

# Analysis of the causes and consequences of accidents occurring in two constructions projects

## Análisis de las causas y consecuencias de los accidentes laborales ocurridos en dos proyectos de construcción

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### Abstract

*Work done on construction sites is considered to be high risk, resulting in instances of occupational accidents that impact the physical, mental and social integrity of the workers as well as company productivity. Therefore, the objective of this article is to analyze the causes and consequences of occupational accidents occurred in the second semester of 2012 in two construction projects in Neiva, Colombia. The approach is documentary, supported by information sources of occupational accidents reported to the Administration of Occupational Accidents (ARL in Spanish); the model developed by Frank E. Bird was used to determine the causes of these accidents. A total of 117 accidents were analyzed, detecting 195 failures of control, 136 personal factors, 112 work related factors, 151 unsafe acts and 54 unsafe conditions; some accidents had more than one cause. In this manner, the authors conclude that the largest percentage of occupational accidents were caused by lack of control, followed by unsafe acts. Therefore, the use of programs of risk management priorities is recommended, based on the proper identification of hazards, allowing the mitigation and control of risk; likewise developing a culture of self-care in workers is recommended.*

*Keywords: Occupational accident, basic causes, immediate causes, lack of control, personal factors*

### Resumen

Las labores que se realizan en los proyectos de construcción son consideradas de alto riesgo al facilitar la ocurrencia de accidentes laborales que afectan la integridad física, mental y social de los colaboradores como la productividad de las empresas. Por tal motivo, el propósito de este artículo es analizar las causas y consecuencias de los accidentes laborales ocurridos durante el segundo semestre del año 2012 en dos proyectos de construcción de Neiva, Colombia. El alcance fue de tipo documental considerando como fuente de información los soportes de los accidentes laborales reportados ante la Administradora de Riesgo Laborales (ARL); para determinar las causas que dieron origen a dichos accidentes se utilizó el modelo de Frank E. Bird. Se analizaron 117 accidentes en los que se identificaron 195 faltas de control, 136 factores personales, 112 factores del trabajo, 151 actos inseguros y 54 condiciones inseguras; lo anterior teniendo en cuenta que en algunos accidentes se presentaron más de una causa. De esta manera se concluye que el mayor porcentaje de accidentes de trabajo, ha sido generado por faltas de control seguidos por actos inseguros. Por tal motivo se recomienda la realización de programas de gestión de riesgos prioritarios, basados en una adecuada identificación de peligros, que permitan mitigar y controlar los riesgos, desarrollando a la vez en los trabajadores una cultura de autocuidado.

**Palabras clave:** Accidente laboral, causas básicas, causas inmediatas, faltas de control, factores personales

## 1. Introducción

The construction sector has a set of occupational hazards that are specific to that activity, involving elevated work, excavation work, hoisting up materials, the seasonal nature of their workplaces, and others; this means that the implementation of a management system for worker safety and health is applied differently (Armengou y Cuéllar, 2002). It is important to note that the activities done on construction sites are considered to be high risk and therefore may result in occupational accidents.

Occupational accidents can result from immediate or basic causes; the immediate causes directly produce the accident and are composed of unsafe acts (inappropriate behavior of the workers that could result in a workplace incident) and unsafe conditions (facilities, equipment, machinery and tools that are faulty and that place the workers at risk of having an accident). But to achieve an effective solution to occupational accidents, it is critical to identify and control the basic causes which result in the immediate causes; they include personal factors (incorrect work habits, incorrect use of equipment, tools or facilities; physical or mental defects, hearing deficiencies, etc.) and work factors (deficient supervision and leadership; unsuitable policies, procedures, guides or practices; unsuitable work planning or scheduling) (Chinchilla, 2002).

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According to the statistics of the Worldwide Labor Organization (Organización Internacional del Trabajo or OIT), in its report of the worldwide day for occupational safety and health, "Approximately 4% of the worldwide Gross National Product (GNP) is lost due to the costs of losses, deaths and illnesses, resulting in work absences, treatments and payments due to disability or death" (OIT, 2005).

The accidental pyramid theory developed by Bird in 1969 showed that for each serious accident there are 10 less serious accidents, 30 accidents with property damage and 600 accidents without visible damage or losses (Chinchilla, 2002). Likewise, Fornés (2011) refers to comparing the amount of incidents that do not cause personal injuries with those that do result in injuries; he also states that the implementation of a system to analyze the incidents can be a key path to prevent or control occupational accidents.

