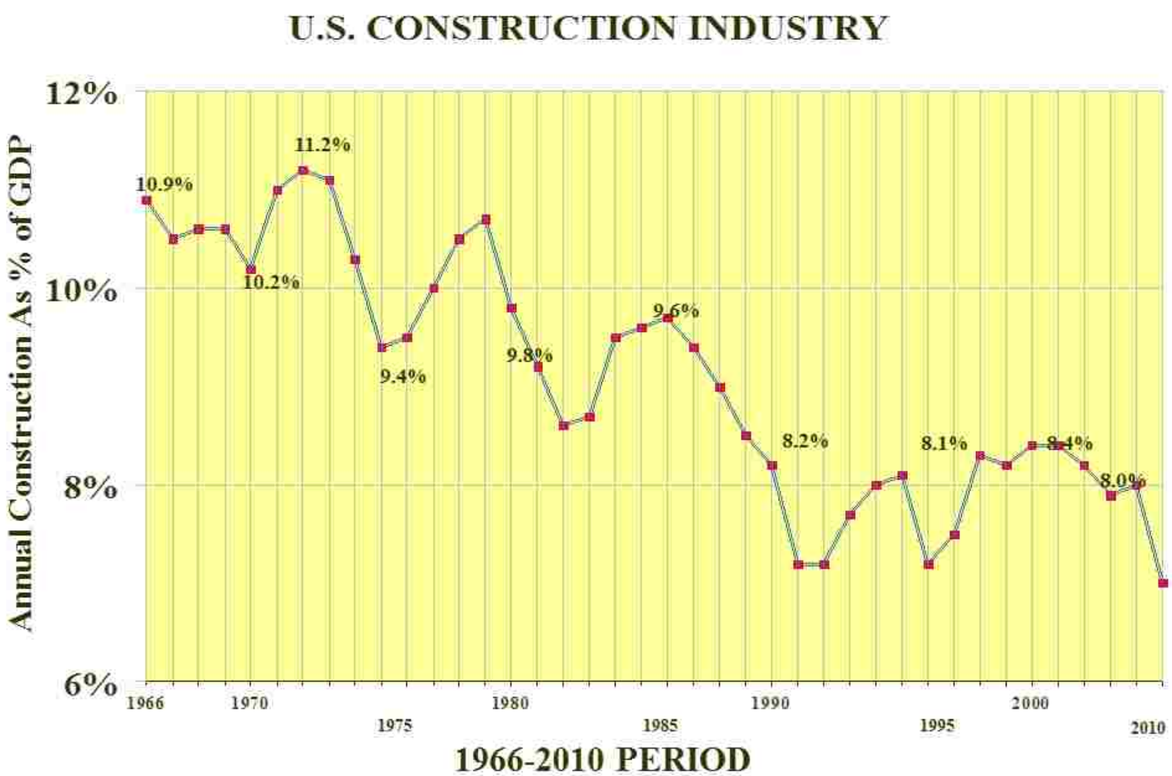

Figure 1.1 - Annual Construction as % of Gross Domestic Product (GDP).

Most of the incidents that lead to fatalities or injuries in the construction industry were the result of a fall. The falling fatality rate was about 34% of the total attributed most common accidents in construction in 2010 (CPWR, 2013), and this percentage increased in 2012 as the number of fatalities due to falls was 280 out of 775 people killed in industrial construction (Bureau of Labor Statistics, 2012). Figure 1.2 shows the percentage of fatality in construction industry by causes.

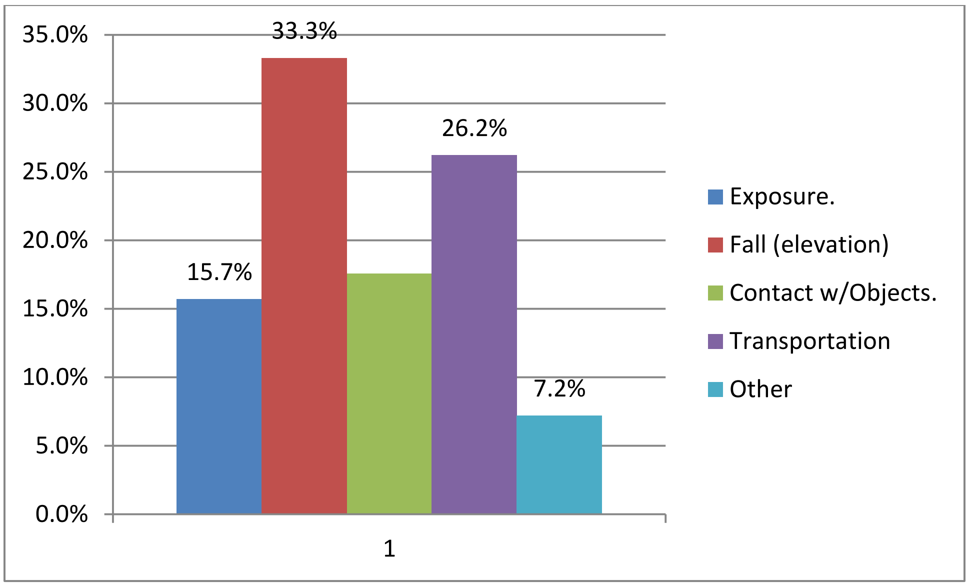

Figure 1.2 - Causes of Construction Fatalities.

In this thesis we will discuss the fall accidents which are statistically the most frequently and dangerous in the construction industry as well as we discuss the impact of these kind of incidents on the economy and productivity. We will compare between costs that may be occur as a result of a fall accidents in the construction industry, and costs of use of Personal Protective Equipment(PPE).

2. REVIEW OF LITERATURE

In 1971, the Occupational Safety and Health Administration (OSHA) was founded. Since then, OSHA worked together with governmental, trade unions, lawyers, health organizations as partner to reduce incidents of injuries and fatalities. OSHA has a high impact on safety at the worksite, and the percentage of injuries and fatalities was significantly decreasing in the workplace. Despite the lack of accurate statistics in 1970, the number of fatalities was estimated to be about 14,000. This number of fatalities was reduced to 4,340 in the 2009. On the other hand, there was an increase in the rate of employment and workplaces to reach more than 130 million workers, and more than 7.2 million worksite. Since the OSHA and application of safety standards were enacted, the rates of incident and disease have dropped from 11 cases per 100 people in 1972 to 3.6 per 100 people in 2009 (U.S. Department of Labor, 2012)

In spite of these excellent results on the reduction of the rate of accidents from 1971 to 2009, there is a negative image is still inherent with construction. Although there have been great achievements that made in the field of construction in the United States, for example, the Gateway Arch in St. Louis, the Sears Tower in Chicago, the Golden Gate Bridge in San Francisco and the Cable Stayed Bridge in Alton, Illinois. The construction industry is seen as considerably dangerous, boring, and having management weakness (Reid, 1995). The 1999 Jobs Rated Almanac ranks the job of a construction worker as 247 out of possible 250 career choices ahead of fisherman (rank 248), and lumberjack (rank 249).

One of reasons that lead to this negative perception or image around the construction; is that construction is considered hazardous work. According to INJURY FACTS (1999) published by the National Safety Council, the probability of accidental death in construction is four times higher than other industries. There are four types of accidents are most common in the construction industry; falls, transportation, contact w/objects, and exposure. Fall hazard represents the highest rates of accidents. Fall accidents were analyzed during the last ten years, and falls from a top are the largest proportion of these accidents. Total falls from 1992 to 2010 were about 7,275 at an estimated cost about $1.9 billion (CPWR, 2013).

A paper was published in April 1998 by George Berg and Richard Dutmer (Berg, 1998) (George Berg and Rick Dutmer are part of FMI's Quality Productivity Improvement Group). This paper discusses the relationship between Productivity, Quality, and Safety on the construction industry. The relationship between them may seem incidental, but they have a stronger correlation than one might think. For safety, the construction industry is only 5% of the Gross Domestic Product (GDP), but it is responsible for 20% of the workplace accidents. The direct cost of the losses, worker's compensation insurance rate increased dramatically. In the 1989, injury losses estimated at $112 Billion in direct cost and another $20 billion to $30 billion of lost productivity due to fatalities, injuries and lost-time accidents. This result has generated difficult problems that led to some construction companies to reduce of worker's compensation rate for new applicants. The relationship between productivity and safety is clear. More attention to safety increases productivity in the workplace and the direct and indirect costs will be reduced of construction accidents, which also improve profits.

In an effort to reduce the number of injuries and fatalities from falls, beginning June 12, 2002, the Ontario Ministry of Labor's fall protection enforcement has worked at a high level of effort. It has introduced some mandatory laws to protect workers from falls hazard. Its inspectors began to visit construction sites; they were looking for how worker training in the use of fall protection equipment was being provided by employers. The Provincial Labor- Management Health & Safety Committee and The Construction Safety Association of Ontario (CSAO) were key contributors to falls protection laws and plans. They were rewriting the laws and put all issues about the hazards of fall protection into one grouping in the regulations. Law 26 says that the protection from the fall required for any work above three meters and law 26.3 under the Act, says that guardrails are required around a scaffold platform above 2.4 meters. The Ministry of Labor's puts all the laws that it has related with workers protection of training and plans and how to use the protective personal equipment (PPE). An important part of the Ministry of Labor's strategy was visiting construction worksites to investigate safe work procedures and how the workers are training in fall protection. Any weakness may cause working cessation, causing lost production, convictions, charges, fines or jail under the Occupational Health and Safety Act.

American Society of Safety Engineering (ASSE) was keen to put new standards for safety and fall protection (ASC Z359), after the old standards that were not adequate to reduce the dangers of falling. Also, ASSE developed the Safety Requirements for Lanyards and Energy Absorbers (BSR/ASSE Z359.13-200x) for Personal Fall Arrest Systems. These standards establish requirements for the design, performance, marking, instructions, inspection, qualification, maintenance and removal from service of energy absorbing lanyards and users of personal energy absorbers within the range of 130 to 310 lb. The requirements of safety design and specifications for Personal Fall Arrest Systems (BSR/ASSE Z359.6-200x) were also under development. This standard was required especially for the design and performance of complete active fall protection systems, including travel restraint, horizontal and vertical fall arrest systems.

The Journal of Safety Research published a report about fall prevention and safety communication training for foremen (Kaskutas, 2013). The recommendation of this journal was that is needed to decrease falls from heights in construction workers. This journal identified a wide range of fall protection and safety communication training opportunities for foremen on the job-site. The research included eight hours of training which was well received among foremen, and there are indicators of improvements in safety protection behaviors.

In the 2007, a paper was published about costs of fatal and nonfatal injuries for the construction industry (Waehrer, 2007). This paper used 2002 national incidence data from the Bureau of Labor Statistics (BLS) and a model of comprehensive cost that includes direct cost and indirect cost which is losses in wage and household productivity. They estimated in 2002 about $11.5 billion represented the total costs of fatal and nonfatal injuries in the construction industry, 15% of the costs of injury for all private industry. The average cost per worker for fatal or nonfatal injury is $27,000 in construction. After all, in this paper, the publisher did not mention the other costs such as

Worker's Compensation Insurance (WCI) that it must be added to the cost of fatal and nonfatal injury.

The Business Roundtable (BR) commissioned a study in 1971; this study was to determine the actual costs of injuries and accidents in the construction industry (Everett, 1996). From 1979, the BR determined that injuries and accidents account for 6.5% of the total cost of the construction industry. Since the time of study, much has changed in the construction industry and the Worker's Compensation Insurance (WCI) has increased significantly. For these, there has been a rash of lawsuits due to accidents on the construction site. Everett used unique models in re-examining the costs of accidents and injuries, and shows that the total costs of accidents increased from a level of 6.5% in 1982 to somewhere between 7.9% to 15.0% of the total costs of new construction in 1996.

A study was submitted by a group of researchers and members in American Society of Civil Engineers (ASCE) about Costs of Construction Injuries (Hinze, 1991). This study was about how to obtain an accurate measurement of all costs that are associated with job-site worker injuries in the construction industry. This study showed that even when the injuries were minor; the costs of these injuries can be considerable. The indirect costs are often hidden and have been neglected when calculating the costs, but in fact, they may be much more than the direct costs. The ratio between the indirect costs to the direct costs is 4:1 that it posted by Heinrich (Hinze, 1991); this ratio is reasonably valid for medical cases injuries. However, the ratio becomes closer to 20:1 for restricted-activity/lost-workday cases. This study concluded that the ratios of indirect costs to the direct costs depended on several factors. For example, small companies with a good safety record may subtend no restricted work lost workday or restricted work cases over a period of several years. If the same companies did experience a serious injury, and the injury caused in a third party suit, the ratio of direct to indirect costs could be many times larger than the 20:1 ratio derived as an overall average for the construction industry. In any case, even if one chooses to neglect the possibility of any claims costs, the indirect costs are still considerable.

A study has been conducted to determine indirect cost of injuries. This study was submitted as part of the requirements for master degree in Civil Engineering at the University of Washington by James R. Van de Voorde (Van de Voorde, 1991). This study was based on data analysis of a study conducted previously by the Construction Industry Institute (CII) on the indirect costs of workplace accident on construction projects. Average indirect cost for 800 cases which have been studied by CII, the analysis detached injuries of medical case from lost time/numbers of activity cases. In this study, two realistic scenarios were developed to analyze and illustrate how the indirect costs have risen through a rise in the cost of medical cases and lost time injuries. CII proposed two mathematical models to help contractors and owners. These models were to estimate the dollar value of the indirect costs which are associated with a particular accident. A second proposed method was more accurate; it was two sets of cost models to estimate the indirect cost after follow-up data had become available. Analysis of the CII data showed four significant results:

- As a project's value increases, so do the indirect costs of accidents
- Injuries on new construction type projects have lower indirect cost than injuries on maintenance contracts.
- Injuries on lump sum or unit price contracts have lower cost than injuries on cost plus contracts.
- There was no difference in indirect cost on union shop or merit/ open shop projects.

A manager will not obtain the actual cost of injuries because the contractor mismanaged their indirect and direct costs of injuries by allowing them to get lost in labor cost codes or overhead. Managers can use the models in this study to achieve best results in determining the indirect cost. In addition, to make the cost accounts balanced, an equal dollar amount would be subtracted from perhaps overhead expenses account. This procedure would clarify the fiscal impact of these accidents to the project team. The truth here, is good job site safety not only saves worker lives and but saves money, as well.

3. BACKGROUND

In addition to the costs and social damages, work- related injuries have a significant impact on the employer. The latest estimates indicate that employers are paying about $1 billion per week for Worker's Compensation Insurance alone (U.S. Department of Labor, 2012). Most previous research projects on the construction industry were about how to determine the total costs of injuries and fatalities, or were limited to account Worker's Compensation Insurance (WCI) for the construction industry in general. These studies have relied on Occupational Safety and Health Administration (OSHA) in determine the number of injuries and fatalities. Also, they depended on the survey data from the Center to Protect Workers' Rights (CPWR), in the rate of injuries and worker's compensation Insurance. Most of these research projects have indicated that the rate of injuries or its costs in the construction industry is greater than in other industries. A previous study showed that the worker or carpenter in the construction industry has a higher cost of work-related injuries and illnesses than other industries (Leigh, 1997). In another study that used the Worker's Compensation Insurance (WCI) data from Washington State it was estimated the average cost of WCI for construction is equivalent to four times the cost in most other industry (Silverstein, 1998).

Despite all research and perspectives, there are no studies that seek to achieve an integrated estimate for the entire construction industry. The exception is one study that was conducted by the National Institute for Occupational Safety and Health (NIOSH), which showed costs of fatalities of the work site, it was shown that the cost of the fatalities for construction were about $10 billion for ten years from 1992 to 2002 (NIOSH, 2006). Another study was conducted in 1990 by Construction Industry Institute (CII) to collect data on the direct and indirect costs of injuries resulting of construction accident. The aim of this study was to show the cost of these incidents by limited the ratio between direct and indirect cost. The conclusion was that the direct costs are much less than the real costs of injuries.

