ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

HEALTH AND SAFETY COST EVALUATION IN CONSTRUCTION PROJECTS CASE STUDY: OMAN DMIA PROJECT

M.Sc. THESIS

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

İNŞAAT PROJELERİNDE İŞÇİ SAĞLIĞI VE İŞ GÜVENLİĞİ MALİYET İNCELEMESİ
ÖRNEK OLAY: UMMAN ULUSLARARASI HAVALİMANI PROJESİ

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FOREWORD

A significant number of fatal, major or minor injuries are happening due to occupational accidents all over the world. Health of workforce is quite important to maintain social, economical and moral development. The purpose of health and safety is to identfy the hazards in advance and provide a safe workplace for the workforce in order to maintain a physical and physocological healthy environment.

Although the attention on occupational health and safety is growing up among public and private companies, accident prevention investments are still low due to their unnecessarily seen own costs.

This study as a postgraduate thesis concentrates on the classification of accident prevention costs and identify the ratio within the total construction cost in an international airport construction project. Literature and actual data are used for classifications and calculations for each section of health and safety implementation.

I would like to thank my supervisor Assoc. Prof. Dr. Gürkan Emre GÜRCANLI for his great support and guidance during my study.

I would like to thank Mr. Emre GÜR and Mr. Kenan BİRDİR for their great contribution on providing data and documents for this postgraduate study.

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ABBREVIATIONS

DMIA	**:** Development of Muscat International Airport
H&S	**:** Health and Safety
HSE	**:** Health, Safety and Environment
PPE	**:** Personel Protective Equipment
NDA	**:** Northern Development Area of Case Project
PMV	**:** Plant Machinery Vehicle
MC-1	**:** Main Contract-1
MC-2	**:** Main Contract-2
MC-3	**:** Main Contract-3
MC-4	**:** Main Contract-4
MC-5	**:** Main Contract-5
İSİG	**:** İşçi Sağlığı ve İş Güvenliği
CAGR	**:** Compound Annual Growth Rate
ILO	**:** International Labor Organization
WHO	**:** World Health Organization
GDP	**:** Gross Domestic Product
OHS	**:** Occupational Health and Safety

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HEALTH AND SAFETY COST EVALUATION IN CONSTRUCTION PROJECTS. CASE STUDY: OMAN DMIA PROJECT

SUMMARY

Construction industry is booming with new investments all over the world in the recent years. Governments provide financial resources and support using new technology in order to build iconic structures, urban regenerations and huge infrastructure developments. Gulf countries are probably leading the construction industry in total amount of investments among others.

Construction is one of the leading industries in the number of occupational accidents. Health and safety in construction projects is a growing matter due to nature of the industry. Recently, governments and contractors pay more attention to minimize fatal, major or minor accidents. Local rules, consultants and related organizations enforce contractors to make more investment on accident preventions.

Accident prevention is a culture of zero accident targets. In-house trainings, hazards analysis, continuous inspections, audits and all site preventions are basic steps for health and safety implementation throughout the project lifecycle.

Many academic studies reveal that investments on health and safety save money against accident caused costs. Researchers found cost of health and safety implementation is always for the benefit of the company.

This study is composition of an overview on construction health, safety, details of risk assessments, applied HSE Plan, procedures, accident prevention methods and health, and safety implementation costs with applied cost management procedures.

Focus is to find out the actual cost of health and safety program and its share within total construction budget in an international airport construction project. In the last chapter, health and safety cost is divided into direct and indirect costs. Direct costs and indirect costs of health and safety system are evaluated under health and safety budget but there are some other safety purposed construction activities which are evaluated under construction costs. These divisions and examples are clearly expanded in the last chapter.

The values of actual costs mentioned in the last chapter are differentiated by a certain ratio due to company privacy. Therefore, none of the amounts represents any specific currency.

As a result, the share of health and safety program within total construction cost is found 1.44%.

Assoc. Prof. Dr. Gürkan Emre Gürcanlı and his student Nesimi Teoman Korkutan committed another postgraduate thesis in 2010 to find out the share of health and safety expenses in total budget in 30 different multi-storey buildings. That study reached 3.7% of total cost is composed of health and safety implementation by involving external health and safety trainings and consultancy costs. Since those are building projects, quantity of labor intensive works are high and health and safety control measures are much costly.

Construction Site Safety Manual in Hong Kong demands that 2% of the contract sum/ total estimated expenditure may be considered for Site Safety Payments. This value does not include any contingency sum or any sum for the payment of fluctuations. In lower value contracts this is likely to be inevitable. In very high value contracts or very simple ones, something less than 2% may be appropriate. This %2 guidance is based on advice from construction industry and is supported by a study carried out by Hong Kong Polytechnic University.

Comparing the result in this study with these reports mentioned above, the ratio of Health and Safety implementation seems quite logical in an earthworks intensive project.

İNŞAAT PROJELERİNDE İŞÇİ SAĞLIĞI VE İŞ GÜVENLİĞİ MALİYET İNCELEMESİ: UMMAN MUSCAT HAVALİMANI PROJESİ

ÖZET

Son yıllardaki yeni yatırımlarla birlikte tüm dünyada inşaat sektöründe büyük bir patlama yaşanmaktadır.İkonik yapıların inşa edilmesi, kentsel dönüşümler ve büyük altyapı projelerinin gerçekleştirilmesi hükümetler finansal kaynaklar sağlamakta ve son teknoloji kullanımı desteklemektedir. Körfez ülkeleri bu açıdan toplam yatırım tutarından başı çekmektedir.

İnşaat sektörü iş kazaları açısından en önde gelen sektörlerden biri olması nedeniyle son dönemde İşçi Sağlığı ve İş Güvenliği konusu daha fazla önem kazanmaktadır. Küçük, büyük ve ölümcül kazaları en aza indirmek için hükümetler ve müteahhit firmalar bu konuya daha fazla ilgi göstermektedirler. Yerel kanunlar, kontrolör firmalar ve ilgili kuruluşlar müteahhit firmaları İşçi Sağlığı ve İş Güvenliği konusunda daha fazla yatırım yapmaları için zorlamaktadır.

Kaza önlemleri konusu temelde sıfır kaza hedefi kültürüne dayanmaktadır. Şirket içi eğitimler, risk değerlendirmeleri, devamlı incelemeler ve alınan kaza önlemleri bu hedefin temel aşamalarıdır.

Birçok akademik çalışma İşçi Salığı ve İş Güvenliği üzerine yapılan yatırımların muhtemel kaza maliyetlerine çok daha tasarruflu olduğunu ortaya koymaktadır. Araştırmacılar da iş güvenliği maliyetlerinin de her zaman firma yararına olduğunu göstermişlerdir.

Bu çalışma inşaat sektöründe İşçi Sağlığı ve İş Güvenliği'ne genel bakış ile başlamaktadır. Bu bölüme temel kavramlar ile giriş yapıldıktan sonra inşaat sektöründe ve projelerinde iş güvenliği ve işçi sağlığı sisteminin yerleştirilmesinde karşılaşılan zorluklar ve ortak karşılaşılan kaza sebeplerine yer verilmektedir. İşçi Sağlığı ve İş Güvenliği sistemlerinin diğer ülkelere nazaran çok daha yerleşik olduğu Amerika Birleşik Devletleri ve İngiltere'den kaza sayıları ve sebepleri konularında istatistiki değerlere yer verilmiş ve tez konusu olan Umman'dan elverişli istatistiki değerler ile karşılaştırılmıştır. Konunun devamında işçi ve işveren sorumlukları, kazaların firmaya olan direkt ve endirekt maliyetleri ve bu konular ile ilgili Umman yerel kanunları ve düzenlemeleri gösterilmiştir.

İkinci bölümde tehlike analizi ve risk değerlendirme konusunu detaylı şekilde incelemektedir. Risk değerlendirme yönteminin temeli olan beş temel aşama literatür bilgisi ve proje uygulama esaslarıyla anlatılmaktadır. Risk derecelendirmenin bağlı olduğu risk olasılık ve risk şiddeti değerlerini etkileyen faktörler anlatılmakta olup sonradan risk matrisinin nasıl oluştuğu gösterilmiştir.

Üçüncü bölümde projede uygulanan İşçi Sağlığı ve İş Güvenliği planı ve prosedürlerinden bahsedilmekte devamında ise projede uygulanan İşçi Sağlığı ve İş Güveliği sistemlerine yer verilmektedir. İş izinleri sistemleri ve örnekleri, iç-dış tetkik ve inceleme sistemi, kaza inceleme ve raporlama esasları ile kişisel koruyucu ekipman kullanım esasları belirtilmektedir.

Dördüncü bölüm, proje genelindeki kaza koruma önlemlerinin literatür bilgileri ve uygulamadaki detayları ile başlamaktadır. Kaza koruma önlemlerinin ana başlıkları olarak kazı koruma önlemleri, yüksekte çalışma önlemleri, vinçle kaldırma ve taşıma işleri için alınan önlemler, yangın tehlikesine karşı önlemler, elle taşıma işlerinde alınacak önlemler, kimyasal depolama ve kullanımında alınacak önlemler ile sıcak havada alınan önlemlerden bahsedilmektedir.

Son bölümde proje kapsamında ana iş kalemlerine bakıp maliyet bazında bir yüzdesel dağılım ile giriş yapılmaktadır. Devamında projedeki maliyet yönetimi esaslarına yer verilmekte ve literatür bazında projede kullanılan Aktivite Esaslı Maliyet Yönetimi Metodu anlatılmaktadır. İş kalemlerinden örnek verilerek metodun uygulama şekli belirtilmiştir. Devamında ise İşçi Sağlığı ve İş Güvenliği sisteminin maliyet incelemesine geçilmektedir.

Çalışmanın odak noktası İSİG programının 2.5 yıllık bir süreç içerisindeki uygulama maliyetini bulup toplam proje maliyeti içindeki payını bulmaktır. Firma gizlilik politikası ve ihale aşamasında İSİG program maliyet tahminlerindeki bilgilerin elverişli olmaması nedeniyle toplam maliyetin bulunmasında gerçek maliyetler baz alınmıştır. Bu doğrultuda maliyet yönetim departmanından alınan bilgiler ile İSİG program maliyetleri direkt ve endirekt olmak üzere ikiye ayrılmıştır. Burada İSİG programının birebir içinde yer alan direkt ve endirekt maliyetler İSİG uygulama bütçesi içinde hesaplanırken diğer yanda iş güvenliği amaçlı inşaat aktivitelerinin maliyetleri hesaba katılmamaktadır. İnşaat kaynaklarının kullanıldığı bu aktiviteler bölüm içinde örneklerle anlatılmıştır. İSİG programının birebir direkt maliyetleri hesaplanırken eğitim çalışmaları, kişisel koruyucu ekipmanlar, toplu koruma önlemleri sırasında kullanılan malzeme ve ekipman maliyetleri hesaba katılmıştır. İşçilik maliyetleri ise işçilerin saha departmanlarından alınması nedeniyle yine inşaat işi bazlı aktivite maliyetlerinde yer aldğı için hesaba katılmamıştır. Yönetim ve uygulama çaplı süpörvizörlük maliyetleri endirek maliyetler içerisinde incelenmiştir.

Firma gizlilik politikası nedeniyle gerçek maliyet değerlerinin hepsi danışman öğretim üyesi ve tez jürisi bilgisi dahilinde belli bir oranda değiştirilmiş fakat ana oran aynı saklanmıştır. Dolayısıyla çalışmada içinde yer alan bütün sayısal maliyet değerlerinin fiktif olduğu unutulmamalıdır.

Sonuç olarak İSİG program maliyeti 2.5 yıllık süreç için 1,341.817.466 olarak hesaplanmış ve proje toplam maliyetinin % 1,44'ü olarak tespit edilmiştir.

Doç. Dr. Gürkan Emre Gürcanlı ve öğrencisi Nesimi Teoman Korkutan tarafından 2010 yılında yürütülen bir yüksek lisans tezinde 30 farklı bina projesi incelenmiştir. Harici iş güvenliği eğitimi ve danışmanlık maliyetlerinin de dahil edildiği bu çalışmada İşçi Sağlığı ve İş Güvenliği uygulamalarının toplam maliyet içerisindeki payının %3.7 olduğu sonucuna ulaşılmıştır. İncelenen projelerin bina projesi olduğu düşünülürse işçi yoğun işlerin daha fazla olması nedeniyle iş güvenliği önlemleri ve maliyetlerinin daha yüksek olması normal görülmelidir.

Hong Kong'da yapılan bir çalışma olan Construction Site Safety Manual, iş güvenliği ve işçi sağlığı uygulamaları için yapılan harcamaların toplam bütçenin %2'sine tekabül ettiğini iddia etmektedir. Düşük keşifli kontratlarda bu oran minimum olarak kabul edilirken yüksek keşifli kontratlarda oranın bir miktar düşebileceği öngörülmektedir. %2'lik bu oran inşaat sektöründen alınan tavsiyeler ve Hong Kong Politeknik Üniversitesi tarafından yapılan çalışmalara dayanmaktadır.

Sonuç bölümünde hesaplanan oran irdelenmekte ve bu oranı etkileyen faktörlerin ne olduğu belirtilmektedir. Öte yandan işçi sağlığı ve iş güvenliği amacıyla yapılan aktivitelerin ve inşaat kaynakları kullanımının yarattığı gizli maliyetin hesaplanmasında kullanılabilecek bir yöntem ile İSİG programı maliyetlerinin ihale aşamasında hesaplanmasında kullanılabilecek diğer bir yöntem ilerleme aşamalarıyla önerilmiştir.

1. INTRODUCTION

Occupational health and safety in the construction industry is a growing matter due to number of minor, major or fatal injuries in project sites all over the world. Governments, civil organizations and corporates emphasize on the issue in order to catch "Zero Accident Target" for human health and safety. Country regulations and corporate policies have more enforcement to maintain the high standard of work environments.

Hence, "Development of Muscat International Airport" is a worldwide reputed project; Omani Government always keep an eye on quality and safety concerns. Assigned bodies, inspectors and third parties have regular checks to maintain the high quality and safety standards.

Briefly, Case Project (Development of Muscat International Airport – MC1) contains construction of runways, taxiways, isolation pads and apron stands, box culverts, airfield lightning, landside road system, new service roads, interchanges, bridges and utility buildings, parking lots, power substations and chiller plant. Inherent to this, Contractor shall erect three concrete batching plants, an asphalt plant, machinery and vehicles workshop, warehouses, material lay-down areas, site offices, a carpentry workshop and a rebar fabrication workshop. A more detailed scope with facts and figures will be introduced in the fifth chapter.

Along with the wide scope of the project, so many activities with those own hazards, risks and specific control measures take place throughout the construction.

The ultimate goal of this study is to evaluate direct and indirect costs of health and safety implementation in order to find out its share within the total actual cost of an international airport construction project providing high standard of workplaces and keeping "Zero Accident Target".

In the first chapter, literature review of construction health and safety will be mentioned. Definitions, nature of construction industry, common causes of accidents, responsibilities of counterparties, worldwide statistics through fatal and non-fatal accidents, costs of accidents and preventions will be under review.

Following that, in the second chapter, hazard identifications and risk analysis will be overviewed through the related literature.

Third chapter will be about project specific HSE implementation, applied HSE Plan with procedures and management systems.

Fourth chapter will reveal project control measures and accident preventions for the most significant hazards or risks including literature.

Final chapter will be about the cost investigation of HSE implementation all over the site. Cost research will not be only based on specific task preventions, management and supervision costs will be investigated as well. This research will give a proportional idea for managers in order to identify the approximate requirement for high standard of HSE implementation within project budget.

Health and Safety costs will be classified as direct and indirect with three subtitles,

- Training Costs
    - Training Personnel
    - Training Materials
    - Training Equipment
    - Training Cost of Employee
- Material Costs
    - Personal Protective Equipment (PPE)
    - Common Materials for Whole Site
- Personnel Costs
    - Site Supervision Personnel
    - Management Costs

Training costs will identify the total cost of qualified trainers, related personnel, required equipment and shared total man-hour cost of trained labor and supervisors.

Material costs will be composed of personal protective equipments (PPE) and other common equipments for protection and prevention in the whole site.

Personnel costs are to be built up by investigating direct and indirect costs of site supervisory. Number of site supervisors and total site area comparison will point out future requirement for other projects.

Management costs will be the review of office indirect costs for top management and assistants.

Number of people working in the site within a specific time range will be the key factor for the calculation of direct training costs, PPE costs and indirect site supervisory, management and common used materials cost.

In the next coming stage of the study, findings will be differentiated into one person basis and compared with a possible accident cost of a person within a cost-benefit analysis

Results will contain total HSE cost observations throughout the project life cycle and cost-benefit analysis of control measures.

1.1 Definitions on Occupational Health and Safety

This section is the introduction of basic terms for understanding health and safety. World Health Organization (WHO) defines Health as "A state of complete physical, mental and social well being and not merely the absence of disease and infirmity" (p. 1). Ferret and Hughes (2007) mentioned that "Safety is the protection of people from physical injury" (p. 2). Holt (2005) states that "An accident is an incident plus its sequences, the end product of a sequence of events actions resulting in an undesired consequence (injury, property damage, interruption, delay)" (p. 3). OSHA (2009) defines that "Injury or illness is an abnormal condition or disorder. Injuries include cases such as, but not limited to, a cut, fracture, sprain or amputation. Illnesses include both acute and chronic illnesses such as, but not limited to, a skin disease, respiratory disorder or poisoning" (p. 8).

1.2 Overview of Construction Industry

The International Labor Organization (1998) classifies the construction industry as "government and private-sector firms erecting buildings for habitation or for commercial purposes and public works such as roads, bridges, tunnels, dams or airports". (Encyclopedia of Occupational Health and Safety, 1998, Chapter 93)

Construction project is a mosaic of owner, designers, employers and employees following a sequence of several successor activities at different workplaces in time ranges with the use of materials and equipments.

Industry is regarded as a dirty and hazardous environment among the community. Work conditions are hard, average qualification of people is low and financial options are usually less than others.

But the real reason why construction work is so poorly regarded has much more to do with the terms on which labour is recruited than the nature of the work itself. For many construction workers around the world the terms of employment have always been poor [6].

Construction workers include about %5-10 of workforce in industrialized countries. Throughout the world, over %90 of construction workers are male. For many countries, unskilled construction work is the entry into the paid labor force in construction or other industries [5].

For a particular project, there is frequent change in the number of workers and the composition of the labor force at any one site. This change results both from the need for different skilled trades at different phases of a work project and from the high turnover of construction workers, particularly unskilled workers. At any one time, a project may include a large proportion of inexperienced, temporary and transient workers who may not be fluent in the common language. Although construction work often must be done in teams, it is difficult to develop effective, safe teamwork under such conditions [5].