On the other hand, Páez & Mejía (2011) mention that currently in industrial health and safety it is common to use corresponding standards; however, these standards are often poorly applied, generating difficulties in project development associated with risks; if these risks aren't evaluated, they can end up affecting the regular progress of construction. The authors refer to delays in the construction project, the economic losses and overcharges as the main problems derived from the lack of risk planning in occupational safety and health. This research indicates that the safety conditions of the construction site within the Colombian context are deficient and therefore result in accidents that cause all types of injuries, disabilities and death (Páez & Mejía, 2011).

Buendía (2013) refers to the importance of identifying the causes of the accidents at the construction site, emphasizing that there must be a search for the true origin of all of the causes that set off the incident. Likewise, Véjar (2009) states that risk evaluation is a process that is focused on decisions being made about the type of preventive actions that should be taken to minimize occupational risks.

Rodríguez (2014) highlights that the construction industry is one of the highest risk occupational activities, given the high incidence of the accidents shown which result in human and material losses. Statistics are fundamental to identify the causes of the accidents, to guide possible intervention plans as well as for the effectiveness of those plans.

Mocondino & Ojeda (2012) affirm that for 2011 in Colombia, the construction sector had the highest accident rate of 22.71%, of which 11% of the accidents were severe or fatal. In Colombia during 2012, of the 532 deaths recorded in workplace accidents, 136 are from the real estate sector, 125 from the construction sector; in the sectors of transportation, storage and communications there were a total of 78 fatal victims. This reflects that 44 people died each month due to occupational accidents. These statistics are included in reports from 10 occupational risk managers (Ministerio del Trabajo, 2013).

The Federation of Colombian Insurers, in one of their publications, indicate that in 2013, every 11 and ½ hours a worker died due to an occupational accident, and that there are an average of 62 occupational accidents per hour in Colombia, or 1,487 cases per day. Therefore, they conclude that last year there were 543,079 occupational accidents in the country (Fasecolda, 2014).

This indicates the need to study the number of accidents in the construction sector, and based on that study, to generate a detailed analysis of the causes that generate those occupational accidents, allowing companies to adopt this project as a foundation to implement measures for prevention and control of accidents; Mocodino & Ojeda (2012) state that a well organized job site is generally a job site that is safe, planned, managed and controlled.

From the results of this research, it is important to value protection systems relating to occupational health and psychological services. Therefore, this article places importance on providing greater knowledge and communicating the need that construction companies' have for the implementation and tracking of a safety and health system to be effective; this includes training, incentives and simulations that represent the possible occupational risks so that they can then be prevented. They also should incorporate evaluation protocol executive functioning as part of personnel selection; this will allow them to have the right people who will be able to reduce the rate of accidents at the job sites, to improve working conditions and the welfare of collaborators, therefore to improve the productivity of construction companies.

## 2. Materials and methods

### 2.1 Type of research:

This study was done with a quantitative-descriptive perspective, integrating Bird's model of causation (Chinchilla, 2002). It includes five variables that indicate the origin of the reasons that resulted in the accident, it describes the accident, as well as the consequences to the individual, property and the work environment: lack of control, basic causes, immediate causes, accidents and losses.

### 2.2 Population or unit of analysis:

The scope of this research was documentary; the source of information and the unit of analysis of the research were the reports of occupational accidents occurred during the second semester of 2012, as registered with the ARL. This provided the following information: date of the accident, description of the accident, name of the person involved in the accident, position, part of the body that was affected, type of injury, agent causing the accident, mechanism or type of accident.

### 2.3 Process:

This research includes a documentary review. To conduct the analysis of the causes of the occupational accidents that occurred in the two construction projects during the second semester of 2012, the units of study were the Unique Forms for Occupational Accidents (FURAT in Spanish) (Ministry of Social Protection 2005) that were issued by the occupational risk insurer ARL. In this case, interviews with witnesses and injured individuals were not conducted, nor was a study completed at the site of the accident, of the tools and equipment involved, since the research was conducted after the event had occurred. To better understand the phenomenon of occupational accidents, we should take into account the accident loss causation model developed by



Frank E. Bird (Chinchilla 2002) which allows the detection of the origin of the accidents.

### 2.4 Instruments:

For the development of this research, the following instruments were used: Unique Forms to Report Occupational Accidents (FURAT in Spanish) (Ministry of Social Protection, 2005) reported to the Occupational Risk Insurer during the second semester of 2012, and the analysis matrix of the causes of occupational accidents. It also included the documentation used by ARL, which is composed of two methods: the International Loss Control Institute (ILCI) (Positiva, 2009) which used the for the analysis of losses and the causes of the accidents and work incidents, and the Normative American Method to code the direct causes and analytical categories.