4. METHODOLOGY

A little attention and measurable information were developed or studied about a comparison between the total cost of fall accidents and costs of protective programs to reduce a fall accidents. The lack of accurate information about costs is one of the main reasons that employers or contractors show weak interest in supporting the protective programs to avoid a fall hazards. Therefore, the result was the inability to reduce the rate of injuries from falling through the last fifteen years. Statistical results have been presented by Occupational Safety and Health Administration (OSHA) on rates of fatal and non-fatal injuries was very disturbing. These statistics still have a negative impact on construction companies and researchers, as well as people who wish to work in this sector. In addition, these statistics have led to the formation of a negative image about the construction industry, which is one of the most important industries that have a distinctive role in the U.S. economy.

All of these reasons and negative images about the construction industry had an impact in determining the topic for this thesis. The idea was to compare between costs resulting from fall accidents and costs resulting from the adoption of protective programs. Most companies and contractors were believed not to put sufficient effort into establishing protective systems from fall hazards, because they were thought that the cost of fully implementing fall protection was higher than the benefit leading to their loss. The thesis's goal is to give an idea for employers about these costs, and try to convince them that the costs of fall accidents are much more than the amount that may be paid for the protection to avoid fall hazards.

Also, this thesis focuses on how to calculate the direct costs, indirect costs, and costs resulting from expense of Worker's Compensation Insurance (WCI). Despite this, there is general information about the ratio between direct and indirect cost of 4:1 that is posted by Heinrich (Hinze, 1991). Managers should not always rely on this ratio because it depends on the site-work, injury cases, and other factors. A greater attention must be paid to safety, especially if the ratio was high.

For the success of this study, it has been relying on a base of data and statistics about the annual incidences of fall in the construction industry. Also, we needed accurate information about the costs of damage due to these incidents, and the cost of fall protective systems. To get all these data, we have been relying on companies and official websites such as; Occupational Safety and Health Administration (OSHA), American Society of Civil Engineers (ASCE), American National Standards Institute (ANSI), Construction Industry Institute (CII), American Society of Safety Engineers (ASSE), and the National Safety Council (NSC).

We began to analyze the data and calculated the total costs of fatal or non-fatal injuries. Some of these costs necessitated simple mathematical equations to calculate them. For example, when calculating the direct costs, we calculated the number of injuries, and the cost per one injury and the same thing for fatalities. There are calculations to determine the Worker's Compensation Insurance (WCI). Also, there are indirect costs that were necessitated by other forms of calculation such as working hours that the injured worker missed work and the wage cost of the worker on the day the injury.

The mechanism that was used in this thesis is a realistic comparison between costs that may occur as a result of a fall accident in the construction industry, and costs of use of Personal Protective Equipment (PPE) to avoid a fall accident and its costs. Costs of a fall accidents include Direct Costs, Indirect Costs, and Worker's Compensation Insurance (WCI), in addition to social and family impacts for the injured person. A cost of fall protection and avoided incidents that may occur as a result of a fall depends on the type of programs and personal protection systems. Personal protection systems depend on the work type, and elevation of work surface. In this thesis we estimated the cost of all the protection systems that can be used to avoid incidents of falling. The table below shows details about how to determine costs of a fall accident in the construction industry, and costs of (PPE) to avoid fall hazards. Table 4.1 shows how to determine costs of fall avoidance and costs of fall accident.

Table 4.1– Costs of Fall Avoidance and Costs of Fall Accident.

Costs of Fall Avoidance Systems	Costs of Fall Accident
1- Personal Fall Arrest System	1- Direct Costs
2- Guardrail systems	a - wage losses
3- Safety Net systems	b - medical expenses
4- Fall Restraint Systems	c - administrative expenses
5- Positioning Device Systems	
6- Warning Line Systems	2- Indirect Costs
7- Worker's Training	a- Time-Related Indirect Injury Cost
	b- Production- Related Indirect Cost
	3- Worker's Compensation Insurance
	a- Medical Care
	b- Temporary Disability (TD)
	c- Permanent Disability (PD)
	d- Transportation Reimbursement
	e- Vocational Rehabilitation (VR)
	f- Death Benefits

5. U.S CONSTRUCTIONS

5.1. U.S CONSTRUCTION INDUSTRY PROFILE

The construction industry in the United States of America represents a significant element in the movement and growth of the economy, and considered a backbone of permanence and stability of the economic activity in the U.S., both public and private. The construction sector is a large, complex, dynamic, and directly affects a broad range of human life. It includes a large number of staff and workers. They are working in various fields in this area. They are responsible for the construction of roads, houses and workplaces, as well as in the maintenance and repair of infrastructure. Construction work involves building a new structures or additions, modifications, or repair and maintenance of established engineering projects such as highways and utility systems.

The construction industry is one of the most volatile industries in the United States. It reacts rapidly with economic expansions and shrinks to a large extent in recession times. Since 2006 to 2011, the construction sector suffers from a sever period, where the annual spending in the United State was a decline on the construction industry more than quarter, or approximately $ 300 million. This reduction represents about 2% of the size of the U.S. economy.

5.2. CONSTRUCTION AND EMPLOYMENT

Increasing the rate of employment in any industry is evidenced by economic growth for this sector in a particular time. The construction industry is one of the significant sources in the U.S. economy, which contributed significantly in increasing the rate of employment growth. During the past years since 1965 to 2006, the construction industry has been the growth rate ranging between (15-30%) for every 10 years. See Table 5.1., and Figure 5.1 (U.S. Department of Labor, 2014).

Table 5.1 - Employment by Major Industry Sector from 1970 to 2010.

	Employment by major industry sector, 1970, 1980, 1990, 2000, 2010									
	Industry sector	Thousands of jobs					Annual rate of change %			
		1970	1980	1990	2000	2010	1970-1980	1980-1990	1990-2000	2000-2010
Goods-producing	Mining and logging	677	1,077	765	599	705	4.8	-3.4	-2.4	1.6
	Manufacturing	17,848	18,733	17,695	17,263	11,524	0.5	-0.6	-0.2	-4.0
	Construction	3,654	4,454	5,263	6,787	5,526	2.0	1.7	2.6	-2.0
Service-providing	Information	2,041	2,361	2,688	3,630	2,711	1.5	1.3	3.0	-2.9
	Education and health services	4,577	7,072	10,984	15,109	19,564	4.4	4.5	3.2	2.6
	Government	12,687	16,375	18,415	20,790	22,482	2.6	1.2	1.2	0.8

Figure 5.1 - Employment by Construction Industry from 1970 to 2010.

Unlike, the rest of the industrial sectors, the construction industry has suffered from vacillating and decline in the employment rate between 2007-2010. There are several reasons that directly affected this sector which led to this a recession during the last decade. Among these reasons is the large number of accidents that lead to the injuries and fatalities. In addition, over the years there is no preceding factors support or stimulating this sector to stability in employment growth. The table 5.2 and figure 5.2

show the contraction was happening in industrial construction at the time between 2007-2010. It caused the fall of 2.1 million jobs between 2007-2010 in the annual employment of salary and wages for workers. This fall represents about 10 percent of the annual rate of decline (U.S. Department of Labor, 2014).

Table 5.2 - The Employment in Construction Industry between 2007-2010

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	7601	7664	7689	7726	7713	7699	7712	7720	7718	7682	7666	7685
2007	7725	7626	7706	7686	7673	7687	7660	7610	7577	7565	7523	7490
2008	7476	7453	7406	7327	7274	7213	7160	7114	7044	6967	6813	6701
2009	6554	6453	6291	6149	6103	6008	5928	5851	5785	5724	5693	5650
2010	5581	5522	5542	5554	5527	5512	5497	5519	5499	5501	5497	5468

Figure 5.2 – The Employment in Construction Industry between 2007-2010.

5.3. VALUE OF CONSTRUCTION SPENDING (PUT IN PLACE)

Spending data in the construction industry represents the cost of the value of work in completed projects (all projects that be completed or which completed the process during the period). Regardless of when the work in any individual project was started or when the payment was made to the implementing agency (Contractors). Some of these estimates are based on the amounts paid during the period rather than the rate of the work done, and some of these estimates depend on the total cost of the project by means of historic construction progress patterns. For an individual project, the value of construction put in place represents of the value of construction erected or installed at work during a given period, including:

1. Cost of labor (both by contractors and force account) and a proportionate share of the cost of
2. Cost of materials installed or erected.
3. Cost of construction equipment rent.
4. Cost of design and engineering work.
5. The value of Contractor's profit.
6. Interest, insurance, and taxes paid during construction
7. Cost of overhead and office that is chargeable to the project.

Construction spending is very necessary for U.S. economy, it represents about 20% of the gross domestic product that making it significant source for information. Economist's perspective of construction spending, it is considered vital clues about the overall economy. The construction industry is the first in a recession when the economy suffers from decline, and, likewise, it is the first in the case of recovery when the economy is booming.

Despite the importance of spending in the construction industry and its large role in the U.S. economy, the spending in this sector gradually reduced in recent years to reach 788,014 in the year 2011 after it was about 1,167,222 in 2006. This means that the total decrease for five years is about 32%. This percentage was large and influential for the construction sector. Reasons that led to this decline were a negative image of the sector in recent years, which we reported it with the causes at the introduction of this thesis. Figure 5.3 shows the annual value of construction put in place (U.S. Department of Commerce, 2013).

Figure 5.3 - Annual Value of Construction Put in Place, 1993-2012.

6. CONSTRUCTION SAFETY

6.1. IMPORTANT OF CONSTRUCTION SAFETY AND HEALTH

Construction industry includes a wide range of activities and works which include erection and building or/and repair, they cause a lot of accidents most of these are a high hazard. These works consist of about 5% of the U.S.A work force, and account for some 20% of the work fatalities and 12% of disabling injuries. They work in various area including residential construction, bridges erection, excavation, paving, demolition, and large projects that expose them to serious hazard, such as, falling from high levels, transportation, contact w/objects, and exposure, and other incidents that be hazardous to workers' lives.

Recent figures from the Bureau of Labor Statistics (BLS) show that the construction industry accounted for more injuries work and fatalities than any other industry in U.S "in 2010''. Although the rate of fatalities and injuries in the construction industry have declined every year since 2006 and are down about 40% over that time (United States Department of Labor, 2012), construction accounted for more fatal work injuries than any other industry in 2010. The rate of injuries among all workers in all other industries was 3.5 percent while the construction industry remained at 9.5 percent; higher than all industries combined (United States Department of Labor, 2012). The direct and indirect costs of construction injuries have been estimated to exceed $31 billion. See figure 6.1 and 6.2.

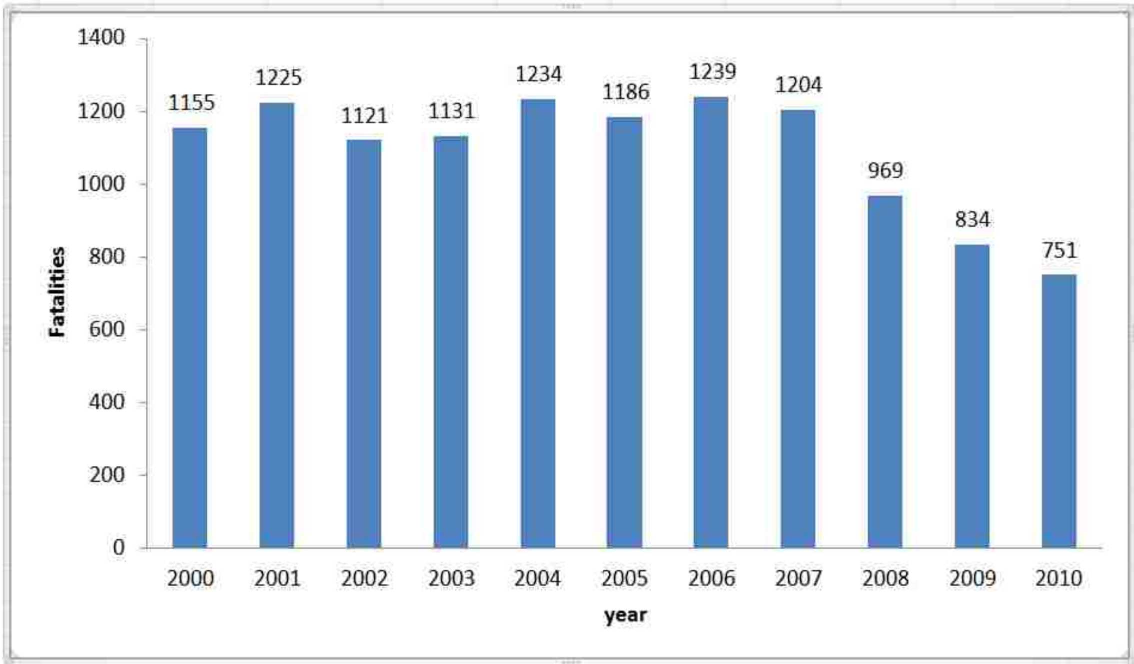

Figure 6.1 - Fatalities in Construction from 2000 to 2010.

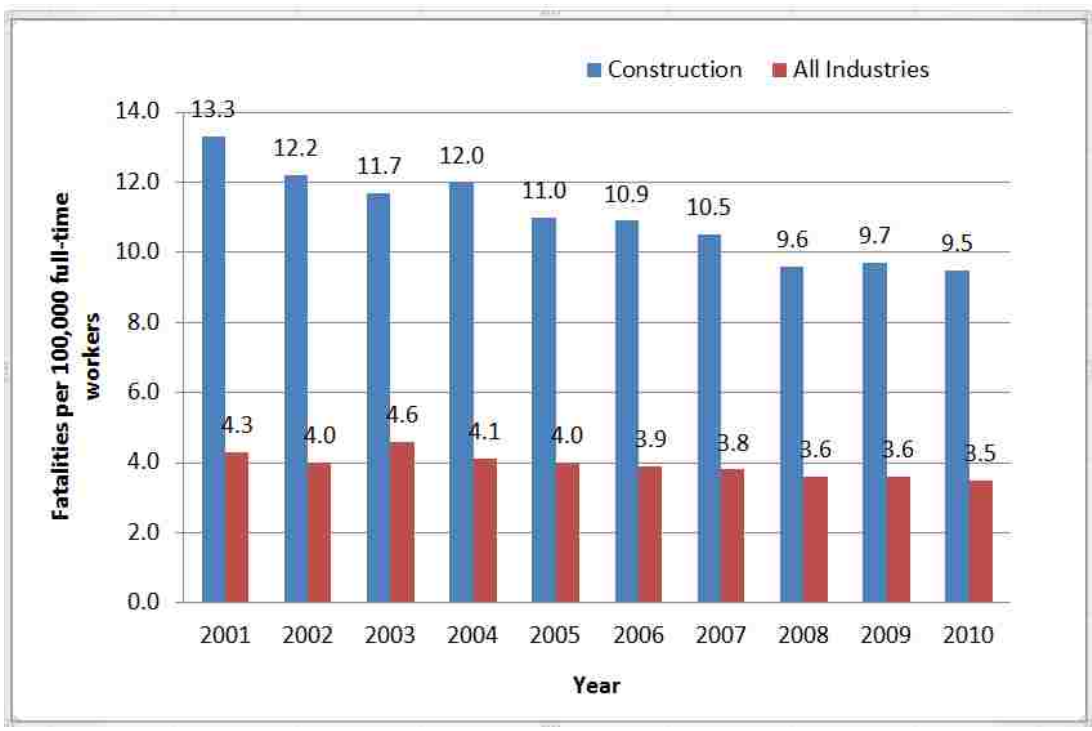

Figure 6.2 - The Rates of Fatalities per 100,000 Workers for Construction and all Industries Combined from 2001 to 2010.

The top four hazards that cause fatalities in construction remain the same. They are fall, transportation, contact, and exposure (CPWR, 2013). Figure 6.3 indicates the causes of the construction industry fatalities for the year 2009. In previous years, the order of arrangement among the four leading causes varied, but the fall always remained at the top.

