



# An Injury Risk Model for Large Oil & Gas Construction Projects in Kuwait

**Maneksha Mohan M<sup>a\*</sup>, Dr. Nehal Anwar Siddiqui<sup>b</sup>**

<sup>a</sup>M.Tech HSE, University of Petroleum and Energy Studies, Dehradun, India

<sup>b</sup>Head, Dept. HSE, University of Petroleum and Energy Studies, Dehradun, India

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## ABSTRACT

Oil and Gas Industry is the backbone of Kuwait's economic and social strength, development & stability. However, Oil & Gas Exploration, Production and Pipeline transportation are involved with high-risk Construction activities. The accidents occurred or continued to occur in the Construction industry had significant impact on personnel, environment or assets. Moreover, the hazards associated with Oil and Gas sector add immense risks to the Construction activities happened around the sector.

The accidents caused during Construction activities at Oil and Gas Industry resulted in significant human loss. Human errors are the major root causes of any industrial accident. H.W. Heinrich's Law on accident causation & Frank E Bird's accident causation theory, which were accepted worldwide, describes that there are number of underlining causes for any accident to occur. Scientific analysis and interpretation of root causes of accidents reveals that human errors are the weakest link.

Technology is rapidly changing and automation is taking place for better controls, and better productivity. Many organizations are looking at changing from legislative compliance to positive proactive measures to achieve the better HSE performances at Project sites. In order to achieve these objectives, one has to focus on understanding the root causes of the accidents.

Therefore, further understanding on the accident patterns and weak links in the process of accident occurrence during Construction activities at Oil and Gas sector, evaluate the Injury Risk and relevant Injury Prevention models for mitigation of accidents could be a recognizable research in the field of Health, Safety & Environment.

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## 1. Introduction

Projects in Oil and Gas Industry are exposed to greater risks at work places. However, every accident is associated with different type of failures with different root causes. If the industry is aware of the root causes, it can act proactively to prevent human loss or damages.

Construction of many major projects in the Kuwait Oil and Gas sector involves inclusion of many world-renowned EPC companies for the project execution. To have competent workforce and deliver the projects

on time with safety, it has engaged multiple contracting companies who further engaged the contract workers from various parts of World.

Even though adequate HSE policies and procedures are in place, a number of work place injuries and property damage incidents occurred during the construction period.

While continuing excellence in the Oil and Gas related business, the whole process of construction stage is exposed to HSE risks and which

\* Corresponding author. Tel.: +965-66129588.

E-mail address: [maneksamohan@yahoo.com](mailto:maneksamohan@yahoo.com)

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may result in unwanted accidents and human loss. Therefore, a focused research on the pattern of accidents, understanding the root causes and its comparison with other accident causation models will help the industry in further preventing the accidents.

## 2. Review of Literature

### 2.1 Objectives:

The specific objectives are:

- The primary objective is to propose a model for planning and management of the prevention of occupational injuries. The model is targeted at large construction projects and aiming at reducing injuries on future projects.
- The second objective is, with reference to the proposed model, to categorize and evaluate existing injury prevention measures implemented at large construction projects in Kuwait during the last few years to demonstrate that improvements are possible.

### 2.2 Scope of the thesis:

The specific objectives are:

- This thesis will focus on large Construction Projects inside the Oil and Gas industry of Kuwait.
- Incidents and factors attributed to them in Construction Projects in Oil and Gas Sector.
- Different Project phases and Injury prevention.
- Study the work HSE management systems in promoting proactive HSE culture, competency of the personnel performing the task, risk mitigation tools, trainings and social environment factors that are contributing for accidents during Project activities.
- Safety legislation and plans should parallel industrial developments to alert a new generation to the importance of safety.

### 2.3 Challenges in HSE at Projects in Oil and Gas Industry:

The increasing complexity of construction projects creates the need for engineers and other professionals trained in all phases of the project's life cycle. Construction engineering is a discipline that attempts to meet this new challenge. An example is the CDIO (conceive, design, implement and operate) syllabus developed at Massachusetts Institute of Technology. The CDIO syllabus objective is to create rational, complete and universal goals for engineering education. A large construction project consists in general of all four project phases: conceive, design, construction and operate. Research and practice has shown that many injuries could be avoided if the occupational risks had been foreseen during conceive and design phases. This paper provides an argument for including all project phases in an injury prevention model targeted at large construction projects.

