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İSTANBUL KÜLTÜR UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

COMPARATIVE ANALYSIS OF HEALTH AND SAFETY MANAGEMENT IMPLEMENTATIONS IN CONSTRUCTION PROJECTS BASED ON INDUSTRY STANDARDS APPLICATIONS: CASE STUDIES OF TURKEY AND AFGHANISTAN

Masters of Applied Science Thesis

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Masihullah AZHAR

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AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
BSI	British Standards Institution
BTH	Bobcat Telescopic Handler
CCTV	Closed-circuit television
E/O	Extraordinary
H&S	Health & Safety
HSE	Health, safety and Environment
ILO	International Labour Office
ISGÜM	İş Sağlığı ve Güvenliği Müdürlüğü (Labour Health and Occupational safety centre)
ISO	Organization for Standardization
LV	Low voltage
MCDM	Multi-Criteria Decision-Making
MH	Manhours (yearly)
MV	Mega voltage
N/A	Not applicable/ Not available
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Health and Safety Association
PPE	Personal Protective Equipment
QFD	Quality Function Deployment

TCIR	Total Case Incident Rate
TRIR	Total Recordable Incident Rate
UAE	United Arab Emirates
UK	United Kingdom
USD	United States Dollars
WH	Working hours (weekly)

Üniversite : **İstanbul Kültür Üniversitesi**
Enstitü : **Lisansüstü Eğitim Enstitüsü**
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ÖZET

SANAYİ STANDARTLARI UYGULAMALARINA DAYALI İNŞAAT PROJELERİNDE SAĞLIK VE GÜVENLİK YÖNETİMİ UYGULAMALARININ KARŞILAŞTIRMALI ANALİZİ: TÜRKİYE VE AFGANİSTAN ÖRNEĞİ

Masihullah AZHAR

İnşaat sektöründe, sağlık ve güvenlik standartlarının ve yönetmeliklerinin geliştirilmesi, faaliyetlerin doğası ve geçmişte yaşanan yüksek olay ve ölüm oranları nedeniyle ortaya çıkan yüksek riskler sonucunda ortaya çıkan en büyük başarılardan biridir. Mevcut araştırmanın amacı, seçilen inşaat organizasyonları için, işletme alanı ve bağlılığının getirdiği standartlara göre bir uygunluk değerlendirmesi yapmaktır. Çalışma amacının yerine getirilmesi için, ISO ve OSHA tarafından uluslararası standartlara dayalı bir sağlık ve güvenlik değerlendirme kontrol listesi geliştirilmiştir. Kontrol listesi dört ana bölümden oluşmaktadır: operasyonel veriler, sağlık ve güvenlik kayıtları, sağlık ve güvenlik planı ve sağlık ve güvenlik gereksinimlerinin uygulanması. Sağlık ve güvenlik kontrol listesini kullanan değerlendirme iki firmaya uygulanır: biri Türkiye'de, diğeri Afganistan'da. Veriler, saha ziyaretlerine ek olarak firmalar tarafından sağlanan dokümantasyon ve veriler temel alınarak toplanmaktadır. Değerlendirmenin sonuçları, Türk firmasının daha iyi sağlık ve güvenlik kayıtları ve sağlık ve güvenlik gerekliliklerinin uygulanmasını gösterdiğini, Afgan firmasının ise biraz daha iyi bir sağlık ve güvenlik planına sahip olduğunu göstermektedir. Türk ve Afgan firması için kesin puanlar sırasıyla 132 (Kabul Edilebilir) ve 119 (zayıf) olmuştur. Çalışmanın bulgularına dayanarak, her iki firmaya da projelerinde sağlık ve güvenlik planlama ve uygulamalarını ve daha sonra kayıtlarını geliştirmeleri için önerilerde bulunulmuştur.

Anahtar Kelimeler: Sağlık ve güvenlik değerlendirmesi; ISO; OSHA; Türkiye; Afganistan

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ABSTRACT

COMPARATIVE ANALYSIS OF HEALTH AND SAFETY MANAGEMENT IMPLEMENTATIONS IN CONSTRUCTION PROJECTS BASED ON INDUSTRY STANDARDS APPLICATIONS: CASE STUDIES OF TURKEY AND AFGHANISTAN

Masihullah AZHAR

In the construction industry, the development of health and safety standards and regulations is one of the greatest achievements, which emerged as a result of the high risks imposed by the nature of the activities and the high incident and fatality rates experienced in the past. The aim of the current research is to perform a compliance assessment for selected construction organizations based on the standards that imposed by its operation area and affiliation. For the fulfilment of the study aim, a health and safety assessment checklist is developed based on international standards by ISO and OSHA. The checklist consisted of four main sections: operational data, health and safety records, health and safety plan, and implementation of health and safety requirements. The assessment using the health and safety checklist is applied to two firms: one firm in Turkey and one firm in Afghanistan. Data is collected based on provided documentation and data by the firms, in addition to site visits. The results of the assessment show that the Turkish firm demonstrated better health and safety records and implementation of health and safety requirements, while the Afghani firm had a slightly better health and safety plan. The final scores for the Turkish and Afghani firm were 132 (Acceptable) and 119 (weak), respectively. Based on the findings of the study, recommendations were provided for both firms to enhance their planning and implementation of health and safety on their projects, and subsequently their records.

Keywords: Health and safety assessment; ISO; OSHA; Turkey; Afghanistan

1. INTRODUCTION

Health and safety practices and assessment were realized to be important a few decades after the start of the industrial revolution. The first documented records of health and safety records were performed by Du Pont in the early 1800s, where the company strived to keep records of the accidents occurring in its factories, analyse their causes and find prevention measures and plans. The continuous work on health and safety at DuPont led to the formulation of the first health and safety prevention theory in 1891, while the decrease in the number of accidents proved the success in adopting and implementing health and safety standards (Cooney, 2016). The continuous work on accident prevention measures and plans led to the invention and development of different types of personal protective equipment (PPE) and site safety equipment from the nineteenth century onwards (Universal Class, 2015).

The construction sector is one of the most contributors to the gross domestic product of any country, due to its necessity for the development. Subsequently, the construction industry provides employment for a significant percentage of the population; directly and indirectly (Suarez Sanchez, et al., 2017). The direct employment is attributed to the people who contribute to the progress on project sites, while indirect employment is attributed to the people employed in material manufacturing and supply (ILO, 2001). Therefore, it is established that the construction sector is a significant division of the economy based on its financial and employment aspects.