## 3. Results

The report included 117 accident cases; 116 of those were presented by men and 1 case involved a woman (Table 1). It is important to note that civil construction projects are generally done by men.

As seen in Table 2, occupational accidents occurred at a similar rate in the two construction projects, indicating the presence of the same risk factors which contribute to the number of accidents.

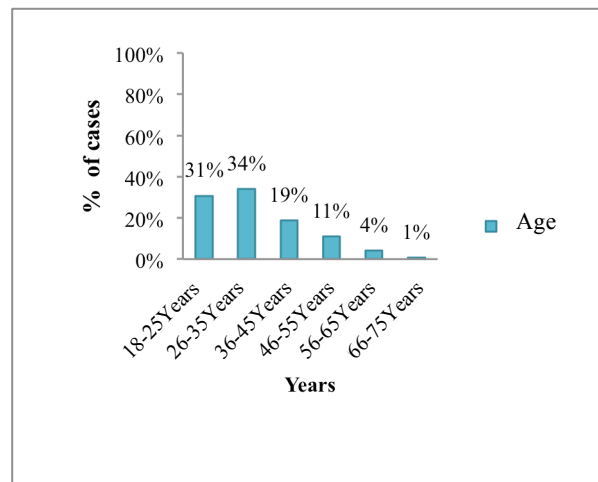
The age range where most occupational cases are seen is in the group of 18 to 35 years, which represents 65% of the population (Figure 1); this data identifies that accident cases are more frequently present in the younger population.

**Table 1.** Gender of the people from the two civil construction projects

CONSTRUCTION PROJECTS	MALE	FEMALE	Total
Construction 1	62	1	63
Construction 2	54	0	54
<b>Total</b>	<b>116</b>	<b>1</b>	<b>117</b>

**Table 2.** Number of occupational accidents by construction project

CONSTRUCTION PROJECTS	NUMBER OF CASES	%
Construction 1	63	54
Construction 2	54	46
<b>Total</b>	<b>117</b>	<b>100</b>



**Figure 1.** Accident cases by age range  
**Source:** the authors

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The data frequency indicates that hands and eyes are the parts of the body that are most affected (Table 3) since they are the parts that are most exposed during construction activities.

The most frequent type of lesion in the occupational accidents was blow, contusion or crushing, identified in 43% of the accidents in the study (Table 4); these types of lesions cause health problems for workers.

**Table 3.** Number of occupational accidents according to the part of the body that is affected

PART OF THE BODY AFFECTED	NUMBER OF CASES	%
Hands	23*	20
Eyes	21*	18
Body	18*	15
Feet	15	13
Lower limbs	12	10
Higher limbs	8	7
Head	7	6
General Injuries	7	6
Multiple Locations	3	2
Abdomen	1	1
Thorax	1	1
Head-Body	1	1
<b>Total</b>	<b>117</b>	<b>100</b>

**Table 4.** Type of injury caused by the recorded accidents

TYPE OF INJURY	NUMBER OF CASES	%
Blow, contusion or crushing	50	43
Superficial Trauma	23	19
Sprain, twist or tear	21	18
Wound	17	14
Other	2	2
Effect of electricity	1	1
Poisoning	1	1
Fracture	1	1
Injury - blow, contusion	1	1
<b>Total</b>	<b>117</b>	<b>100</b>

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According to Table 5, there were 75 cases of accidents reported which were due to the erroneous use of materials or substances.

As seen in Table 6, the most frequent causal mechanisms were falling objects, followed by being stepped on, crashes and blows.

**Table 5.** Agents causing the accidents studied

AGENT IN THE ACCIDENT	NUMBER OF CASES	%
Materials or substances	75	64
Tools used or utensils	19	16
Machinery and/or equipment	9	8
Other non-classified agents	7	6
Work environment	6	5
Device	1	1
<b>Total</b>	<b>117</b>	<b>100</b>

**Table 6.** Causal mechanisms of the accidents studied

ACCIDENT MECHANISM	NUMBER OF CASES	%
Objects dropped	34	29
Being stepped on, crashes or blows	28	24
Excessive force or exertion	18	15
Exposure or contact with harmful substances	12	10
Person falling	7	6
Foreign body in the eye	5	4
Presence of air particles	5	4
Being trapped	3	3
Cuts	3	3
Exposure to or contact with electricity	1	1
Puncture	1	1
<b>Total</b>	<b>117</b>	<b>100</b>

**Table 7.** Lack of controls that caused the accidents studied

LACK OF CONTROL	NUMBER OF CASES
Analysis and work processes	58*
Planned work inspections	50*
Worker training	42
Planned inspections	16
Personal protection equipment	15
Group communications	6
Health services and controls	4
Engineering controls	2
Security outside of work	1
System of program evaluation	1
<b>Total</b>	<b>195</b>

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Table 7 indicates that the largest percentage of lack of control is in the analysis and work processes, with 58 cases of the 117 accidents studied.