Injury prevention is a multi-disciplinary area and may involve interaction among many cognate disciplines, including safety engineering, statistics,

epidemiology, occupational medicine, ergonomics, toxicology, public health, public policy, sociology and psychology.

#### 2.3.1 Injury rates

In Kuwait, with an estimated expatriate construction labour force of 186,087 (almost 17.1% of the total expatriate work force. Out of which 62.1% Asians, 35% Arabs, and rest are others) employees, approximately 2100 work related injuries were reported during the year 2014 in the construction sector as a total. Out of this 2100, only 95 were reported from the Oil and Gas sector. The number of fatalities was 17 and more than 1900 cases with physical disability of different degrees during this period. The overall injury rate has been falling for some years, even though a real scope for improvement is there to attain complete Safety at construction workplaces in the Oil and Gas sector.

Experienced human resources were transferred to the construction sector of Kuwait during the past two decades, where attempts to improve safety and health went much further. The call for tenders contained occupational safety and health as an integral part of the construction work. Special safety and health committees were established with the client in lead and with the participation of relevant stakeholders including the various concerned parties. At the beginning of the construction period the injury rates were high, whereupon the client-led safety and health organization successfully implemented various occupational safety and health measures as detailed in the upcoming chapters. The number of accidents has been reduced to a greater extent compared to previous periods nowadays.

#### 2.3.2 Injury risk factors

Injury prevention models have developed from focusing on technical causes to focusing on dynamic interactions between man, machine, environment, organization and society. The first age of safety was concerned with the technical measures to guard machinery, prevent fire and explosions, and prevent structures from collapsing. It lasted until the 1950s. It was then realized that technical risk assessment and technical prevention measures alone could not prevent injuries from occurring. The dominance of the technical view of safety in risk analysis and prevention was broken and the study of human error and human recovery came on the agenda. The second age of safety was concerned with the interaction between man and machine: the socio-technical injury prevention concept. The 1980's was characterized by an increasing dissatisfaction with the idea that health and safety could be captured simply by matching the individual to technology. This led to the third age of safety, concerned with the interaction between man, machine, environment, organization and society, and where management systems are the focus point of injury prevention methods and involvement of the employees has become a key issue together with norms and values of the society. The safety management methods started in high risk enterprises, that is, nuclear power plants and the aviation industry, but have spread to other industries, including the construction industry. This concept is a holistically approach to injury prevention, where the enterprises are viewed as social and cultural systems.

Injury risk is a combination of likelihood and consequence, and injury prevention measures may have an effect on both parameters: Injury risk + injury prevention measure=>Reduced injury risk, i.e. reduced likelihood and/or reduced consequences.

#### **2.4 An Injury Prevention Model for Large Construction Projects:**

Recent researches have shown that a large percentage of construction injuries could have been eliminated or the risk reduced by making better choices in the design phase of a project. The research concerning the key role of design professionals in construction safety provides an argument for including conceive and design phases in an injury prevention model targeted at large construction projects. The operation phase is also included in the injury prevention model. Some of the safety measures, used for protection of the workers during the construction phase, are re-used during the operation phase for protection of the users of the traffic link, for example, barriers systems and surveillance systems. By preparing the interim solutions for the operation phase the most cost effective solutions may be obtained. The second reason for including the operation phase in the model is the obligation of the client and the design team to design and built the structures such that safe work environment conditions can be obtained for the maintenance and repair workers during the operation phase.

The injury prevention model targeted at large construction projects is obtained by combining the engineering CDIO-phase model (conceive, design, implement or construction, operate) with the socio-cultural approach to injury prevention. Secondary (through quick and effective medical care in order to reduce the initial effects) and tertiary (includes various return to work schemes) injury prevention has been included in the model. The model may be applied in countries with a modern approach to occupational safety.