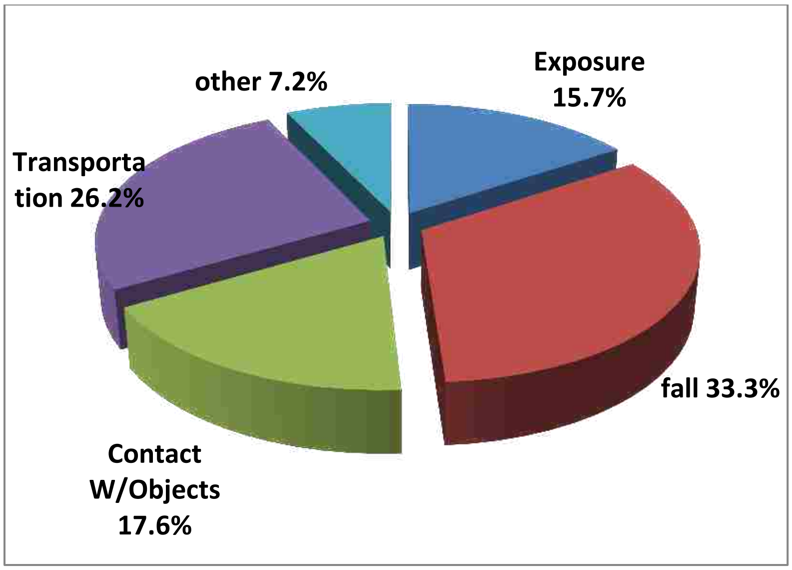

Figure 6.3 - Causes of Construction Fatalities.

6.2. FALL ACCIDENT IMPORTANCE IN THE CONSTRUCTION INDUSTRY

Fall accidents in construction are the most common that lead to fatalities, severe injuries, and other consequences. For example, work stopped, negative impact on productivity for companies, and economic impact through indirect costs can result from a fall. Falling from any level of height remains the single cause of the largest number of fatalities in the construction industry. There is 34% of all fatalities in the construction industry are the result of a fall. Thirty percent of them as a result of the fall from height of 11 to 20 ft., and nineteen percent of them from a height of 20 ft. or under. Figure 6.4 shows the varying heights of the fall in 2009 (National Safety Council, 2013).

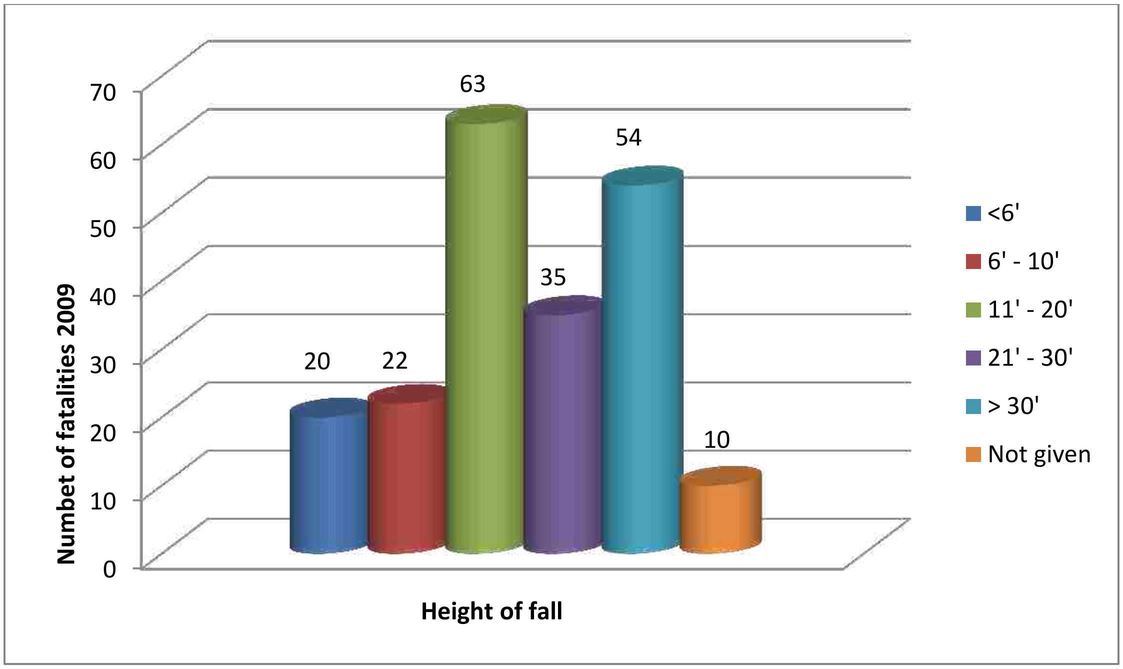

Figure 6.4 - Analysis of Fatalities Caused by Fall Accidents.

Falls occurs as a result of various activities within the worksite in the construction industry. Figure 6.5 shows the percentage of falls from various activities (National Safety Council, 2013).

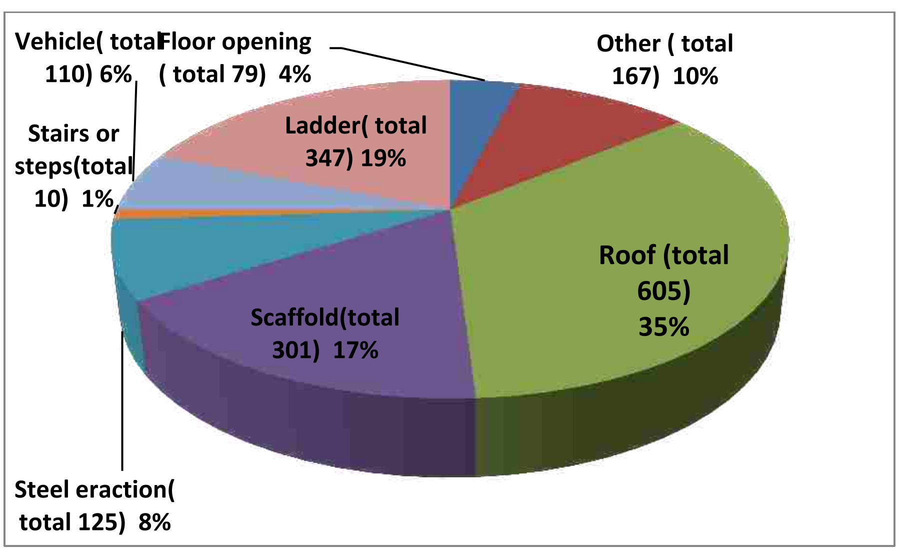

Figure 6.5 – The Percentage of Fall Accidents from Various Activities.

7. FALLS IMPACT ON ECONOMY

By all relevant measures, the construction industry is not safe. It represents a big challenge to investors in how to deal with the hazards that occur during the work, and how to reduce the high costs that result from these incidents. These costs represent a significant financial burden on companies and institutions. We mentioned earlier that the percentage of the workforce in construction accounted about 5% of all sectors, but it is responsible for about 20% of the accidents. Fall accidents are responsible for the largest rate of these incidents, which represent more than 34%. The actual costs of falls accident in the construction industry include direct and indirect costs. Direct costs represent the worker's compensation claims, and indirect costs are often less tangible and clear, but certainly real in terms of lost profits.

7.1. DIRECT COST

Direct costs usually associated with worker's compensation claims that can be calculated relatively simply, these include expenses paid to patients who are receiving treatment as a result of accidents. In most cases, these costs are documented and included in the form of bills paid by the employer or insurance companies. Falls represents 25% of all claim volumes and 36% of all claim costs. See the Figure 7.1 through 2010 – 2012 (Work Safe BC, 2012).

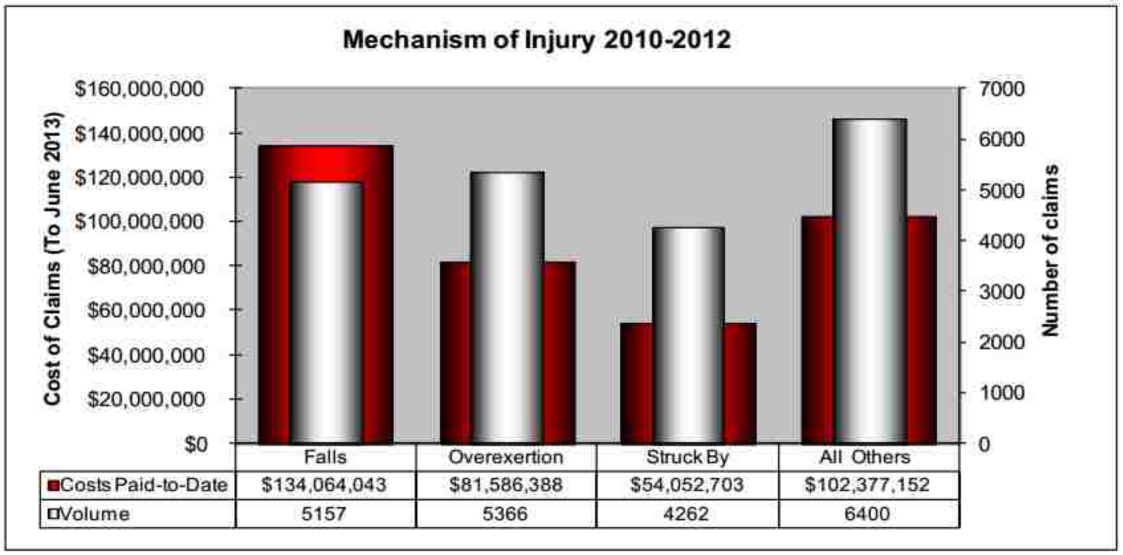

Figure 7.1 – Percentage of Fall Claims Volume and Cost.

Falls appear the highest average cost and the most workdays lost per claim, as shown in the below table 7.1 through 2010 – 2012 (Work Safe BC, 2012).

Table 7.1 – Average Cost and Days Lost Per Day through 2010-2012.

TYPE OF ACCIDENT	AVERAGE COST PAID-TO-DATE (PER CLAIM)	AVERAGE DAYS LOST-TO-DATE (PER CLAIM)
Falls	25,997	91
Overexertion	15,204	62
Struck By	12,682	42
All others	15,996	49

Based on Bureau of Labor Statistics (BLS) in 2010, the average cost per death about $1,390,000 and cost per injury about 37,000 for the construction industry, so the direct cost for fatalities and injuries through 2010 is shown in table 7.2 (National Safety Council, 2013).

Table 7.2 – Direct Cost of Total Construction and Falls.

	No. of fatalities	Cost/ Death	total cost for fatality (Million)	No. of injuries	cost / injury	total cost for injuries (Million)	Total cost of Fatalities & Injuries (Million)
All Construction	774	$ 1,390,000.00	$ 1,075.86	320,000	$ 37,000.00	$ 11,840.00	$ 12,915.86
Falls	264	$ 1,390,000.00	$ 366.96	12,950	$ 37,000.00	$ 479.15	$ 846.11

7.2 INDIRECT COST

Indirect costs are not clear and therefore cannot be calculated accurately because they depend on the situation and the workplace. In general, indirect costs include the costs of training, workers' compensation, accident investigation, repair damaged property, maintain on insurance coverage, and cost resulting from the delay in the project schedule due to accidents.

The rate of indirect costs of injuries to the direct costs may be 20 times (OSHA). Recent study shows that the ratio of indirect cost to direct cost varies widely; from a high of 4:1 to a low of 1:1(U.S. Department of Labor, 1982). See figure 7.2.

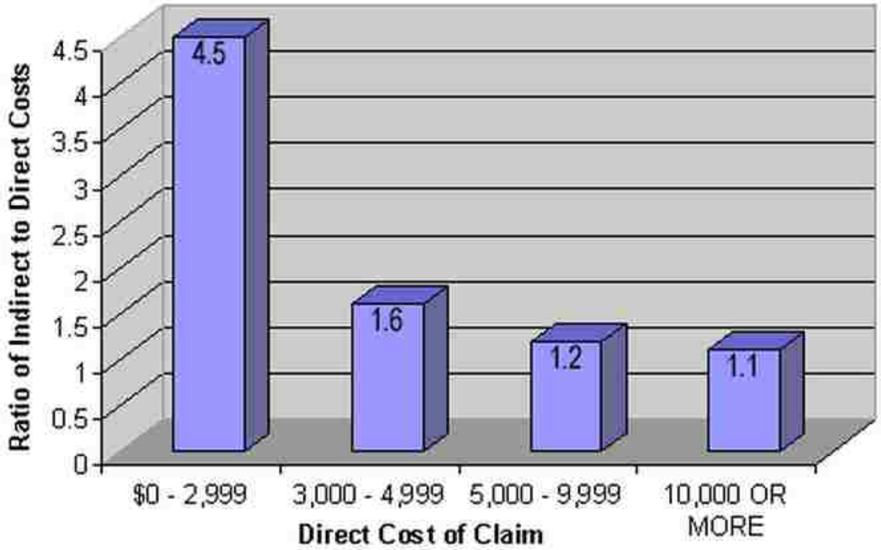

Figure 7.2 - The Ratio of Indirect Cost to Direct Cost for Construction Accidents.

The following table shows the indirect cost calculation associated with injuries, and also shows the overlap of the work environment and the impact of injuries on the environment.

Table 7.3 show the indirect costs that are associated with personal- related time and includes non-compensable time related to the worker on the day of the injury and consequences; loss of worker productivity due to the injury, time lost by other workers assisting the injured worker; watching; and interviewed; time lost to find alternative worker, and the time required to new worker training. The total time that related indirect cost associated with the injury was $22,730.00.

Table 7.3- Time-Related Indirect Injury Cost Calculations.

Category	NO. of workrs	Time per worker (hrs)	Days per Worker	Total Time	Cost per hour($)	Total cost ($)
1- Non-Compensable Time						
a. Day of injury	1	2.00	1.00	2.00	50.00	100.00
b. Doctor's Offic/ Hospital	1	24.00	1.00	24.00	50.00	1,200.00
c. Follow-up vists	1	2.00	12.00	24.00	50.00	1,200.00
d. Rehabilitation (3/week x 20 weeks)	1	1.00	60.00	60.00	50.00	3,000.00
Subtotal Non-compensable time						5,500.00
2- Overtime						
a. Overtime	3	2.00	10.00	60.00	75.00	4,500.00
Subtotal Overtime						4,500.00
3- Time Lost by Non-Injured Workers						
a. Workers who assisted injured party	3	1.00	1.00	3.00	50.00	150.00
b.Workers who watched	5	2.00	1.00	10.00	50.00	500.00
c. Workers who were interviewed	8	2.00	1.00	16.00	50.00	800.00
Subtotal Non-Injured Lost Time						1,450.00
4- Supervisor time						
a. Time to complete first report of accident/injury form	1	1.00	1.00	1.00	80.00	80.00
b. Time to investigate accident/injury						
b1. Worker interviews	8	2.00	1.00	16.00	80.00	1,280.00
b2. Physical eviidence collections and evaluation	1	4.00	1.00	4.00	80.00	320.00
c. Time to procure and train replacement worker(s)						
c1. New worker(s)	1	8.00	10.00	80.00	50.00	4,000.00
c2. Supervisor time	1	4.00	10.00	40.00	80.00	3,200.00
d. Time to assist production before replacement worker procurement	1	2.00	10.00	20.00	80.00	1,600.00
e. Time to address associated production problems	1	1.00	10.00	10.00	80.00	800.00
Subtotal Supwrvisor Time						11,280.00
Total Time-Related Costs						22,730.00

Table 7.4 shows the calculation of indirect costs associated with productivity-related indirect costs. Examples include loss in productivity as a result of the injured worker, and others who are helping the injured worker. In addition, the loss in productivity after the injured worker returns to work, and the percent of his production capacity; and other things that related to the injury and affect the productivity are in the table below. The total lost production-related indirect cost associated with this injury about $130,000.

Table 7.4 - Production- Related Indirect Injury Cost Calculations.