Of the basic causes and personal factors most frequently cited in the 117 cases studied, 70 indicated that workers' lack of judgement was the cause of occupational accidents (Table 8). Workers don't have an adequate work

speed while they work, and they are not aware of the risks that they are exposed to in each activity.

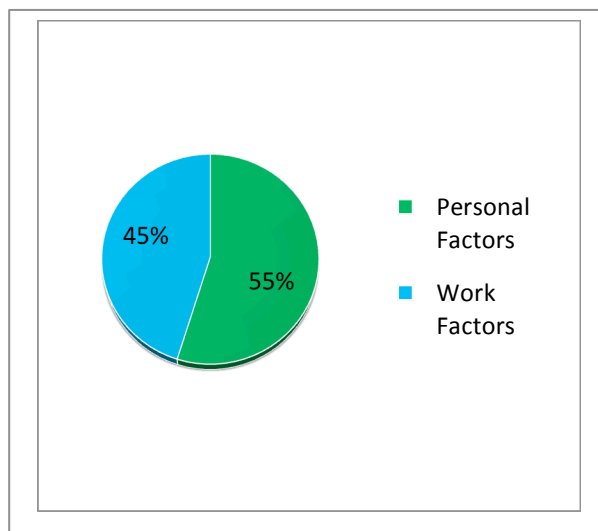
The basic causes-work factors that most frequently are involved in the occupational accidents studied were Programming or Planning, and Insufficient Instructions/Orientation/Training, representing 35 and 23 cases respectively of the total of 117 accident cases studied (Table 9).

**Table 8.** Basic causes-Personal Factors influencing the accidents studied

BASIC CAUSES – PERSONAL FACTORS	NUMBER OF CASES
Lack of judgement	70*
Low level of coordination	13
Inadequate initial training	9
Inappropriate height, weight, size, strength, reach	6
Fatigue due to the weight or the duration of a task	6
Lack of preparation	5
Restricted movement	5
Insufficient experience	5
Lack of positive efforts for correct behaviors	4
Body movement ability	2
Lack of experience	2
Sporadic operation	2
Deficient orientation	2
Slow reaction time	1
Standard performance causes discontent	1
Fatigue due to pressure or time limitations of a mental task	1
Inability to understand	1
Allergies or Sensitivity to substances	1
<b>Total</b>	<b>136</b>

**Table 9.** Basic causes-Work factors that influence the accidents studied

BASIC CAUSES-WORK FACTORS	NUMBER OF CASES
Insufficient programming or planning of work	35*
Insufficient instruction and/or /orientation	23*
Insufficient evaluation of needs and risks	12
Insufficient identification and evaluation of exposures to loss	7
Inadquate definition of policies, procedures, practices or action steps	6
Inadequate standards or specifications	5
Inadequate storage of materials	4
Inadequate control and inspections of construction sites	2
Inadequate handling of materials	2
Inadequate maintainance of standards, following work flows, updating, control of the use of standards/processes/rules	2
Inadequate usage planning	2
Lack of attention to ergonomic/humana factors	2
Inadequate adjustments/repairs/maintainence	1
Insufficient evaluation of the apt operating conditions	1
Insufficient evaluation of the exposure to losses	1
Lack of understanding of supervisory/administrative work	1
Inadequate identification of risky items	1
Inadequate inspection of reception and acceptance	1
Inadequate inspection or control	1
Inadequate maintainence	1
Excessive prolonging of the shelf life of an element	1
Inadequate transport of materials	1
<b>Total</b>	<b>112</b>



**Figure 2.** Basic causes that impact the accidents studied  
**Source:** the authors

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The main basic causes for occupational accidents were personal factors, representing 55% of the accident cases (Figure 2).

The immediate causes-unsafe work acts most frequently mentioned in the occupational accident cases were lack of safety measures and not using personal protection equipment, representing 38 and 29 cases respectively of the 117 accidents studied (Table 10).