The strength of the proposed injury prevention model is that it relates to the mechanism behind the specific injury prevention measure, and provides an overview of the types of injury prevention measures already implemented, and in which project phase they apply. The model thus provides the opportunity to carry out the recommended orchestrating of injury prevention measures.

The contracting methods in construction, which implies that only the client takes part in all four project phases, and the new proactive role of the client provide an argument for letting the client be responsible for establishing the proposed injury prevention model, hereby creating a total overview of injury prevention measures to be implemented during all the project phases of a large construction project. Implementation of the proposed injury prevention model may be voluntary or statutory.

##### **2.4.1 The project phases and injury prevention**

Construction engineering is a phased process. A large construction project consists in general of four project phases: conceive, design, implement (construction) and operate – CDIO. These main phases may be divided into sub-phases. In the conceive phase the owner produces a list of requirements for a project, giving an overall view of the project's goals.

Owners of these large projects are usually government agencies, under the relevant ministry. Construction procurement describes the merging of activities undertaken by the owner (client) to obtain a building or a construction. There are many different methods of construction procurement; however, the three most common types of procurement are traditional design-bid-build, design and build, and management contracting.

##### **2.4.2 Contracting methods**

All three contracting methods (design-bid-build, design and build, and management contracting) have been used at the Construction projects in Oil and Gas Industry depending on the project specific requirement. In all three methods only the owner/client takes part in all four project phases. The contracting methods provide an argument for letting the client be responsible for establishing an overview of injury prevention measures to be implemented during all the project phases of a large construction project.

##### **2.4.3 The designers' role in construction site safety**

The safety and health obligations of the designer are not to prescribe a substance or material that could be dangerous; point out the specific risks and other special circumstances involved with the specific project; indicate if there are specific conditions of the surroundings of the construction site, which may pose a particular risk to the workers; indicate how individual work or work processes must be organized in relation to each other. Furthermore, the design team should, as part of project material, provide a description of the characteristics of the construction to the extent they are relevant to safety and health during maintenance or repair of the structures. The description should include a list of the specific conditions to be observed in relation to safety and health of such future work.

##### **2.4.4 The contractors' role in construction site safety**

Safety during the construction phase is primarily the responsibility of the client and contractors. The safety of workers is often compromised by competing forces such as interrelationships between trades, the position and power of the trade, the nature of the work and economic and time pressures to complete a job. These provide challenges for the main contractor in maintaining an integrated and consistent level of safety for workers of both the main contractor and subcontractors.

##### **2.4.5 Clients' role in construction site safety**

The client has to oblige with four main obligations which according to various legislations (with subsequent amendments on duties of the client): coordinate the safety work at the site; define the limits of each contractor's safety work in site areas with more than one contractor; prepare a plan concerning safety and health at the site; notify the working environment authority about the site. These four obligations apply for all contracting methods. It is not possible for the client to delegate these obligations to the consultancy or the contractor. Thus, the client has a decisive role in construction site safety. The new proactive role of the client in construction site safety provides an argument for letting the client be responsible for establishing an overview of injury prevention measures to

be implemented during all the project phases of a large construction project.

#### **2.4.6 Operation Phase Safety**

The operation phase is also included in the injury prevention model. This is due to the fact that some of the safety measures, used for protection of the workers during the construction phase, are used during the operation phase for protection of the users of the traffic link, for example, barriers systems and surveillance system). By preparing the interim solutions for the operation phase the most cost effective solutions may be obtained.

The second reason for including the operation phase in the model is the obligation of the client and the design team to design and built the structures such that safe work environment conditions can be obtained for the maintenance and repair workers during the operation phase.

#### **2.5 Injury Preventive Measures for Large Construction Projects:**

In 1996 the European Agency for Safety and Health at Work was founded and member states of the European Union have all transposed into their national legislation a series of directives that establish minimum standards on occupational safety and health (the European Agency for Safety and Health at Work's homepage). These directives follow a similar structure requiring the employer to assess the workplace risks and put in place preventive measures based on a hierarchy of control. This hierarchy starts with elimination of the hazard and ends with personal protective equipment. In the European Union, member states have enforcing authorities to ensure that the basic legal requirements relating to occupational safety and health are met. The organization of the large construction projects in Denmark (international joint ventures) and the common EU guidelines for occupational safety suggests that the following conclusions also apply to large construction projects in other EU countries.