1.3 Health and Safety in Construction

Construction industry is regarded as a hazardous and high-risk environment where workers face a greater risk of work-related fatality or injury than workers in other industries.

There are commonly observed challenges to reach health and safety targets for a construction project site. Here are some examples of these obstacles,

- Various types of simultaneous interdisciplinary operations bearing own characteristics and hazards.
- Nature exposed work environment and workforce experiencing climate changes
- Pressure on workers caused by performance, financial and quality concerns.
- Multinational relations and lack of communication among the workforce.
- Lack of qualified manpower.

- Temporary workforce being shifted from one project to another

Therefore, it is usually quite difficult to set up a particular H&S culture within a specific project. People having continuous trainings within different projects usually gain the awareness of health and safety.

1.3.1 Literature review on causes of accidents

1.3.1.1 Worker and work-team factors

The explanations from the accident study interviews and focus groups for construction workers engaging in unsafe acts were three-fold;

- Safety being overlooked in the context of heavy workloads and other priorities
- Taking shortcuts to save effort and time
- Inaccurate perception of risk with feelings of invulnerability and "it won't happen to me".

Underlying each of these are inadequate safety knowledge, pointing to deficiencies with education and training [7].

1.3.1.2 Workplace factors

The workplace factors, most notably poor housekeeping and problems with the site layout and space availability were considered to have contributed in half of the accident studies. Problems included slip and trip hazards, such as trailing cables, uneven ground or debris and muddy conditions. Other accidents involved injury from protruding hazards such as nails or scaffolding components. These were often coupled with a lack of clearly defined walkways and poor housekeeping. Site constraints, typically inadequate space or difficult access to perform a task, were identified as being involved in 15% of the accident studies [7].

1.3.1.3 Materials and equipment

Shortcomings with equipment, including personal protective equipment (PPE), were identified in over half (56%) of the incidents. Deficiencies with the suitability and condition of materials, including packaging, featured in more than a quarter (27%) of incidents. There appears to be a significant opportunity with the design of materials

and equipment to improve safety, with many of the problems relatively straightforward to overcome. However, this will need much better liaison within the supply purchase chain. The manner in which this operates at present appears to stifle developments [7].

1.3.1.4 Construction design and processes

Elimination or reduction of risks through design or alternative methods of construction is highly desirable. Frequently, construction design and construction process are interlinked, with the process being dictated by the design and decisions from the design team [7].

1.3.1.5 Project management

- Subcontracting arrangements lead to problems with blurred responsibility and difficulties with communication between one and another.
- Deficiencies in project management and planning can lead to difficulties with the project schedule. These in turn result in time pressure on all involved within a project, with subsequent problems such as trade overlap, crowded workplace and reduced attention to detail [7].

1.3.1.6 Risk management

- Accidents invariably involve an inadequately controlled risk, indicative of management training.
- The findings from the accident studies and focus groups leads to the conclusion that there is a pervasive failure of the industry to engage in effective risk management [7].

1.3.1.7 Client and economic ınfluences

- The economic climate in which construction activity takes place affects competition for projects, pricing, availability of labor and so forth. All of these are likely to impinge on safety [7].

1.3.1.8 Safety education and training

- A need exists across the industry, encompassing designers and suppliers, as well as site-based personnel, to raise awareness and understanding of the generic safety risks that are commonplace in construction [7].

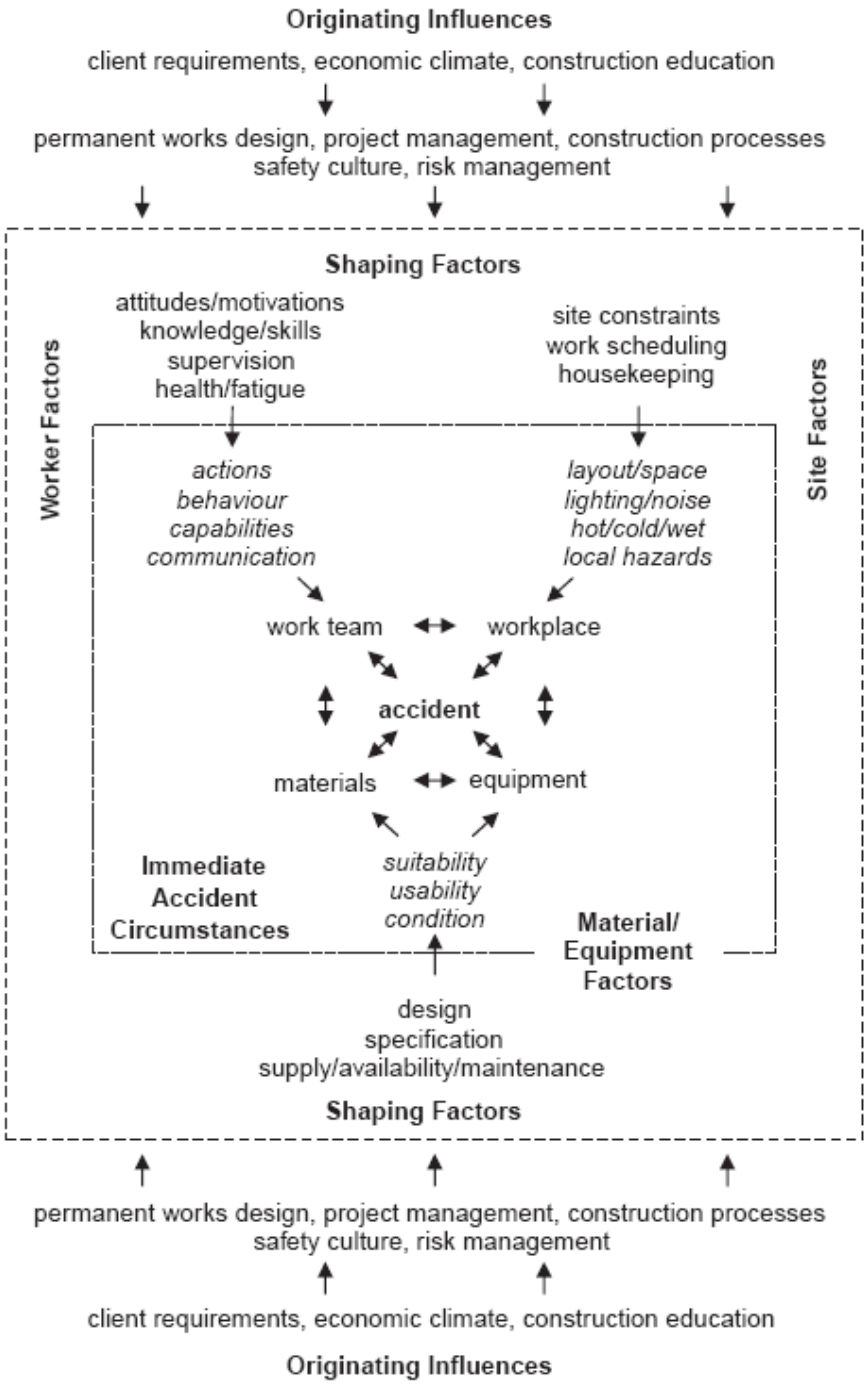

Figure 1.1: Hierarchy of causal influences in construction accidents [7].

1.4 Statistics in Construction Industry and Occupational Health and Safety

Many statistical researches take place regarding occupational injuries, illnesses or fatal accidents in countries. Here some figures will be given from United States, United Kingdom and Oman.

The ILO estimates that each year about 2.3 million men and women die from work-related accidents and diseases including close to 360.000 fatal accidents and estimated 1.95 million fatal work related diseases.

In economic terms it is estimated that roughly 4% of the annual global Gross Domestic Product, or US$ 1.25 trillion, is siphoned off by direct or indirect costs of occupational accidents and diseases such as lost working time, workers' compensation, the interruption of production and medical expenses.

Data from a number of industrialized countries show that construction workers are three or four times more likely than other workers to die from accidents at work [8].

This section is a statistical overview of with charts on construction employment, trends of major and fatal injuries and identification of most common causes of construction accidents. Emphasized countries will be United States, United Kingdom and Oman. These selected countries are well known about employment procedures and statistical records.

1.4.1 United states

Table 1.1: Fatal Occupational Injuries by US Construction Industry, 2003 – 2010.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
TOTAL	1171	1278	1243	1297	1239	1016	879	780
AGE								
16 to 17	5	5	7	5	9	7	-	-
18 to 19	28	24	33	31	29	12	14	(P) 11
20 to 24	132	116	114	118	109	80	57	(P) 46
25 to 34	259	266	254	285	256	204	175	(P) 143
35 to 44	315	328	285	298	278	233	186	(P) 159
45 to 54	237	304	308	301	331	272	245	(P) 230
55 to 64	136	165	174	187	162	153	142	(P) 135
65 +	58	67	68	69	63	54	59	(P) 53

EVENT or EXPOSURE								
Contact with objects and equipment	235	272	249	224	215	209	156	(P) 139
Falls	365	448	396	436	450	337	287	(P) 264
Exposure to harmful substances or environments	182	172	168	193	182	134	133	(P) 126
Transportation incidents	322	319	353	367	318	267	246	(P) 194
Fires and explosions	29	34	41	31	25	26	14	(P) 27
Assaults and violent acts	37	33	35	42	41	42	42	(P) 28
Other or not reported	-	-	-	4	8	-	-	-
WORKER ACTIVITY								
Vehicular and transportation operations	292	308	333	353	305	251	234	(P) 190
Using or operating tools machinery	83	87	104	80	80	96	59	(P) 66
Constructing repairing cleaning	608	675	590	672	668	510	436	(P) 401
Protective service activities	-	-	5	5	3	6	-	-
Materials handling operations	60	71	74	72	69	51	51	(P) 50
Physical activities	86	96	95	71	74	71	57	(P) 42
Other activities	19	10	16	25	12	14	14	(P) 11
Not reported	22	30	26	19	28	17	26	(P) 18

Table 1.2: Incidence rates (1) of nonfatal occupational injuries and illnesses involving days away from work (2) by selected worker and case characteristics and industry, All U.S., private industry, 2003 - 2010

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
TOTAL	259.4	243.7	239.5	219.5	190.3	174.3	157.8	149.6
Number of days away								
Cases involving 1 day	34.1	32.8	31	27.7	26	25.6	21.3	18.9
Cases involving 2 days	26.9	24.7	25.1	24.4	21.1	19	13.4	13.9
Cases involving 3-5 days	43.2	41.6	45.2	37.8	30.5	28.7	24.9	24.2
Cases involving 6-10 days	28.9	29.8	31.3	28.4	22	18.3	17.8	15.6
Cases involving 11-20 days	27.4	28.8	27.1	25.6	21	19.6	16.5	17.1
Cases involving 21-30 days	18.7	17	16.6	16.1	11.7	11.5	10.6	9.6
Cases involving 31 or more days	80.2	69.1	63.2	59.6	58.1	51.7	53.2	50.3
Source of injury								
Chemicals chemical products	2.3	2.6	2.5	2.5	1.8	2.4	1.7	1.7

Containers	12.6	10.7	10.4	10.7	8.1	8.1	7.8	5.5
Furniture fixtures	4.4	3.1	4.3	3.4	4.1	3.4	3.8	2.9
Machinery	16.4	16.4	14.8	15.7	11.9	10.8	10	9.9
Parts and materials	56.5	52	56	50	42	40.5	35.2	30.3
Worker motion or position	30.3	32.8	31.7	28.3	22.4	23	19.5	19.5
Floor ground surfaces	54.2	50.7	48.8	40.1	41.2	33.2	30.6	32.1
Hand tools	24	23.1	20.2	19.7	16.4	15.2	11.2	12.6
Vehicles	13.5	13.1	12.8	12	10.3	9.6	9.3	9.2
Health care patient	-	-	0.0	-	-	-	-	-
All other	45.2	39.2	38	37.1	31	26.8	26.9	25
Event or exposure:								
Contact with object equipment	90.5	82.5	84.8	83.8	67.3	62.3	51.7	49.3
Fall to lower level	33.8	33.3	33.2	26.1	27.9	22.6	20.6	20.1
Fall on same level	23.4	20.2	18.8	17.5	17.7	13.3	13.8	14.3
Slips trips	7.9	7.1	7.5	6.1	5.3	5.5	4.4	5.2
Overexertion	50.7	48.5	43.5	38.2	33.1	30.9	28.6	28.7
Repetitive motion	4.5	5.2	3.8	3.8	2.3	2.2	4	3
Exposed to harmful substance	9.4	8.3	8.4	7.4	7.1	7	6.5	6.3
Transportation accidents	10	9	9.4	9.1	7.5	6.3	6.1	5.8
Fires explosions	0.5	0.8	0.6	0.8	0.5	0.6	0.4	0.4
Assault violent act	0.6	0.8	0.7	0.7	0.7	0.4	0.6	0.6
All other	28	28.1	28.8	26.1	21	23.2	21	15.8

1.4.2 United kingdom

Table 1.3: Fatal Occupational Injuries by Construction Industry,UK, 2004 – 2010

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
TOTAL	**69**	**60**	**79**	**72**	**52**	**41**	**50**
EVENT or EXPOSURE							
Contact with moving machinery			1	3	1	2	-
Struck by moving, including flying/falling, object			17	10	6	2	6
Struck by moving vehicle			5	9	4	4	8
Strike against something fixed or stationary			1	1	2	1	1
Injured while handling, lifting or carrying			5	-	1	-	1
Slips, trips or falls on same level			-	-	1	-	-
Falls from a height			24	33	27	25	13
Trapped by something collapsing/overturning			7	6	4	2	13
Drowning or asphyxiation			5	3	2	-	2
Exposure to, or contact with, a harmful substance			1	1	-	-	-
Exposure to fire			1	-	-	-	-

Exposure to an explosion	-	-	1	-	-
Contact with electricity or electrical discharge	9	3	2	2	3
Injured by an animal	-	-	-	-	-
Acts of violence	-	-	-	-	-
Other kind of accident	-	2	-	3	1
Injuries not classified by kind	3	1	1	-	2

Figure 1.2: Number and rate of fatal injuries to workers 2004/2005 to 2010/11p

Table 1.4: Major Occupational Injuries by Construction Industry,UK, 2004 – 2010

	2004	2005	2006	2007	2008	2009	2010
TOTAL	**4529**	**4500**	**4474**	**4438**	**3950**	**3145**	**2857**
EVENT or EXPOSURE							
Contact with moving machinery	-	-	210	195	171	135	125
Struck by moving, including flying/falling, object	-	-	777	713	624	491	405
Struck by moving vehicle	-	-	93	76	82	68	75
Strike against something fixed or stationary	-	-	121	128	114	68	80
Injured while handling, lifting or carrying	-	-	615	653	503	371	345
Slips, trips or falls on same level	-	-	1 189	1 209	940	789	757
Falls from a height	-	-	1 217	1 196	1 244	1 029	883
Trapped by something collapsing/overturning	-	-	684	663	686	618	515
Drowning or asphyxiation	-	-	433	425	350	253	274
Exposure to, or contact with, a harmful substance	-	-	100	108	208	158	94
Exposure to fire	-	-	33	29	31	19	20
Exposure to an explosion	-	-	1	2		3	
Contact with electricity or electrical discharge	-	-	58	67	46	42	27

Injured by an animal	-	-	10	12	15	15	6
Acts of violence	-	-	8	8	10	5	4
Other kind of accident	-	-	46	27	35	35	34
Injuries not classified by kind	-	-	4	4	6	4	3

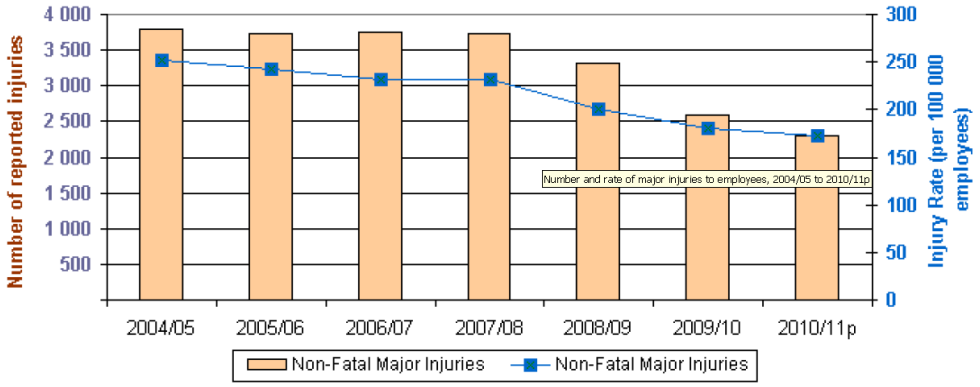

Figure 1.3: Number and rate of major injuries to workers 2004/2005 to 2010/11p

Table 1.5: Over 3-days occupational Injuries by Construction Industry,UK, 2004 – 2010

	2004	2005	2006	2007	2008	2009	2010
TOTAL			**7974**	**8243**	**7429**	**6239**	**5328**
EVENT or EXPOSURE							
Contact with moving machinery	-	-	283	299	306	231	201
Struck by moving, including flying/falling, object	-	-	1 270	1 267	1 130	979	793
Struck by moving vehicle	-	-	71	106	70	54	46
Strike against something fixed or stationary	-	-	342	301	299	231	193
Injured while handling, lifting or carrying	-	-	2 915	3 081	2 621	2 214	1 851
Slips, trips or falls on same level	-	-	1 906	1 948	1 563	1 293	1 141
Falls from a height	-	-	694	686	869	736	621
Trapped by something collapsing/overturning	-	-	468	456	576	508	465
Drowning or asphyxiation	-	-	165	162	133	115	83
Exposure to, or contact with, a harmful substance	-	-	61	68	160	113	73
Exposure to fire	-	-	28	15	25	9	8
Exposure to an explosion	-	-		1	1	1	1
Contact with electricity or electrical discharge	-	-	150	155	149	135	103
Injured by an animal	-	-	23	20	21	19	26
Acts of violence	-	-	10	15	5	10	7
Other kind of accident	-	-	70	81	74	63	49
Injuries not classified by kind	-	-	18	17	20	11	16

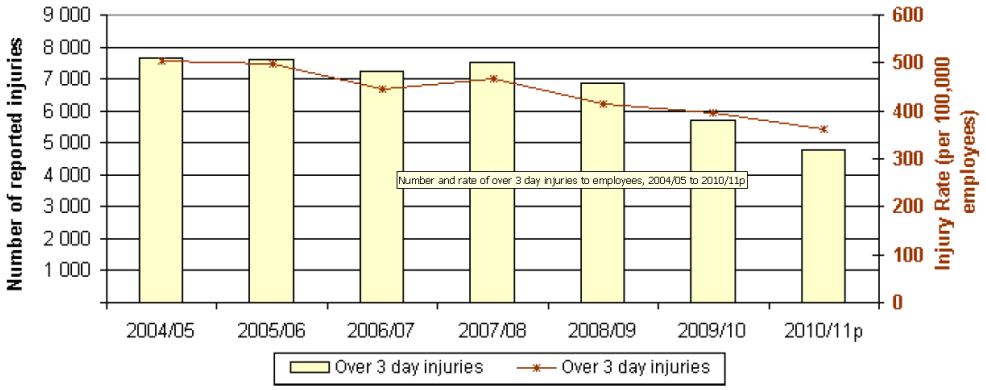

Figure 1.4: Number and rate of over-3-day injuries to workers 2004/2005 to 2010/11p

1.4.3 Oman

Petroleum is the locomotive industry for Oman economy with its huge contribution to total GDP. Real Estate and Construction sectors accounted for 4.6% and 5.4% of GDP over the period respectively. Construction sector saw its share to GDP growing over years from 3.8% in 2005. In addition on a CAGR basis, construction is considered the second fastest growing sector after mining and quarrying, it grew 21.4% during the period 2005-10 to reach OMR1.2bn.