The immediate causes-unsecure work equipment in the occupational accidents studied were the inadequate barriers and protections, as well as inadequate or improper protection equipment, representing 15 and 13 cases respectively of the 117 accidents studied. Also we can see that various accidents identify various immediate causes-unsafe conditions.

**Table 10.** Immediate causes-unsafe acts involved in the accidents studied

IMMEDIATE CAUSES-UNSAFE ACTS	NUMBER OF CASES
Lack of safety measures	38
Not using personal protection equipment	29
Inadequate position for the task	28
Inadquate load	16
Ineffective warnings	13
Inadequate lifting	10
Use of defective equipment	6
Inadequate positioning	5
Making the safety instruments inoperable	2
Inappropriate operating or handling speed	2
Adjusting equipment while operating	1
Doing maintainance when the equipment is operating	1
<b>Total</b>	<b>151</b>

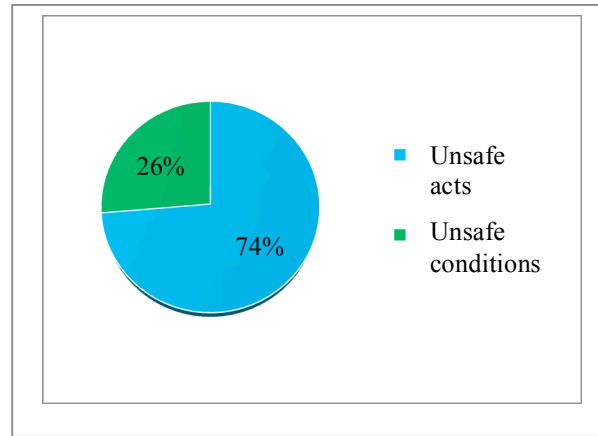
**Table 11.** Immediate causes-unsafe conditions that influence the accident cases studied

IMMEDIATE CAUSES – UNSAFE CONDITIONS	NUMBER OF CASES
Inadequate protection and barriers	15
Inadequate or improper protection	13
Inadequate warning system	13
Disorder	10
Defective tools, equipment or material	3
<b>Total</b>	<b>54</b>



In the review of the immediate causes, we found that accidents were mainly caused by unsafe acts, representing 74%, which were caused by human error, with people not following safety practices and procedures, and not being aware that they may have an accident when they conduct those activities (Figure 3).

Table 12 illustrates that the highest number of occupational accidents among workers occurs on Monday; this is possibly due to being the first day of the work week after a rest period during the weekend, since the human body takes some time to adjust to being back at work again.



**Figure 3.** Immediate causes that influence the accidents studied  
**Source:** the authors

**Table 12.** Number of accidents by day of the week

DAY OF THE WEEK	NUMBER OF CASES	%
Monday	24*	21
Tuesday	20	17
Wednesday	19	16
Thursday	23	20
Friday	21	18
Saturday	10	9
<b>TOTAL</b>	<b>117</b>	<b>100</b>

#### 4. Discussion & conclusions

According to the results from this research, we found that among the 117 occupational accidents analyzed, the hands and eyes were the most affected body parts, with a total of 23 and 21 injuries respectively. In regards to hands, this is due to the fact that they are the main part of the body involved in the entire activity, specifically in the case of manufacturing as well as construction; one of the main areas where occupational accidents were reported to the ARL is

construction at 10.46%. Likewise, the eyes were the second part of the body that are most impacted due to the presence of foreign bodies present during activities in this sector (Quintero, 2010). In reviewing the causes, the research identified 195 instances of lack of control, where the most relevant were the lack of analysis and work processes, planned work observations and worker training; 248 basic causes included 136 for personal factors, and 112 due to

work factors; there were 205 immediate causes, of which 151 were due to unsafe acts and 54 due to unsafe conditions.

Therefore we conclude that the occurrence of occupational accidents have mainly been caused by lack of controls, followed by unsafe acts; as defined by Chinchilla (2002), they are due to all types of actions or omissions done by individuals that allow these accidents to occur. The age of workers is a relevant aspect since this research and other authors (European Agency for the Occupational Safety and Health, , 2007; Madridiario.es, 2010) coincide that young workers (from 18 to 35 years) are the ones that have the most work accidents, due to the lack of experience, as well as the lack of awareness of the dangers and risks present in their positions at work. The third most important cause of the occupational accidents analyzed was due to personal factors related to workers' abilities (training, skill, aptitude, and others) (2002). The main causal mechanisms of occupational accidents were falling objects (29%) followed by being stepped on, crashes or blows (24%); similar results were found by other authors (Cruz et al., 2009).