The majority of the injury prevention measures were implemented during the construction phase. The Oresund Link safety campaign was primarily based on the KAP-model (Spangenberg, 2002). The effect of the campaign was a 25 per cent reduction of injuries. This effect became only just statistically significant when heterogeneity of type of work before and after the campaign was taken into account. The modest effect of the safety campaign indicates that safety campaigns only result in limited behaviour change unless combined with an effective behavioural safety intervention. Safety bonuses were used to promote safe behaviour. Incentives like safety bonus and safety awards alter the exchange relationship between employer and employees, and increase task performance. However, there is a risk that money as incentive may lead to underreporting of injuries.

The safety walk-rounds aimed at reducing injuries by making the physical conditions at the site safer. Feedback concerning safety performance was used as incentive to change behaviour. Effect evaluations of walk-rounds indicate that safety walk-rounds both predict and prevent injuries. The average time period to the next injury is substantially increased after a safety walk-round. Safety audits aimed at increasing safety and reducing injuries by checking for compliance between safety practices of the

employees and the safety management system. Feedback concerning non-compliance was used as incentive to change behaviour.

The contractor must protect the employees inside the work zone. Protection involves primarily the use of physical safety measures like barriers and surveillance systems). It is argued that while barriers are necessary, they basically represent a reactive approach which is insufficient by itself to guarantee safety. Furthermore, the barrier systems are typically very expensive.

The onsite medical facilities are examples of secondary injury prevention. The primary objective of the medical facilities was to provide immediate medical assistance and good health care to workers subjected to injury incidents at work, in order to reduce the consequences of the injuries. The secondary objective was to reduce the amount of lost working time. There is a need for on-site medical facilities, particularly at remote construction sites, for which it is essential that the medical personnel have both the qualifications and authorization to effectively treat site-specific workplace injuries in order to obtain high on-site treatment rates.

Only a few injury prevention measures have been implemented during conceive and design phases so far. Most of these measures also covered the construction phase. In the Pioneer-client campaign it is realized that the client plays a crucial role in the work environment at the centre of the construction projects from idea to finished structure.

Injury prevention has increasingly become a topic of interest for stakeholders. The clients on the most recent large construction projects established safety committees with the participation of relevant stakeholders). This development may be seen as part of the more comprehensive development in corporate social responsibility (CSR), where enterprises are expected to take responsibility for the prevention and resolution of social problems.

The studies carried out by the relevant ministries of Kuwait shows that injury rates at the large construction projects have decreased significantly during the last 20 years. Behind the improvements had been concerted efforts among the different stakeholders. Major public or semi-public clients, The Kuwait Environment Protection Agency, Labor inspection authorities, the occupational health services, consultancies, contractors worked together to reduce injuries during construction work. Several injury prevention measures were introduced at the projects and the preventive lessons of these measures have been evaluated in this study. The evaluations show that further reduction of injury rates is possible.

The character (international joint ventures) of the large construction projects in Kuwait and common guidelines for occupational safety suggests that the conclusions and recommendations also apply to large construction projects in other countries.

#### **2.6 Importance of HSEMS:**

Use of the HSEMS throughout the Company will assure that the HSE policy and principles are applied consistently to all operations. The

HSEMS is a management tool to achieve the Company's commitment to conduct its business in a way that protects the health and safety of its employees, contractors and the public and is environmentally responsible.

The HSEMS will ensure that all business units conduct business in accordance with the HSE Policy. For the Management System to be successful, employees should have an appropriate understanding of the process and their accompanying responsibilities within it. Managers are responsible for establishing programs and procedures to meet these principles and expectations.

### 2.7 HSE Plan Development:

The Contracting Plan has identified the HSE Plan as an important reference document that should be developed, reviewed and updated as necessary. It should start at the tender and award stage of the contract and continue through to the final evaluation and close out. After award audits or reviews may be conducted against the HSE plan.