The nature of construction activities imposes several types of risks on the participant workers in any project. Continuous fire and electrocution hazards continuously arise due to the need for storage and use of power on site. Furthermore, the unfinished project contains several elements that lack protection, such as the risk of falling from elevated areas and the risk of falling objects. Other hazards can be recorded in association with construction material that are flammable, poisonous, or radioactive that impose other types of hazards on human health and the environment.

Additionally, many installations put construction workers in positions, where they have to work at heights or confined areas, which increases the possibilities for falling, dropped objectives and entrapment. Other hazards many also depend on the nature of the activities on site, such as electrocutions, lacerations and crushed or lost limbs (Vitharana, et al., 2015). However, the volume of the planned development, the high potential of accidents and the pressures to meet the budget and time limitation on the project can have adverse effects on the implementation of health and safety standards, and subsequently increase incidents on the construction site (Shuen & Abdul Wahab, 2016)

The importance of health and safety practices within the construction sector emerges from the increasing number of injuries that are witnessed through the development process. For instance, occupational accidents in the Turkish construction sector increased by 18.84% between the years 2011 and 2012, while permanent disabilities from construction activities increased by 39.9% at the same period. However, the decreased in fatalities can be attributed to the increased attention towards the significance of health and safety practices (Yilmaz & Celebi, 2015). Another statistics from South Africa showed that construction accidents and injuries costed the construction sector more than 1.9 million US dollars of financial and non-financial injuries in 2010 (Haupt & Pillay, 2016). Thus, construction accidents and injuries form an insisting problem in the sector with effects on human, time and financial losses.

According to Suarez Sanchez, et al. (2017), the interaction in health and safety in the construction site can be illustrated through the cycle of the occupational health and safety. While the construction and development activities are continuing, it is the role of the government and the concerned authorities to develop standards and regulations that contribute into accident prevention. However, the development of these standards and regulations are driven by the accident analysis and risk assessment activities that are performed on-site on a regular basis. The inputs provided by health and safety assessments enable specialist to develop the suitable training and education programs, as well as the risk prevention and control strategies, which ultimately contribute into preventing accidents from happening. The significance of health and safety assessments is evident through its contribution to the necessary measurements before, during and after the incident (Gunduz & Laitinen, 2018)

Due to the high possibility of injuries, which can lead to fatalities, governments and experts from the construction sector developed standards, practices and prevention strategies in order to minimize the number of injuries, with the goal of total elimination. Therefore, safety manuals, compulsory personal protective equipment (PPE) and safety assessment and monitoring became an essential part of the construction sector in order to ensure sound developments with no impact on human lives (Choudhry, et al., 2008).

There are several construction and occupancy health and safety standards and regulations that are established around the world based on the geographical locations or affiliations of the organizations. It is evident that the developed countries, and the majority of the most developing countries, focus on health and safety standards in order to ensure the well-being of the employees in the construction sector, as one of the driving sectors for development (Bilir, et al., 2014). It is important to be target and performance driven to maintain the planned development rate (Molamohamadi & Ismail, 2014); however, these rates can come with a price of incidents that can lead to fatality in some cases (Jilcha & Kitaw, 2016).

Another side of construction health and safety is the extent of implementation of these standards and regulation within the organization in the sector. Therefore, health and safety compliance assessment is a methodology that can provide the status quo of standards' implementation, and facilitate corrective measurements and actions (Marhavilas, et al., 2011)

There are several tools that are proposed for the assessment of health and safety risks and hazards on construction sites. Gunduz and Laitinen (2018) suggested a general safety scoring scale consisting of nine levels, which classifies health and safety risks based on the current level of prevention and control and the potential severity of the incident in case of occurrence. Some studies identified the specific risks associated with each construction activities and the types of injuries and diseases that can be caused by them (Sawat & Birajdar, 2016). Other studies identified the most effective health and safety strategy in order to increase the positive impacts of preventive measures, where conducting regular site safety inspections and providing fulltime safety supervision, as well as providing adequate safety trainings, were the top

influencers on construction safety according to engineers, architects and construction specialists (Priyadarshani, et al., 2013).

Moreover, there are several health and safety standards and guidelines that are developed by government entities in order to impose prevention measures and systems on developers and construction firms. These guidelines are also used by committed firms in order to develop health and safety policies based on their experience and needs. Occupational Health and Safety Association (OSHA) standards for occupational health and safety were developed in the United States based on a government act in 1970, where trainings and regular assessments were enforced on the national construction sector from the following two years onwards (OSHA, 2009). Other standards were developed by international organizations, such as International Organization for Standardization (ISO), where domestic governments worked on developing their national health and safety standards for better communication and adaption to local work environments.

The current research studies health and safety standards, regulations, guidelines and assessment systems in order to develop a comprehensive assessment scale for construction projects. Thereafter, the developed assessment scale is applied to a construction firm in order to measure the scale's success in diagnosing health and safety pitfalls of the participating construction companies.

The main aim of the research is to perform a compliance assessment for selected construction organizations based on the standards that imposed by its operation area and affiliation. The fulfilment of this aim requires achieving the following research objectives:

1. Studying the most implemented health and safety standards that are implemented by construction organizations around the world and enforced by government entities.
2. Understanding the similarities and differences between the different health and safety standards and regulations, especially in the standards and regulations that are adopted in Afghanistan and Turkey, and on the international level.
3. Narrowing the health and safety main requirements into a checklist that can be used for organizational evaluation.

4. Selecting two construction companies as a case study for the research and assessing their compliance with the developed health and safety standards' checklist.
5. Comparing the results with similar ones in the literature and providing the necessary recommendations to enhance the organizations' compliance to health and safety regulations.

Based on these objectives, the main question of the thesis is "What is the extent of health and safety standards and regulations within the selected construction firms operating in Turkey and Afghanistan?"

Many questions are answered through the course of this research in order to provide a justified and structured answer for the main question:

Q1: What are the health and safety standards and regulations that are imposed on the construction sector in Turkey and Afghanistan?

Q2: How does the systems and process adopted by the organization consider the health and safety standards and regulations? i.e. Health and safety manual of the organization.

Q3: What is the perception of the organization towards the necessity and importance of health and safety standards and regulations?

Q4: How are the health and safety standards and regulations adopted by the organization implemented in reality?

Q5: Is there a significant difference between the two companies operating in different countries? If so, what are these differences?