(OMRmn)	2005	2006	2007	2008	2009	2010*	1Q-2011**
Petroleum Activities	**5,876**	**6,740**	**7,139**	**11,705**	**7,317**	**10,332**	**2,969**
Oil	5,434	6,158	6,539	10,856	6,610	9,420	2,739
Natural Gas	442	582	600	849	707	912	231
Industrial Activities	**1,694**	**2,289**	**2,760**	**3,858**	**3,325**	**3,721**	**998**
Mining & Quarrying	28	27	43	70	82	85	24
Manufacturing	1,007	1,527	1,749	2,459	1,853	2,202	621
Electricity & Water Supply	203	169	176	187	210	230	49
Construction	457	566	792	1,142	1,179	1,204	303
Agriculture & Fishing	**183**	**191**	**210**	**234**	**259**	**270**	75
Services	**4,400**	**5,176**	**6,251**	**7,640**	**7,519**	**8,343**	2,236
Wholesale & Retail Trade	859	1,089	1,489	2,109	1,731	1,943	519
Hotels & Restaurants	89	115	146	188	175	181	49
Transport Storage & Communication	636	803	909	1,193	1,082	1,206	452
Financial Intermediation	462	547	698	829	856	899	249
Real Estate Services	548	595	692	812	934	1,017	265
Public Administration & Defense	910	1,063	1,192	1,241	1,334	1,500	340
Other Services	896	965	1,123	1,268	1,407	1,596	364
Non-Petroleum Activities	**6,277**	**7,656**	**9,220**	**11,732**	**11,103**	**12,334**	**3,309**
Less: Financial Intermediation Services	214	240	294	369	420	465	126
Gross Domestic Product at Producers Prices	**11,939**	**14,156**	**16,066**	**23,068**	**18,000**	**22,201**	**6,152**
Plus: Import Taxes	(56)	(5)	48	117.4	19.9	42	0
Gross Domestic Product at Market Prices	**11,883**	**14,151**	**16,114**	**23,185**	**18,020**	**22,243**	**6,153**

Source: Central Bank of Oman

Figure 1.5: Oman GDP by Economic Activity

Both sectors continued to report annual growth rates over the whole period. Their growth was driven by the continued expansion of physical infrastructure, together with major tourism, commercial, as a well as residential real estate projects. By the end of 2010, both sectors accounted for 10% of GDP to stand at OMR2.2bn, as compared to an 8.5% share in GDP in 2005 to stand at OMR1.0bn [10].

1.4.3.1 Oman OHS statistics

The latest statistics show that the total manpower in the Sultanate is 32 % of population and that the total number of workers in the government is 133,000, whereas, there are 770,000 workers in the private sector. Of the latter, 132,000 workers are Omanis and the rest (638,000) are expatriates according to the statistics of the Ministry of National Economy in 2008. The preliminary data show that occupational accidents and diseases are real burden on the shoulders of social and healthcare services since they cost around 4 % of the gross national product.

The total numbers of occupational accidents per 1000 workers were 1.8 and 1.4 in 2006 and 2007 respectively.

Here is a summary of the main distribution of these primary indicators: [11].

- The majority of accidents took place in the age group 25 – 34 years
- Type of occupations: most injuries were reported in manufacturing and construction industries
- Category of employees: workers are the most vulnerable group to occupational accidents
- The commonest injuries were cut wounds
- Injuries caused by machineries were the commonest
- Hands and fingers are the commonest body parts involved

1.4.3.2 A statistical research in Oman

Results of an OHS study observed in Petroleum Development of Oman which is the major petroleum and natural gas exploration and production company are here below. According to study, 170 work related injuries were recorded from April 1st 2007 to December 31st 2009.

The nature of the work environment, in which welding works take place too much, the most common injury was foreign body to the eye by 27.6%. Following that,

falls/slips was the second by 11.6%. Other injuries were happened during drilling, scaffolding, shuttering, grinding, object movement and tire testing.

The highest frequency of injury was reported among employees aged under 30 years (n= 89, 52.4%), while the lowest frequency of injury was reported among employees aged between 35-39 years (n=17, 10%). Moreover, employees aged above 39 years exhibited a relatively low frequency rate of injuries (n= 8, 12.9%) [12].The total working hours in the Harweel project totalled 36.48 million hours. The average injury rate per 1000 exposed workers was 19.8 injuries per year [12].

1.5 Responsibilities of Counterparties

1.5.1 Employer responsibilities

Employer shall provide a comprehensive and applicable organization fitted with local law and regulations and notify all workers about control measures. Methodology and planning for the work sequence shall bring a complete understanding about hazards rising up with activities. A safe workplace, required plant, equipment and tools shall be provided for workers in order to minimize the risk of accidents or injuries.

Related article for Oman Occupational Safety Regulation,

Article (87)

Every employer or his representative shall acquaint the worker before employing him with the hazards of his occupation and the protective measures he has to take, and shall take the necessary precautions for the protection of the workers during the course of their work against health hazards and the dangers of the work and machinery and for that he shall:

- Endeavour to provide whatever is necessary of the conditions of safety and health in the workplaces or the equipment which he provides to the workers to enable them to perform their duties.
- Ensure that the places of work are always clean and satisfy the conditions of comfort, safety and occupational health.

- Ensure that the machinery, equipment and tools are installed and maintained in the best conditions of safety.

The employer shall not charge the workers or deduct any amount from their wages for providing such protection [13].

Employer should take all practicable steps to ensure that workers are aware of relevant national or local laws, regulations, standards, codes of practice, instructions and advice relating to prevention of accidents and injuries to health [14].

All workers should be informed about the hazards and precautions of their specific works and interdisciplinary activities taking place simultaneously in the same place.

Employer should assign qualified people to make regular health and safety inspections for workplaces, plants and tools in order to maintain requirements mentioned in company H&S procedures and local regulations.

Employer should provide adequate medical facilities for first-aid cases, injuries or illnesses. Workplace welfare facilities should be sufficient according number of workers.

Related article for Oman Occupational Safety Regulation,

Article (89)

The following shall be determined by a decision of the Minister in coordination with the relevant governmental authorities:

The general measures of safety and occupational health which shall be applied in all places of work especially in connection with lighting, ventilation, air circulation, drinking water, water closets, carrying away of dust and smoke and workers lodging [15].

1.5.2 Employee responsibilities

Employee should be careful their own health and safety and use required personal protective equipment. Unlike the common practice of time and cost pressure, employee has the right not to work under unsafe circumstances and to demand good welfare and safe workplace conditions. Employees should participate daily toolbox

talks and regular Health and Safety meetings. Dining, resting, smoking or other requirements should be done in Employer designated areas. Workers should not interfere with any plant or equipment since they have not been authorized to operate, maintain or use.

Article (8):

Workers shall use the means of protection , safeguard them carry out the instructions on keeping themselves away from injuries and refrain from all acts intended to obstruct the implementation of these instructions or cause harm or damage to the means set up to protect the safety and health of their fellow workers [16].

1.6 Literature Review on Costs of Work Related Accidents

Construction accidents cause many human tragedies, demotivate construction workers, disrupt construction processes, delay progress and adversely affect the cost, productivity and reputation of the construction industry [17].

The true cost of accidents is not only the economic costs to the construction industry but also the social costs such as pain and sufferings of the affected workers, emotional and psychological impacts caused to friends, families and co-workers [18].

Health and Safety Executive (HSE) report on Costs of Britain workplace fatalities, injuries and ill health reveals quantified accident cost elements for employers as classified,

A. Loss of Income
    a. Occupational Sick Pay or Statutory Sick Pay payments net of reimbursements
    b. National insurance paid on Occupational Sick Pay or Statutory Sick Pay
B. Compensation
    a. Employer's insurance premiums
C. Product Disturbance
    a. Work reorganization
    b. Recruitment and induction costs for temporary/permanent replacement staff
D. Health and Rehabilitation

a. Proportion of corporate private health insurance premiums attributable to work related illness/injury

E. Administration and Legal

a. Administration of Occupational Sick Pay or Statutory Sick Pay, insurance and compensation claims

b. Health and Safety Executive or Local Authority investigation / prosecution - internal costs + legal costs

c. Fines paid

According to (Ferret & Hughes, 2007) direct costs are claims on employers and public liability insurance, damage to buildings, equipment or vehicles which may be insured and fines, sick pay, damage to product, equipment or process which may not be insured. Indirect costs are business loss, product or process liability which may be insured and loss of goodwill, extra overtime payments, accident investigation time, production delays which are uninsured. Therefore, insurance policies can never cover all of the costs of an accident or disease, either because some items are not covered by the policy or the insurance excess is greater than the particular item cost.

1.7 Literature Review on Costs of Accident Preventions and Safety Investment

A research among 79 contractors in UK construction industry has found that the total benefits of accident prevention outweigh the total costs of accident prevention by a ratio of approximately 3:1 (62% benefit gain to 38% benefit loss). The method has the potential to improve decision-making process on accident prevention and contribute to a reduction in costs, deaths and injuries in the construction industry [19].

According to Business Roundtable (1991) data collected from a significant sample of contractors working at various construction sites in the United States of America in 1980 indicated that the cost of administering a construction health and safety programme usually amounts about 2.5% of direct labor costs.

These costs include salaries for health and safety and certain administrative personnel, health and safety meetings, inspection of tools and plant and equipment, site inspections, personal protective equipment (PPE), health and safety programme and miscellaneous supplies and equipment [20].

Tang & Ngai (1997) classified three components of safety investment as follows:

(a) Safety administration personnel
   - Site staff and head office staff: according to Hong Kong law, a contractor has to employ safety officers and safety supervisors on site to monitor safety-related matters
   - Some large contractors will also employ safety managers / senior safety officers to direct and coordinate site safety staff
   - The salary of these personnel and their supporting staff (e.g. clerks, typists) are part of the safety investment

(b) Safety equipment
   - Purchasing of safety boots, goggles, helmets, safety fences, first-aid facilities, etc which are related to the provision of safety on site

(c) Safety training and promotion
   - Safety training courses are organized by contractors for their employees
   - Safety promotion includes the printing of pamphlets and posters, the production of safety advertising banners and boards, organization of safety campaign and monetary rewarding of individual workers who achieve a good safety standard of work, etc [22].

1.8 The National Occupational Health Plan (2009 – 2012) in Oman

4-year National Plan acts as a guide for the country to evaluate the extent of developments in carrying out the various relevant activities and in order to follow up the implementation of occupational plans, programs, and targeted strategies.

The national occupational plan aims to achieve the following:

Objective 1: To devise and implement policy instruments on workers' health

Objective 2: To protect and promote health at workplace

Objective 3: To improve the performance and access to occupational health services

Objective 4: To provide and communicate evidence for action and practice

Objective 5: To incorporate workers' health into other policies

Objective 1: To devise and implement policy instruments on workers' health

This should be achieved through:

- Build political commitment for action on workers' health – incorporation of workers' health into national health plan, national labour strategy, raising awareness among policy makers, media involvement, evidence.
- Develop and publish national profile on workers' health and safety according to ILO and WHO recommendations.
- Strengthen the occupational safety and health committee to become a national committee on workers health at highest level under the direct authority of the Minister of Manpower and having representatives from the concerned ministries at undersecretary levels with clear terms of reference, accountability and responsibility with financial independency for implementing the national frameworks. It should take care of planning and executing national occupational programs under the supervision from the executive office of the undersecretary of the Ministry of Manpower; together with having occupational health and safety members and staff.
- Ensure active participation by employers and workers' organizations in development and implementation of actions on workers' health.
- Improve communications, networking and sharing of experiences between the concerned ministries and private sectors.
- Ratify ILO Convention 187 on the promotional framework for occupational safety and health and Convention 155 on occupational safety and health.
- Introduce complete ban of the use of all types of asbestos.
- Develop national programme for occupational safety and health for Health care workers.
- Carry out analysis and develop a program for protecting and promoting health for expatriate worker.
- Enforce the implementation of Regulation of Occupational Safety and health for establishments governed by the labour law(MD 286/2008).

Objective 2: To protect and promote health at workplace

The following strategies need to be adopted in order to provide healthy and safe work environments:

- Ban completely tobacco smoking in all indoor workplaces and public places according to the guidelines issued by the Conference of Parties of the Framework Convention on Tobacco Control, – improve control, develop

guidance on smoke free workplaces and encourage smoking cessation programmes.

- Introduce guidance, tools and mechanisms for stimulating healthy workplace initiatives by enterprises as specified in the regulation on occupational safety and health, including physical, psycho-social environment and individual risk factors, such as diet and physical activity.
- Train the trainers from enterprises and regions in developing, implementing and evaluation of healthy workplace programmes.
- Strengthen workplace health inspection, train labour inspectors in occupational health and safety.
- Introduce healthy workplace criteria into the HM award for best factories based on Canadian and other good national practices. In addition, another national award specialized for excellence in occupational health and safety that covers all industries and businesses should be established.
- Introduce practical tools for assessment and management of occupational risks (control banding), including training of trainers.

Objective 3: To improve the performance and access to occupational health services

- Ratify ILO Convention 161 on occupational health services
- Introduce regulation on occupational health services, including standards, financing and quality assurance with emphasis on prevention.
- Incorporate the development of occupational health services into the National Health Policy and into the plans for primary health care.
- Training of trainer on occupational health service and implantation of occupational health in primary health care.
- Development of basics Infrastructure and human resources development in all level including general practitioners and nurses in occupational health.

Objective 4: To provide and communicate evidence for action and practice

- Update the national list of occupational diseases in line with the ILO and GCC lists. This table should also be incorporated in the rules and regulations of the Ministry of Civil Services and the Public Authority of Social Insurance.
- Improve medical surveillance of workers - pre-placement, periodic and final medical check ups

- Update legislation and strengthen capacities for management of work-related disability according to the GCC recommendations. Ensuring that the members in the evaluation committees are competent and knowledgeable of the international guideline in disability assessment.
- Strengthening the surveillance of occupational risks, diseases and injuries
- Incorporate workers' health into the national research agenda. This is best achieved through allocating special financial grants and considering workers' health as a cornerstone in national researches.
- Organizing occupational health awareness campaigns and celebrating World Day for Safety and Health at Work on the 28th of April each year and improve continuous communication and interaction with all other concerned parties to activate this day.

Objective 5: To incorporate workers' health into other policies

- Strengthen collaboration between ministries of health and all other ministries (agriculture, environment and municipality) on prevention of pesticide poisoning and incorporation of occupational health measures into good agricultural practices.
- Incorporate workers- health measures into the national plan of action on environmental protection, particularly with regards to chemicals management, hazardous waste and emergency preparedness and response
- Include workers' health into the national strategy for climate change adaptation and mitigation
- Carry out health impact assessment of employment policies (health and environment impact assessment as a prerequisite for starting the activity)

Further development of the occupational health component of student curricula in secondary education and diplomas and bachelor degrees.

2. HAZARD ANALYSIS and RISK ASSESSMENT

A preliminary hazard identification and risk evaluation shall be committed in order to specify accident preventions and calculate related costs to the contractor. Risk assessment is the basic tool to help employee and employer for comprehensive understanding of how to deal with related hazards during the work process. Control measures complying with regulations, legislations and HSE plan shall be provided by the employer within HSE management system.

Many construction employers use generic or model assessments covering the generalities of particular tasks or activities, which can be made site-specific relatively quickly. These are the most appropriate where a similiarity is among activities and associated risks, although those will be carried out in various physical areas or workplaces [3]. Case project contains many different activities which involve specific and similiar hazards. This study does not concentrate on each specific hazard but grouping typical hazards for similar activities. In example, utility lines have common excavation risks depending on their depths or buildings and bridges have common hazards for work at height.

2.1 Definitions

"Hazard is the intrinsic property or potential of a product, process or situation to cause harm, adverse health effects on someone or damage to something [23].

"Risk is the likelihood of a substance, activity or process to cause harm. Risk (or strictly level of risk) is also linked to the severity of its consequences. A risk can be reduced and hazard controlled by the good management [2].

It is very important to distinguish between a hazard and a risk – the two terms are often confused and activities often called high risk are in fact high hazard. There should only be high residual risk where there is poor health and safety management and inadequate control measures. Electricity is an example of a high hazard since it has the potential to kill a person. The risk associated with electricity – the likelihood of being killed on coming into contact with an electrical device – is, hopefully, low

[2]. A risk assessment is simply a careful examination of what, in your work, could cause harm to people, so that you can weigh up whether you have taken enough precautions or should do more to prevent harm [24].

2.2 Risk Assessment System

HSE (Health and Safety Executive) defines Risk Assessment as a careful examination of what, in your work, could cause harm to people, so that you can weigh up whether you have taken enough precautions or should do more to prevent the harm.

Ferret and Hughes (2007) points the goal of risk assessment to reduce all residual risks to low as low a level as reasonably practicable [2].

Risk assessment is based on five basic steps;

- Identifying hazards.
- Deciding who might be harmed and how
- Evaluate the risks and decide on precautions
- Record findings and implementation
- Review assessment and update if necessary.

2.2.1 Hazard identification

Considering process related people, materials and equipment in a workplace is the start in order to identify hazards. Risk assessment team should make a tour around the workplace or if not applicable; review of past accident causes, inspection records, local government records, manufacturer instructions, material data sheets and literature review of process will be the source to identify hazards of the activity.