Category	NO. of worker	Mean # of units per hr.	Actual # of units per hr.	Total hours per	Total unts lost	Value per unit ($)	Total value of lost production
1- Lost Production							
a. Injury worker	1	25.00	0.00	8.00	200.00	50.00	10,000.00
b. Workers assisting injured worker	3	25.00	0.00	2.00	150.00	50.00	7,500.00
c. Onlookers(interview time	5	25.00	0.00	2.00	250.00	50.00	12,500.00
Subtotal Lost Production							30,000.00
2- Reduced Output							
a. Injured worker after return							
week 1	1	25.00	15.00	40.00	400.00	50.00	20,000.00
week 2	1	25.00	20.00	40.00	200.00	50.00	10,000.00
b. Workers assisting injured woker	3	25.00	20.00	20.00	300.00	50.00	15,000.00
c. Onlookers	5	25.00	20.00	20.00	500.00	50.00	25,000.00
d. Replacement worker(s)							-
week 1	1	25.00	15.00	40.00	400.00	50.00	20,000.00
week 2	1	25.00	20.00	40.00	200.00	50.00	10,000.00
Subtotal Reduced Output							100,000.00
Total production-Related Costs							130,000.00

From these two tables above. The indirect cost of non-fatal injuries for one worker equal to the sum of (Time-Related Indirect Injury Cost and Production-Related Indirect Injury Cost), which will be about $ 152,730.

7.3 WORKERS' COMPENSATION INSURANCE

Workers' compensation insurance premium (industrial insurance) coverage protects both employers and workers from the funding impact of a work related injury or job disease. Workers' compensation insurance pays to an injured worker for medical services, hospitals, and related services that are necessary for the treatment of the injured worker and recovery. Also, it pays portions of wages to workers who are temporarily unable to work due to injuries. Employer must provide adequate coverage for their employees. The coverage is mandatory on the employer. On the other hand, workers cannot establish a lawsuit when any injuries happen or other related event. Employers provide the workers by workers' compensation insurance (WCI) through the Department of Labor & Industries (L&I). Workers' Compensation insurance coverage the following:-

- Hospital and medical services needed to treat the job-site injuries and illness.
- Temporary payments to the worker instead of his lost wages.
- Permanent payments to the worker to recompense for permanent effects of the injury.
- A death benefit for the worker's survivors in the event of a fatal injury.
- Lawful representation for the employer by the insurance company carrier.
- Employer protection against most lawsuits for on-the-job injuries and illnesses.

Workers' Compensation Insurance depends on three factors.

- Different worker use different rates depending on their individual jobs that are grouped into class codes.
- Annual payroll and individual occupation class codes are used to calculate the company's rates.

- Each company has an experience modifier based on the company's track record of accidents, safety, and claims filed.

The general equation to determine the (Workers' Compensation Insurance) is:

(WCI) = [(Payroll/100) x Manual rate] x Experience Modifier.

In this case, we will take a carpenter as a case to calculate the (WCI), who is more exposed to fall during his work. Calculate the amount of benefit that he will obtain from the workers' compensation insurance. This amount will be added to the falling cost that is calculated before (direct cost and indirect cost) which costs the employers or the companies. Average national wage for a carpenter is from $ 45 to $ 65, so we will use the Missouri rate of $50. Manual rates vary from $18 to $29, so again we will use the Missouri rate of $20.18 for our calculations. So:-

- Annual Payroll for Carpenter at Missouri= $50/hr. x 2080 hours (full time around year).

  Annual Payroll= $50/hr. x 2080hr. = $104000.00
- Manual rate for Carpenter at Missouri = 20.18 (MO Comp Rates, 2013)
- Experience modifiers are typically between 0.6 and 1.6 an industry average modifier would be 1.00.

To calculate the Workers' Compensation Insurance (WCI). The equation will be

(WCI) = [(Payroll/100) x Manual rate] x Experience Modifier.

(WCI) = [($104000/100) x $20.18] x $1.00

(WCI) = $ 21,000 per person

Total amount of (WCI) for all fall fatalities and injuries =

Average of (WCI) = $ 21,000 x 1.0 x [No. of (fatalities) + No. of (injuries)].

Average of (WCI) = $ 21,000 x 1.0 x [264 + 12,950] = $ 277,494,000

Very safe of (WCI) = $ 21,000 x 0.6 x [264 + 12,950] = $ 166,496,400

Savings = $ 277,494,000 - $ 166,496,400 = $ 111,000,000

So from these results that we have obtained in this part of the thesis, the total cost equal (direct cost, indirect cost and cost of (WCI)) of falls for 2013 is calculated through this simple equation.

Total Cost = Direct Cost + Indirect Cost + Cost of WCI

- Direct Cost = $ 846.11 Million. (Cost of fatalities and non-fatalities injuries. Table (7.2)
- Indirect Cost = No. of injuries * Indirect cost for one worker tables (7.3, 7.4).
  = 12,950 * $ 152,730 = $ 1,977,853,500
- Workers' Compensation Insurance (WCI) = $ 111,000,000

Total Cost = Direct Cost + Indirect Cost + Cost of WCI

Total Cost = $ 846,110,000 + $ 1,977,853,500 + $ 111,000,000

= $ 2,934,963,500

If we divided this amount on the number of a fall accident in 2011, which includes fatalities and injuries. It will be $ 222,000 per worker who affected by a fall incident. In addition, the ratio between indirect costs to direct costs in this case about 3.6 to 1. In some cases, the rate is more than 20 times based on the American Society of Safety Engineers (ASSE).

8. FALLS PROTECTION AND COST

8.1 FALLS PROTECTION

Fall protection involves a broad concept of planning, training and uses appropriate personal protective equipment. Fall protection includes the development of appropriate procedures, proper planning, rules, regulations, and styles that are all aimed to protect from falls, and minimizing damage and losses resulting from these incidents on projects. Fall protection does not mean the use of bulky equipment or cumbersome equipment; also it does not interfere or intersect with the procedures and workflow of the worker if we understand the concept (fall protection) correctly, and apply it in properly.

8.1.1 Fall Protection System. The fall protection system refers to how to design especially equipment to control fall hazards. In general, the fall protections systems use on either prevent a fall from occurring or safely arrest a fall. Typical fall protection systems include the following:

- Personal fall-arrest systems
- Guardrail systems
- Safety-net systems
- Positioning-device systems
- Warning-line systems
- Safety-monitoring systems
- Controlled-access zones.

Personal fall-arrest systems, guardrail systems, and safety net systems are used in most industries where workers are faced to fall hazards, they are called conventional fall protection. Warning lines, positioning devices, and safety monitoring systems are used with more specialized applications; they are used primarily to protect workers doing roofing tasks, and concrete formwork. Controlled-access zone defines an area where the worker is doing at the edge in the workplace, overhand bricklaying and related work, or working and without using conventional fall protection.

8.1.2 Conventional Fall Protection

8.1.2.1 Personal fall arrest systems. In general, a personal fall arrest system consists from anchor, connectors, and a body harness, they are working together to prevent a person from falling and to minimize the arrest force. Sometimes a personal fall arrest system includes a lanyard, a lifeline, and a deceleration device. However, this system becomes effective only if you know how these groups that make up this system to work together to arrest a fall. OSHA's design and performance requirements for personal fall arrest systems were in Subpart M, 1926.502 (d).

8.1.2.1.1 The anchor. An anchor provides an important secure point of attachment for a lanyard, lifeline, or deceleration device. It is considered the most important personal fall arrest system component. It must be able to withstand or support a minimum load of 5,000 pounds. There are some challenges or constrains, when it used on wood framed and residential-type structure. Important points for using an anchor of arrest fall system are it must be installed under the supervision of the person with qualifications, and it must take a safety factor of at least twice the impact force of a worker that has six feet free falling.

8.1.2.1.2 Connectors. A pair of conductors is the basic components of a personal fall arrest system. Snap hooks and D-rings are common types of connectors. Connectors must be pressed; drop forged or made from formed steel or strong material. They must be made in a way that it is a high resistance of corrosion, with a smooth surface, and The edges are fair curve to avoid damage other parts of the personal fall arrest system.

The D-ring and a body harness component are attaches to a lanyard or to a deceleration device. D-rings are necessary have a minimum breaking strength 5,000 lbs.

The snap hook consists of a keeper and a hook-shaped member. It is opening to receive a connecting component and when released, automatically closes. Snap hook must also have a minimum breaking strength of 5,000 lbs. There are two common types of snap hooks: locking and non-locking. The locking types will not open until it is unlocked because they have a self-locking keeper. OSHA considers; the non-locking type is not always safe. It uses only locking snap hooks as part of the system.

8.1.2.1.3 The body harness. There are many types of body harness; all of these consist of tapes that distribute fall arrest forces over the chest, pelvis, waist, thighs, and shoulders. Body harnesses are light and comfortable. Any harness must include a back D-ring for attaching lanyards, lifelines, or retractable devices and back pad for support. A body harness must exert an inhibition force of no more than 1,800 lbs. on a falling worker. The following must be remembered when you use a body harness:

- Body harnesses must not be made from natural fibers.
- There are different sizes of body harnesses. The body harness must fit properly.
- The attribution point of a body harness must be located in the back center, around shoulder level.
- Must do not use recreational climbing harnesses.

8.1.2.1.4 Lanyards. A lanyard is a specially designed strap, rope, or webbing. It connects a body harness to a deceleration device on one end, and to an anchor or a lifeline on the other end. There are a variety of designs of a lanyard including self-retracting and shock-absorbing types. Self-retracting type is moving easier either shock-absorbing type is reducing fall-arrest forces. All of the types of lanyards must have a minimum breaking strength of 5,000 lbs. The following must be remembered when you use a lanyard;

- Self-retracting lanyards with free-fall distance to equal or less of two feet must have held a minimum load of 3,000 lbs. and the lanyard in the fully extended position.
- Self-retracting lanyards that do not limit free-fall distance to equal or less of two feet must have held a minimum load of 5,000 lbs. and the lanyard in the fully extended position.
- When self-retracting lanyards do not limit free-fall distance to equal or less of two feet, it is recommended to work near or directly below the anchor to prevent swing falls.

- Lanyards should not be made from natural fibers.

8.1.2.1.5 <u>Deceleration devices.</u> There are three types of deceleration devices; shock-absorbing lanyard, self-retraction lifeline, and rope grab. All of these types and minimizing the fall distance are reduced to reduce the fall-impact force on the anchor. The third type (rope grab) allows to move up and down a vertical lifeline. It automatically locks onto the lifeline if worker fall.

8.1.2.1.6 <u>Lifelines.</u> In general, there are two types of lifeline, vertical and horizontal. These types are flexible rope or cable that connect to a lanyard, a body harness, or deceleration device and at least one anchor. Vertical lifelines must have a minimum breaking strength of 5,000 lbs. They attach to a lanyard, a body harness, or deceleration device and to an anchor.

The self-declining lifeline is both a vertical lifeline and a deceleration device. It is comprised of a drum-wound line that unwinds and declines from the drum as a worker moves. When the worker falls the drum automatically locks. Self-declining lifelines that automatically limit the free-fall distance to equal or less of two feet must have a minimum breaking strength of 3,000 lbs. Self-declining lifelines that do not limit the free-fall distance to equal or less of two feet must have a minimum breaking strength of 5,000 lbs.

If you are moving horizontally over a long distance, the vertical lifeline can be a risk because it creates the potential for a swing fall - a movement of the pendulum swing that result from swinging under the anchor point. In contrast to the vertical lifeline, the horizontal lifeline extends between two anchors. This allows moving freely across a flat surface when connect to the line with a lanyard, body harness, or deceleration device. Horizontal lifelines and the anchors are under high loads greater than the vertical lifelines. Therefore, if not anchored correctly, horizontal lifelines may fail at the anchor points. For these reasons, it is essential the horizontal lifelines be designed and installed under the supervision of a qualified person to maintain a safety factor of at least twice the impact force of a worker that has six feet free falling. To maintain the integrity of the work, the lifeline must support at least 5,000 lbs. and lifeline of horizontal must support at least 5,000 lbs. per the worker. Lifeline must not be made from natural fiber rope because the fiber deteriorates with time, and the line must be protected against cuts or abrasions. A fall arrest system must remove from service immediately and do not use it after it stops a fall until a relevant person determines that it is safe to return to service (OSHA). See figure 8.1.

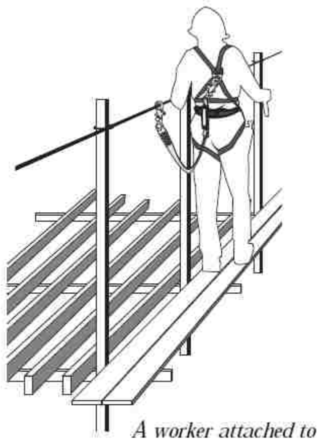

Figure 8.1- Shows Horizontal Lifeline.

8.1.2.2 Guardrail systems. Guardrail systems are preventing workers, materials and equipment from falling to lower level. Guardrail systems are consisting of top rails, mid rails, and vertical members between them. OSHA design and performance requirements for guardrail systems are in CFR 1926.502 (b), and include the following:

- Guardrail systems must be free of bumps or sharp edges that may cause harm to the worker or tearing his clothes. The thickness of the protection systems must be at least a quarter inch, in order to reduce the risk of hand lacerations. Plastic or steel banding is not permitted for top and mid rails.
- Wire rope that is used with a top rail must be signed at least every six feet with high-visibility material.

- The top edge must be 42 inches, plus or minus three inches, above the surface to which it is attached. The top edge height may exceed 45 inches when conditions warrant.
- When there is no wall or parapet at least 21 inches high, mid-rails, mesh, screens, or similar protection must be installed between the top edge of the guardrail system and the working surface. Mid-rails must be installed between the top edge of the guardrail system and the working surface. Mesh and screens must extend from the top rail to the working surface.
- Vertical members, between the top and mid rail, must be no more than 19 inches.
- The guardrail systems must have the ability to withstanding a 200 lbs. force applied within two inches of its top edge in any outward or downward direction. Screens, mid-rails, and vertical members must withstand at least 150 lbs. applied in any downward or outward direction. See figure 8.2.

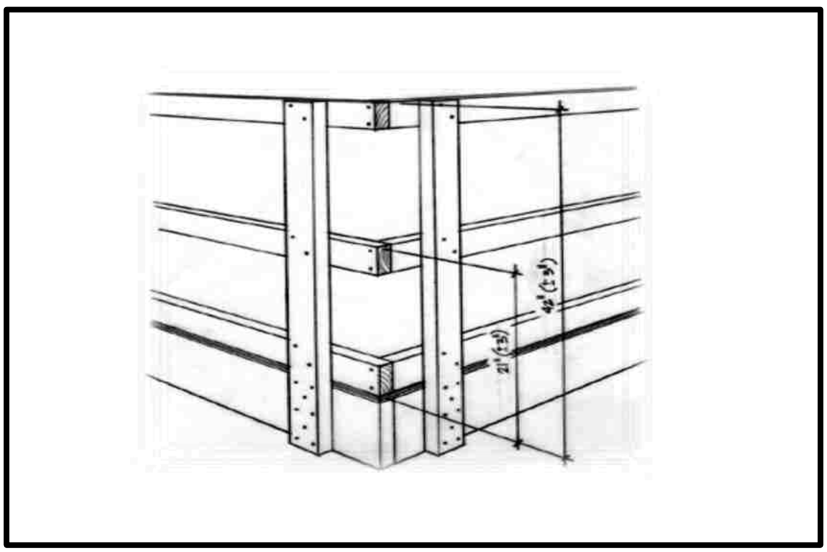

Figure 8.2- Shows Design of A guardrail Systems.

8.1.2.3 Safety net systems. Safety net systems typically are used to protect workers who work at 25 feet or more above lower levels at building construction sites. Safety net systems are comprised of mesh nets, panels, and a system of connecting them.

OSHA's design and performance, the maximum net opening must not be more than 6 inches on a side, center-to-center (OSHA, CFR 1926.502 (c)).

Safety net systems must be installed to withstand a drop test involving a 400 lb. bag of sand 30 inches in diameter dropped from a working surface. It must be able to resist the impact without supporting anything below it. Safety nets system must be set up as close as possible below working surfaces, but no more than 30 feet below the surfaces. The outer edge of a safety net system must extend at least 8 feet from the edge of the working surface. However, this distance depends on how far the net is below the working surface. In the table 8.1 we can see the minimum distances (U.S. Department of Labor, 1996).

Table 8.1 – Minimum Required Horizontal Distance of Outer Edge of Net from the Edge of the Working Surface.