The first question clarifies the legal obligations of the organization towards implementing health and safety within their projects and developments, while the second question measures the internal management response to these standards and regulations. The third question assesses the readiness of the management and employees to enforce compliance throughout the organization. The fourth question leads to answering the main question of the research after defining the imposed and adopted health and safety standards and regulations, the system and process response to them and the actual compliance achieved by the organization towards them. The fifth question adds to the specifics of the main research question on the differences and

similarities in health and safety policies and implementation between the two companies that are selected for the case study.

The current research is focused on developing a health and safety assessment checklist based on standards and regulations that are adopted internationally. The main contribution of the current research to the literature is through developing this comprehensive health and safety assessment checklist that can assist construction companies in evaluating their health and safety status and issues. Such a tool would help managers to discover their shortcomings and propose the suitable measures to enhance their health and safety management in comparison with the relevant regulations and standards. The study is applied to the construction industry; therefore, items in the checklist takes into consideration the common activities that performed on different types of construction projects. The comprehensively of the checklist can be debated, as it is developed based on the available standards and regulations, in addition to the nature of construction activities that are considered and the perspectives of the researcher.

The health and safety checklist is applied on two construction firms, one operating in Turkey and the other in Afghanistan, where the results reflect the status of health and safety within the selected companies. Furthermore, this is the first study that comparatively analyses the two companies operating in different countries, from a holistic perspective on health and safety implementations. Finally, the nature of the study conveys its importance based on the sector it targets and the cruciality of the domain it evaluates.

In order to achieve the main aim of the research, ensure the fulfilment of the subsequent objectives and answer the research questions, the thesis report is divided into five main chapters:

- Introduction: the chapter provides a summary of the subject addressed in the research, defines the main and objectives of the study, structures the research questions and provide the significance of the study and its scope.
- Literature review: a review of the history of health and safety regulations and prevention measures, as well as their importance and statistical evidence of their success. It is essential to understand the direct causes of accidents in the

construction industry and distinguish accident types based on their severity, frequency, and impact. Through the literature review performed in this research, several studies on the root causes and the impact of health and safety on individual, corporation, and industry levels are analysed. The most common health and safety regulations and standards are introduced to define the regulating bodies globally for this domain. Furthermore, the chapter identifies a few health and safety regulations and standards in order to be compared and used to build the health and safety checklist used in the study application. Other health and safety assessment studied are examined in order to survey the previously used techniques and the results yielded through using them. The methods are reviewed based on their aims, complexity, and outcomes.

- Methodology: Health and safety evaluation methods are classified and refined to develop a health and safety checklist for construction companies, which can assist them to ensure that they are on the right track in implementing health and safety standards based on several indicators. A health and safety assessment checklist is developed from the different standards in order to suit the nature of the construction project and its activities.
- Implementation and Results (Case Study): The last stage of the research is implementing the developed health and safety checklist to construction companies. Two construction firms are selected for the implementation of the developed health and safety check list. Information and data about the companies are presented, especially their safety records. Health and safety data are collected from the company targeting several aspects: health and safety records, safety plan and implementation of health and safety regulations and standards. An assessment of the health and safety status of each company using the developed checklist is performed. That provides a comprehensive preliminary evaluation to highlight the strengths and weaknesses in the adopted health and safety policy and measures. After performing the evaluation, recommendations are provided to the participating construction companies in order to enhance their health and safety adoption level, subsequently outcomes.
- Conclusions: a summary of the research is presented, along with the final findings and comparative analysis. Recommendations concerning the

developed checklist, its application and the health and safety status of the selected construction firm are provided, in addition to future opportunities for research.

The checklist is also provided in Appendix A for reference and information.

2. LITERATURE REVIEW

2.1 History of Health and Safety

The realization the challenges of health and safety in construction and manufacturing started with the industrial revolution, as mass workers joined the labour force. The operations carried out by the different activities resulted into different types of injuries and causes for fatalities, which made experts think of methods and techniques to minimize hazards and work to eliminate them. However, the movement towards solutions took separate paths in different countries depending on the experiences that led companies and governments to understand the significance of hazards and the main causes for health and safety incidents (Hughes & Ferrett, 2011).

In the United Kingdom, the construction of the national railway in the 1800s was the main driver for the development of health and safety concerns for the labour unions and the government. In a single segment of the rail network connecting Manchester with Sheffield through a tunnel, thirty-two workers lost their lives, while another hundred forty workers suffered from serious injuries that affected their lives later on. Due to lack of sanitary measures on the project, another twenty-eight workers lost their lives by cholera. The construction projects opened the eyes of the social and professional activists towards the high risks in the construction industry, as they were compared to the death tolls of battlefield. The awareness campaign led to the government issuing a law that imposes the responsibility for the health and safety of workers on their companies. Such a law changed the whole perception of the British companies towards their employees and gathered momentum over the following hundred years to find solutions for the health and safety problem (Crates, 2017).

Nonetheless, the attention towards health and safety continued to be inadequate in the United Kingdom up to the 1960s, which was changed by another governmental action, which is the work act of 1974 that followed the death of 166 workers in the construction sector in that year. The construction industry was responsible for more

than 25% of the total workplace fatalities in 1974 (Almond & Esbester, 2019). In the 1980s, massive governmental awareness campaigns were established in order to encourage workers to use safety equipment or warn them from the usage of old and unsafe tools. Posters were distributed throughout the major construction projects for that purpose (Turk, 2018), as shown in the examples presented in Figure 2.1.

In the 1990s, the focus was drawn more towards the main causes of incidents in the construction site, such as falling from heights. The introduction of modern plants and equipment, as well as the persistence on using personal equipment (PPE) with a government act in 1993, helped enhancing safety records in the country and reducing the death tolls by 85% between the 1800s and the 1990s (Turk, 2018). The continuous persistence through the 2000s on health and safety in the construction industry led to eliminating fatalities on some mega projects such as the Olympic park, which completed more than 60 million manhours with zero deaths. However, two out of each 100,000 construction workers lose their lives in the UK, calling for the need for more developments in health and safety measures (Crates, 2017).

Figure 2.1: Posters used by the British Safety Council to increase safety awareness in construction projects in the 1980s

In the United States, the realization for the importance of health and safety followed a similar timeline to that of the United Kingdom. The attention was first drawn to the deaths caused by the mining industry, reaching to the continuous labour rights and health and safety acts in the 1970s (Institute of Medicine, 2000), as shown in Figure 2.2.