The lack of control of these activities causes greater exposure to risk; when control measures or control barriers are not implemented, the worker is totally exposed to the risks associated with the activity. Studies conducted by Slovic et al., (1982) found that one of the attributes that was most closely related to the size of the perceived risk was fear, which is evident in activities such as not using individual protections, working in low-lit spaces, the use of faulty electrical installations and exposure to gases and vapors; the size of the risk is high together with the fear. This can be seen in daily situations where the general population is exposed, whereas the activities that were the subject of this research were specifically for workers in the construction sector, where there are greater benefits for those who are exposed.

Another attribute that is mentioned in studies done by Slovic et al., (1982) is the knowledge of those who are exposed; many studies have found that more risk is perceived in activities that are considered to be the most common activities. However in this study, the attributes known to those exposed had a high value of awareness, whereas they assigned a low value of risk to activities including exposure to noise, to dust, unkept worksites and handling of objects and tools. According to the results obtained in this study, we see that when an activity has immediate consequences, workers state that the perceived size of the risk is highest, whereas when consequences are perceived to be delayed, the importance of the damage perceived is lower. Therefore workers would be referring to a sensation of immediacy of consequences to determine the seriousness of damages, with a degree of fear or rejection for those activities that they consider to be more harmful to health and wellbeing, in line with finding from traditional studies regarding risk perception (Fischhoff, 1984).

Comparing the results of this research to the results obtained by Fontaneda et al., (2010), and Consumer (2003), Monday is identified as one of the days when more occupational accidents happen; it confirms that this has to do with the loss of daily momentum that workers have with their operations, since when they are starting work after a weekend of rest the human body takes some time to adjust to the movement at work and the dangers that this carries. In

addition, it is believed that alcohol consumption during the weekend is common for the workers in this sector (Confederate Executive Commission of UGT, 2011) and this activity means that the rest period, sleep and relaxation prior to returning to work may have been interrupted, so that this may also contribute to accidents occurring.

In this manner, it is critical to have the resources and continual planning by the agents involved in this specific study, so that construction companies can fully comply with the required activities of occupational safety and health. With the results obtained in this research, we suggest that this sector should implement a safety program; this program would have the objective of the appropriate identification, awareness, evaluation and control of the different dangers and risks that originate in the workplace so as to protect hands and eyes, which are the parts of the body that are most impacted during these activities. Likewise we suggest that workers be provided with the necessary training and information so they can perform their functions in optimal safety conditions; daily training regarding basic safety behaviors is critical for each and every worker; and finally we suggest implementing programs of appreciation and awareness of safety as an essential value, so as to contribute to reducing unsafe actions which constantly occur during work on construction projects.

Likewise, we recommend that companies create and standardize the analysis and work processes, particularly critical tasks which can be identified with an appropriate risk evaluation, which will allow them to be quantified so as to design management programs that will support their intervention and control. In addition, as is indicated in the European Agency for Occupational Safety and Health (2002), management's commitment is essential to establish clear policies regarding health and safety, and so as to supply the necessary resources for its implementation.

Planning is considered to be a fundamental step that every organization should conduct to prevent occupational accidents; all essential information should be collected in a clear and detailed document, so as to implement systematic, coherent and effective preventive actions, to confront the occupational risks inherent in the company's activities (Collado, 2008). Time and money expended in this activity are recouped by obtaining effective and quick results; it is important to clarify that it is not enough to simply put it on paper, but rather it must be implemented. For that reason, supervising the appropriate implementation of this is key. The data presented in this research shows the need to undertake the topic of safety and health in the workplace in all of its dimensions and with the participation of all of those involved in the organization (employers, occupational risk administrators, contractors, workers and educational institutions); this way they can offer a common approach with the goal of improving the quality of life for workers in this sector, reducing workplace incidents.

Finally, it is very important to continue to deepen the expertise with future research on the topic of individuals' behavior and motivation, because unsafe acts are the main causes of accidents in those construction projects; these accidents may be related to motivation since this is the force that moves a person to do something (Mualem, 2007), and it can come from an external stimulus such as the environment,



family problems, economic problems, problems coming from the mind of the worker, etc. Therefore, a psychological study of the topic would help to deepen the understanding of the basic causes related to personal factors and the immediate causes related to the unsafe acts of workers who work in the

construction sector. This sector is such an important contributor to the country's economy (Portafolio.co, 2013) but on a daily basis it presents a large amount of latent dangers and risks that can affect the physical, mental and social integrity of the collaborators.

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