Vertical distance from working level to horizontal plane of net	Minimum required horizontal distance of outer edge of net from the edge of the working surface
Up to 5 feet	**8 feet**
5 to 10 feet	**10 feet**
More than 10 feet	**13 feet**

8.1.3 Other Fall Protection Systems and Methods.

8.1.3.1 Fall restraint systems. In contrast to the personal fall-arrest system that is designed to stop a fall, the fall restraint system prevents a fall. A fall restraint systems consist of an anchor, a body harness or a body belt, and connectors. The fall restraint system's anchor must be designed to support at least 3000 lbs. Addition; it must be installed, designed, and used under the supervision of a skilled person.

8.1.3.2 Positioning device systems. Positioning device systems help to work on vertical surfaces such as a wall or vertical structure, and enable to work with both hands free. This system is typically used as protection for placing rebar and concrete formwork. There is a difference between a positioning device system and fall-arrest system: the positioning device system supports the worker on an elevated surface and limits fall to two feet. On the other hand, a personal fall arrest system stops a free fall without support it. OSHA design and performance requirements for positioning device systems are in CFR 1926.502 (e).

Positioning device anchors must be designed to support at least 3,000 lbs. Other positioning device such as snap hooks and D-rings must be proof tested to a minimum tensile load of 3,600 lbs. without a failure. To maintain the integrity of the positioning device system the components must always be inspected for wear and damage before using them.

8.1.3.3 Warning line systems. Warning line systems consist of wires, ropes, or chains that are supported by stanchions. This system forms a barrier to warn those who are working near the surfaces that do not have edges or rail. Warning lines systems mark off an area within which worker can do roofing work without using safety nets or guardrails. Warning line systems can be involved with personal fall arrest systems, guardrail systems, or safety monitoring; which protect those doing roofing work on low slope roofs (4:12 or less). OSHA's design and performance requirements for warning line systems covered in CFR 1926.502 (f). See figure 8.3.

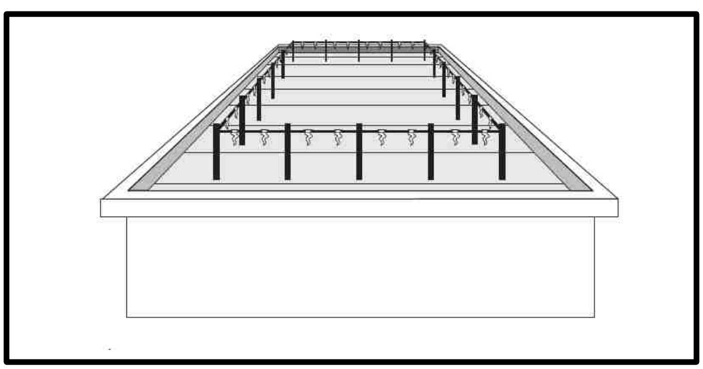

Figure 8.3 – Shows Simple Design of A warning Line System.

8.1.3.4 Safety monitoring systems. A safety monitoring system is a set of steps and procedures that take by a qualified person this person responsible to warning and monitoring workers who may be unmindful of fall hazards. This system works in conjunction with a controlled access zone and a fall protection plan is also adequate in situations where conventional fall protection is not feasible. CFR 1926.502 (h) includes the design and performance requirements for safety monitoring systems.

8.1.3.5 Controlled access zones. The controlled access zone defines as an area where ones can do nearing the edge, overhand bricklaying and another related work, or work under a fall hazard without using conventional fall protection. All others are forbidden from entering a controlled access zone. This zone created by establishing lines, or a control line, to restrict access to the area. The control line alerts the workers to work or access to the zone is limited to authorized persons. See figure 8.4.

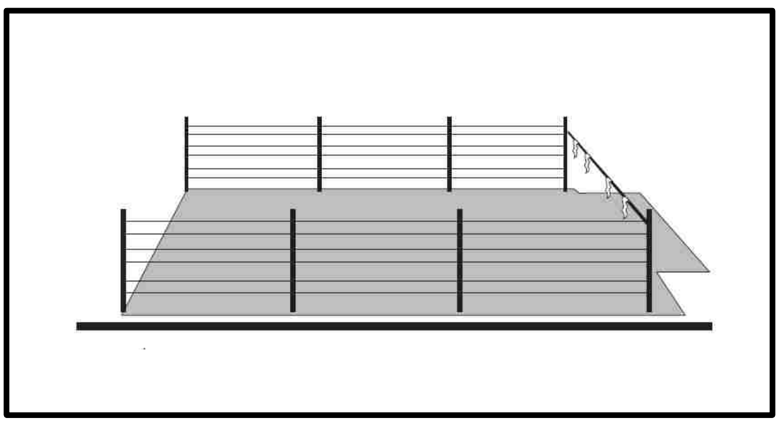

Figure 8.4 – Shows Controlled Access Zone.

The following criteria must be considered when used the control lines:

- Consist of wires, tapes, ropes, or equivalent materials and supporting Pillars.
- Be marked at least every 6 feet, and used high visibility material
- Must be no more than 45 inches from the working surface at its highest point and no less than 39 inches from the working surface at its lowest point.
- Must be a design at a minimum breaking strength of 200 lbs.
- OSHA's design and requirements for controlled access zones. CFR 1926.502 (g)

8.1.3.6 Covers. A cover includes the use of any rigid or solid object to cover opening in roofs, floors, and other working surfaces. A covering material must be able to load at least twice the maximum load of workers, materials, and equipment. Covers must have enough of edges to cover all parts of the hole, and all covers must be colored marks and writes the word (Hole or Cover). Cover must be safety to prevent accidental displacement. CFR 1926.502 (i) the design and performance requirements for covers. See figure 8.5.

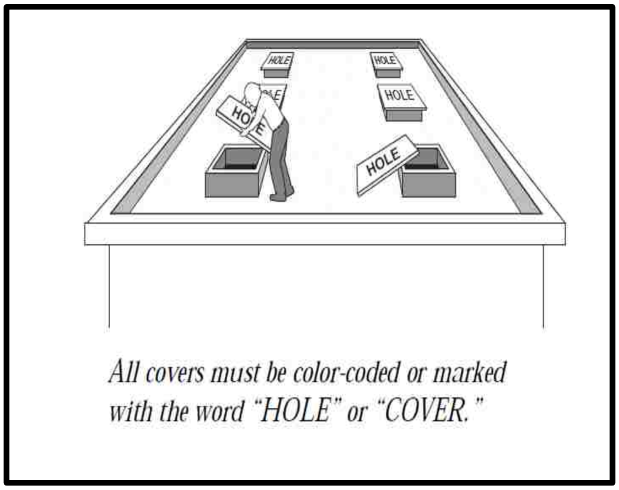

Figure 8.5- Shows Covers Systems.

8.1.3.7 Training workers about fall protection. Employer must be aware of fall hazards at his workplace, and they must work to minimize hazards of falling. The first step must be selecting the fall protection toward meeting that responsibility. Training workers is the second step, so the workers are familiar with the fall protection that they will use. CFR1926.503 requires from employers to provide training for all workers who are exposed to fall hazards.

Responsible person must be qualified to train that ensures workers will recognize hazards of falls and use adequate procedures to reduce exposure to the hazards. In addition, workers should know exactly how to use personal fall arrest systems and know the following:

- How to wear and use the equipment.
- The attachment methods and adequate hookup for the equipment.
- Storage and inspection procedures equipment after used it.
- Appropriate anchoring and tie-off distances.
- Self-rescue methods and techniques

8.2 COST OF FALL PPE

There are a lot of types of personal protective equipment (PPE) that are used by individual workers to protect them from falling. These types vary depending on the work-site at the construction industries, and also depend on the level of elevation from the surface of the work place.

In this section, we will focus on the calculation the cost of PPE, which are generally used to protect from a fall in construction industries. Tables 8.2, 8.3 show the cost of PPE that it is reported by OSHA.

Table 8.2 – Cost of PPE to Protect from A fall in Construction Industries.

Systems	Category	Rate $/each	Number	Dimensions		Total cost ($)
				Length(ft)	Width(ft)	
Personal Fall Arrest System	Anchor	34	1	-	-	34
	Connectors	10	2	-	-	20
	Body Harness	44	1	-	-	44
	Lanyards	35	1	6	-	35
	Deceleration Devices	70	1	-	-	70
	Lifelines	341	1	20	-	341
Guardrail systems	HUGS Upright and accessories	144	20			2880
Safety Net systems		990	1	30	15	990
Total cost						4,414.00

Table 8.3 – Other Fall Protection Systems and Methods Cost.

	Other Fall protection System and Methods					
Fall Restraint Systems	Anchor	34	1	-	-	34
	Connectors	10	2	-	-	20
	Body Harness	44	1	-	-	44
Positioning Device Systems		2120	1	-	-	2120
Warning Line Systems	Flag Line	46	1	100	-	46
	Warning Line System – Single Stanchion	148	4	-	-	592
Worker's Training		25	1			25
Total cost						**2881**
Total all systems cost						**7,295.00**

Through the above results, the expected cost to protect a person from falling equal **$7,295.00** per person who is exposed to falling. This amount represents a cost of personal protective equipment (PPE) which mentioned it by (OSHA). This equipment is sufficient to protect any worker of falling hazard.

Employers or companies are obliged to provide worker with these equipment to protect them. The cost of these materials is much less than the cost that may result from in the event of a fall, which in Section 7 has been estimated at **$ 222,000** per person.

9. CONCLUSION AND RECOMMENDATION

The main purpose of this research is to encourage employers and companies in the construction industry to take necessary and appropriate measures to reduce falls accidents. A lot of employers may believe that the costs of providing the protection systems to reduce falls accidents are large. They believe this spending will lead to a reduction of profits or perhaps economic loss in construction projects. The consequences of these convictions have contributed to a lot of fatal and non-fatal a fall accidents in the construction industry. Fall accidents in construction are the most common that lead to fatalities and severe injuries; during the last decade falls reached about 34% of the total accidents in the construction industry (BLS 2009 CFOL Data). This percent is high when the construction industry is representing 5% of the labor force in the U.S., but is responsible for 20% of the work fatalities and 12% of disabling injuries.

We have been relying in this research on data and statistics that derived from Occupation Safety and Health Administration (OSHA), and Bureau of Labor Statistics (BLS) in the study and analysis. The study was to compare between the total cost of fall accidents and costs of protective systems to reduce a fall accidents. The total costs of fall accidents include Direct Costs, Indirect Costs, and Worker's Compensation Insurance (WCI), in addition to social and family impacts for the injured person. Costs of protective systems depend on work type, and elevation of work surface. In this thesis, we estimated the cost of all the protection systems that can be used to avoid incidents of falling.

The result was an unexpected. The cost of all fall protection systems through the use of all necessary equipment to protect worker from fall hazard was equal to $7,295.00 per person. It is much lower than the costs loss that may result from falls accidents. The costs of a fall loss was equal to $ 222,000 per person which represents the Direct Costs, Indirect Costs, and Worker's Compensation Insurance (WCI), in addition to social and family impacts for the injured person.

Construction Industry has a prominent role in the growth of the U.S. economy in terms of productivity and employment rat. Through study and analysis in this research, we recommend taking appropriate measures, and seek to develop a new mechanisms and production systems to reduce all accidents that are causing a loss in money, time and productivity. Also, the loss in worker's lives which is most important, and a negative consequence that impacts on the society and his family.

Also, we recommend the companies to adopt Zero Injury Policy; Preparation programs in the field of process safety to reduce fall accidents in the construction industry. The workers must be trained in safety programs on a regular basis to ensure the preservation their lives and health. In the end, we will reduce the costs that result from a fall accidents.

10. AREAS OF FUTURE RESEARCH

Clearly this research was a study of an important part of the problem facing the construction industry. It has a recurrent incident that is causes a decline in productivity, an increase in wasted spending, and stagnation in economic growth for this sector. Falls are the main factor for incidents in the construction industry, and this was the basis for the subject in this research. This research has been to clarify and correct some concepts about costs of fall accidents and the cost of protection from them, but this certainly is not the only reason that causes injuries.

Future study we will focus on a larger area of reasons that falls have a role in these incidents. One of those reasons is worker's negligence in how use of protection systems. A lot of time and study must be given on how to obligate a worker to be responsible about use protection systems by using the appropriate procedures. One of the measures that can be taken is a list of instructions that must be signed by the worker before starting any work which requires fall protection. These instructions include procedures for checking protection systems before use, measures to make sure of a worker's knowledge for use these systems, procedures to bring equipment back to its original position after use, and a lot of instructions that can be included to reduce these incidents.

In addition, we can study other reasons for accidents that occur in the construction industry. Transportation, contact w/objects, and exposure are equal 59.5% of construction incidents; these represent a large opportunity to improve construction safety.

Another study for future research would be a survey of employers about their perception about the cost of accidents and the cost of protection from accidents in the construction industry. This will help in finding appropriate solutions to increase their interest in supporting programs and protection systems to reduce the rate of accidents.

APPENDIX A

FATAL OCCUPATIONAL INJURIES BY INDUSTRY AND EVENT OR EXPOSURE, ALL U.S.

TABLE A-1. Fatal occupational injuries by industry and event or exposure, All U.S., 2012

Industry[1]	NAICS code[1]	Total fatal injuries (number)	Event or exposure[2]: Violence and other injuries by persons or animals[3]	Transportation incidents[4]	Fires and explosions	Falls, slips,trips	Exposure to harmful substances or environments	Contact with objects and equipment
Construction		775	32	216	9	280	102	135
Construction		775	32	216	9	280	102	135
Construction of buildings	236	133	8	20	--	67	11	23
Residential building construction	2361	81	6	9	--	44	7	13
Residential building construction	23611	81	6	9	--	44	7	13
New single-family housing construction (except operative builders)	236115	24	--	3	--	14	3	--
New multifamily housing construction (except operative builders)	236116	4	--	--	--	3	--	--
Residential remodelers	236118	38	5	3	--	18	4	7
Nonresidential building construction	2362	49	--	8	2	23	4	10
Industrial building construction	23621	12	--	--	2	6	--	--
Commercial and institutional building construction	23622	36	--	6	--	16	4	8
Heavy and civil engineering construction	237	169	--	97	--	19	18	32
Utility system construction	2371	68	--	32	--	4	14	16
Water and sewer line and related structures construction	23711	22	--	10	--	--	--	10
Oil and gas pipeline and related structures construction	23712	19	--	14	--	--	--	3
Power and communication line and related structures construction	23713	26	--	8	--	4	11	3
Land subdivision	2372	6	--	6	--	--	--	--
Land subdivision	23721	6	--	6	--	--	--	--
Highway, street, and bridge construction	2373	84	--	57	--	8	4	14
Highway, street, and bridge construction	23731	84	--	57	--	8	4	14
Other heavy and civil engineering construction	2379	11	--	--	--	7	--	--
Specialty trade contractors	238	456	19	97	5	188	70	77
Foundation, structure, and building exterior contractors	2381	182	--	27	--	109	19	25
Poured concrete foundation and structure contractors	23811	25	--	4	--	6	4	11
Residential poured concrete foundation and structure contractors	238111	6	--	--	--	--	--	3
Nonresidential poured concrete foundation and structure contractors	238112	6	--	--	--	--	--	--
Structural steel and precast concrete contractors	23812	18	--	4	--	11	--	3
Nonresidential structural steel and precast concrete contractors	238122	8	--	1	--	5	--	--
Framing contractors	23813	16	--	--	--	11	--	4
Residential framing contractors	238131	6	--	--	--	4	--	--
Masonry contractors	23814	21	--	7	--	11	--	--
Glass and glazing contractors	23815	3	--	--	--	1	--	--
Non residential glass and glazing contractors	238152	2	--	--	--	1	--	--

See footnotes at end of table.