In order to adequately assess the risks associated with the tasks, a manageable level of detail is required and this may require the task to be broken down into steps or component tasks. Each of these tasks is then defined in terms of activities, use of plant and equipment, use of material and substance, workplace and procedures used. The method proposed for identifying the tasks is to categorize the tasks according to lead job trade or discipline involved in carrying out the work. Manufacturer instructions or material data sheets may help to stop hazards and put risks in their true perspective. Only significant hazards, which could cause serious harm to people or damage should be identified. Trivial hazards should be ignored [2].

Carter and Smith (2006) proposed two main types of barriers for hazard identification improvement as follows,

- Knowledge and information barriers
    - Lack of information sharing across projects
    - Lack of resources on smaller projects
    - Subjective nature of hazard identification and risk assessment
    - Reliance upon tacit knowledge
- Process and procedures barriers
    - Lack of standardized approach
    - Undefined structure for tasks and hazards

(Journal of Construction Engineering and Management, 2006, p. 201)

2.2.2 Hazard impact analysis

This stage is to determine who or what will be affected by possible hazards. Each stage should be carefully overviewed for impact severity. Type of possible injuries or damages should be taken into account. Risk assessment team shall consider all people, equipment and materials at the workplace during the activity under progress.

2.2.3 Risk evaluation

Risk evaluation is based on estimation of hazard likelihood and consequence. Likelihood can be defined as how often an event will occur and is usually based on historical data and statistics. Consequence is a description of how bad and severe the event might be.

In order to finalize the risk rating of a hazard, a simple formula has been used;

Risk Rating = Likelihood (Probability) x Consequence (Severity)

The objective of this process is not to reach a certain number but to provide a systematic method of ensuring that consequence and likelihood ratings are analyzed carefully and a record made of the analysis for the future reference and review.

Case project risk assessment team classified likelihood and consequence by five levels.

Typical factors affecting the likelihood are,

- The number of times that situation occurs
- Duration of exposure
- Quantities of materials involved

- Environmental conditions
- Competence of people involved
- Condition of equipment
- Lightning
- Distractions

Here is table below shown for likelihood (probability) ratings.

Table 2.1: Risk Likelihood Ratings

Likelihood	Rating
Certain / Imminent	10
Very Likely	8
Likely	6
May Happen	4
Unlikely	2

Typical factors affecting the consequence are,

- Injury effect on people who are directly involved in the process.
- Damage effect on assets which are directly involved in the process
- Effect in the environment

Here is table below shown for consequence ratings.

Table 2.2: Risk Consequence Rating Guidance

Injury	Asset Damage	Environmental Damage	
Multiple Fatalities	Extensive damage	Massive leak /spill	10
Single fatality or permanent disability	Major damage	Major leak/spill	8
Major injury, lost time incident more than 3 days	Localised damage	Localised leak/spill	6
Minor / serious injury	Minor damage	Minor leak/spill	4
Slight Injury	Slight damage to equipment	Slight leak, minimal spill	2

A risk matrix is to be developed combining two ratings to find out the particular risk rating for the event.

Table 2.3: Risk Matrix

Likelihood / Severity		Slight	Minor	Major	Single Fatality	Multiple Fatality
		2	4	6	8	10
Certain	10	20	40	60	80	100
Very Likely	8	16	32	48	64	80
Likely	6	12	24	36	48	60
May happen	4	8	16	24	32	40
Unlikely	2	4	8	12	16	20

This will assist later in deciding priorities of action and the authorization levels for the work to commensurate with the risks. Assigned values for likelihood and severity completely depend on company risk assessors' perception.

According to risk rating, risks are classified as follows,

Trivial Risk

Hazards with ratings less than 12 are usually considered as Trivial Risk. Further improvements are not required as provided control measures are maintained and managed through competent personnel for the activity or task who are conversant with the hazards, risks and control measures.

Adequately Controlled Risk

Hazards with residual risk ratings greater than 12 but equal or less than 24 can be considered as adequately controlled risk (A). Control measures should be integrated in the composite risk assessment and give a composite set of key control measures. These risk and key control measures should be communicated to all relevant persons likely to be involved in the activity or task. Risk is tolerable when control measures identified are implemented.

Moderately Controlled Risk

Hazards with residual risk ratings greater than 24 but equal or less than 48 must be considered as *moderately controlled risk* (M). The control measures identified for these risk categories should be regarded as HSE critical and thus require tight management control. Further risk reduction measures should be considered or alternative ways of carrying out the task must be identified and implemented.

Intolerable Risk

Hazards with residual risk ratings greater than 48 must be considered as *intolerable* (I) *and not adequately* controlled. The control measures identified for these risk categories should be regarded as HSE critical and thus require tight management control. Further risk reduction measures should be considered or alternative ways of carrying out the task must be identified and implemented.

2.2.3.1 Risk control measures

When assessing the adequacy of existing controls or introducing new controls, a hierarchy of risk controls should be considered by following these steps,

a. Avoiding the risks
b. Evaluation of risks which cannot be avoided
c. Combating the risks at source
d. Adapting the work to the individual
e. Adapting to the technical progress
f. Replacing dangerous by non-dangerous
g. Developing a coherent overall prevention policy
h. Giving collective protective measures priority over individual
i. Giving appropriate instructions to employee

2.2.3.2 Method statements

Method Statement is the official paper submitted by the contractor revealing the full details of work process with works sequence, materials in use, construction method, quality concerns and HSE issues.

Health and Safety part of method statement consists of basic risk assessment principles, protective and safety equipment, general work instructions, environmental issues and mitigation measures.

Carter and Smith (2006) stated "One of the aims is to identify hazards relating to discrete sections of work and to perform a risk assessment for those hazards identified for that work."

A Safe Work Method Statement should include the specific risk controls that must be implemented to manage the risks for the proposed high risk construction work activity (for example, the need to complete a confined space entry permit). Safe

Work Method Statement must deal with the specific hazards and risks at the workplace where the high risk construction work is being undertaken [26].

Method Statements are built by construction experience, previous projects, manufacturer instructions, material data sheets and construction manuals or other publications. Hazards should be identified by these sources.

2.2.4 Recording and implementation

Each hazard risk assessment value reached by multiplying the likelihood and severity should be recorded on risk assessment forms. There should be a brief information about the hazard which contains following;

- People to be involved during the hazard
- Information about hazard identification process
- Control measures to be applied and residual risk value

2.2.5 Assessment review

Risk assessments are to be monitored to ensure validity when risk conditions change or encounter a new risk condition.

Risk assessments and specified control measures should be reviewed by a certain time interval. Annual review is usual and also a review over an incident should be done. Changes notified by suppliers in the contents of data sheets, or the specification of the substance, will also prompt a review of the assessment [3].

2.3 Advanced Risk Assessment Techniques

According to Ferret and Hughes, if the operation being considered is a new one involving high loss potential, the use of formal hazard techniques such as HAZOP (Hazard and Operability Study), FTA (Fault Tree Analysis) or FMEA (Failure Mode and Effects Analysis) should be considered. However where the potential is lower, a more similar approach, such as JSA (Job Safety Analysis) will be sufficient.

2.3.1 FMEA (failure modes and effects analysis)

FMEA is a tool to evaluate potential failure modes and their causes. It prioritizes potential failures according to their risk and drives actions to eliminate or reduce their likelihood of occurrence [27].

2.3.2 HAZOP (hazard and operability)

A HAZOP study is a systematic search for hazards which are defined as deviations within these parameters that may have dangerous consequences. In the process industry, these deviations concern process parameters such as flow, temperature, pressure etc. [28].

2.3.3 FTA (fault tree analysis)

A fault tree is a diagram that displays the logical interrelationship between the basic causes of the hazard. The tree is structured so that the hazard appears at the top. It is then necessary to work downwards, firstly by identifying causes that directly contribute to this hazard. When all the causes and sub-causes have been identified, the next stage is to construct the fault tree [28].

2.3.4 JSA (job safety analysis)

Job safety analysis is one of the most effective tools that can be used to spot potential accident causes and eliminate potential accident causes.
Major considerations to use for the selection of the job to be analyzed are,

- Job accident frequency
- Job injury severity
- Potential injury severity
- Newly established jobs

Basic steps to do a job analysis are,

- Select the job to be analyzed
- Break the job down into steps
- Identify all hazards and potential accidents
- Develop solutions for potential accidents

In practice, the most difficult part of the job analysis is split the task into sequence of steps. Factors influencing selection will include known levels of risk, any legal requirement, the number of people carrying out the task, and whether they are familiar with it [3].

3. HEALTH and SAFETY IMPLEMENTATION

3.1 HSE Plan

HSE plan shall be defined as a composition of project specific Health, Safety and Environment procedures, responsibilities and regulations in conjunction with local rules and regulations and international practice. HSE plan is the milestone to set up a good implementation in the site which outlines key arrangements and displays the contractor safety vision. Plan is prepared by the main contractor in coordination with subcontractors and submitted to Client through Project Management bodies. It should be revised including top management comments and finalized as an official record.

The content of HSE plan would differ among projects but general concept consists of,

- Scope of work and site information
- Company eligibility certificates by third parties
- Project specific objectives
- Organization Chart
- HSE Program Structures and Implementation Details
- References for local or international regulations.
- A site HSE map including first-aid clinic locations, firefighting equipment locations, access roads and speed limits, limited or prohibited access areas, emergency areas.
- Training and Orientation programs
- Audit and inspection details
- Accident Reporting and Investigation Details
- Emergency Response Flow Charts
- Summaries of hazard or risk specific procedures.
- Information about welfare arrangements, site offices,

HSE plan should be revised during certain periods through the project life cycle by considering changes in actual conditions or local regulations and reviewing accident causes.

3.1.1 Objectives

Main health objectives are;

- Provide adequate medical facilities on site through establishing sufficiently equipped first aid clinics and first aid stations
- Provide proper First Aid Treatment and the necessary equipment for its administration at site.
- Properly track and register first aid cases on a logbook designed for such purposes.
- Develop and encourage preventive medical care attitude through increasing Health and Hygiene Awareness.
- Conduct periodic health inspections so as to ensure and maintain a good standard of health and hygiene.

Main safety objectives are;

- Prevent all occupational accidents by implementing the necessary HSE procedures for such purposes.
- Prevent off-duty accidents by implementing proper HSE control procedures.
- Ensure that there is an effective HSE Management System by establishing a comprehensive HSE Organization Chart that delegates authority and responsibilities.
- To address critical HSE activities during the construction and present methods and procedures for preventing accidents.
- To promote HSE awareness and consciousness in employees and ensure implementation of HSE procedures through a proper HSE awareness program.
- To establish audits for monitoring the implementation of the HSE Plan and HSE procedures.

Main environmental objectives are;

- To implement an environmental awareness program that aims at developing environmental friendly attitudes and promote understanding, and acceptance of environmental responsibilities among employees
- To reduce or eliminate the creation of pollution through efficient use/reuse of raw material, energy, or other sources, and through environmentally sound effluent management.
- To reinstate work areas to environmentally acceptable levels.
- To minimize environmental impacts in accordance with Local Authority Requirements.

3.1.2 HSE procedures

Procedure is an outline of the steps to be taken that are essential for the protection of men, materials, and plants in construction work, and for ensuring effective control of injuries and losses in construction work undertaken by the company.

HSE Procedures describe the following,

- What critical activities are controlled
- Who is responsible
- When controls are applied
- Where controls are applied
- Why controls are applied
- NCR: Non-Compliance Report

3.2 HSE Training

Induction training is aimed at the work just about to join the construction site and its aim is to improve basic safety awareness [44].

All employees being assigned to the project receives a new start training induction covering the following points,

- Project overview, a description of the project and an understanding of hazards.
- Working hours, transport schedule to work site and site security arrangements
- Overview of site rules and regulations.
- Site organization and project structure

- Individual responsibilities
- The employees' responsibility for reporting all injuries to their supervisor and acquiring treatment.
- Emergency evacuation procedure and assembly points.
- Risk Assessments, START Cards / JSA's
- Principle Hazards in Construction
- Emergency Procedures.
- Housekeeping, Waste Management and Environmental Considerations
- Plant and Equipment.
- Working at Height.
- Material Handling.
- Fire Prevention.

Newcomers to project should receive induction before they start work, as it has been found that new arrivals are statistically more likely to be injured, and soon after starting the work [3].

A specific site induction and orientation program will be conducted to orient the personnel to the operations and environmental requirements of the project.

- Defensive driving for all motor vehicle operators and safe equipment operation practices for construction equipment operators
- General and personal safety in workplace
- A detailed HSE instruction covering specific job or craft work duties on Site for construction personnel shall be constructed prior to commencing the work.

HSE Department will be responsible for the planning and implementation of the HSE training program and to monitor the effectiveness of the training given. They will also develop a database for all training provided. All personnel who receive training will be registered and have their names and courses tracked by HSE Department.

Training given will be subject to a field assessment, inspections and walkthroughs to all project's sections to determine effectiveness and suitability of the training program among project employee.Multi variable analysis

3.3 Work Permit System

Work permit is used to provide necessary controls in achieving the safe performance of a specified range of hazardous tasks.

Description of the work, location, start/end date and time, duration, equipments to be used, all personnel involved and responsible supervisor should be clearly mentioned in specific work permits.

The direct supervisor of the task shall ensure all isolations are in place, permit and its supporting documents are fully satisfying and all personnel involved in the task are aware hazards and risks. The approving authority must visit the location where the task takes place prior to approving and signing the work permit. Once the task has been completed, location should be left in a tidy position and permits should be submitted to authority for close-out.

3.3.1 Hot work permit

This permit is used for tasks involving the use of a naked flame, ignition or possible ignition source, including:

- Welding / flame cutting
- Electrical induction pre-heating / stress relieving
- Use of heat shrink blowers
- Grinding
- Use of electrical / electronic equipment, which has not been certified as suitable for use in flammable atmospheres i.e. spark potential (battery drills, power tools, etc.)
- Use of air or hydraulic powered metal cutting, chipping or caulking tools
- Use of electrical soldering irons
- Use of powered steel wire brushes
- Dry grit / shot blasting
- Needle gunning

3.3.2 Cold work permit

This permit shall be used for tasks, which do not fall into the preceding categories of Permit to Work but still require to be covered by a permit. For example,

- Brush painting

- General maintenance
- Erection and dismantling of scaffolds
- Work on isolated electrical equipment
- Any work affecting the integrity or availability of safety or emergency systems e.g., fire pumps, fire mains, shutdown systems, fire and gas detection
- Pressure testing of plant and equipment

Person(s) working in exposed locations e.g., outboard of handrails, or where persons may fall 2 meters or more if unprotected.

3.3.3 Confined space permit

Confined spaces include chambers, tanks (sealed and open-top), vessels, furnaces, ducts, sewers, manholes, pits, flues, excavations, boilers, reactors and ovens.

If the space has limited or restricted access, which means for entry or exit or is not designed for continuous employee occupancy then it is considered as a confined space.

Permit required confined space program is the over-all program for controlling, and, where appropriate, for protecting employees from permit space hazards and for regulating employee entry into permit required spaces.

Permit required confined space;

- Contains or has a potential to contain a hazardous atmosphere
- Contains a material that has the potential for engulfing an entrant
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross section, limits access and egress, and restricts rescue efforts.
- Contains any other recognized serious safety or health hazard

3.3.4 Excavation permit

This permit is used to avoid damages for existing underground utilities in order to contact relevant body to establish the location of existing services such as electricity, water, gas and others. These services should be deactivated, if not possible, excavation should be done under supervision of an attendant from the relevant body.

Overhead power lines must be de-energized and visibility grounded or insulated by barriers to avoid contact by equipment that cannot maintain the minimum clearance.

3.4 Audit and Inspections

The purpose of the audit is to monitor and evaluate the HSE Management system and determine the effectiveness of its implementation. Term of "audit" shall be defined as "The structured process of collecting independent information on the efficiency, effectiveness and reliability of the total health and safety management system and drawing up plans for corrective actions [30].

The qualified auditors could be HSE Audit team leaders, specialists, management representatives, auditors-in-training or employee as a part of audit team.

According to Ferret and Hughes (2007), the aim of auditing is to establish the system showing three major components in place, which are;

- Appropriate management arrangements
- Adequate risk control systems implemented and consistent with the hazard profile
- Appropriate health and safety precautions

Three types of audits take place within the case project,

Group Internal HSE Audits: Group HSE Manager carries out this audit in order to assess procedure implementation and performance of HSE management. These are usually conducted every six months but shall be repeated when one of the following conditions exists in the project,

- Significant changes in functional areas of the project organization
- Significant procedure alterations
- Systematic lack of effectiveness in HSE related aspects
- Major Incident / Accident that could reflect general lack of effectiveness
- Frequency rate higher than 0.5
- Violation of any of ISO 14001 or / and OHSAS 18001 requirements.

The role of the HSE manager during this auditing process is to;

- Verify the implementation of recommended corrective actions and improvement plans.
- Provide advisory service to the Construction Manager and Line Management on the correct implementation of this procedure.
- Arrange periodic independent audits to assure the effective implementation of this procedure throughout the Project.
- Collate information and lessons learnt gained from field experiences implementing this procedure and initiate periodic reviews to identify opportunities for improvement.

In particular following areas will be checked;

- Records and files whether correct, up to date or complete
- Whether the work is performed in accordance with the approved procedures.
- Whether the personnel know the requirement of procedures.
- How internal communications work as well as relations with the Engineer and subcontractor
- How new procedures and issues are transmitted to the workforce
- HSE awareness of management and site employees
- Any ISO 14001 or OHSAS 18001 non-conformities

Upon completion of the audit, an audit report will be written showing the findings with following attachments,

- Audit report form
- Non-Conformance Report (NCR)
- Observations

HSE Inspections: Inspections are carried out to maintain the implementation of HSE procedures, preventions, risk assessments and other arrangements within work areas of the project. Those ensure site, locations, equipment and material arrangements are conform to requirements. Inspections are more concentrated on physical conditions rather than systems.

HSE management should set up minimum one inspection for each month. Management is responsible for maintaining adequate records for inspection including an Inspection Records Register, copies of Inspection reports, NCRs and checklists.

Upon completion of inspection, the team shall meet to discuss and evaluate any non-conformity, analyze apparent HSE rules violations or conditions against HSE rules or procedures. Objective evidence should be recorded and attached to Non-Compliance Reports. A copy of each NCR shall be handed to inspected area manager for action. The inspected area manager shall be requested for his detailed corrective action proposal with implementation date and response to NCR date.