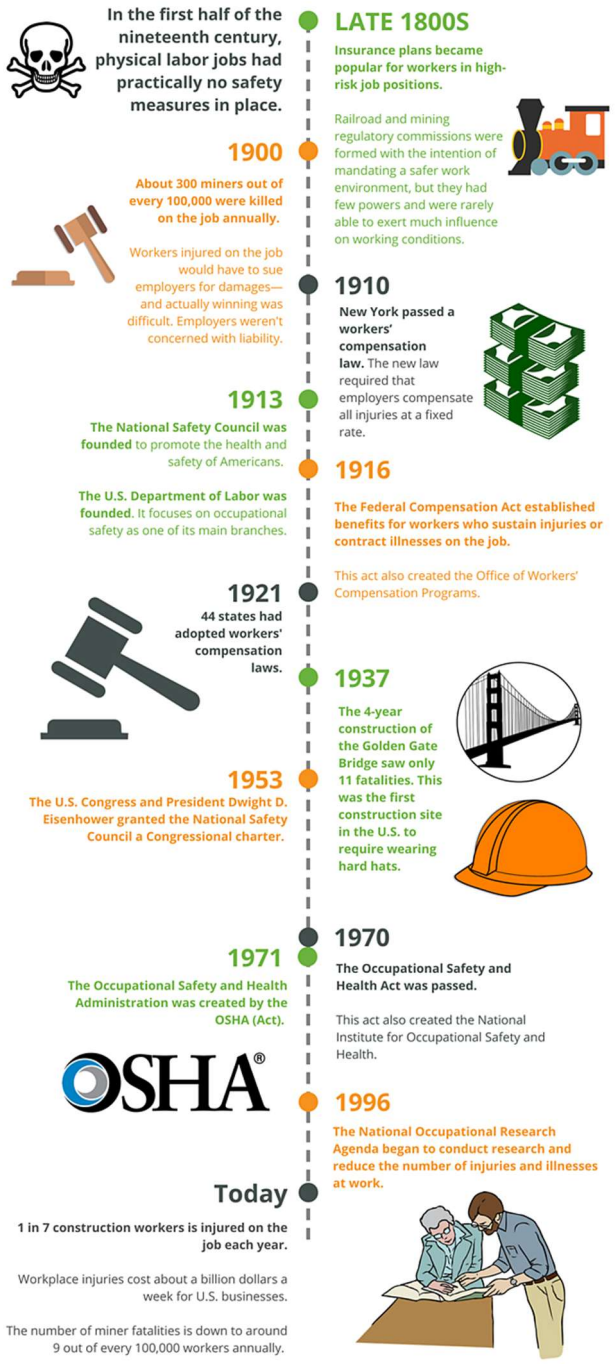

Figure 2.2: History timeline of health and safety development in the United States

2.2 Health and Safety Issues, Causes and Prevention Measures in Construction

There are several studies that worked on identifying the different types of issues or incidents in the construction site and their causes. The classification of the incident types is based on their impact on the worker and the construction operations at different levels. The main indicator of importance for an incident type is the frequency of its occurrence. According to statistics from the British construction industry in 2013, the main cause of fatalities in construction site is falling from a height, which formed 39.3% of the total fatalities. Other incidents related to contact with moving machinery or a falling object were also responsible for a significant percentage of fatalities at construction sites in the same period. Moreover, falling from a height was the direct cause for 30.6% of major injuries and 11.3% of moderate to minor injuries. Major injuries were also caused by tripping or falling at the same level (27.4%), while the most frequent cause of the moderate and minor injuries was lifting, carrying and handling objects (30.1%) (Bhole, 2016).

It is established that injuries and hazards on the construction project are related to the nature of the activity. Therefore, several items were identified as the main health hazards on the construction site, as shown in Table 2.1. Hazards are divided into two main categories: hazards with chronic impact and hazards with acute impact. Hazardous substances were identified in the literature as the most frequent cause for chronic injuries, followed by physical hazards, corrosive material and skin irritants. Acute injuries were mostly correlated to falling from heights and electrocutions. Other hazards including ladders, working at roofs, machinery usage and fire hazards were also important causes for acute injuries (Vitharana, et al., 2015).

Table 2.1: Identification of health hazards in construction

Hazards with chronic impact	Hazards with acute impact
Hazardous substances	Falling from heights
Physical hazards (noise, heat, radiation)	Electrocutions
Corrosive material	Ladders
Skin irritants	Working at heights
Welding	Material handling
Contaminated material	Usage of tools and machinery
Vibratory tools	Handling of chemicals
Confined spaces	Fire hazards
Working with lack of adequate light	Excavation
Dirty water	

Several causes were related to the identified construction hazards, which were categorized under five main points:

- Hazards related to safety equipment due to labour dislike or lack of awareness PPE, or the unavailability of adequate PPE (Rameezdeen, et al., 2003).
- Hazards caused by safety management practices due to inadequate training and knowledge of safety managers or inadequate staffing of safety officers to monitor and enforce safety practices (Shibani, et al., 2013).
- Hazards arising from awareness issues by either its lacking towards safety regulations and practices, or the lack of willingness to follow them (Charehzehi & Ahankoob, 2012).
- Hazards caused by inadequate safety training or inadequate technical training with the related safety practices (Shibani, et al., 2013).
- Hazards related to other types of safety issues such as inadequacy of safety measures on site, unsafe behaviours that do not follow the safety regulations, and irresponsible behaviours by working under the influence of drugs or alcohol (Jackson, et al., 2011).

The most frequent cause of accidents in the construction site is falling from heights, which is imposed due to the nature of some of the activities that require

workers to work on scaffoldings, ladders and roofs. The cause of the injury or fatality is the impact after falling or jumping between two elevated levels. The root cause of these accidents vary between unprotected edges or openings, unsafe scaffolding, unsafe scaffolding construction or dismantling practice, overstretching to reach work areas that are beyond scaffolding or roof, improper hinging or securing of scaffolding against a stable structure, improper inspection of scaffolding by competent personnel or the lack of use of safety harnesses or their improper usage. Injuries vary due to this hazard from fractures in different body parts to intrathoracic injuries. The main prevention measures is implementing safety codes and regulations in securing edges with guardrails (Figure 2.3), using safety harnesses correctly with the required safe anchorage distance (Figure 2.4), increasing awareness and training on these types of hazards and their safety measures, ensuring the construction, dismantling and inspection of scaffolding and roofing structures by competent personnel, and prioritize testing permanent and temporary structures for stability (OSHA Training Institute, 2011).