TABLE A-1. Fatal occupational injuries by industry and event or exposure, All U.S., 2011

Industry[1]	NAICS code[1]	Total fatal injuries (number)	Event or exposure[2]					
			Violence and other injuries by persons or animals[3]	Transportation incidents[4]	Fires and explosions	Falls, slips, trips	Exposure to harmful substances or environments	Contact with objects and equipment
Stone mining and quarrying	21231	9	1	4	--	1	--	3
Dimension stone mining and quarrying	212311	2	--	1	--	--	--	1
Crushed and broken limestone mining and quarrying	212312	1	--	--	--	--	--	--
Sand, gravel, clay, and ceramic and refractory minerals mining and quarrying	21232	5	--	--	--	1	--	3
Construction sand and gravel mining	212321	5	--	--	--	1	--	3
Support activities for mining	213	105	4	48	12	8	9	24
Support activities for mining	2131	105	4	48	12	8	9	24
Support activities for mining	21311	105	4	48	12	8	9	24
Drilling oil and gas wells	213111	41	--	15	5	4	5	12
Support activities for oil and gas operations	213112	58	3	29	7	4	4	11
Construction		738	32	197	11	262	112	122
Construction		738	32	197	11	262	112	122
Construction of buildings	236	129	3	26	4	54	22	20
Residential building construction	2361	72	3	17	--	27	14	9
Residential building construction	23611	72	3	17	--	27	14	9
New single-family housing construction (except operative builders)	236115	22	1	7	--	8	--	4
New multifamily housing construction (except operative builders)	236116	3	--	--	--	--	--	--
Residential remodelers	236118	38	1	7	--	18	11	--

TABLE A-1. Fatal occupational injuries by industry and event or exposure, All United States, 2010 - continued

Industry[1]	NAICS code[1]	Total fatalities (number)	Event or exposure[2]					
			Transportation incidents[3]	Assaults and violent acts[4]	Contact with objects and equipment	Falls	Exposure to harmful substances or environments	Fires and explosions
Construction		774	188	30	138	264	126	26
Construction	23	774	188	30	138	264	126	26
Construction of buildings	236	159	23	9	28	80	15	3
Residential Building Construction	2361	91	10	6	15	51	6	--
Residential Building Construction	23611	91	10	6	15	51	6	--
New Single-family Housing Construction (except operative builders	236115	34	7	--	9	13	--	--
New Multi-family Housing Construction (except operative builders)	236116	4	--	--	--	--	--	--
Residential Remodelers	236118	36	--	--	5	23	4	--
Nonresidential Building Construction	2362	61	12	3	12	24	9	--
Industrial Building Construction	23621	13	4	--	--	4	--	--
Commercial and Institutional Building Construction	23622	43	6	--	11	18	6	--
Heavy and Civil Engineering Construction	237	147	70	4	29	13	23	8
Utility System Construction	2371	67	18	--	18	7	14	8
Water and Sewer Line and Related Structures Construction	23711	30	11	--	12	3	4	--
Oil and Gas Pipeline and Related Structures Construction	23712	13	--	--	5	--	4	--
Power and Communication Line and Related Structures Construction	23713	24	6	--	--	4	6	6
Highway, Street, and Bridge Construction	2373	68	47	--	8	6	5	--
Highway, Street, and Bridge Construction	23731	68	47	--	8	6	5	--
Other Heavy and Civil Engineering Construction	2379	10	--	--	3	--	4	--
Other Heavy and Civil Engineering Construction	23799	10	--	--	3	--	4	--
Specialty Trade Contractors	238	447	89	14	79	164	86	14
Foundation, Structure, and Building Exterior Contractors	2381	146	9	4	22	85	24	--
Poured Concrete Foundation and Structure contractors	23811	19	4	--	6	--	6	--
Residential Poured Concrete Foundation and Structure Contractors	238111	4	--	--	--	--	--	--
Nonresidential Poured Concrete Foundation and Structure Contractors	238112	6	--	--	--	--	--	--
Structural Steel and Precast Concrete Contractors	23812	15	--	--	6	6	--	--
Nonresidential Structural Steel and Precast Concrete Contractors	238122	5	--	--	3	--	--	--
Framing Contractors	23813	9	--	--	--	6	--	--
Residential Framing Contractors	238131	4	--	--	--	3	--	--
Masonry Contractors	23814	19	--	--	6	12	--	--
Residential Masonry Contractors	238141	5	--	--	--	--	--	--
Nonresidential Masonry Contractors	238142	4	--	--	--	4	--	--
Glass and Glazing Contractors	23815	3	--	--	--	--	--	--

See footnotes at end of table.

TABLE A-1. Fatal occupational injuries by industry and event or exposure, All United States, 2009 - continued

Industry[1]	NAICS code[1]	Total fatalities (number)	Event or exposure[2]					
			Transportation incidents[3]	Assaults and violent acts[4]	Contact with objects and equipment	Falls	Exposure to harmful substances or environments	Fires and explosions
Other Nonmetallic Mineral Mining and Quarrying	21239	4	--	--	--	--	--	--
Support Activities for Mining	213	58	22	--	19	3	8	6
Support Activities for Mining	2131	58	22	--	19	3	8	6
Support Activities for Mining	21311	58	22	--	19	3	8	6
Drilling Oil and Gas Wells	213111	29	9	--	13	--	4	--
Support Activities for Oil and Gas Operations	213112	27	12	--	5	--	4	5
Construction		834	213	41	151	283	132	14
Construction	23	834	213	41	151	283	132	14
Construction of buildings	236	154	20	9	24	77	22	--
Residential Building Construction	2361	89	11	7	11	44	15	--
Residential Building Construction	23611	89	11	7	11	44	15	--
New Single-family Housing Construction (except operative builders)	236115	36	7	4	4	14	7	--
New Multi-family Housing Construction (except operative builders)	236116	7	--	--	--	--	--	--
Residential Remodelers	236118	37	--	--	4	21	7	--
Nonresidential Building Construction	2362	60	9	--	13	29	6	--
Industrial Building Construction	23621	12	--	--	--	8	--	--
Commercial and Institutional Building Construction	23622	42	9	--	10	16	5	--
Heavy and Civil Engineering Construction	237	169	88	4	36	11	23	7
Utility System Construction	2371	76	30	--	16	7	16	--
Water and Sewer Line and Related Structures Construction	23711	25	10	--	6	--	6	--
Oil and Gas Pipeline and Related Structures Construction	23712	25	12	--	5	--	--	--
Power and Communication Line and Related Structures Construction	23713	26	8	--	5	4	7	--
Land Subdivision	2372	3	--	--	--	--	--	--
Land Subdivision	23721	3	--	--	--	--	--	--
Highway, Street, and Bridge Construction	2373	72	49	--	13	3	4	3
Highway, Street, and Bridge Construction	23731	72	49	--	13	3	4	3
Other Heavy and Civil Engineering Construction	2379	16	8	--	6	--	--	--
Other Heavy and Civil Engineering Construction	23799	16	8	--	6	--	--	--
Specialty Trade Contractors	238	487	98	25	86	190	83	5
Foundation, Structure, and Building Exterior Contractors	2381	170	22	9	24	98	17	--
Poured Concrete Foundation and Structure contractors	23811	15	6	--	4	--	3	--
Residential Poured Concrete Foundation and Structure Contractors	238111	5	--	--	--	--	--	--
Structural Steel and Precast Concrete Contractors	23812	20	--	--	5	13	--	--
Nonresidential Structural Steel and Precast Concrete Contractors	238122	10	--	--	3	7	--	--
Framing Contractors	23813	12	--	--	--	11	--	--

See footnotes at end of table.

TABLE A-1. Fatal occupational injuries by industry and event or exposure, All United States, 2008 - continued

Industry[1]	NAICS code[1]	Total fatalities (number)	Event or exposure[2]					
			Transportation incidents[3]	Assaults and violent acts[4]	Contact with objects and equipment	Falls	Exposure to harmful substances or environments	Fires and explosions
Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying	21232	5	4	--	--	--	--	--
Construction Sand and Gravel Mining	212321	3	3	--	--	--	--	--
Support Activities for Mining	213	104	42	--	28	9	11	14
Support Activities for Mining	2131	104	42	--	28	9	11	14
Support Activities for Mining	21311	104	42	--	28	9	11	14
Drilling Oil and Gas Wells	213111	30	6	--	13	4	4	3
Support Activities for Oil and Gas Operations	213112	69	36	--	12	4	6	11
Support Activities for Coal Mining	213113	5	--	--	3	--	--	--
Construction		975	241	38	201	336	132	26
Construction	23	975	241	38	201	336	132	26
Construction of buildings	236	206	37	15	39	85	26	4
Residential Building Construction	2361	97	16	10	17	40	12	--
Residential Building Construction	23611	97	16	10	17	40	12	--
New Single-family Housing Construction (except operative builders	236115	40	10	6	6	16	--	--
New Multi-family Housing Construction (except operative builders)	236116	10	--	--	3	3	--	--
Residential Remodelers	236118	34	3	3	6	14	6	--
Nonresidential Building Construction	2362	99	19	5	20	40	13	--
Industrial Building Construction	23621	25	6	--	10	5	--	--
Commercial and Institutional Building Construction	23622	70	13	3	9	33	11	--
Heavy and Civil Engineering Construction	237	190	85	5	46	20	27	6
Utility System Construction	2371	86	18	--	28	15	19	4
Water and Sewer Line and Related Structures Construction	23711	35	8	--	17	3	5	--
Oil and Gas Pipeline and Related Structures Construction	23712	22	7	--	6	--	4	4
Power and Communication Line and Related Structures Construction	23713	29	3	--	5	11	10	--
Land Subdivision	2372	6	4	--	--	--	--	--
Land Subdivision	23721	6	4	--	--	--	--	--
Highway, Street, and Bridge Construction	2373	86	59	3	17	5	--	--
Highway, Street, and Bridge Construction	23731	86	59	3	17	5	--	--
Other Heavy and Civil Engineering Construction	2379	9	--	--	--	--	4	--
Other Heavy and Civil Engineering Construction	23799	9	--	--	--	--	4	--
Specialty Trade Contractors	238	567	117	16	115	225	78	16
Foundation, Structure, and Building Exterior Contractors	2381	220	36	4	43	113	19	5
Poured Concrete Foundation and Structure contractors	23811	24	3	--	8	6	6	--
Nonresidential Poured Concrete Foundation and Structure Contractors	238112	6	--	--	--	--	--	--
Structural Steel and Precast Concrete Contractors	23812	38	4	--	14	18	--	--

See footnotes at end of table.

TABLE A-1. Fatal occupational injuries by industry and event or exposure, All United States, 2007 - continued

Industry[1]	NAICS code[1]	Total fatalities (number)	Event or exposure[2]: Transportation incidents[3]	Assaults and violent acts[4]	Contact with objects and equipment	Falls	Exposure to harmful substances or environments	Fires and explosions
Support Activities for Oil and Gas Operations	213112	65	33	--	19	--	5	6
Construction		1,204	296	41	206	447	182	24
Construction	23	1,204	296	41	206	447	182	24
Construction of buildings	236	249	49	16	39	107	34	--
Residential Building Construction	2361	129	23	13	13	55	22	--
Residential Building Construction	23611	129	23	13	13	55	22	--
New Single-family Housing Construction (except operative builders	236115	53	14	6	6	22	4	--
New Multi-family Housing Construction (except operative builders)	236116	11	--	3	--	6	--	--
Residential Remodelers	236118	36	3	3	--	13	13	--
Nonresidential Building Construction	2362	103	19	--	24	46	12	--
Industrial Building Construction	23621	20	--	--	7	8	3	--
Commercial and Institutional Building Construction	23622	77	15	--	15	37	8	--
Heavy and Civil Engineering Construction	237	219	99	--	58	31	28	3
Utility System Construction	2371	99	25	--	34	20	17	3
Water and Sewer Line and Related Structures Construction	23711	49	10	--	27	4	8	--
Oil and Gas Pipeline and Related Structures Construction	23712	12	5	--	3	--	--	--
Power and Communication Line and Related Structures Construction	23713	36	9	--	4	14	8	--
Highway, Street, and Bridge Construction	2373	95	64	--	18	9	4	--
Highway, Street, and Bridge Construction	23731	95	64	--	18	9	4	--
Other Heavy and Civil Engineering Construction	2379	20	6	--	5	--	7	--
Other Heavy and Civil Engineering Construction	23799	20	6	--	5	--	7	--
Specialty Trade Contractors	238	690	132	21	103	292	118	19
Foundation, Structure, and Building Exterior Contractors	2381	252	22	--	35	157	33	--
Poured Concrete Foundation and Structure contractors	23811	26	5	--	5	8	8	--
Residential Poured Concrete Foundation and Structure Contractors	238111	9	--	--	--	3	--	--
Nonresidential Poured Concrete Foundation and Structure Contractors	238112	4	--	--	--	--	--	--
Structural Steel and Precast Concrete Contractors	23812	40	--	--	9	30	--	--
Residential Structural Steel and Precast Concrete Contractors	238121	3	--	--	--	--	--	--
Nonresidential Structural Steel and Precast Concrete Contractors	238122	23	--	--	4	18	--	--
Framing Contractors	23813	24	--	--	5	16	--	--
Residential Framing Contractors	238131	11	--	--	4	6	--	--
Nonresidential Framing Contractors	238132	4	--	--	--	4	--	--
Masonry Contractors	23814	38	5	--	11	16	5	--
Residential Masonry Contractors	238141	9	--	--	3	3	--	--

See footnotes at end of table.

TABLE A-1. Fatal occupational injuries by industry and event or exposure, All United States, 2006 - continued

Industry[1]	NAICS code[1]	Total fatalities (number)	Event or exposure[2]: Transportation incidents[3]	Assaults and violent acts[4]	Contact with objects and equipment	Falls	Exposure to harmful substances or environments	Fires and explosions
Construction Sand and Gravel Mining	212321	4	--	--	--	--	--	--
Support Activities for Mining	213	103	37	--	35	7	9	14
Support Activities for Mining	2131	103	37	--	35	7	9	14
Support Activities for Mining	21311	103	37	--	35	7	9	14
Drilling Oil and Gas Wells	213111	36	11	--	14	5	4	--
Support Activities for Oil and Gas Operations	213112	67	26	--	21	--	5	12
Construction		1,239	323	42	216	433	191	30
Construction	23	1,239	323	42	216	433	191	30
Construction of buildings	236	219	44	14	36	99	21	5
Residential Building Construction	2361	132	20	11	19	62	16	--
Residential Building Construction	23611	132	20	11	19	62	16	--
New Single-family Housing Construction (except operative builders	236115	48	7	3	8	26	3	--
New Multi-family Housing Construction (except operative builders)	236116	16	--	--	5	4	3	--
New Housing Operative Builders	236117	3	--	--	--	--	--	--
Residential Remodelers	236118	37	3	8	5	16	5	--
Nonresidential Building Construction	2362	69	21	3	14	29	--	--
Industrial Building Construction	23621	12	3	--	--	6	--	--
Commercial and Institutional Building Construction	23622	49	15	--	10	20	--	--
Heavy and Civil Engineering Construction	237	224	123	3	47	21	24	6
Utility System Construction	2371	103	35	--	25	17	21	4
Water and Sewer Line and Related Structures Construction	23711	52	17	--	16	5	11	--
Oil and Gas Pipeline and Related Structures Construction	23712	22	11	--	7	--	--	--
Power and Communication Line and Related Structures Construction	23713	29	7	--	--	10	9	--
Highway, Street, and Bridge Construction	2373	106	81	--	16	4	--	--
Highway, Street, and Bridge Construction	23731	106	81	--	16	4	--	--
Other Heavy and Civil Engineering Construction	2379	12	5	--	6	--	--	--
Other Heavy and Civil Engineering Construction	23799	12	5	--	6	--	--	--
Specialty Trade Contractors	238	724	134	22	122	290	135	19
Foundation, Structure, and Building Exterior Contractors	2381	271	29	4	40	165	29	--
Poured Concrete Foundation and Structure contractors	23811	39	12	--	8	7	8	--
Residential Poured Concrete Foundation and Structure Contractors	238111	11	3	--	4	--	3	--
Nonresidential Poured Concrete Foundation and Structure Contractors	238112	6	--	--	--	--	--	--
Structural Steel and Precast Concrete Contractors	23812	33	5	--	4	24	--	--
Nonresidential Structural Steel and Precast Concrete Contractors	238122	16	3	--	3	10	--	--
Framing Contractors	23813	25	--	--	6	17	--	--

See footnotes at end of table.