The HSE Plan should define what should be in place during the various phases of the contract and the steps required to be taken, by whom and by when in order to meet client and contractor requirements.

## 3. Material and Methods

The number of personnel working (including contract employees) in Oil and Gas sector industry under Kuwait Petroleum Corporation (KPC Companies like KOC, KNPC, etc.) is already thousands in number. Moreover, the government of Kuwait has already commenced the initial preparation works of two major mega projects, which may call for the mobilization of double the current work force related to construction projects inside Kuwait Oil and Gas sector. It indicates the growth in business and the engagement of workforce, which is directly related to the risk of work place injuries.

KPC companies are having the best Health, Safety and Environmental practices since long term. While continuing its best efforts in achieving Health Safety and Environmental excellence, there is a scope to review and understand the gaps in system due to which accidents are occurring during Project activities in the Oil and Gas industry.

The paper first discussed the need for enhanced efforts on injury prevention at large construction projects. Second, an injury prevention model that describes the mechanisms behind the prevention measures and takes into account the phased process of construction projects is proposed. The model may be applied not only in the Kuwait construction industry, but also in any country with a modern approach to Occupational Safety and Health. The proposed injury prevention model is used to evaluate the effect of the existing injury prevention measures. The effect of safety measures implemented during the last few years at large construction projects in Kuwait are evaluated and discussed in relation to the proposed injury prevention model.

This study is primarily based on quantitative methods from safety engineering, statistics and epidemiology in combination with socio-cultural methods from the third age of safety involving both personal (attitude and behaviour) and contextual (physical and organizational environment, social norms and culture) injury prevention factors.

### 3.1 Source of Data

The source of the data is from:

- Primarily data collected from HSE departments of various companies.
- Data and information collected from various EPC Contractors.
- Survey carried out by Kuwait University.
- Journals analysing the Project site incidents.
- Arab Times Articles.

## 4. Recommendations and Conclusions

The recommendations of the study may be seen as input to the occupational injury prevention strategy for future large Construction projects, especially in the Oil and Gas sector.

Based partly on the contracting methods in construction, it is recommended to let the client be responsible for establishing the proposed injury prevention model, and hereby create an overview of injury prevention measures to be implemented during all the project phases of a large construction project.

It is recommended to supplement personal and structural injury prevention measures with measures influencing social norms and safety culture, and to increase the orchestration of injury prevention measures on future projects.

Many injury incidents originate from the design phase. It is recommended that future safety research and practice focuses more on injury prevention measures for the design phase. It is recommended that safety and health be seen in a broader perspective in future large construction projects.

Workers' participation in safety programs should be a job requirement, especially since they are the ones who are exposed to the danger of daily job hazards. Training should be provided especially for the new workers, and PPE should be provided to all workers at site. More safety coordination among subcontractors is also needed, especially for large projects. Safety planning should be practiced from the early stages of project scheduling and planning and should be reviewed regularly as construction work progresses. Management should require the work force to act safely and in accordance with hazard-prevention methods.

Safety could be better managed by a centralized safety centre that acts as a liaison between the different safety departments in the State of Kuwait. The main purposes of such a proposed centre are to develop and establish unified safety standards; create a construction accident data bank; provide training, technical safety consultation, and inspections; and to require the

implementation of the lasted methods of accident prevention at construction sites.

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## 5. Abbreviations

HSE	: Health, Safety and Environment
HSEMS	: Health, Safety and Environment Management System
KPC	: Kuwait Petroleum Corporation.
KNPC	: Kuwait National Petroleum Company.
KOC	: Kuwait Oil Company.
BBS	: Behavior Based safety
SOC	: Safety Observation & Conversation
OSHA	: Occupational Safety and Health Administration.
EU	: European Union.
EPC	: Engineering, Procurement, and Construction.
PPE	: Personnel Protective Equipment.
KAP	: Knowledge, Attitude, and Practice.
CSR	: Corporate Social Responsibility.

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