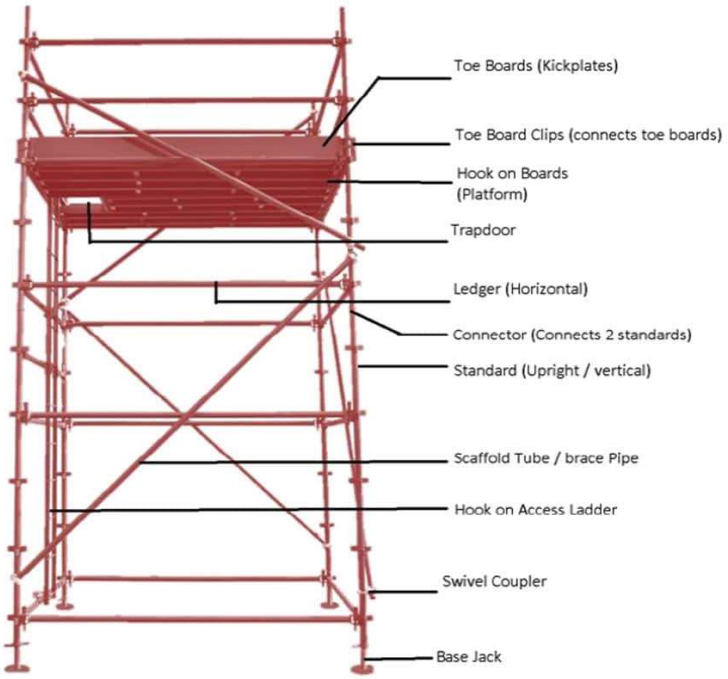

Figure 2.3: Scaffolding assembly with guardrails and toe boards

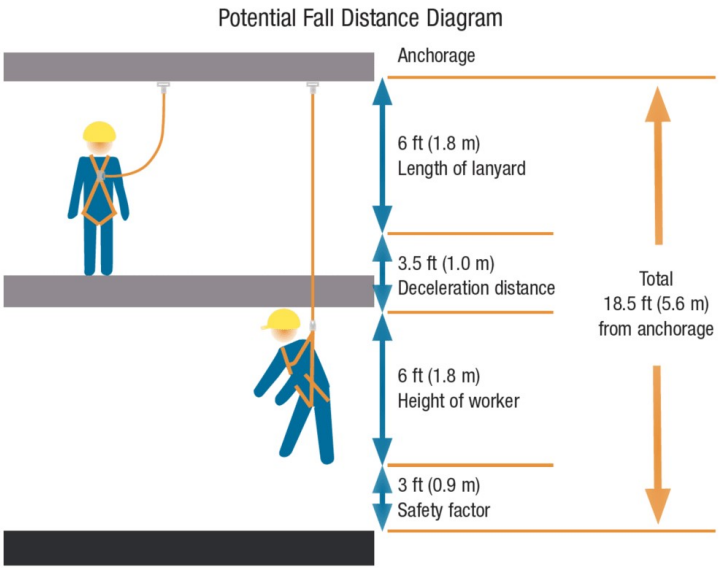

Figure 2.4: Calculation for safety harness safe distance

The second most frequent hazard in the construction site is tripping and falling on the same level due to unorganized work areas, poor housekeeping or uneven floors. The cause of injury under this hazard is the impact or friction of the worker body against floor, tools or material. The tripping, slipping or falling can be caused by spills of liquid or rainwater, transition between wet and dry areas, dusty surfaces, availability of inclinations with poor lighting, improper footwear (Figure 2.5), lose or greasy flooring, uneven or missing floor tiles, damaged stair steps and lack of handrails, unorganized electrical cables that are properly placed, or ramps lacking skid resistance. The injuries from this hazard vary from cuts and bruises to fractures. The prevention measures include frequent and proper housekeeping (Figure 2.6), elimination of wet surfaces, avoidance of pathway obstacles, placement of adequate lighting throughout the site, adequate footwear and increase awareness and training towards the hazard and encourage workers to increase their alert level during mobilization (Safe Work Australia, 2012).

Figure 2.5: Example of improper footwear on the construction site

Figure 2.6: Examples of poor (up) and good (down) housekeeping in construction site

Electrocutions are the third most frequent cause of injuries and fatalities on in construction, which are often a result of unfinished electrical systems and exposed wiring. The cause of injury is the electrical current impact on body systems when encountering an electrical hazard. Several practices cause the increase of the probability of the occurrence of electrocution including presence of water pools on site, improper earthing of electrical tools, not fitting power sockets with residual current device or a breaker, electrical current leakages from tools, and not disconnecting electrical supply prior carrying out works on the system. Injuries from electrocution vary between burns, shocks and fatality. Prevention measures for this hazard can be implemented through proper PPE, regular and frequent inspections of electrical cords and tools, providing adequate electrical safety training for the workers, ensuring that machinery and tools are correctly earthed, checking wires for tears and wears, disconnection of power supply prior carrying out electrical works, ensuring a safe distance from overhead power lines, and avoiding the use of metal tools near power supplies (OSHA Training Institute, 2011). Moreover, Table 2.2 shows a summary of the most common hazards on construction sites, along with their injuries, causes and prevention measures.

Table 2.2: A summary of the causes and prevention measures of the most common hazards on the construction site

Hazard	Injury	Common causes	Prevention Measures
Falling from height	Fractures Intrathoracic Fatality	• Unprotected edges or openings • Unsafe scaffolding • Unsafe scaffolding construction or dismantling practice • Overstretching beyond scaffolding or roof • Improper hinging or securing of scaffolding • Improper inspection of scaffolding • Lack or improper of use of safety harness	• Guardrails • Using safety harness correctly • Increasing awareness and training • Use competent personnel for scaffold construction and inspection • Testing permanent and temporary structures for stability

Table 2.2: A summary of the causes and prevention measures of the most common hazards on the construction site

Hazard	Injury	Common causes	Prevention Measures
Tripping and falling on same level	Cuts Bruises Fractures Fatality	• Spills of liquid or rainwater • Transition between wet and dry areas • Dusty surfaces • Inclinations with poor lighting • Improper footwear • Lose or greasy flooring • Uneven or missing floor tiles • Damaged stair steps • Absence of handrails • Unorganized and misplaced electrical cables • Ramps lacking skid resistance	• Frequent and proper housekeeping • Elimination of wet surfaces • Avoidance of pathway obstacles • Adequate lighting • Adequate footwear • Increase awareness and training • Increase worker alert level during mobilization
Electrocutions	Burns Shocks Fatality	• Presence of water pools • Improper earthing • Lack of electrical breakers • Current leakages • Not disconnecting power supply	• Proper PPE • Inspections of electrical cords and tools • Adequate electrical safety training • Ensuring correct earthing of tools and machinery • Checking wires for tears and wears • Disconnection of power supply when working on systems • Overhead power lines safe distance • Avoiding metal tools near power sources and tools
Hits by flying, falling, swinging or rolling objects	Fractures Smashing Intrathoracic Fatality	• Equipment failures • Unavailability of toe boards at edges • Lack of machinery driver attention during movement • Tripping	• Equipment and machinery inspection • Proper PPE • Use of toe board • Training for new workers • Barricades around excavators and cranes