3.5 Incident Investigation and Reporting

The commitment to careful reporting and investigation of accidents / incidents involving injury, property damage, and production interruption is a major factor in accident prevention. The accident investigation process provides the accurate information needed to prevent recurrences. In case of serious injury, an incident investigation team shall be formed in order to investigate.

Supervisors or foreman should carry out immediate investigation of every accident occurs within his working area. An immediate oral report shall be made to HSE management. Any delay in immediate action prevention will lead to diminished and unclear facts. Following that, he shall complete a report and directly submit to HSE management. All injury and damage records are collected from the site and incorporated in the monthly statistics report.

Near Miss Investigations will be conducted in order to provide facts rather than faults. The point of such investigations is to prevent recurrence of similar incidents. The term “Near Miss” is defined “as an opportunity to improve safety, health, environmental and security of an operation based on a condition or an incident with potential for more serious consequence.” (Near-Miss: A tool for Integrated Safety, Health, Environmental and Security Management, Ulku G. Oktem, 2002)

Accident Investigations will be conducted in a manner that will provide facts rather than faults. The point of such investigations is to prevent recurrence of similar accidents. Each accident will be followed by an investigation.

The main purposes of an accident investigation are;

- To find out causes so that similar accidents shall be prevented.
- To determine the point where 'unplanned' event took over from the planned sequence of events.

- To recommend the corrective action.

All accidents have to be recorded into “Daily Accident Register” which to be sent HSE Manager daily basis. Site Doctor and Nurse are responsible for First-Aid treatment and recording details. As per their recommendation;

- If the injury is minor the injured person will be sent back to work after treatment.
- If the injured is transported to the hospital, a designated person will accompany the patient and stay with him to ensure proper treatment.
- If the injured person requires leave from duty or to go to hospital this will require approval by the Doctor. The injured person's supervisor will be kept informed of the situation.
- If a leave from duty or visit to hospital is required the person responsible for First Aid will complete the form 'Application for Medical Treatment'(See Attachment 1). This form will require authorization by the injured person's Superintendent.

All those details should be mentioned in the site clinic First-Aid treatment report.

3.6 Personal Protective Equipment

Personnel Protective Equipment and Respiratory Protective Equipment (PPE & RPE) are considered as the last defense in the prevention of risk exposure and should not be considered as a substitute for eliminating or controlling the risks at source. All employees shall be provided with the necessary PPE for their particular work activity. PPE and the necessary training courses shall be given to the employee on the use and care for PPE. Additional personal protective equipment beyond the basic PPE will be distributed as mandatory based on the outcome of detailed Risk Assessment in order to properly protect personnel against the residual risk inherent to the work activity. All employees shall be held responsible for the proper care and use of any PPE supplied to them. The Project shall replace, free of charge to the employee, any PPE which becomes deficient and deflective in any way through normal work usage or wear and tear such that at all times the worker has adequate protection. Normal wear and tear shall include the period or effective use specified by the manufacturer and requirements of basic hygiene standards. All employees

shall wear the appropriate PPE supplied to them at all times while working at their assigned tasks. Supervisors shall apply disciplinary action in accordance with the project procedure to any employee who fails to comply.

3.6.1 Eye protection

Table 3.1: Tasks Eye Protection Equipments

TASK	EYE PROTECTION EQUIPMENT
Hitting steel upon steel	Safety glasses with side shields or mono-goggles over prescription glasses
Grinding	Face shield with safety glasses for all grinding applications
Sandblasting	Air supplied sand blast hood
Power sawing	Mono-goggles or side shield safety glasses
Laser exposure	Goggles with shaded lens depending on laser wave length
Abrasive cut-off sawing	Face shield with side shield safety glasses
Chipping	Face shield over side shield safety glasses
Gas cutting	Face shield, Welding goggles, #3 to #6 shade lens (UV)
Electric arc welding	Welding helmet, #10 to #14 shade lens with hard hat combination (UV Protection)
Welder's helper	Side shield safety glasses or flash goggles with #5 shade lens (UV Protection)
Insulation spraying	Air supplied face mask
Concrete breaking or placing	Mono-goggles/side shield safety glasses
Corrosive acids or alkaline	Chemical goggles and face shield
Machine wire brushing	Face shield over side shield safety glasses
Airborne objects in workshop	Side shield safety glasses
Wind and other air turbulence	Mono-goggles
Working with coiled wire, wire mesh roll or banding materials	Side shield safety glasses or monogoggles

Chemical Areas	Green and white lines indicate chemical areas. Chemical mono-goggles shall be worn with face shield.
Ceramic Fiber	Mono-goggles
Live Areas	Coverall

3.6.2 Head protection

Hard hats shall be worn properly in all construction areas including roads, shops, and outlying work areas. Hard hats shall not be modified or painted. Supplementary hardhat equipment includes winter liners, sweatbands, chinstraps, and cloth caps. If a worker must work in an inverted position then chinstraps are required. Hearing protectors (earplugs) can be used in conjunction with head protection (attached to the hard hat). When using a face shield, welding hood or sandblasting hood, the type that combines with a hard hat shall be used unless an alternative is designated by the HSE Department.

3.6.3 Hand protection

Hand protection is essential to protect employees from sharp edges, burns, rough material, corrosive or infections substances, hot or cold items, electrical contacts, and generally when handling material. Employees shall be required to wear proper hand protection for tasks which expose them to recognized potential hand injuries, such as handling rough and sharp edged materials, and shall be worn for protection against concrete, solvents, epoxies, creosote, acids, and other harmful chemicals.

3.6.4 Foot protection

Various types of standard footwear protect against impact, puncture, compression forces, chemical and radiological contamination, electric shock, static spar, and flammable materials.

3.6.5 Fall protection

A full body harness shall be worn when there is a potential of a fall and no other fall protection is provided. All employees and Subcontract personnel who are required to work on or inspection of items higher than 6 feet (1.8 meters) must wear and use a full body harness. Safety Belts are not considered to provide adequate protection to the individual; therefore, they are not acceptable for use.

4. ACCIDENT PREVENTION

4.1 Excavation Hazards and Preventions

Major hazards for excavation works shall be classified as,

- Slope stability and collapses
- Material falling down to the excavation area
- Personnel struck by moving plant
- People falling in or vehicle driving into the trench
- Underground services contact
- Lack of oxygen
- Insufficient access/egress

4.1.1 Slope stability and collapses

- Soil types to be investigated prior to start excavation
- Soil types give idea about approximate plasticity limits and collapsing limits for benching.
- Benching slope and number of of steps are determined as per soil conditions.

4.1.2 Materials falling down

- All excavated spoil to be placed at least 1.5m from leading edges
- Personal Protective Equipment should be fully occupied during excavation.
- Stop blocks shall be used where plant is working near the trench. The stop blocks must of sufficient height and strength to stop the vehicle and of sufficient distance from the trench to stop collapse.

4.1.3 Personal struck by moving plant

Banksman should be clear in line of vision with operator. All plants are to be fitted with reversing alarms that are automatically activated on the selection of reverse gear. Banksman should guide reversing plant.

People falling in or vehicle driving into the trench

- All excavations will have suitable fixed barriers at least 1.5m from leading edges
- Adequate signage should be provided.
- Safe access and egress shall be provided for all excavations and access bridges over the trenches should be provided.
- Safe pedestrian access routes away from the excavation should be provided

4.1.4 Contact with underground services

The Company shall be contacted and advised of the proposed work in order to establish the location of underground utilities such as electrical, gas, sewer, communication, fuel, and water lines. Overhead power transmission lines must be de-energized and visibility grounded or insulated by barriers to avoid contact by equipment that cannot maintain the minimum clearances.

- Area to be visually checked for markers or physical signs of services, i.e. manholes.
- Up to date Drawings detailing existing services shall be obtained and checked thoroughly.
- Liaison with concerned authority
- Prior to excavation the affected area shall be surveyed with a cable locator
- Use of trial holes and hand excavation around known services
- Non-conductive hand tools shall be used when excavating around existing services.

4.1.5 Lack of oxygen as a confined space

All trenches and excavations greater than 4 feet (1.2m) in depth shall be atmospherically tested prior to employees entering the excavation or trench. Excavations at locations where hazardous atmospheres can be reasonably expected to exist, such as landfills or plants that process and store hazardous substances. These shall be air monitored on a continuous basis. Employees who may be subjected to hazardous dusts, gases, fumes or an oxygen deficient atmosphere shall be provided with appropriate respiratory protection.

4.1.6 Insufficient egress/access

A stairway, ladder, ramp or other safe means of access or egress shall be provided in all trenches that are 4 feet (1.2.m) or more in depth and shall be positioned at adequate intervals of lateral travel for employees. In addition, two access and egress points should be established if possible.

4.2 Work at height hazards and preventions

Falls from a height is the most common cause of serious injury or death in construction industry.

Common hazards for works at height are as follows,

- Slips, trips and falls at the same level
- Falls from openings, scaffoldings from high level
- Falling objects

Accident preventions

- All personnel shall wear an approved full body harness fitted with a lanyard.
- Crafts / departments shall make maximum use of primary fall protection systems such as scaffolds, aerial lifts, personnel hoists, etc. These systems shall be equipped with complete working / walking surfaces free of floor openings, standard guardrail systems, toe-boards and safe means of access / egress.
- Fall protection devices such as lifelines, safety harness / lanyards, etc. shall be inspected daily for damage and / or deterioration
- Fall protection devices and systems shall not be used for any other purpose other than employee safeguarding.
- Floor opening / hole covers are used to close openings and holes in floors, platforms and walkways. The cover must completely cover the opening / hole and be secured against accidental displacement.
- Lifelines may be mounted either vertically or horizontally and are generally intended to provide mobility to personnel working at elevated areas.
- Horizontal lifelines should be positioned so as to provide points of attachment at waist level or higher (preferably above head height) when personnel utilizing them.

- Lifelines shall be arranged to provide adequate mobility in all areas of the structure while maintaining 100 % fall protection for personnel.
- All ladders will be of sound construction (Aluminum Preferable) and will be properly maintained and in accordance with International Safety Regulations.
- Ladders will be inspected and logged once per quarter. They shall be inspected before and after use and any observed defect remedied at once.
- The best angle for easy use and security is about 75 degrees to the horizontal, i.e. one meter out of for each four meter up.
- Working platforms should be kept clear and clean as possible to avoid slip, trips, and the accidental loss of material to the ground below.

Temporary work platforms/walkways shall be made to ensure all are equipped with solid decks free of openings with scaffold grade planks and standard guardrail systems.

4.2.1 Scaffolding

- The foundations shall be level and adequate to carry the load imposed
- Base plates shall be placed under every standard irrespective of the foundation surface.
- Standards shall be plumbed vertical
- The spacing between standards is determined by the intended use of the scaffold.
- Joints in standards can be made with sleeve couplers or spigots (joint pins). Joints must be staggered, i.e., they must not occur at the same level in adjacent standards.
- The vertical distance (lift height) between ledgers must not exceed 2 meters
- All scaffolds will be braced in both directions. Braces, whether facade or ledger to ledger, will be extended to the full height of the structure.
- Working platforms will normally be five boards wide but may be reduced to two boards where the scaffold has been erected for inspection or access purposes only.
- Guardrails will be fixed to the inside of the standards on all working platforms to a height of between 1.1 meters (minimum) and 1.5 meters

(maximum). The space between the top of the toe-board and the underside of the guardrail will not exceed 690mm.

- A mid guardrail will be fixed to the inside of standards in every instance.
- Toe-boards including stop end boards will be fitted to all working platforms. The minimum height will be 150mm.
- Ladders will project beyond working platforms or ladder access platforms by a minimum distance of 1.05 meters (five rungs).
- Ladders will be based on a sound footing. They will be lashed or secured by a proprietary clamp at both the foot and near the top.
- Long ladders will be supported and lashed at their mid point to remove any bounce.
- All ladders will be of good repair and sound construction. The Approved Scaffolding Supervisor, before use, will check them for damage, faults and wear & tear.
- Scaff-tag is a system of inspection whereby a weather proofed plasticized tag or equivalent, is placed at all the access points of a scaffold. Information on tag will include the date built, safe working load, inspector's initial, name and signature and Company name. The tag (generally GREEN) indicates that the scaffold is "Safe to Use".

Within a period not exceeding 7 days, the scaffold will be re-inspected by a Scaffolding Supervisor and a signature and date placed upon the tag. Where a scaffold does not meet safety standards, the tag will be removed and a prohibition notice placed at the access to inform personnel not to use. Generally a RED Tag will be used for 'unsafe scaffolds'.

4.3 Lifting Operations

Accidents involving the failure and damage of lifting equipment are frequent on construction sites and usually very severe when they do occur.

Causation factors leading to such accidents include:

- Operator error (human error).
- Inadequate inspections and maintenance of equipment (unsafe condition)

- Failure to plan the operation and take precautions against overhead power lines.
- Poor ground conditions and other obstructions (unsafe condition)
- Overloading and misuse of equipment (unsafe action).
- Weather conditions (wind atmosphere, low visibility)

4.3.1 Planning

- All lifting steps should planned considering weight of load, method of lifting, working radius, communication system and selection of equipment.
- All lifting operations shall be controlled by a trained and competent Banks-man, who shall be screened by the rigging department before being hired as a Banks-man
- All cranes shall be correctly supported and all outriggers and other lifting aids shall be deployed before lifting commences.
- Cranes and other side booms shall be positioned so that they only lift vertically.
- During lifting operations, no person shall be positioned beneath the load, hoist or jib. Similarly, loads shall not be lifted over the heads of personnel.
- All mobile equipment must have reversing audible reversing alarms.

4.3.2 Ground stability

- Sound timber packing or metal plates shall be positioned under each outrigger pad to distribute the load.
- Outriggers must be extended on both sides when performing a lifting operation.

4.3.3 Testing and examination

- Cranes brought to site will be load tested by a third party authority. They shall have a load radius indicator fitted.
- Crane operators shall check their cranes daily, for oil, hydraulic oil, leaks, water etc.

- No part of a crane, which is subject to lifting stresses, shall be altered, welded or changed in any way without reference to the crane manufactures procedures and instructions.
- Slings, shackles, belts spreader bars and any other piece of lifting equipment, shall have a valid certificate

4.3.4 Safety marking

All mobile cranes shall have a conspicuously posted sign, stating the length or lengths of the boom, which may be fitted, safe working load capacities at the appropriate radius, and recommended operating conditions.

4.3.5 Wind speed and crane operations

- The most common restriction to crane operations is bad weather, specifically high wind that can blow the load out of the safe operating radius, possibly resulting in an overload situation.
- The maximum wind speed allowable is dependent on the actual crane design and specifications.
- All lifts above ground level, must account for the "Wind Force"
- When wind velocities are above 32 Km/h (20 mph), the rated load and boom lengths shall be reduced according to the manufactures specifications.

4.4 Fire Protection and Prevention

The main objective of this plan is the safety and protection of all employees and properties in the event of fire specifically to prevent death or injury to personnel.

- Portable Fire Extinguishers are designed for small fires because of their short period of discharge. Fire Extinguishers have been selected based on the type of fire which could occur, the type of operation and the number of employees who might be available for fire fighting.
- The FIRE/SAFETY EQUIPMENT CHECKLIST for each area lists the location of each Fire Extinguisher, fire hose and fire hydrant
- The PRE-FIRE PLAN shows the location of all firefighting equipment, fire alarm stations and contains a list of all firefighting equipment.

- The operator, mechanic, lab technician, or office assistant in the area shall inspect all portable Fire Extinguishers at least monthly.
- All employees are instructed in the use of Fire Extinguishers
- All flammable material is stored in designated areas.
- Gas containers are stored in isolated areas.
- A competent person periodically checks all electrical installations.
- Emergency telephone numbers are posted.
- Building evacuation plans are posted.
- In the case where the evacuation has been ordered, all employees are to gather at the allocated assembly points.
- A Hot Work permit shall be obtained before commencing any welding or burning operations.
- Fire drills shall be conducted on a routine basis to ensure that plans for the evacuation of personnel

4.5 Manual Handling

The followings are pattern of typical accidents that may occur due to handling materials:

- Crush injuries and serious body harm from falling loads and objects, collapsing stacks materials, not properly secured loads etc.
- Mechanical damage to storage containers, vessels, equipment and other properties.
- Leaking and spillage of chemicals with the risk of toxic contamination, explosion or fire.
- Cuts, falls, back injuries, pulled muscles, etc, of personnel being from poor or unsafe lifting methods, careless, negligence and or unsafe storage facilities

Following precautions should be taken prior or during the handling process;

- In order to avoid injury and harm to the personnel body and or damage to equipment, utmost care shall be taken when lifting or moving a load manually.

- All personnel involved in the handling operations (manually or mechanically), shall be briefed on the hazards related to the work, and shall be trained on the correct and safe manual handling procedure.
- Always lift using the leg and thigh muscles with back straight
- Never twist or bend your back when carrying a heavy load.
- Be sure that the load is within your lifting capability and ensure that the Center of Gravity of the load is nearest to you.
- Body posture is very important when lifting. Correct positioning will reduce the risk of back and muscle injuries
- Handling of materials and items that are heavier in weight and reasonably bigger in size than the human body (e.g. drums, pipelines, metal sheets, pallets etc.), shall be carried out in a safe manner, using mechanical tools and devices, so as to prevent the occurrence of accidents and avoid harm to people and damage to equipment.
- Drums shall never be handled manually up or down stairways, elevated areas or into excavated locations and ditches.
- Pipes shall be stacked in the designated storage area, in horizontal layers, supported if necessary, with suitable packing materials between them
- Falling of metal sheets and plates due to wrong and or unsafe handling or lifting can cause serious accidents, particularly severe crushing or guillotine injuries. Personnel handling sheet metal shall always wear suitable protective gloves (e.g. chrome leather with armored palms).

4.6 Chemical Storage and Hazard Communication

- Any mixture presenting a physical hazard shall be labeled as a hazardous chemical and an appropriate Material Safety Data Sheet (MSDS) will be maintained with the relevant information.
- The labels must remain on the containers and remain legible at all times. In addition, an employee should not transfer a hazardous chemical from a labeled container to an unlabeled container (pail, bottle, can or similar container).

- All employees will receive appropriate training whenever a new chemical hazard is introduced into their work area.
- Authorized employees shall be made aware of MSDS locations and how to understand them through toolbox talk
- Employees shall be made aware of the appropriate PPE to use (gloves, goggles.)