TABLE A-1. Fatal occupational injuries by industry and event or exposure, All United States, 2005 - continued

Industry[1]	NAICS code[1]	Total fatalities (number)	Event or exposure[2]					
			Transportation incidents[3]	Assaults and violent acts[4]	Contact with objects and equipment	Falls	Exposure to harmful substances or environments	Fires and explosions
Other Nonmetallic Mineral Mining and Quarrying	21239	6	4	--	--	--	--	--
Support Activities for Mining	213	85	32	--	24	9	10	7
Support Activities for Mining	2131	85	32	--	24	9	10	7
Support Activities for Mining	21311	85	32	--	24	9	10	7
Drilling Oil and Gas Wells	213111	34	9	--	10	7	4	--
Support Activities for Oil and Gas Operations	213112	47	21	--	13	--	5	5
Construction		1,192	318	31	244	394	164	40
Construction	23	1,192	318	31	244	394	164	40
Construction of buildings	236	227	27	9	40	128	17	6
Residential Building Construction	2361	128	12	8	23	71	11	3
Residential Building Construction	23611	128	12	8	23	71	11	3
New Single-family Housing Construction (except operative builders	236115	50	8	--	9	26	3	--
New Multi-family Housing Construction (except operative builders)	236116	11	--	--	--	8	--	--
Residential Remodelers	236118	35	--	3	3	23	3	--
Nonresidential Building Construction	2362	71	10	--	14	38	6	3
Industrial Building Construction	23621	19	--	--	7	9	--	--
Commercial and Institutional Building Construction	23622	47	9	--	6	26	4	--
Heavy and Civil Engineering Construction	237	244	125	3	61	12	27	16
Utility System Construction	2371	106	32	--	32	8	19	14
Water and Sewer Line and Related Structures Construction	23711	49	17	--	26	--	3	--
Oil and Gas Pipeline and Related Structures Construction	23712	22	3	--	3	--	--	14
Power and Communication Line and Related Structures Construction	23713	33	12	--	3	5	13	--
Land Subdivision	2372	3	--	--	--	--	--	--
Land Subdivision	23721	3	--	--	--	--	--	--
Highway, Street, and Bridge Construction	2373	116	84	--	20	3	5	--
Highway, Street, and Bridge Construction	23731	116	84	--	20	3	5	--
Other Heavy and Civil Engineering Construction	2379	16	7	--	6	--	3	--
Other Heavy and Civil Engineering Construction	23799	16	7	--	6	--	3	--
Specialty Trade Contractors	238	677	158	15	136	237	113	17
Foundation, Structure, and Building Exterior Contractors	2381	247	41	4	44	130	27	--
Poured Concrete Foundation and Structure contractors	23811	29	15	--	9	--	3	--
Residential Poured Concrete Foundation and Structure Contractors	238111	3	--	--	--	--	--	--
Nonresidential Poured Concrete Foundation and Structure Contractors	238112	13	8	--	--	--	--	--
Structural Steel and Precast Concrete Contractors	23812	35	4	--	11	20	--	--
Nonresidential Structural Steel and Precast Concrete Contractors	238122	20	--	--	6	13	--	--

See footnotes at end of table.

TABLE A-1. Fatal occupational injuries by industry and event or exposure, All United States, 2004 - continued

Industry[1]	NAICS code[1]	Total fatalities (number)	Event or exposure[2]					
			Transportation incidents[3]	Assaults and violent acts[4]	Contact with objects and equipment	Falls	Exposure to harmful substances or environments	Fires and explosions
Coal Mining	21211	26	8	--	14	--	--	--
Bituminous Coal and Lignite Surface Mining	212111	3	3	--	--	--	--	--
Bituminous Coal Underground Mining	212112	14	--	--	10	--	--	--
Metal Ore Mining	2122	5	--	--	--	--	--	--
Nonmetallic Mineral Mining and Quarrying	2123	19	5	--	9	4	--	--
Stone Mining and Quarrying	21231	6	--	--	3	--	--	--
Crushed and Broken Limestone Mining and Quarrying	212312	3	--	--	--	--	--	--
Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying	21232	12	4	--	5	--	--	--
Construction Sand and Gravel Mining	212321	9	--	--	4	--	--	--
Support Activities for Mining	213	71	28	--	21	7	5	9
Support Activities for Mining	2131	71	28	--	21	7	5	9
Support Activities for Mining	21311	71	28	--	21	7	5	9
Drilling Oil and Gas Wells	213111	30	6	--	11	6	3	--
Support Activities for Oil and Gas Operations	213112	39	22	--	10	--	--	5
Construction		1,234	287	31	267	445	170	34
Construction	23	1,234	287	31	267	445	170	34
Construction of buildings	236	225	43	6	52	106	17	--
Residential Building Construction	2361	118	13	4	24	64	12	--
Residential Building Construction	23611	118	13	4	24	64	12	--
New Single-family Housing Construction (except operative builders	236115	41	5	--	9	24	3	--
New Multi-family Housing Construction (except operative builders)	236116	9	--	--	--	6	--	--
New Housing Operative Builders	236117	5	--	--	--	--	--	--
Residential Remodelers	236118	31	--	4	3	16	5	--
Nonresidential Building Construction	2362	81	24	--	23	29	4	--
Industrial Building Construction	23621	24	8	--	8	8	--	--
Commercial and Institutional Building Construction	23622	49	12	--	13	19	4	--
Heavy and Civil Engineering Construction	237	220	90	--	73	18	27	11
Utility System Construction	2371	95	20	--	41	11	19	4
Water and Sewer Line and Related Structures Construction	23711	53	12	--	31	--	7	--
Oil and Gas Pipeline and Related Structures Construction	23712	9	--	--	4	--	--	--
Power and Communication Line and Related Structures Construction	23713	30	4	--	6	10	9	--
Highway, Street, and Bridge Construction	2373	100	59	--	29	5	5	--
Highway, Street, and Bridge Construction	23731	100	59	--	29	5	5	--
Other Heavy and Civil Engineering Construction	2379	23	9	--	3	--	--	6
Other Heavy and Civil Engineering Construction	23799	23	9	--	3	--	--	6
Specialty Trade Contractors	238	759	142	20	136	316	124	21
Foundation, Structure, and Building Exterior Contractors	2381	301	44	7	48	170	27	5

See footnotes at end of table.

TABLE A-1. Fatal occupational injuries by industry and event or exposure, All United States, 2003 - continued

Industry[1]	NAICS code[1]	Total fatalities (number)	Event or exposure[2]					
			Transportation incidents[3]	Assaults and violent acts[4]	Contact with objects and equipment	Falls	Exposure to harmful substances or environments	Fires and explosions
Dimension Stone Mining and Quarrying	212311	4	--	--	--	--	--	--
Crushed and Broken Limestone Mining and Quarrying	212312	3	--	--	--	--	--	--
Other Crushed and Broken Stone Mining and Quarrying	212319	3	--	--	3	--	--	--
Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying	21232	13	6	--	4	--	--	--
Construction Sand and Gravel Mining	212321	10	4	--	4	--	--	--
Support Activities for Mining	213	69	22	--	23	4	4	16
Support Activities for Mining	2131	69	22	--	23	4	4	16
Support Activities for Mining	21311	69	22	--	23	4	4	16
Drilling Oil and Gas Wells	213111	26	5	--	13	--	--	5
Support Activities for Oil and Gas Operations	213112	42	17	--	10	--	3	10
Construction		1,131	290	37	231	364	179	29
Construction	23	1,131	290	37	231	364	179	29
Construction of buildings	236	227	51	13	39	96	25	--
Residential Building Construction	2361	129	32	8	21	50	18	--
Residential Building Construction	23611	129	32	8	21	50	18	--
New Single-family Housing Construction (except operative builders	236115	57	17	--	10	20	8	--
New Multi-family Housing Construction (except operative builders)	236116	9	--	--	--	4	--	--
Residential Remodelers	236118	29	--	6	4	12	5	--
Nonresidential Building Construction	2362	80	10	5	16	39	7	--
Industrial Building Construction	23621	19	--	--	3	11	--	--
Commercial and Institutional Building Construction	23622	55	5	3	12	27	5	--
Heavy and Civil Engineering Construction	237	247	90	--	79	25	46	6
Utility System Construction	2371	131	27	--	53	16	32	3
Water and Sewer Line and Related Structures Construction	23711	66	12	--	39	3	11	--
Oil and Gas Pipeline and Related Structures Construction	23712	15	6	--	3	--	--	--
Power and Communication Line and Related Structures Construction	23713	49	8	--	11	11	19	--
Highway, Street, and Bridge Construction	2373	95	52	--	23	6	12	--
Highway, Street, and Bridge Construction	23731	95	52	--	23	6	12	--
Other Heavy and Civil Engineering Construction	2379	19	10	--	3	--	--	--
Other Heavy and Civil Engineering Construction	23799	19	10	--	3	--	--	--
Specialty Trade Contractors	238	629	135	21	110	235	107	21
Foundation, Structure, and Building Exterior Contractors	2381	228	33	5	39	125	21	5
Poured Concrete Foundation and Structure contractors	23811	23	11	--	6	--	3	--
Residential Poured Concrete Foundation and Structure Contractors	238111	5	--	--	--	--	--	--
Nonresidential Poured Concrete Foundation and Structure Contractors	238112	5	3	--	--	--	--	--

See footnotes at end of table.

APPENDIX B

CURRENT EMPLOYMENT STATISTICS SURVEY, ALL U.S.

Bureau of Labor Statistics

Employment, Hours, and Earnings from the Current Employment Statistics survey (National)
Original Data Value

Construction Industry 1970 - 2014

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1970	3615	3703	3697	3669	3634	3636	3645	3649	3618	3626	3643	3688
1971	3643	3633	3674	3735	3750	3759	3786	3786	3820	3867	3903	3867
1972	3912	3888	3921	3931	3957	3969	3939	3983	4000	4038	4002	3937
1973	4004	4071	4089	4106	4137	4193	4232	4233	4237	4232	4232	4239
1974	4196	4259	4255	4225	4198	4146	4045	4059	4009	3972	3911	3860
1975	3841	3718	3628	3565	3552	3526	3501	3547	3573	3587	3604	3641
1976	3688	3687	3685	3684	3649	3632	3627	3632	3634	3645	3678	3688
1977	3660	3775	3859	3904	3930	3962	3981	3995	4023	4034	4058	4087
1978	4029	4058	4178	4308	4302	4379	4403	4420	4424	4447	4453	4450
1979	4373	4389	4552	4516	4565	4604	4621	4634	4625	4620	4617	4630
1980	4625	4605	4548	4473	4434	4395	4351	4377	4401	4411	4409	4415
1981	4374	4357	4396	4414	4343	4311	4299	4278	4254	4238	4209	4177
1982	4069	4131	4108	4083	4092	4030	4001	3977	3962	3940	3947	3948
1983	4021	3964	3942	3948	3960	4006	4055	4100	4138	4178	4217	4248
1984	4305	4410	4393	4423	4456	4507	4534	4547	4576	4590	4617	4652
1985	4668	4662	4730	4764	4787	4789	4799	4823	4852	4868	4879	4887
1986	4908	4904	4914	4950	4924	4917	4930	4943	4939	4954	4960	4993
1987	5007	5038	5039	5053	5080	5086	5092	5102	5096	5142	5152	5180
1988	5094	5162	5201	5227	5228	5261	5270	5268	5270	5262	5273	5277
1989	5289	5278	5260	5295	5299	5298	5317	5330	5323	5347	5364	5309
1990	5422	5416	5392	5355	5321	5303	5274	5234	5197	5134	5095	5047
1991	4972	4929	4881	4842	4800	4782	4752	4733	4728	4698	4640	4647
1992	4667	4612	4621	4603	4605	4584	4570	4581	4584	4600	4606	4630
1993	4664	4714	4676	4690	4753	4760	4783	4806	4823	4868	4887	4925
1994	4940	4923	4990	5047	5084	5097	5125	5139	5175	5177	5210	5226
1995	5234	5192	5242	5252	5220	5250	5262	5286	5324	5353	5358	5344
1996	5355	5415	5446	5474	5498	5534	5557	5586	5610	5643	5668	5675
1997	5675	5722	5751	5764	5793	5793	5817	5846	5874	5883	5899	5938
1998	5983	5997	5969	6049	6087	6130	6172	6215	6225	6262	6301	6378

Source: Bureau of Labor Statistics

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Bureau of Labor Statistics

1999	6357	6429	6402	6480	6516	6547	6571	6586	6613	6640	6687	6709
2000	6752	6730	6811	6794	6770	6778	6794	6796	6807	6814	6817	6792
2001	6824	6841	6862	6844	6849	6840	6845	6827	6813	6804	6784	6785
2002	6775	6766	6755	6710	6684	6701	6688	6701	6702	6689	6713	6700
2003	6704	6667	6654	6689	6706	6723	6735	6760	6783	6784	6796	6827
2004	6848	6838	6887	6901	6948	6962	6977	7003	7029	7077	7091	7117
2005	7095	7153	7181	7266	7294	7333	7353	7394	7415	7460	7524	7533
2006	7601	7664	7689	7726	7713	7699	7712	7720	7718	7682	7666	7685
2007	7725	7626	7706	7686	7673	7687	7660	7610	7577	7565	7523	7490
2008	7476	7453	7406	7327	7274	7213	7160	7114	7044	6967	6813	6701
2009	6567	6446	6291	6154	6100	6010	5932	5855	5787	5716	5696	5654
2010	5587	5508	5536	5555	5524	5512	5502	5525	5503	5507	5504	5462
2011	5432	5464	5475	5496	5520	5524	5551	5553	5590	5584	5585	5606
2012	5627	5622	5627	5630	5613	5620	5635	5647	5648	5666	5687	5720
2013	5743	5789	5813	5811	5816	5829	5830	5836	5849	5864	5896	5876
2014	5926	5941										

Source: Bureau of Labor Statistics

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Employment, Hours, and Earnings from the Current Employment Statistics survey (National)
12-Month Percent Change

Construction Industry 1970 - 2014

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1970	2.3	3.6	3.3	2.2	0.0	-0.8	-0.5	-0.1	-1.6	-1.3	-1.1	-0.5
1971	0.8	-1.9	-0.6	1.8	3.2	3.4	3.9	3.8	5.6	6.6	7.1	4.9
1972	7.4	7.0	6.7	5.2	5.5	5.6	4.0	5.2	4.7	4.4	2.5	1.8
1973	2.4	4.7	4.3	4.5	4.5	5.6	7.4	6.3	5.9	4.8	5.7	7.7
1974	4.8	4.6	4.1	2.9	1.5	-1.1	-4.4	-4.1	-5.4	-6.1	-7.6	-8.9
1975	-8.5	-12.7	-14.7	-15.6	-15.4	-15.0	-13.4	-12.6	-10.9	-9.7	-7.8	-5.7
1976	-4.0	-0.8	1.6	3.3	2.7	3.0	3.6	2.4	1.7	1.6	2.1	1.3
1977	-0.8	2.4	4.7	6.0	7.7	9.1	9.8	10.0	10.7	10.7	10.3	10.8
1978	10.1	7.5	8.3	10.3	9.5	10.5	10.6	10.6	10.0	10.2	9.7	8.9
1979	8.5	8.2	9.0	4.8	6.1	5.1	5.0	4.8	4.5	3.9	3.7	4.0
1980	5.8	4.9	-0.1	-1.0	-2.9	-4.5	-5.8	-5.5	-4.8	-4.5	-4.5	-4.6
1981	-5.4	-5.4	-3.3	-1.3	-2.1	-1.9	-1.2	-2.3	-3.3	-3.9	-4.5	-5.4
1982	-7.0	-5.2	-6.6	-7.5	-5.8	-6.5	-6.9	-7.0	-6.9	-7.0	-6.2	-5.5
1983	-1.2	-4.0	-4.0	-3.3	-3.2	-0.6	1.3	3.1	4.4	6.0	6.8	7.6
1984	7.1	11.3	11.4	12.0	12.5	12.5	11.8	10.9	10.6	9.9	9.5	9.5
1985	8.4	5.7	7.7	7.7	7.4	6.3	5.8	6.1	6.0	6.1	5.7	5.1
1986	5.1	5.2	3.9	3.9	2.9	2.7	2.7	2.5	1.8	1.8	1.7	2.2
1987	2.0	2.7	2.5	2.1	3.2	3.4	3.3	3.2	3.2	3.8	3.9	3.7
1988	1.7	2.5	3.2	3.4	2.9	3.4	3.5	3.3	3.4	2.3	2.3	1.9
1989	3.8	2.2	1.1	1.3	1.4	0.7	0.9	1.2	1.0	1.6	1.7	0.6
1990	2.5	2.6	2.5	1.1	0.4	0.1	-0.8	-1.8	-2.4	-4.0	-5.0	-4.9
1991	-8.3	-9.0	-9.5	-9.6	-9.8	-9.8	-9.9	-9.6	-9.0	-8.5	-8.9	-7.9
1992	-6.1	-6.4	-5.3	-4.9	-4.1	-4.1	-3.8	-3.2	-3.0	-2.1	-0.7	-0.4
1993	-0.1	2.2	1.2	1.9	3.2	3.8	4.7	4.9	5.2	5.8	6.1	6.4
1994	5.9	4.4	6.7	7.6	7.0	7.1	7.2	6.9	7.3	6.3	6.6	6.1
1995	6.0	5.5	5.1	4.1	2.7	3.0	2.7	2.9	2.9	3.4	2.8	2.3
1996	2.3	4.3	3.9	4.2	5.3	5.4	5.6	5.7	5.4	5.4	5.8	6.2
1997	6.0	5.7	5.6	5.3	5.4	4.7	4.7	4.7	4.7	4.3	4.1	4.6
1998	5.4	4.8	3.8	4.9	5.1	5.8	6.1	6.3	6.0	6.4	6.8	7.4
1999	6.3	7.2	7.3	7.1	7.0	6.8	6.5	6.0	6.2	6.0	6.1	5.2
2000	6.2	4.7	6.4	4.8	3.9	3.5	3.4	3.2	2.9	2.6	1.9	1.2