Table 2.2: A summary of the causes and prevention measures of the most common hazards on the construction site

Hazard	Injury	Common causes	Prevention Measures
			• Adequate warning signages • Adequate training for crane and excavator operators • Increase worker alert level during mobilization
Falling objects and material	Cuts Bruises Fractures Brain damage Fatality	• Placing material at edges • Improper stacking of material • Lack of required enclosures around material • Improper fencing of work areas • Working on two levels at the same time • Improper communication between machine operator and other workers • Tipping over of vertically placed panels and pipes	• Use and inspection of suspended working platforms • Proper material placement and stacking • Provide needed enclosures around material • Alert working mode for crane and machinery operators • Hand signals and communication • Proper PPE, especially helmets all the time • Avoid access under scaffolds • Avoid high stacking • Securing tools when working at higher levels • Staying within the lifting capacity of cranes and machinery
Fire	Burns Fatality	• Flammable liquids • Welding and metal cutting • Gas cylinders and chemical leaks • Sparks from electrical sources • Combustible material • Inadequate training	• A fire protection plan for the site • Proper firefighting equipment depending on activity • Prioritizing construction of exits and firewalls • Installation of fire alarm systems • Fire safety trainings

Table 2.2: A summary of the causes and prevention measures of the most common hazards on the construction site

Hazard	Injury	Common causes	Prevention Measures
			• Appointing fire marshals for each team

2.3 Root Causes and Effects of Health and Safety on Construction

Understanding the effects and root causes of health and safety issues in construction leads to indications and diagnosis strategies that can help for problem definition and future planning. Furthermore, it is suggested that adopting health and safety policies and regulations and implementing them on construction projects has positive effects on the worker, his family, the construction company, the community, the environment and the country, while accidents similarly have negative effects (Kawuwa, et al., 2018). Diugwa, et al. (2012) studied the implications of health and safety regulations and standards on the construction industry in Nigeria. Through collecting 217 valid questionnaires from employees in the construction industry in the country, the authors found several effects on the employees and outcomes of the operations. Despite the state efforts on implementing requirements, the results expose a high level of lack of awareness of health and safety processes and policies among the construction employees.

The majority of the construction companies did not have a health and safety policy, while a big percentage only had safety processes implementation when accidents or near misses occur. Only 20.5% of the participants indicated that their companies or projects had health and safety representatives, while the vast majority were not aware of the health and safety regulations in the country (Diugwa, et al., 2012). The results of such level of implementation of health and safety regulations and policies in Nigeria costs the country 2.8 million fatalities and 374 million non-fatal injuries annually (AllAfrica, 2019). Such results suggest a high correlation between health and safety regulations and policies and the fatality and losses level on the project and country levels.

In addition to the direct accident causes in construction that were reviewed earlier, research studied the indirect causes in order to ensure solving the problem from its roots. Kavya and Pradeep (2019) analysed data from several construction workers, where communication was highlighted as one of the main root causes from construction accidents. The results show that different aspects of communication on site play a role in influencing probability of accidents, including the existence of proper and continuous communication between management, supervision and workers, as well as the mode of communication and the used signal system on site.

Bakeli and Hafidi Alaoui (2018) classified the root measures and their effectiveness in influencing health and safety in construction projects through a hierarchy structure for the risk management practice, as shown in Figure 2.7. The highest level of health and safety risk management is elimination through removing the reasons that can lead to accidents. The second level is substituting the hazard through an alternative construction method or adopting a different sequence or approach. The third level is isolating people on the site from safety risk sources. The fourth level is to change the methods used in the construction site. The last measurement would be implementing a stringent PPE policy and monitoring mechanisms in order to ensure all people on site conform to using the basic and activity-specific requirements.

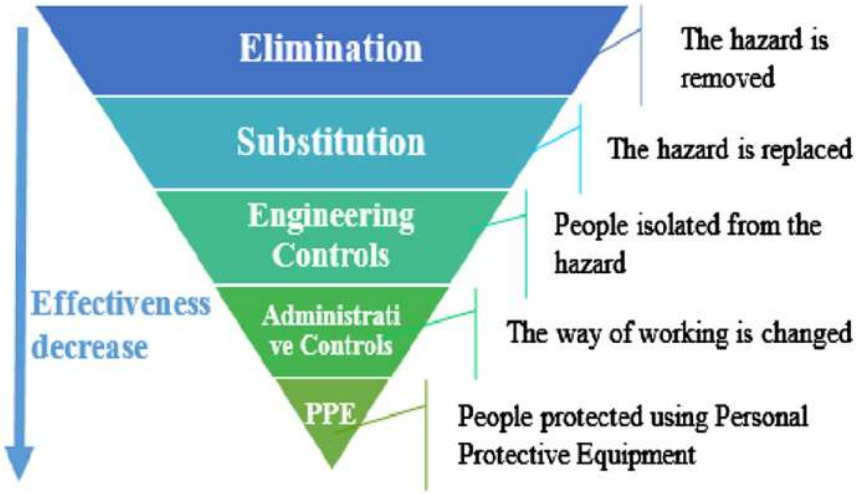

Figure 2.7: Health and Safety risk management and control hierarchy

Sarkam, et al. (2018) tested a framework for the effect of three factors on construction safety performance: management commitment, time barriers and safety awareness. The authors used a questionnaire tool, where workers, safety officers and site managers participated. The correlational analysis showed that safety awareness had the strongest relationship to safety performance with a positive and strong relationship ($\rho = 0.739$), followed by time barriers with a positive moderate relationship ($\rho = 0.574$) and management commitment with a positive moderate relationship ($\rho = 0.326$). The multiple regression analysis performed reflected similar results; however, management commitment was shown with a higher impact that time barriers. The multiple regression model indicated that the combination of these three factors has a high potential in influencing safety in construction projects as the R square value was shown as 0.615, with $p < 0.05$ significance level.