For each chemical that is hazardous, Company will keep on file a Material Safety Data Sheet (MSDS). This sheet will provide specific information about the chemical, including:

- The chemical and common name of the chemical substance;
- The chemical and common name of all hazardous ingredients in the substance;
- The physical and chemical characteristics of the substance;
- The substance's physical and health hazards; i.e. skin contact, inhalation, absorption;
- Permissible exposure levels;
- Whether the hazardous chemical is considered to be a carcinogen;
- Precautions for safe use and handling;
- Protective equipment and other information ensuring safe industrial use of the chemical;
- Emergency first aid measures;
- The name and address of the chemical manufacturer or supplier who prepared the MSDS;
- The date the MSDS was prepared;
- Proper Storage for the chemical; and
- Clean up and decontamination procedure in case of a spill.

These points should be taken care for chemical storage,

- Storage drums containing hazardous liquids should be placed on a rack, not stacked on the ground and bounded so that it contains possible leaks.

- Natural ventilation is recommended for storage areas, however in case it is not applicable, mechanical ventilation is recommended and this depends on the nature of chemicals stored
- Damaged or leaking drums and containers must be emptied of their contents first by using a device classified for the materials being used to detect content and amount, rinsed with water to remove hazardous contents, and then the damaged or leaking drums must be properly discarded.
- The drum should be moved to a safe place where other employees who are not involved in the operation are evacuated to a safe distance.

4.7 Electric Equipment and Grounding

- Safe routing of electrical cables shall prevent tripping and slipping hazards as well as protect them against physical damage, which may create an electrocution hazard. All electrical distribution panels are equipped with circuit breakers.
- All wiring shall have appropriate internal and external grounding, for personal protection. All materials and equipment used shall be in accordance with International Standards. Never use bridge fuses.
- De-energize all lines, on which work will be performed, install padlocks and lockout tags.
- All appliances, equipment and materials used for temporary electrical installations shall be constructed, installed, protected, worked and maintained so as to eliminate the potential electrical related hazards.
- Unessential electrical equipment and appliances shall be disconnected or turned off when not in use.
- Temporary electrical extension cords shall be elevated off the ground.
- The use of 110v electrical equipment is recommended, whenever possible. Suitability of equipment for an identified purpose may be evidence by a Color Code System for the ready identification of maintained tools.
- Live parts of electrical equipment operating at 50 volts or more must be guarded against accidental contact.

- Electrical installations that are over 600 volts and that are open to unqualified persons must be made with metal-enclosed equipment or enclosed in a vault or area controlled by a lock. In addition, equipment must be marked with appropriate caution signs.
- Exposed non-current carrying metal parts of cord-and-plug-connected equipment that may become energized must be grounded.

Lock-out/Tag-out ensures, in addition to good checking maintenance, that all work on electrical equipment is performed safely.

4.7.1 Portable power tools

- All handles of power electrical cutting tools shall have shields or guards projections that prevent the hand from slipping onto the blade. The cutting edges of cutting tools shall be kept sharp.
- A Competent and Experienced Person in the workshop shall carry out maintenance and repair of power electrical tools.
- Monthly or daily inspections prior to use shall be made of all portable electrical tools in use and records of these monthly inspections shall be maintained.
- If any defects are identified, the tool shall be removed from service, tagged (not to be used) and be either repaired or replaced and records shall be maintained.
- Double insulated tools shall be used
- Only insulated or non-conductive tools shall be used on or near live electrical equipment, where there is a risk of electrical shock.
- Prior to storing, power tools shall be regularly inspected for defects and where necessary, repaired or disposed of. Only safe and good condition tools shall be stored for future use.
- Power tools shall not be left lying around where personnel have to pass (especially on elevated work platforms where they might fall on persons below).

4.7.2 Grinding and abrasive wheels

- The maximum permissible peripheral speed of an abrasive wheel shall never be exceeded, and the spindle shall not be operated at a speed in excess of the maximum permissible speed or the wheel.
- A guard shall be provided to enclose the wheel to the greatest possible extent, with the opening as small as possible consistent with the nature of the work
- Adequate eye protection shall be used when working with grinding machines and abrasive wheels i.e. Full Face shield and safety glasses.
- Adequate protection shall also be in place at the point of operation, i.e. circular or band saw blades, grinding wheels, power presses, etc., to prevent operator injury from both the equipment and debris such as metal chips, sawdust etc created in the work process.
- Grinding wheels shall be covered with a solid guard over that part of the circumference not used for grinding, in order to protect operators in case of wheel breakage. In addition, an adjustable guard shall be set over the usable area of the wheel.
- A foot pedal actuation (dead man device), should be installed to prevent the grinder being left running unattended. Additionally, visual indication (flashing light) should be considered.
- Fire Extinguisher shall be placed close to portable-fixed electrical tools, workshops etc.

4.8 Hot Weather and Heat Stress

- Employees shall have access to cool potable water at their place of work. Water coolers shall be provided for all crews.
- Shaded areas shall be provided for rest periods and instructions given to workers that resting adjacent to, or under plant and equipment is strictly prohibited.
- First Aid equipment provided on site shall include treatment for dehydration e.g. electrolytes.

- Workers shall avoid eating large meals before working in hot environments
- Workers shall drink water before work each day, and drink at least two liters of water every two to three hours during work.
- Worker's diet shall include fruits and vegetables on a daily basis, and workers shall add a little extra salt to their meal.
- Workers must avoid beverages with caffeine, these make the body lose water and increase the risk of heat stress.
- Advise workers to check their urine color, it must be pale yellow, if not they must drink water immediately.
- Workers shall wear light clothing that permits the evaporation of sweat (e.g., cotton cloth) and shall cover their head all the time.

Heat stress cases must be reported to the project's clinic and treated as soon as possible.

5. CASE STUDY

This section will provide information about scope of works, applied cost management system, evaluation of HSE implementation cost and its share within total budget.

Cost values mentioned and evaluated in sections below are demonstrative in order to cover the confidentiality of the company actual costs. These values are proportioned by a certain coefficient of actual real values.

5.1 Scope of Works

Oman Muscat Development of International Airport Project is composed of four main construction packages. MC-1 (Main Contract -1) package contains construction of runways, taxiways, aprons, utility buildings, underground utilities, construction of service roads and distributor roads, flyovers and interchanges as well as site facilities. MC-2 packages contain ATC Tower and some other utility buildings. MC-3 package is the construction of passenger terminal building and MC-4 package is construction of Civil Aviation Headquarters.

Case in subject is the MC-1 package which is composed of many different types of work packages.

Here below table shows major quantities of the project,

Table 5.1: Major Quantities of the Case Project

Description	Percentage	Quantity	Unit
Excavation	16.9 %	14,063,703	m^3
Filling Works	22.5 %	17,554,100	m^3
- Rock Fill		9,038,781	m^3
- Soil Fill		8,033,478	m^3
- Aggregate Fill		175,390	m^3
- Bedding		306,451	m^3

Concrete Works	23.3 %	675,598	m^3
- Structural Concrete		293,263	m^3
- Non-Structural Concrete		242,871	m^3
- APC Pavement		139,465	m^3
Subbase Course	0.5 %	464,457	m^3
Base Course	2.5 %	1,278,362	m^3
Asphalt	4.9 %	555,225	m^3
Structural Steel	0.3 %	430,217	Kg
Riprap and Boulder Concrete	1.3 %	377,404	m^3
Piling Works	0.7 %	14,756	Lm
Stone Columns	4.9 %	758,494	Lm
Finishing Works	0.8 %	160,145	m^2
- Wall Finishing		136,270	
- Floor / Ceiling Finishing		23,875	
Piping Works	1.6 %	1,887,481	Lm
- GRP		33,444	
- HDPE		1,272,957	
- UPVC		158,939	
- Carbon Steel		47,329	
- Ductile Iron		28,767	
- Others		69,209	
Power Cables	2.4 %	249,087	Lm
Mechanical – Electrical Works	17.4 %		

5.2 Costing Principals in the Project

Project contract is based on unit rates in bill of quantities. Each work activity has a unit rate in bill of quantities for the basis of the payment. Completed up-to-date quantities shall be measured and multiplied by each individual rate and included in interim payment certificate.

Cost department divides each of those rates into direct costs, indirect costs, overheads and profit by workgroups of activities. Indirect costs, overheads and profit may vary for each item but direct costs are certain depending on the quantity of work activity.

Total Cost = Direct Costs + Indirect Costs

A direct cost of an activity is physically traceable to the activity in an economic manner. A direct cost is one not counted if the activity is not performed. Indirect costs are business costs other than direct costs; they are not physically traceable and are counted even if the activity is not performed [32].

Activity Based Cost System is applied due to the large scale of the project in order to identify the actual and theoretical cost amounts based on activities and those sub-operations with resources.

5.2.1 Literature on activity based costing

Activity Based Costing (ABC) is a method for developing cost estimates in which the project is subdivided into discrete, quantifiable activities or a work unit.

Here below mentioned some facts of Activity Based Costing system,

- ABC is a management tool that provides better allocation of resources.
- ABC principles are applicable to both appropriations and revolving funds
- ABC relates total cost (resources consumed) to work accomplished (outputs produced)
- The ABC or unit cost goal is a financial benchmark that represents an expectation of the maximum total cost incurred in the production of an output.
- ABC aligns costs to outputs thereby increasing cost visibility, and is useful in forecasting financial baselines.
- ABC provides a clear metric for improvement

Steps to implement activity based cost system are as follows,

1. Identify Activities: This steps in-depth analysis for sub-operations
2. Assigning resource costs to activities:
    a. Direct costs
    b. Indirect costs
    c. Overheads and Administrative Costs:
3. Identify Outputs: Output can be one item or a consequence of continuous operations.

Assigning activity costs to outputs: Activity drivers assign activity costs to outputs based on individual outputs' consumption or demand for activities.

5.2.2 Project cost engineering applications

Works are divided into discrete small groups, packages or activities in order to identify total composition to reach the total cost. A breakdown structure system is applied for each type of work. Applied work-breakdown structure includes,

1. Work Activities (a specific type of work defined by its resources for construction)
2. Work Packages (these are a number of smaller work activities grouped together based on the type of work that fits a certain logic during construction)
3. Tasks (these represent a group of work packages based on a geographical area or a typical activity such as, Civil Task, Mechanical Task, Roads, Buildings etc.)

Here below is a sample workgroup breakdown for the work concreting a Bridge Pier by the quantity of 50 m3. This sample shows all requirements and individual costs of a concrete work for a bridge pier.

First and second columns are specific resources/operations with those individual costs. Each row belongs to an activity demonstrating required quantity, unit cost and total cost to be incorporated in the main work cost.

Table 5.2 Cost Breakdown Structure Example

OPER/RES	DESCRIPTION	TOTAL QTY	UNITS	UNIT COST	TOTAL COST
COMDEL	CONCRETE MIX & DELIVERY	50	M3	3.1960	159.80
CONC50	STRUCTURAL CONCRETE CLASS C 50	50	M3	19.4478	991.84
CRESFW	LABOUR - FORMWORK ERECTING & STRIKING	479.2	HR	0.5291	253.57
CRPGCR	LABOUR - CONCRETE PLACING	250	HR	0.5082	127.05
CRUSHF	CRUSHING / SCREENING OF SAND	36.25	TON	2.0720	78.87
CRUSHN	CRUSHING OPERATION (CONCRETE AGGREGATES)	54.45	TON	2.0720	121.85
CURING	CURING CONCRETE	50	M3	0.5336	26.68
FWKCOL	FORMWORK FOR COLUMN	98.55	M2	0.0000	0.00
FWPRTA	FORMWORK SYSTEM FOR BRIDGE PIERS TYPE A	50	M3	98.4624	4,923.12
PLHDFW	PLANT for HANDLING FORMWORK	95.85	M2	0.6612	63.37

PLPLCR	PLANT for PLACING CONCRETE	50	M3	2.1131	105.65
QUARRY	QUARRY OPERATION FOR WADI GRAVEL	54.35	TON	0.0000	0.00
ROYAL2	ROYALTY FEES FOR QUARRY	34.05	M3	0.0000	0.00
SPEXWR	STOCKPILING WADI GRAVEL AT QUARRY	34.05	M3	0.0000	0.00
TRAN65	TRANSPORT *40 KM*	90.7	TON	0.6239	56.59
				TOTAL COST	-----

Cost types to be considered during the budget process for each activity are as follows,

- Staff Salaries
- Labor Wages
- PMV (Plan, Machinery, Vehicles) Billings
- Subcontracting Billings
- Materials Costs
- General Costs
- Recoveries

Salary and wage costs include for,

- Basic Pay
- Allowances
- Over-time
- Indemnity
- Leave
- Social Security
- Insurance
- Notice Pay
- Tax

PMV (Plant-Machine-Vehicle) costs include for,

- Area Plant Hire
- External Plant Hire from 3rd Parties or Subcontractors

5.3 Health and Safety Cost Evaluation

There are plenty of studies about accident costs in the literature however number of studies on accident prevention costs or health and safety implementation costs is quite limited. Research on prevention costs has been usually done for building projects in which unit area differentiation method could be used. In example, multi-storey buildings have mostly repetitive accident prevention methods and safety costs could be integrated into the average cost of per storey or per square-meter. This way is much easier for cost evaluation and proportional comparison by the specified calculation unit. Unlike the superstructures, infrastructural or mixed projects mostly face the problem of certain unit cost differentiation. Various types of structures have different prevention methods. This makes the repetitive evaluations quite difficult for considering the whole project.

Panapoulos has classified accident prevention costs as any expenditure made in an effective and timely way to prevent accidents occurring and broken down into eleven sub-cost items.

- Safety Management System Documentation (Development of HSE Plan and its documentation works)
- Staffing (Employment procedures, wages, car and fuel expenses, accommodation expenses, travel expenses and office operational costs are basic costs for staffing.)
- Meetings (Hourly rate of participants, meeting rooms, meeting documentation costs, idle time of delays are some basic meeting costs to be considered.)
- Safety Studies (Tender, proposals approve orders, improvements and modifications are some safety studies costs.)
- Training (Internal research for training requirements, training room and operation costs, trainers' wages and trainer expenses for car and accommodation.)
- Personal Protective Equipment (PPE) (Research for identifying the HSE needs, offers, proposals, orders, storage of materials)
- External Services (Tender, proposal, approve orders)
- Safety Equipment (Tender, proposals, approvals, orders, storage, maintenance etc.)

- Fire Safety (Tender, proposals, approvals, orders, storage, maintenance etc.)
- Medical Surveillance (Wages, operational costs, equipments, clinical examinations etc.)
- Agents monitoring (Internal research for agent monitoring needs, market research, tender, proposals, approvals, orders, storage, maintenance etc.)

Preliminary project cost evaluation in the tender stage is done by the JV partner head offices considering a total HSE lump-sum cost. Due to privacy of company know-how, access to evaluation details is limited. Therefore, this study is focused on actual cost investigation of the case project instead of preliminary cost calculation methods. Health and safety implementation cost assessment follows same the classification principle which divides the total cost into direct costs and indirect costs. Labor, material and equipment costs are considered under direct costs whereas staff and management are under indirect costs.

These items have direct effect on the total cost of Health and Safety implementation. Besides there are some health and safety precautions affecting the activity construction cost but not considered under health and safety cost. Examples and details of these items will be revealed in further sections.

Actual values divided by a certain proportion are to be used due to company privacy in order to reach a total figure and identify the share within total budget. Therefore, there is no specific currency used for figures and all numbers are imaginary.

5.3.1 Health and safety costs

This section will provide actual information for items having direct cost effects in health and safety budget. This tools are fully under control of Health and Safety team. Major components of the direct costs are as follows;

- Training costs
- Personal Protective Equipment (PPE) costs
- Cumulative accident prevention costs
- Supervisory and top management costs.

These divisions contain direct and indirect costs but whole division breakdown will reviewed together and be separated distribution table. (Table 5.14).

5.3.1.1 Health and safety training

Evaluation of training costs will be divided into following steps;

- Training staff (Training supervisors, trainers, clerk) as an indirect cost item.
- Training materials (All training handouts, fixed training instruments, samples, training office materials etc.) as a direct cost item.
- Training equipment (Training bus) as a direct cost item.

There are only in-house trainings held by contractor's own staff. No hired 3rd party has given any training. Therefore, for the all labor of whole site, training costs are only changing by number of training staff and their salary or allowance increments. Assuming a 3rd party has given training to employees, the cost would be evaluated for each person and changed by number of employee in the site. Each person joining the company would increase the total training cost. This study concentrates of total training staff and their costs to company during a specific date interval considering each body's work period in this interval.

Training staff costs

Salaries and wages of supervisors, trainers and clerks are considered for evaluation of training personnel costs. Basic pay, allowances, overtime, travel costs are all included monthly cost of each personnel shown in the table below.

Cost period is from the beginning October 2009, up to end of March 2012.

Table 5.3: Training Personnel Costs

#	Title	Work Period (months)	Monthly Cost	Total Cost
1	Training Manager	30	2,174.96	65,248.88
2	Training Supervisor	30	1,199.46	35,984.05
3	Training HSE Officer	11	274.09	3,015.01
4	Training HSE Officer	24	483.06	11,593.42
5	Training HSE Officer	24	525.61	12,614.78
6	Training HSE Officer	22	284.59	6,260.99
7	Training HSE Officer	21	438.86	9,216.04
8	Training HSE Clerk	19	166.09	3,155.77
			TOTAL	**147,088.94**

Training material costs

Table 5.4: Training Material Costs

Training Room and Offices	Unit	Quantity	Unit Cost	Total Cost
Training Centre (200 m2)	m2	1	26	5200
Tables	Pcs	25	15.6	390
Chairs	Pcs	30	2.6	78
Desktop Computers	Pcs	6	104	624
Projector with Wall Mounts	Pcs	4	130	520
			TOTAL	**6,812**

HSE training equipment costs

HSE training bus is located in the site for running subject-specific trainings all week days. Cost of training personnel taking place in the bus is evaluated in above section. Training man-hours spent in the bus to be evaluated in the further section. In this section only rental payment for the bus will be taken into consideration.

HSE Training Bus rental cost from 3rd Party is 416 per month. It has been allocated from the beginning of the project.
The total rental cost for the training bus is 416 * 30 months = 12,480.

5.3.1.2 Personal protective equipment (ppe) costs

Total cost of personal protective equipment depends on number of labor and unit costs of PPEs. Tables below show related costs for each type of PPE. Labor and staff have the option to renew their PPE belonging each 6 months. Evaluation will be based on renewal number for every six months.

Table 5.5 Personal Protective Equipment Market Research.