Source: Bureau of Labor Statistics

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2001	1.1	1.6	0.7	0.7	1.2	0.9	0.8	0.5	0.1	-0.1	-0.5	-0.1
2002	-0.7	-1.1	-1.6	-2.0	-2.4	-2.0	-2.3	-1.8	-1.6	-1.7	-1.0	-1.3
2003	-1.0	-1.5	-1.5	-0.3	0.3	0.3	0.7	0.9	1.2	1.4	1.2	1.9
2004	2.1	2.6	3.5	3.2	3.6	3.6	3.6	3.6	3.6	4.3	4.3	4.2
2005	3.6	4.6	4.3	5.3	5.0	5.3	5.4	5.6	5.5	5.4	6.1	5.8
2006	7.1	7.1	7.1	6.3	5.7	5.0	4.9	4.4	4.1	3.0	1.9	2.0
2007	1.6	-0.5	0.2	-0.5	-0.5	-0.2	-0.7	-1.4	-1.8	-1.5	-1.9	-2.5
2008	-3.2	-2.3	-3.9	-4.7	-5.2	-6.2	-6.5	-6.5	-7.0	-7.9	-9.4	-10.5
2009	-12.2	-13.5	-15.1	-16.0	-16.1	-16.7	-17.2	-17.7	-17.8	-18.0	-16.4	-15.6
2010	-14.9	-14.6	-12.0	-9.7	-9.4	-8.3	-7.2	-5.6	-4.9	-3.7	-3.4	-3.4
2011	-2.8	-0.8	-1.1	-1.1	-0.1	0.2	0.9	0.5	1.6	1.4	1.5	2.6
2012	3.6	2.9	2.8	2.4	1.7	1.7	1.5	1.7	1.0	1.5	1.8	2.0
2013	2.1	3.0	3.3	3.2	3.6	3.7	3.5	3.3	3.6	3.5	3.7	2.7
2014	3.2	2.6										

Source: Bureau of Labor Statistics

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APPENDIX C

ANNUAL VALUE OF CONSTRUCTION PUT IN PLACE, 1993 - 2013

Annual Value of Construction Put in Place 2008-2013
(Millions of dollars. Details may not add to totals due to rounding.)

Type of Construction:	2008	2009	2010	2011	2012	2013[r]
Total Construction	1,067,564	903,201	804,561	788,014	856,953	899,206
Residential	357,746	253,928	249,112	252,657	286,524	337,270
Nonresidential	709,818	649,273	555,449	535,357	570,429	561,936
Lodging	35,806	25,499	11,635	9,129	11,423	14,356
Office	68,563	51,908	37,850	36,011	38,433	38,584
Commercial	86,212	54,069	39,450	43,386	46,303	49,144
Health care	46,902	44,845	39,344	40,204	41,797	40,553
Educational	104,890	103,202	88,405	84,985	84,618	79,355
Religious	7,225	6,192	5,288	4,239	3,768	3,457
Public safety	13,083	13,787	11,153	10,407	10,295	9,418
Amusement and recreation	21,829	19,404	16,943	15,995	14,977	14,440
Transportation	35,471	36,701	38,340	34,737	38,210	41,266
Communication	26,487	19,753	17,730	17,685	17,528	15,513
Power	81,075	88,861	77,945	75,185	94,068	83,730
Highway and street	81,361	82,166	82,529	79,322	80,517	81,302
Sewage and waste disposal	25,696	24,830	25,991	22,710	22,066	21,787
Water supply	16,752	15,471	15,322	14,163	13,227	13,831
Conservation and development	5,234	5,750	7,172	7,538	6,350	5,918
Manufacturing	53,234	56,836	40,350	39,660	46,850	49,283
Total Private Construction [1]	758,827	588,306	500,595	501,607	577,930	627,447
Residential	350,257	245,912	238,819	244,133	280,257	331,355
Nonresidential	408,569	342,394	261,776	257,474	297,673	296,091
Lodging	35,364	25,388	11,201	8,395	10,783	13,864
Office	55,502	37,282	24,368	23,738	27,963	30,678
Commercial	82,654	50,460	36,504	39,723	43,163	46,734
Health care	38,437	35,309	29,552	28,906	30,767	29,736
Educational	18,624	16,851	13,418	14,081	16,440	16,556
Religious	7,197	6,177	5,237	4,205	3,739	3,429
Public safety	623	471	241	205	121	130
Amusement and recreation	10,508	8,402	6,483	6,744	5,788	6,132
Transportation	9,934	9,056	9,894	9,537	11,372	12,205
Communication	26,343	19,712	17,689	17,536	17,320	15,350
Power	69,242	76,064	66,117	64,262	83,151	71,396
Sewage and waste disposal	665	468	439	520	600	418
Water supply	466	319	717	635	417	694
Manufacturing	52,754	56,296	39,778	38,869	45,833	48,561

10:00 AM EST 03/03/14

Annual Value of Construction Put in Place 2008-2013
(Millions of dollars. Details may not add to totals due to rounding.)

Type of Construction:	2008	2009	2010	2011	2012	2013[r]
Total Construction	1,067,564	903,201	804,561	788,014	856,953	899,206
Residential	357,746	253,928	249,112	252,657	286,524	337,270
Nonresidential	709,818	649,273	555,449	535,357	570,429	561,936
Lodging	35,806	25,499	11,635	9,129	11,423	14,356
Office	68,563	51,908	37,850	36,011	38,433	38,584
Commercial	86,212	54,069	39,450	43,386	46,303	49,144
Health care	46,902	44,845	39,344	40,204	41,797	40,553
Educational	104,890	103,202	88,405	84,985	84,618	79,355
Religious	7,225	6,192	5,288	4,239	3,768	3,457
Public safety	13,083	13,787	11,153	10,407	10,295	9,418
Amusement and recreation	21,829	19,404	16,943	15,995	14,977	14,440
Transportation	35,471	36,701	38,340	34,737	38,210	41,266
Communication	26,487	19,753	17,730	17,685	17,528	15,513
Power	81,075	88,861	77,945	75,185	94,068	83,730
Highway and street	81,361	82,166	82,529	79,322	80,517	81,302
Sewage and waste disposal	25,696	24,830	25,991	22,710	22,066	21,787
Water supply	16,752	15,471	15,322	14,163	13,227	13,831
Conservation and development	5,234	5,750	7,172	7,538	6,350	5,918
Manufacturing	53,234	56,836	40,350	39,660	46,850	49,283
Total Private Construction [1]	758,827	588,306	500,595	501,607	577,930	627,447
Residential	350,257	245,912	238,819	244,133	280,257	331,355
Nonresidential	408,569	342,394	261,776	257,474	297,673	296,091
Lodging	35,364	25,388	11,201	8,395	10,783	13,864
Office	55,502	37,282	24,368	23,738	27,963	30,678
Commercial	82,654	50,460	36,504	39,723	43,163	46,734
Health care	38,437	35,309	29,552	28,906	30,767	29,736
Educational	18,624	16,851	13,418	14,081	16,440	16,556
Religious	7,197	6,177	5,237	4,205	3,739	3,429
Public safety	623	471	241	205	121	130
Amusement and recreation	10,508	8,402	6,483	6,744	5,788	6,132
Transportation	9,934	9,056	9,894	9,537	11,372	12,205
Communication	26,343	19,712	17,689	17,536	17,320	15,350
Power	69,242	76,064	66,117	64,262	83,151	71,396
Sewage and waste disposal	665	468	439	520	600	418
Water supply	466	319	717	635	417	694
Manufacturing	52,754	56,296	39,778	38,869	45,833	48,561

10:00 AM EST 03/03/14

Annual Value of Construction Put in Place 2002-2007

(Millions of dollars. Details may not add to totals due to rounding.)

Type of Construction:	2002	2003	2004	2005	2006	2007
Total Construction	847,874	891,497	991,356	1,104,136	1,167,222	1,152,351
Residential	401,960	451,251	538,408	617,507	619,814	500,468
Nonresidential	445,914	440,246	452,948	486,629	547,408	651,883
Lodging	10,869	10,712	12,363	12,840	18,139	28,706
Office	44,277	39,418	42,404	45,763	54,187	65,259
Commercial	62,520	61,529	67,057	70,242	76,713	89,684
Health care	27,139	29,329	32,184	34,430	38,472	43,766
Educational	73,862	74,316	74,250	79,687	84,928	96,758
Religious	8,339	8,569	8,159	7,735	7,749	7,540
Public safety	7,827	7,161	7,019	7,314	7,768	10,201
Amusement and recreation	17,328	16,847	16,695	15,236	19,033	21,212
Transportation	25,781	24,710	25,059	25,052	27,964	31,877
Communication	18,457	14,550	15,546	18,906	22,219	27,580
Power	36,804	41,450	35,638	38,371	42,244	66,055
Highway and street	57,484	57,139	58,623	64,139	72,040	76,682
Sewage and waste disposal	16,237	16,581	17,929	19,867	23,186	24,872
Water supply	12,442	12,492	12,620	14,028	14,960	15,798
Conservation and development	3,621	3,935	4,044	4,453	5,130	5,260
Manufacturing	22,926	21,508	23,360	28,568	32,677	40,633
Total Private Construction [1]	634,435	675,370	771,173	869,976	911,837	863,278
Residential	396,696	446,035	532,900	611,899	613,731	493,246
Nonresidential	237,739	229,335	238,273	258,077	298,105	370,032
Lodging	10,467	9,930	11,982	12,666	17,624	27,481
Office	35,296	30,579	32,879	37,276	45,680	53,815
Commercial	59,008	57,505	63,195	66,584	73,368	85,858
Health care	22,438	24,217	26,272	28,495	32,016	35,588
Educational	13,109	13,424	12,701	12,788	13,839	16,691
Religious	8,335	8,559	8,153	7,715	7,740	7,522
Public safety	217	185	289	408	419	595
Amusement and recreation	7,478	7,781	8,432	7,507	9,326	10,193
Transportation	6,773	6,568	6,841	7,124	8,654	9,009
Communication	18,384	14,456	15,468	18,846	22,187	27,488
Power	32,608	33,619	27,603	29,210	33,654	54,115
Sewage and waste disposal	246	278	331	240	305	408
Water supply	397	393	405	326	477	516
Manufacturing	22,744	21,434	23,219	28,413	32,264	40,215

10:00 AM EDT 07/01/13

Annual Value of Construction Put in Place 2002-2007

(Millions of dollars. Details may not add to totals due to rounding.)

Type of Construction:	2002	2003	2004	2005	2006	2007
Total Public Construction [2]	213,438	216,127	220,183	234,160	255,385	289,073
Residential	5,264	5,216	5,508	5,608	6,083	7,222
Nonresidential	208,174	210,911	214,675	228,552	249,303	281,852
Office	8,982	8,839	9,525	8,487	8,507	11,445
Commercial	3,512	4,024	3,862	3,658	3,345	3,827
Health care	4,701	5,112	5,912	5,935	6,456	8,179
Educational	60,753	60,892	61,549	66,899	71,089	80,068
Public safety	7,610	6,976	6,730	6,906	7,350	9,606
Amusement and recreation	9,851	9,066	8,263	7,728	9,707	11,019
Transportation	19,007	18,142	18,219	17,928	19,310	22,868
Power	4,196	7,831	8,035	9,161	8,590	11,940
Highway and street	57,350	56,974	58,294	63,790	71,567	76,248
Sewage and waste disposal	15,991	16,304	17,598	19,627	22,881	24,464
Water supply	12,045	12,100	12,215	13,703	14,483	15,282
Conservation and development	3,516	3,694	3,869	4,322	5,047	5,155

[1] Includes the following categories of private construction not shown separately: highway and street and conservation and development.

[2] Includes the following categories of public construction not shown separately: lodging, religious, communication, and manufacturing.

Annual Value of Construction Put in Place 1993-2001

(Millions of dollars. Details may not add to totals due to rounding.)

Type of Construction:	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total Construction [1]	485,548	531,892	548,666	599,693	631,853	688,515	744,551	802,756	840,249
Total Private Construction [2]	358,186	401,471	408,655	453,018	478,416	533,737	575,469	621,431	638,337
Residential	208,180	241,033	228,121	257,495	264,696	296,343	326,302	346,138	364,414
Nonresidential	150,006	160,438	180,534	195,523	213,720	237,394	249,167	275,293	273,922
Lodging	4,590	4,657	7,131	10,914	12,898	14,818	15,955	16,304	14,519
Office	19,999	20,443	22,996	26,530	32,813	40,394	45,052	52,407	49,745
Commercial	34,396	39,615	44,096	49,381	53,088	55,681	59,376	64,055	63,606
Health care	14,939	15,447	15,259	15,420	17,390	17,737	18,388	19,455	19,506
Educational	4,814	5,009	5,699	6,985	8,802	9,829	9,756	11,683	12,846
Religious	3,894	3,871	4,348	4,537	5,782	6,604	7,371	8,030	8,393
Public safety	215	327	185	321	569	586	465	423	274
Amusement and recreation	4,601	5,108	5,886	7,016	8,537	8,589	9,550	8,768	7,828
Transportation	4,680	4,704	4,759	5,820	6,208	7,290	6,525	6,879	7,058
Communication	9,751	10,149	11,112	11,824	12,452	12,473	18,405	18,799	19,596
Power	23,554	21,043	22,006	17,413	16,362	21,690	22,040	29,344	31,499
Sewage and waste disposal	373	299	576	637	468	339	516	508	402
Water supply	426	567	670	468	448	543	413	714	563
Manufacturing	23,371	28,845	35,364	38,101	37,624	40,485	35,126	37,583	37,815
Total Public Construction [1]	127,362	130,421	140,011	146,675	153,437	154,778	169,082	181,325	201,912

[1] Detailed types of construction not available prior to 2002.

[2] Includes the following categories of private construction not shown separately: highway and street and conservation and development.

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VITA

Mr. Sultan Noori Al-karawi. He was born in Jalawlaa, Diyala, Iraq in 1981. He studied at Jalawlaa High School; he completed it in 1999. He entered collegiate studies at Technology University in Baghdad, Iraq. Majoring in Civil Engineering, he graduated with a Bachelor of Science with Good in September of 2003.

After graduation, He worked in a number of construction projects in his country for three years. Since 2006 to 2011 he served in the Civil Engineering Department, Diyala University to help civil engineering students in laboratories (Soil Lab, Concrete Lab). In August 2011, he got a scholarship from the Higher Committee for Education Development in Iraq to complete a master degree in Civil Engineering at Missouri University of Science & Technology.

He focused in Construction Engineering and management when he studied at Missouri University of Science and Technology, and he graduated with a Master of Science in Civil Engineering in May 2014.