Lyu, et al. (2018) studied the correlations between safety behaviour, safety climate and safety outcomes in fifteen construction sites in Hong Kong. The theoretical model of the study is shown in Figure 2.8, where safety climate is expected to positively affect the safety behaviour of the workers, and subsequently affect safety outcomes negatively. The research adopted a questionnaire methodology distributed to 289 foreign workers from Nepal and Pakistan. Three main factors with sixteen indicators were used to evaluate safety climate, while safety outcomes where measured through frequencies of injuries and near misses from each worker's perception. The safety behaviour was evaluated through the extent of participation and compliance of the workers into the site safety requirements. The regression analysis of the data showed a positive impact from the safety climate on safety participation (F=0.491) and safety compliance (F=0.395). Negative impacts on safety outcomes by safety participation (F=-0.342) and safety compliance (F=-0.207) were also found, as expected by the study model.

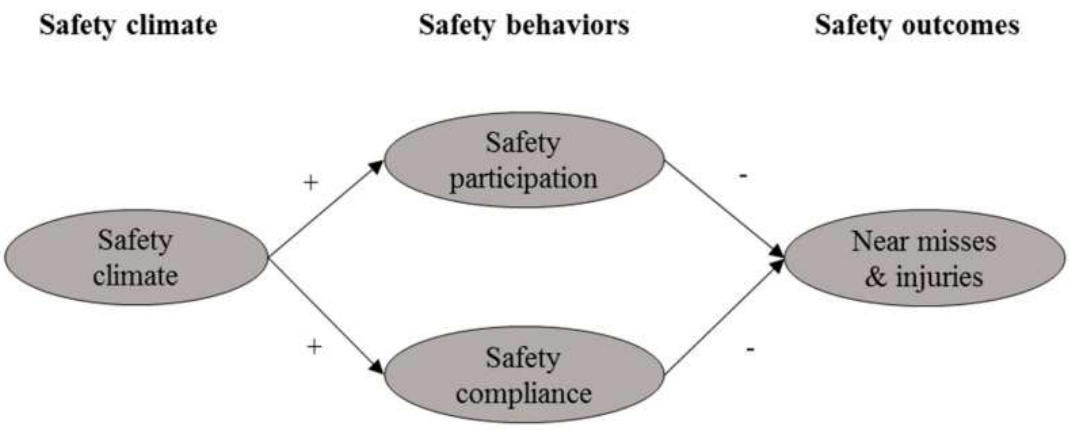

Figure 2.8: Theoretical framework on the impact of safety climate on safety outcomes

The negative impacts of health and safety risks are various on the employee, the company and the community. Olouch, et al. (2017) studied the effect of health and safety hazard on different aspects of the business environment. The research adopted a case study on three industrial water companies in Kenya, which perform several construction activities. The correlational analysis indicated a negative relationship between health and safety hazards and the work environment. Moreover, the study ranked the types of hazards based on the respondents' answers, where the most high-risk types were biological and chemical hazards.

Udo, et al. (2016) assessed the negative impacts of recklessness towards safety measures on Nigerian construction sites through a questionnaire methodology with 114 construction employees. The negative impacts were ranked from the most frequent to the least as, including but not limited to:

- Employee demotivation and decreased morale
- Bad company reputation
- Increase of construction costs
- Damages to equipment
- Costs for injury and death claims
- Disrupted construction activities and operations
- Costs for repairs and reworks

- Disqualification for future business opportunities
- Human physical injuries
- Costs for lost time and compensations
- Reduced operational efficiency

It is observed that financial implications are imposed on construction projects due to ignoring or not fully implementing health and safety measures. These implications form a significant part of the negative impacts that accompany such a strategy in site management. Therefore, a study estimates that financial losses and additional costs are positively proportional to the degree of health and safety policy and regulation implementation (Muhammad, et al., 2015).

Similarly, there are several practices that were proven efficient in enhancing health and safety outcomes on construction sites. Aboagye-Nimo and Emuze (2016) showed evidence from four construction sites in South Africa that safety hazards and risks can be reduced significantly through proper housekeeping. The created Hawthorne effect led to creation of a sense of awareness for the workers, reducing safety incidents and impacting the records positively. Moreover, Bahn and Barratt-Pugh (2013) showed that the implementation of state safety legislations and the imposed induction safety training had positive impacts on employees and business benefits, as well as the reduction in accident rates on Australian projects.

Famakin, et al. (2012) performed a subjective evaluation on the impact of health and safety legislations and measures on several construction project aspects. The study collected questionnaires from fifty-five executive level employees in the sector. Quantity surveyors indicated that client's satisfaction was the most advantage achieved by health and safety legislations. On the same scale, architects indicated cost as the most advantageous aspect, while engineers and contractors indicated worker's health and safety as the most important objective achieved. On the impact on project performance, the implementation of health and safety legislations was found to primarily enhance quality, environment, maintenance, as well as increasing productivity and profitability. Another finding of the study is the difference in views and perception towards health and safety regulations and their impacts between the contractor and the consultant, despite the agreement of both on their high importance.

Adeyemo and Smallwood (2017) performed a similar research on the impact of health and safety regulations on construction project performance through surveying the opinions of forty-nine employees from client, consultant and contractor firms in Nigeria. The client and consultant employees had a consensus that health and safety regulations' implementation predominantly impact the project's performance through reducing cost overruns; however, the client employees indicated productivity as the second most affected performance factor. The consultant employees indicated quality issues and time losses as the second most affected performance factors on the project by health and safety issues. Nonetheless, the contractor employees indicated productivity, time and cost, respectively, as the most affected performance factors in construction projects.

2.4 Health and Safety Standards and Regulations

There are several domestic and international health and safety regulations, acts and standards that are adopted according to the geographic location of the construction project and the affiliation of the stakeholders. For the benefit of the current research, three occupational health and safety standards and regulations are introduced.

2.4.1 ISO standards (UK-BSI)

The International Organization for Standardization (ISO) provides a few codes for occupational health and safety, which can be applied to construction and industrial companies and projects. ISO 45001:2018 is a set of health and safety requirements, which is an update to the ISO 18001:2007. The ISO 45001 is a comprehensive occupational health and safety system that provides an integrated approach with the organization's plan, empowers the engagement of all employees and ensures the integration of health and safety into the business process (NSF, 2018). The ISO standards identifies the several parties that need to participate in health and safety in order to ensure the most comprehensive planning and execution, as shown in Figure 2.9.