	1st Supplier	2nd Supplier	3rd Supplier	4th Supplier	**APPROVED PRICES**
Labor Helmet (Blue Color)	0.650	0.572	0.598	0.666	**0.572**
Staff Helmet (White Color)	1.134	1.040	1.071	1.274	**1.040**
Safety Goggles	0.296	0.255	0.260	0.250	**0.255**

Safety Reflector Vest	0.302	0.286	0.276	0.307	**0.286**
Safety Steel Toe Boots	2.990	2.184	3.827	3.546	**2.184**
Coverall	2.132	1.716	1.950	2.054	**1.716**
Full Body Safety Harness	9.568	8.320	9.022	10.140	**8.320**
Gloves	0.250	0.218	0.234	0.239	**0.218**
Welder's Helmet	6.427	5.200	5.980	6.890	**5.200**
Ear Muffs	0.052	0.042	0.048	0.045	**0.042**
Dust Mask	0.572	0.520	0.624	0.572	**0.520**

As an evaluation proposal each PPE unit price should be multiplied by number of manpower but circulation in the project especially for local people makes the differentation per person difficult. Therefore, actual PPE spendings for each month is the right way to find out total PPE cost.

Here below table shows monthly PPE cost distribution for the period between October'2009 and March'2012.

Table 5.6 : Monthly PPE Cost Distribution.

Month	Total Cost
Oct'2009	3,003.936
Nov'2009	3,109.288
Dec'2009	7,247.724
Jan'2010	16,870.074
Feb'2010	7,422.714
Mar'2010	5,220.332
Apr'2010	18,673.247
May'2010	7,317.492
Jun'2010	27,035.746
Jul'2010	6,375.210
Aug'2010	3,673.727
Sep'2010	8,180.328
Oct'2010	2,148.479
Nov'2010	8,546.496
Dec'2010	1,064.066
Jan'2011	5,744.950

Feb'2011	4,170.000
Mar'2011	4,971.190
Apr'2011	9,884.087
May'2011	14,333.436
Jun'2011	6,045.328
Jul'2011	4,055.912
Aug'2011	4,883.476
Sep'2011	14,163.022
Oct'2011	19,627.189
Nov'2011	8,131.500
Dec'2011	5,585.263
Jan'2012	4,856.090
Feb'2012	6,648.310
Mar'2012	10,793.410
TOTAL	**249,782.020**

5.3.1.3 Site collective accident prevention costs

Common equipments costs including signs, New Jersey barriers, warning tapes, gas detectors, testers etc. are clearly classified in the table below.

Warning signs and boards

Table 5.7: Warning Signs and Boards Monthly Cost Distribution.

Month	Expense Items	Cost
Jan' 2010	Stickers	392.080
Feb'2010	Printing and Supply Charges	60.320
Mar'2010	Safety Signs and Rollers	585.780
	Scaffolding Tags and PVC Stickers	522.600
Apr'2010	Plywood	124.800
	Bristol Paper	9.100
	Flourescent Paint	1,456.000
May'2010	Scaffolding Tag and Reflective Sheets	715.000
	Printing and Supply Charges, Rotating Light	119.184
Jun'2010	Primer Wood Paint	134.992
	Enamel Paint	77.012
	Plywood and Whitewood	344.500

Jul'2010	Paint and Thinner	99.216
	Turpentine and Thinner	32.510
	Plywood and Fire Extinguisher Refill	437.008
	Commercial Plywood	317.200
Aug'2010	Fluorescent Paint	531.440
Oct'2010	White Wood	218.400
	Flag, Cloth and Turpentine	73.216
Nov'2010	Repair of Jigsaw Machine	23.400
	White Wood and Torch	297.440
Dec'2010	Plywood and Whitewood	665.600
Feb'2011	Plywood	543.140
May'2011	Primer and Enamel Paint, Thinner	56.992
Jun'2011	Refilling and Lanyards	988.520
Dec'2011	Timber	27.040
	Tools Bag, Commercial Plywood etc.	332.800
	TOTAL	**9,185.290**

Traffic safety expenses

Table 5.8: Traffic Safety Monthly Cost Distribution.

Month	Expense Items	Cost
Sep'2009	Safety Road Barriers	2,496.000
Nov'2009	Jsb Safety Road Cone	74.100
	Safety Traffic Cone	74.100
Dec'2009	Safety & Road Barriers	4,793.880
	Pvc Traffic Cone	148.200
Jan'2010	Road Safety Cone,Warning Tape	592.800
	Safety Bariers,Warning Tape	2,480.400
	Safety Barreirs	2,392.000
	Safety Barr R/W	2,392.000
Feb'2010	Traffic Exps	1,375.400
	Traffic Exps	4,232.800
	W.Primer,Paint,Thinr,S.R.Cone	395.044
	Safety Barrier	598.000
Mar'2010	Safety Barrier	1,196.000

	Jsp Sfty Road Cone	296.400
Apr’2010	Sfty Barrier/ L.Rope,Tape	3,442.660
	Safety Barriers	5,118.880
	Jsp Safety Road Cone	444.600
	Jsp Safety Road Cone	74.100
	Jsp Safety Road Cone	1,796.808
	Safety Barriers	2,870.400
	Road Safety Diversion	304.512
May’2010	Road Marking Charges	3.380
	Safety Post	535.600
	Maintenance Of Traffic	1,662.440
	Maintenance Of Traffic	326.820
	Safety Barriers	3,815.240
Jun’2010	Safety Barreirs	3,540.160
	Traffic Cone	222.300
	Safety Barriers	5,525.520
	Maintenance Of Traffic	4,840.940
	Maint Of Traffic	442.000
	C/O Safety Barriers	14,950.000
	Safety Barrier	478.400
Jul’2010	Barrier	3,588.000
	Maintenance Of Traffic	4,670.806
	Maintenance Of Traffic	1,234.168
Aug’2010	Safety Barriers	263.120
	Maintenance Of Traffic	3,300.211
Sep’2010	Safety Barriers	287.040
	Maintanance Of Traffoc	2,962.762
Oct’2010	Safety Barreiers	275.080
	Traffic Cone	148.200
Dec’2010	Safety Barriers	310.960
	Safety Barriers	1,260.288
Jan’2011	Safety Barriers	5,022.160
Feb’2011	Road Barriers	1,097.200
	Traffic Cone	101.790
Mar’2011	Safety Sign,Traffic Cone,Safety Barrier	2,030.454
	Jersey Barrier	382.200

Apr'2011	Safety Barriers(Diff On Prov Jv# 116/03-2011	30.358
	Lamp,Safety Road Cone	1,005.358
	Traffic Cone,Safety Barrier,Paint	748.119
May'2011	Jsp Safety Road Cone	222.300
	Safety Barrier	6.193
	Safety Barrier,Contactor Etc	771.680
Sep'2011	Traffic Cone	78.000
	Safety Barriers	1,029.600
Oct'2011	Safety Barriers	353.600
	TOTAL:	**105,111.531**

Warning tapes and meshes

Table 5.9: Warning Tapes and Meshes Monthly Cost Distribution

Month	Expense Items	Cost
Sep'2009	Warning Tape	44.200
Oct'2009	Safety Mesh,Warning Tape	143.000
Nov'2009	Warning Tape	353.600
	Warning Tapered & White	265.200
Dec'2009	Warning Tape	44.200
	Waring Tape Red & White	3.770
Jan'2010	Safety Mesh	36.400
Mar'2010	Safety Mesh	91.000
Apr'2010	Safety Mesh	58.240
	Safety Mesh	364.000
Jun'2010	Warning Tape	44.200
Aug'2010	Warning Tape	88.400
	Total:	**1,536.210**

Fire Safety Expenses

Table 5.10: Fire Safety Monthly Cost Distribution

Month	Expense Items	Cost
Sep'2009	Fire Extinguisher	73.528
	Fire Extinguisher	1,647.750
Dec'2009	Fire Extinguisher	30.576
	Fire Extinguisher	153.088
	Fire Extinguisher	158.808
	Emergency Light,Fire Exingushers	660.400
Jan'2010	Fire Extinguisher	17.160
Feb'2010	Siren	1,722.240
Mar'2010	Fire Extinguisher	286.000
Apr'2010	F.Blanket/Paint/Trpntine	264.914
	Light -Emergency	192.400
	Fire Extinguisher	1,183.000
	Fire Extinguisher	3,556.800
Jun'2010	Fire Extinguisher	204.651
	Fire Extinguisher	17.160
Sep'2010	Fire Extinguisher	790.400
Oct'2010	Fire Extinguisher	239.200
	Fire Extinguisher	494.000
	Fire Extinguisher	286.000
Nov'2010	Fire Extinguisher	17.160
Dec'2010	Fire Extinguisher	582.400
	Fire Extinguisher	34.320
May'2011	Chgs-Refilling For Fire Extinguisher	580.923
Jul'2011	Chgs-Refilling For Fire Ext,Safety Pin	673.317
Sep'2011	Smoke Detector	39.520
	Total :	**13,905.715**

5.3.1.4 Management costs

Site supervisory personnel costs

Following figures including salary and allowances as for site controllers, site officers and site inspectors. .

Table 5.11: Site Supervisory Personnel Costs

Work Section	Team	Monthly Cost	Total Cost
SAFETY-NDA		3,463.817	61,048.478
SAFETY-PMV		1,712.330	28,106.877
SAFETY-BUILDING		1,481.236	24,771.380
SAFETY-MEP		2,228.938	35,844.213
SAFETY-AIRFIELD	All Site	3,615.579	63,915.013
SAFETY-INTERCHANGE	Teams	4,989.141	77,203.360
SAFETY-QUARRY	included	1,737.005	17,266.513
SAFETY-NIGHT		1,545.755	27,460.330
SAFETY-TRAFFIC		3,120.973	44,484.257
SAFETY-FIRE		2,429.36	39,784.240
SAFETY-SCAFFOLDING		4,089.61	76,485.760
		TOTAL:	**496,370.420**

Top management costs

Following figures including salary and allowances as mentioned in the procedure above.

Table 5.12: Top Management Costs

Title	Work Period	Monthly Cost	Total Cost
HSE Manager	30	2,799.83	83,994.950
Deputy HSE Manager	30	2,021.33	60,639.800
Assistant	30	427.29	12,818.650
		TOTAL	**157,453.400**

5.3.2 Health and safety implementation construction cost effects

This section will reveal some examples of indirect cost effects of health and safety implemantation. These indirect costs are not assigned to HSE budget but increase activity budget itself due to accident preventions.

5.3.2.1 Guardrails for trench excavations

New Jersey barriers are usually used as physical prevention but it is so costly to use it everywhere. Therefore, site teams are using scaffolding elements in order to provide physical barriers against falls. Small scaffolding towers are built for every 10m spans with a height of 1.5m and connected by two bracing pipes. One should be at waist level and one foot level. Following that, warning tapes are used to surround the gap between two pipes. This guardrail is done minimum 1m ahead of excavation edges.

5.3.2.2 Benching for excavations

Deep excavations require multiple benching for each 1.5m at maximum. This requirement causes extra excavation quantity and cost for the company. Difference in the excavation quantity for a single structure like a lifting station, pump house or valve chambers shall be minor but there could be a huge difference while considering a long trench. For instance, a fuel hydrant system with a total length of 15 kms and by an average depth of 5m has a very big variation in the excavation and backfilling quantity.

This variation could be foreseen during quantity and cost studies at preliminary stage. Most important part of this planning is identifying soil types and safety specifications of the project. Beyond that, basic excavation quantity shall be multiplied by an uplift factor for each depth.

5.3.2.3 Spent man-hour for ınductions and subject specific trainings

In order to reach the total cost due to employee induction and subject specific trainings related spent man-hour should be evaluated.
Tables below show spent man-hours for each related subjects separately.

Table 5.13: Monthly Spent Man-hour Values for Trainings

Months	Induction MH	Specific Subject Mh	Months	Induction MH	Specific Subject Mh
Jan'10	4820	142	Jan'11	3984	2224
Feb'10	3096	64	Feb'11	3330	2700
Mar'10	4000	305	Mar'11	3522	1248
Apr'10	3888	728	Apr'11	4953	835
May'10	3197	2305	May'11	6880	1148
Jun'10	3148	2300	Jun'11	6880	2294
Jul'10	3232	3136	Jul'11	9875	2052
Aug'10	2352	2326	Aug'11	10433	2448
Sep'10	6929	1193	Sep'11	8000	3901
Oct'10	10720	837	Oct'11	8304	4229
Nov'10	5506	847	Nov'11	7464	641
Dec'10	3744	1215	Dec'11	13152	1963
TOTALS	**54632**	**15398**		**86777**	**25863**

As per figures shown above, total value for inductions and subject specific trainings is 182,670 man-hours.

5.3.2.4 De-nailing activity

One of the most common accidents in the site is the nail bite from timber pieces therefore carpenters should remove all nails from timber pieces after dismantling formwork units. This causes time and cost loss for carpentry works.

5.3.2.5 Guardrails for work platforms

All lanyards and work platforms should be surrounded by guard rails and toe-boards. This causes scaffolders to spend extra cost and time for safety purpose. It is quite difficult to differentiate this cost per specific unit because this activity should be done only once at the end of scaffold erection for column, beam or slab. Method of scaffolding may vary from site to site or person to person. For instance, for a column, guardrail should be done as a square surrounding but for a single roof beam, it would be two-sided straight type by linear-meter. For a roof slab, it would be done only once for beams and slab. This cost is directly included in scaffolding cost for safety purpose.

5.3.2.6 Chemical storage area

Chemical storage areas require concrete foundation and bunds around in order to collect any chemical leakage. Besides this area should be shaded against sun-shine and ventilated against high temperatures inside. All of these prevention cause extra cause for safety purpose.

5.3.2.7 Periodic control of electrical equipments

Electrical cables, transformers and generators are weekly checked by qualified people in order to find out damages against any accident. Every month has a different color code announced by safety department to apply for indication after controlling the electrical instrument. This causes extra time to spend for electrical people.

5.3.2.8 Speed humps

Humps are provided to keep the driving speed under control at site internal service roads. These are done by asphalt at specified intervals. Cost of humps are to be included for road works for safety purpose.

5.3.2.9 Regular housekeeping

Work areas shall be kept tidy and all kind of scrap materials shall be cleaned regularly and removed from work areas in order to slipping and tripping. The cost of this work is also involved in the construction work.

5.3.3 Health and safety implementation cost distribution

Table 5.14: Division of Health and Safety Implementation Cost Items.

Expenses Classified in the Health and Safety Budget		**Expenses Classified under Construction Activity Budget**
Direct H&S Costs	**Indirect H&S Costs**	**H&S Purposed Costs**
Training Materials	Training Staff with Allowances	Barricading for excavations
Training Equipment	Site Supervisory Staff with Allowances	Benching for excavations
Personal Protective Equipment	Management Staff with Allowances	Spent Man-hour for trainings
Warning Signs and Boards		De-nailing activities

Traffic Safety Materials	Guardrailing for scaffolds and work platforms
Fire Safety Materials	Erecting chemical storage areas
Warning Tapes and Meshes	Periodic electrical inspections
	Housekeeping

Table 5.15: Amount Distribution of Health and Safety Cost Items.

Division	**Total Cost**	**Percentage**
Direct Costs		
Training Materials	6,812.000	
Training Equipment	12,480.000	
PPE	249,782.020	
Warning Signs and Boards	9,185.290	
Traffic Safety Expenses	105,111.531	
Warning Tapes and Meshes	1,536.210	
Fire Safety Expenses	13,905.715	
Sub-Total	398,812.766	29.72%
Indirect Costs		
Training Staff	147,088.940	
Site Supervisory Staff	496,370.420	
Clinic and First-Aid Staff	142,091.940	
Management Staff	157,453.400	
Sub-Total	943,004.700	70.28%
TOTAL	**1,341.817.466**	**100.00 %**

There is no assigned amount for health and safety purposed construction activity costs due to uncertainty of spent resources up to date. A proposal about evaluation of these costs is mentioned in conclusion part of the study.

5.4 Project Actual Cost Data

Table below shows the total actual costs from beginning of the project up to the end of March-2012. Divisions are classified as direct costs, indirect costs, materials, PMV (Plant-Machinery-Vehicle) and maintenance and factory productions.

Table 5.16: Project Actual Total Cost Data (End of March-2012).

Cost Division	Overall Completion	Actual Cost
Direct Construction Costs	29.33%	29,010,952.201
Indirect Costs	50.12%	30,599,511.177
PMV and Maintenance Costs	60.20%	9,339,032.631
Factory Production Costs	57.65%	12,107,119.890
Material Costs	30.58%	11,810,823.032
TOTAL COST	**38.08%**	**92,867,438.931**

CONCLUSIONS

Airport projects are composed of various construction activity types. Superstructure and infrastructure works are usually estimated by different methods. Building health and safety costs could be differentiated into per 'm^2' but infrastructure health and safety costs could not follow same the procedure. This makes difficult for estimators to embed the supportive departments' (Quality, H&S) costs into unit prices.

This study has witnessed the limited literature on HSE cost evaluation. Although there has been some studies about building accident prevention costs, infrastructure prevention or other collective protection cost literature studies are quite less due the high characteristic variability. The lack of evaluation method in the literature and company confidentiality concerns made this study to concentrate one actual cost data provided by invoices of materials, subcontracted works and supervisor salary information. The only information could be gathered that H&S cost is estimated as a total figure based on the experience of previous projects. Using this limited information make this study to reach an actual proportion and propose H&S cost evaluation.

As the first result, the total cost of H&S implementation except indirect safety purpose costs for 2.5 years of this particular project is 1,341,817.466. The share of this figure within total project budget is 1.44%.

Secondly, since MC-1 is the main infrastructure part of the Oman Muscat International Airport Project, the ratio is low when compared to a building project due to excess quantity of infrastructure works. Basic reason for behind that is the high cost amount of earthworks compared to structures. As seen in the Table 5.1, earthworks and asphalt related works comprise 47.3% of the total cost. These items have minimum H&S requirement and costs. Assuming the cost of earthworks is omitted from the total cost, the share of health and safety cost may increase about 80% or more. The remarkable point here is machinery weighed works contributes less in health and safety cost while labor weighed works put too much.

Thirdly, comparing H&S direct cost divisions, management is leading due to huge size of the project site and spread activities. All labor dominant sites such as buildings, bridges, utility structures, workshop and other utilities have been spread all around the site and require supervisors or inspectors for continuous check. This requirement increases number of supervisors and cost of supervisory. Assuming a building project in one place, supervisory cost amount would be lower.

Following classification result can be reached from this study,

- Earthworks are equipment intensive works and require minimum health and safety control measures and cost is at minimum.
- Utilities and other mechanical-electrical activities are material intensive works, require moderate (medium) health and safety control measures and cost is at the average.
- Superstructure works are usually labor intensive works, require maximum health and safety control measures and cost is at maximum.

Cost and volume distribution of these three divisions in a construction project affects the share of health and safety implementation cost in the total budget.

Besides these results, following evaluation system in the below shall be proposed for infrastructure works,

1. Minimum H&S requirements to be identified based on similar activity groups.
2. Accident preventions for these activity groups should be formulized by their own variables. For example, trench excavations shall be differentiated into certain length, width or depth dimensions that clarify the requirement or required number of banks man shall be evaluated for machine weighing earthworks.
3. Items those cannot be formulized by dimensions or numbers should be evaluated lump sum by itself. In example, confined space H&S cost depend on number of people inside, their specific protective equipment and number of entries affecting supervisory cost.
4. In the next step, frequency and schedule of similar activities should be identified by using construction activity planning. Aimed quantity of

construction works within one month and its sequence would highlight required quantity of accident prevention materials and required labor. For example, total aimed length of trenches in a month will clarify the minimum requirement of physical barriers quantity and sequence of trenches will highlight driving H&S resources in order to evaluate total requirement.

5. Cost of similar lump-sum evaluated items should be multiplied by the number of repetitions in the construction activity schedule. Sequence will enlighten the evaluation again for shifting resources. Since this is a lump-sum evaluation, duration of that construction activity is another specific factor affecting the resource allocation period for that work. This could be materials, equipment, labor or supervisors for regular checks.
6. Next step is the calculation of total activity based H&S costs due to similarity, frequency, schedule, sequence and durations.
7. Final step is the differentiation of H&S costs into activity cost breakdowns. Assigning a lump-sum H&S cost based on unit quantity would be much better in order to identify actual figure by physical progress.

This activity based cost evaluation can be used in the future airport projects or others having similar complexity.

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APPENDICES

APPENDIX A: Work Permits
APPENDIX B: Examples of Job Safety Analysis
APPENDIX C: Checklists
APPENDIX D: HSE Training Matrix
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APPENDIX A

TAV Construction	**EXCAVATION PERMIT**	**Permit No.**

1. Site/Section Engineer **Name :** **Signature :**

Date : ……/……/…….. **Requested Duration From :** ……/……/…….. **To :** ……/……/……..

2. Project Engineer **Name :** **Signature :**

Date : ……/……/…….. **Start Date :** ……/……/…….. **Completion Date :** ……/……/……..

3. HSE Representative **Name :** **Signature :**

Date : ……/……/…….. **Duration of Permit From :** ……/……/…….. **To :** ……/……/……..

4. Location and Description of Excavation

Location : ……

Description : ……

……

5. Hazard – Review and Identify potential hazards (tick appropriate box ☒)

Collapse of Excavation	☐	**Manual Handling**	☐
Access / Egress	☐	**Plant & Equipment**	☐
Buried Services	☐	**Falls on level**	☐
Drainage required	☐	**Fire**	☐
Flooding of excavation	☐	**Caught by / Struck by**	☐
Surcharging	☐	**Overhead Power Lines**	☐
Noise	☐	**Lighting**	☐
Edge Protection	☐	**Excavated material**	☐

The following inspections of the work during course of operations ☐

Others (Specify) ……

……

6. Precautions

……

……

7. PERMIT CLOSE OUT

All Excavation Work (Digging) has been completed, the excavated area in safe manner.

Site / Section Engineer **Date :** ……/……/…….. **Time :** ……

Project Engineer **Date :** ……/……/…….. **Time :** ……

NOTE : This PTW valid for ONE WEEK ONLY. If the work is continue beyond this period the PTW must be revalidated. Return to Section HSE Supervisor to obtain revalidation sheet. The getting of this permit, perform the task with relevant permit form and close out of this permit responsibility is belongs to Site Engineer.

	HOT WORK PERMIT	Permit No.

1. Site/Section Engineer **Name :** **Signature :**

Date: ……/……/…… **Requested Duration From :** ……/……/…… **To :** ……/……/……

2. Project Engineer **Name :** **Signature :**

Date : ……/……/…… **Time :** …… days **Valid for a period of** …… days

3. HSE Representative **Name :** **Signature :**

Date: ……/……/…… **Duration of Permit From :** ……/……/…… **To :** ……/……/……

4. Location and Description of Hot Work

Location: ……

Description: ……

5. Precautions (tick appropriate box ☒)

Location examined	☐	**Oxygen/Acetylene hoses fitted with flashback arrestor**	☐
Operatives been told what to do in the event of fire	☐	**Welding machine and cylinders to be turned off when the work left for any reason**	☐
Combustible materials removed and protected against sparks including below area	☐	**Removal of flammable materials from hot work area**	☐
		Equipment protected from Hot metal and sparks	☐
Fire Extinguisher	☐	**Ventilation fan if required**	☐

The following inspections of the work during course of operations ☐

Others ……

6. Gas Testing (If Required)

Test Required	Result	Name	Signature	Date / Time
Oxygen (Min. %19 Max %23)				
Carbon Monoxide (CO) %0				
LEL Flammable Gases %0				
Other (Specify)				

7. PERMIT CLOSE OUT

All Hot Work has been completed, the men & equipment withdrawn from the area identified above and the area left in safe manner.

Site / Section Engineer …… **Date:** ……/……/…… **Time:** ……

Project Engineer …… **Date:** ……/……/…… **Time:** ……

NOTE : This PTW valid for ONE WEEK ONLY. If the work is continue beyond this period the PTW must be revalidated. Return to Section HSE Supervisor to obtain revalidation sheet. The getting of this permit, perform the task with relevant permit form and close out of this permit responsibility is belongs to Site Engineer.

	COLD WORK PERMIT	**Permit No.**

1. Site/Section Engineer **Name :** **Signature :**

Date : ……/……/…… **Requested Date From :** ……/……/…… **To :** ……/……/……

2. Project Engineer **Name :** **Signature :**

Date : ……/……/…… **Time :** ……

3. HSE Representative **Name :** **Signature :**

Date : ……/……/…… **Duration of Permit From :** ……/……/…… **To :** ……/……/……

4. Type of work to be performed

Brush Painting ☐ **Erection & Dismantling of Scaffold** ☐

Work at Height ☐ **Heavy Lifting Operation** ☐

Working on isolated electrical equipment ☐ **Working with Man Basket** ☐

Other ……

5. <u>Location</u> and <u>Description</u> of Work

Location : ……

Description : ……

……

6. Equipment to be used

……

7. Hazard Identification

……

……

8. Precautions

……

……

……

The following inspections of the work during course of operations ☐

9. PERMIT CLOSE OUT

All Cold Work has been completed, the men & equipment withdrawn from the area identified above and the area left in safe manner.

Site / Section Engineer …… **Date :** ……/……/…… **Time :** ……

Project Engineer …… **Date :** ……/……/…… **Time :** ……

NOTE : This PTW valid for ONE WEEK ONLY. If the work is continue beyond this period the PTW must be revalidated. Return to Section HSE Supervisor to obtain revalidation sheet. The getting of this permit, perform the task with relevant permit form and close out of this permit responsibility is belongs to Site Engineer.

CONFINED SPACE PERMIT

Permit No.

1. Site/Section Engineer **Name :** **Signature :**

Date : ……/……/…… **Requested Time From :** …… **To :** ……..

2. Project Engineer **Name :** **Signature :**

Date : ……/……/…… **Time :** …… hours **Valid for a period of** …… hours

3. HSE Representative **Name :** **Signature :**

Date : ……/……/…… **Duration of Permit From :** ……/……/…… **To :** ……/……/……

4. Location and Description of Work

Location : ……

Description : ……

5. Equipment to be used

……

6. Associated Permits & Safety Requirements

Hot Work Permit ☐ **Excavation** ☐ **Access** ☐ **Gas Test** ☐

7. Precautions and Protective Equipment (tick appropriate box ☒)

Entry log attached	☐	**Ventilation Fan/Blowers**	☐
Emergency Rescue Equipment	☐	**Self Contained Breathing Apparatus (SCBA) Required**	☐
Emergency Communication	☐	**Life line / Harness**	☐
Trained Standby Man (Fire Team)	☐	**Lighting 110 V with ELCB**	☐
Safe means of Entry / Exit	☐	**Lighting 24 V with GFCI**	☐
Personnel trained in confined space	☐		

The following inspections of the work during course of operations ☐

Others (Specify) ……

8. Gas Testing (Prior to entering & throughout the shift)

Test Required	Result	Name	Signature	Date / Time
Oxygen (Min. %19 Max %23)				
Carbon Monoxide (CO) %0				
LEL Flammable Gases %0				
Other (Specify)				

9. PERMIT CLOSE OUT

All Confined Space Work has been completed, the men & equipment withdrawn from the area identified above and the area left in safe manner.

Site / Section Engineer …… **Date :** ……/……/…… **Time :** ……

Project Engineer …… **Date :** ……/……/…… **Time :** ……

NOTE : This PTW valid for ONE SHIFT ONLY. If an operation is incomplete a new permit should be issued to ensure precautions remain in operation. Return to Section HSE Supervisor to obtain revalidation sheet. The getting of this permit, perform the task with relevant permit form and close out of this permit responsibility is belongs to Site Engineer.

APPENDIX B

	Job Safety / Hazard Analysis Procedure Attachment No. 1 Job Safety / Hazard Analysis Form		Doc. ID : **PP714-JSA-F01** Issue Date : **02/01/2007** Rev. No: **A** Rev. Date: **02-01-07** Data Update: Page No.: **1 of 1**
Job Description:	***Location / Department: JSA:***	***Prepared by: Kenan BIRDIR***	***Date:29.05.2011***
Task **Lifting and Rigging**	**JSA # 011**	**Page 1 of 1**	
Job Steps **(List each separately)**	**Activity** **(What must be done? i.e. tools, equipment, and material)**	**Hazards** **(How could an injury occur?)**	**Recommendations** **(Can hazards be eliminated or modified? How can an injury be avoided?)**
Train the Workers		Injury / damage as due to lack technical knowledge	Train in PTW System Train in Safe Lifting and Rigging Train in Lifting Gear Inspection Train in Manual Handling Train in Hand Signals for Crane Operations (incorporated into Safe Lifting & Rigging)
Identify Work Area		Risk of injury due to low awareness of work environment	Communicate the environmental characteristics of the workplace with the workers. Dry-Lift to be performed to check the suitability of the operational place.
Positioning of the Crane Operational Position Pre – Operational Check		Overturn of the crane	Crane to be positioned on an even and solid ground, away from exaction edges. Outriggers to be fully extended. Check and set the maximum radius Outrigger pads to be placed.
General Lifting and Rigging Operations		Workers hit by moving objects	No contact with the crane Barricading off the crane peripheral
		Contact with overhead power lines.	Crane positioned so as to lend a minimum of 3 meters distance between the boom end and the power line. Cut off the power if possible and necessary
		Falling loads due to; High Wind; Over Load Incorrect Sling Selection.	Loads are securely slung with proper and correct type of slings. Pre – Slinging check for all kinds of slings be done
			Correct color coding is in place Monitor wind speed and stop work if necessary
		Overturn of the suspended load	Center of gravity of any load containing materials shall be determined prior to lifting. Tag lines to be used to guide the load during hoisting, horizontal travel and lowering.
GENERAL			Barricading the area around the crane, placement of signage.

	Job Safety / Hazard Analysis Procedure **Attachment No. 1** **Job Safety / Hazard Analysis Form**		Doc. ID : **PP714-JSA-F01** Issue Date : **02/01/2007** Rev. No: **A** Rev. Date: **02-01-07** Data Update: Page No.: **1 of 1**
Job Description:	***Location / Department: JSA:***	***Prepared by: Kenan BIRDIR***	***Date:29.05.2011***
Task **Confined Space**	**JSA # 001**	**Page 1 of 1**	
Job Steps (List each separately)	**Activity (What must be done? i.e. tools, equipment, and material)**	**Hazards (How could an injury occur?)**	**Recommendations (Can hazards be eliminated or modified? How can an injury be avoided?)**
Train workers		Injury / damage as due to lack technical knowledge	Train in PTW System
Obtain PTW		Injury / damage as a result of incorrect information	Obtain Proper PTW No person may enter a confined space until the appropriate person issues a confined space entry permit and a fully trained safety watch person is positioned at the point of entry/exit.
Identify Work Area		Risk of injury due to low awareness of work environment	Communicate the environmental characteristics of the workplace with the workers.
Confined Space Entry		Electric shock, upper limb disorder, hand injuries resulting from miscellaneous activities, Slips, Trips and Falls Entrapment, oxygen deficiency, toxic & explosive atmospheres, and asphyxiation uncontrolled energized equipment.	All persons must be signed in and out of the confined space on an entry log sheet which is held by the safety watch person. No work is permitted on a confined space entry permit; any work to be performed will require a "hot" or "cold" work permit. Housekeeping to be maintained in and around the entry point of confined space. Full body harness to be used during entry and work inside the confined space. For vertical entries, tripod to be utilized. The air must be tested for dangerous contamination or oxygen deficiency. The test will be for : Carbon Monoxide, Lower Explosive Limit, Hydrogen Sulfide and Oxygen Level.

APPENDIX C

	Electricity				
No.	**Item Addressed**	**Compliant**			**Comments**
		Y	**N**	**N/A**	
1	Has all electrical supply equipment been tested and appropriately colour coded?				
2	Has power supply equipment (i.e. generators) been properly earthed? i.e. steel rod placed >1.5m into the ground?				
3	Are all electrical devices covered to prevent exposure to moving/electrical components?				
4	Are all electrical cords suitable for use and in general good condition and free from visible defect?				
5	Are electrical cords and cables situated in safe location? i.e. not creating trip hazard; not placed in puddles etc.				
6	Are electrical power outlets suitable for outdoor use, in general good condition and free from visible defect?				
7	Have all power tools been inspected prior to their use that day, in general good condition and free from visible defect?				
8	Do all electrical distribution boards have GFCI's or residual current devices fitted?				
9	Is there evidence of any power supplies being overloaded i.e. more than one cable running into one plug?				
10	Where cables have been extended, have the correct fittings been utilised and has the connection been made safe?				

Assessment Completed By ……Date/Time……...……..Location……

Excavations and Trenching

No.	Item Addressed	Compliant			Comments
		Y	N	N/A	
1	Is an excavation permit displayed/available at the work location and is it valid and in date?				
2	Has the excavation been inspected by a competent person that day and is that inspection recorded formally and displayed at the work site?				
3	Has the excavation been clearly signed to warn those working around the area? i.e. "Warning - Deep Excavation"				
4	Have suitable barricades been installed around the excavation? i.e. physical barrier for vehicles; soft barrier for pedestrians;				
5	Are all barricades kept at least 1.8m from the edge of the excavation?				
6	Is spoil removed from the excavation kept at a suitable distance away from the edge of the excavation? i.e. at least same width away as depth of excavation				
7	Is the excavation in general good condition with no evidence of cracks/minor collapse of material?				
8	Have excavations deeper than 1.2m been designed to prevent collapse? i.e. use of sloping/benching/stepping				
9	If adequate sloping/benching/stepping is not possible, have the use of trench boxes been used to protect workers from collapse?				
10	Has sufficient access been provided to/from the excavation? i.e. access through barricades; access points every 25ft within excavation				

Assessment Completed By ……Date/Time……...……..Location……

Fire Prevention

No.	Item Addressed	Compliant			Comments
		Y	N	N/A	
1	Is the area free from the accumulation of combustible materials? i.e. oily rags; woods etc.				
2	Are flammable/combustible materials stored away from buildings?				
3	Are general warning signs posted designated fire risk areas?				
4	Are no smoking signs posted in areas where combustible materials/hot works are being performed and is the prohibition adhered to?				
5	Is adequate access/egress from work areas in place should an evacuation be required?				
6	Are flammable/combustible materials kept clear from ignitable sources? i.e. oxygen/acetylene				
7	In areas where refuelling takes place, is the area free from any ignitable sources and is equipment shut off prior to refuelling?				
8	Are flammable liquids in properly labelled containers?				
9	Are fire extinguishers available generally around the work location and specifically close to hot works?				
10	Are fire extinguishers of correct type, maintained regularly, stored safely, in good condition and is signage placed to inform others of their location?				

Assessment Completed By ……Date/Time……..……..Location……

Hot Works

No.	Item Addressed	Compliant			Comments
		Y	N	N/A	
1	Is a hot work permit in place covering the work activity and is it valid, in date, with relevant method statement/risk assessment attached?				
2	Is the area cleared of any combustible materials prior to hot works commencing?				
3	Is a fire extinguisher located nearby and is it of a suitable type, in good condition and maintained?				
4	Are all operatives involved in the operation competent and trained to carry out hot works?				
5	Do all operatives have the correct PPE for hot works? i.e. face/eye protection; flame resistant clothing;				
6	Is a fire watch in attendance at the location both during and 30 minutes after hot works activities?				
7	Is the area signposted and controlled to protect other work areas nearby, where appropriate? i.e. welding screens				
8	Are compressed gases stored upright, valves working correctly and in general good condition?				
9	Do hoses have flashback arrestors installed at both torch and bottle ends?				
10	Is the area well ventilated to minimise inhalation of welding fumes?				

Assessment Completed By ……Date/Time……...……..Location……

Hand Tools and Equipment

No.	Item Addressed	Compliant			Comments
		Y	N	N/A	
1	Are hand tools in good condition and free from any visible defect?				
2	Are hand tools suitable for the activity they are being used for?				
3	Are employees trained in the correct usage of hand tools?				
4	Are employees wearing the correct PPE relevant to the hazards presented by the hand tool? i.e. gloves; additional eye protection; ear protection;				
5	Have hand tools been altered in any way to suit the task being performed?				
6	Are defective tools removed from the site immediately and returned to the stores?				
7	Do all hand tools have the appropriate guarding systems as installed by the manufacturer and have not been tampered with?				
8	For power tools, is the electrical supply safe, in good condition and tagged in date?				
9	Are hand tools of 240v double insulated? i.e. black square denoted on tool				
10	Are electrical sockets adequate, in good condition and not overloaded? i.e. 2 lines into one plug				

Assessment Completed By ……Date/Time……...……..Location……

GROVE
12.22.2010 13:53

HSE INFORMATION BOARD
AIRFILD BRANCH-UTILITY
SEWAGE LIFT STATION
No. 7
خطر
حفريات عميقة
DANGER
DEEP EXCAVATION

REST
SHELTER

THEY EXPECT YOU
TO COME HOME
SAFELY
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