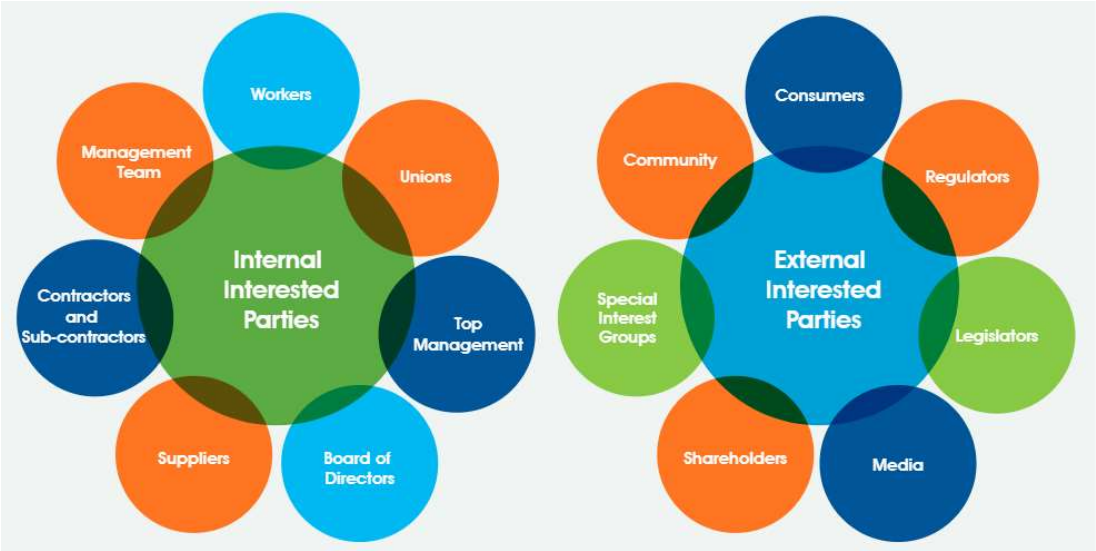

Figure 2.9: Stakeholders participating in construction health and safety according to ISO 45001:2018

The requirements of the ISO 45001 define the context of the construction organization as the key player in planning, implementing and auditing health and safety. Furthermore, the standards emphasize on the importance role of a strong leadership in driving the required changes and ensuring full worker participation into all processes. Planning is one of the most important steps identified by the standards, where hazards are identified, requirements are determined, and action plans are produced in accordance with business and health and safety objectives. The ISO standards also define the communication channels that need to be established with in internal and external stakeholders in order to support planning and execution. Hazard elimination, change management, procurement, response, performance evaluation and corrective actions are all important topics that are included in the ISO 45001, providing a comprehensive view on all health and safety necessities for the construction industry (ISO, 2018).

2.4.2 OSHA and NIOSH (USA)

As a result of the Occupational Safety and Health Act approved by the United States Congress in 1970, the Occupational Safety and Health Administration (OSHA)

was established to monitor the health and safety of all-American workforce. Subsequently, OSHA have produced many documents with guidelines and regulations on health and safety, which includes the construction sector. OSHA have issued their requirements that include instructions on PPE, machinery and vehicle operations, violence in the workplace, surfaces' safety, hazard communication, safety of energy sources, confined spaces, first aid requirements, hearing at site, fall protection, respiratory protection, bloodborne pathogens, ergonomics, radiation, electrical safety, protection during incident investigation, employee assistance, medical management, decontamination and field staff exposure monitoring. For each of these sections, the instructions provide definitions, scopes, responsibilities and procedures to be followed during the planning and the execution of the construction operations (OSHA, 2011).

Moreover, the National Institute for Occupational Safety and Health (NIOSH) is responsible for conducting a continuous research on health and safety issues and challenges in order to issue the required recommendations to federal agencies for actions and implementation. Both OSHA and NIOSH offer different types of certifications on the individual and organizational levels for training and compliance (NIOSH, 2019).

2.4.3 ISGÜM (Turkey)

The research and guidelines were established since the middle of the nineteenth century in order to regulate and provide proper procedures for mining workers. Since then, Turkey has been a pioneer in the field of occupational health and safety through a strong relationship with the International Labour Organization (ILO) in order to cooperate with worldwide nations in developing and implementing health and safety requirements. In 1969, the Labour Health and Occupational Safety Centre (ISGÜM) was established with the support of ILO and the United Nations (ISGÜM, 2018).

ISGÜM provides variety of services in training, testing and quality control that support its purpose of maintaining and monitoring health and safety in the country. Furthermore, the agency provides health and safety principles and guidelines to construction, industrial and mining companies that include requirements on environment, personal and task health and safety (ISGÜM, 2019).

2.5 Construction Health and Safety Assessment Studies

There are several methods that can be used for health and safety assessment, where the selection of the method mainly depends on the outcome desired. A diagnostic approach can be adopted through comparing safety records between two companies or countries or more in order to discover pitfalls and their presence. Such an approach is illustrated in the studies of Bakeli and Hafidi Alaoui (2018). A more detailed and comprehensive approach can be observed by the study of Phoya (2012), where health and safety records and perceptions were correlated to root causes, such as organizational structures and risk management processes and controls. Other approaches were also used through comparing against health and safety standards in different countries, as shown in the study of Pathak and Jha (2015), where a safety performance index was developed.

Muiruri and Mulinge (2014) performed a preliminary evaluation of health and safety in the construction sector in Kenya. The analysis included the health and safety measures by the companies and the legislations and their enforcement by the government. In health and safety measures, the authors focused on site planning, PPE, availability of first aid kits, accident reporting systems and processes, warning signs, safety policies, risk assessments, trainings, facilities and the working environment. The evaluation uncovers a huge gap in the implementation of the basic requirements for construction health and safety in the country. Despite an effective law issued by the government on the compulsory nature of health and safety requirements, the laws and acts remain not enforced, which causes the construction companies to ignore it due to lack of awareness or for cost saving that does not take into account human losses as part of it.

Bakeli and Hafidi Alaoui (2018) performed a health and safety diagnosis for construction projects in Morocco in comparison with different countries: United Kingdom, United States, Australia, Ireland, France and European Union. The authors used the fatality rate per 100,000 employees as a basis for comparison based on official numbers from the concerned authorities. Based on the statistics of health ministry in Morocco, the fatality rate of the employees was 47.8 in 2013, which is 13.8 times the same rate in the United Kingdom, 6.8 times the same rate in Australia and 4.1 times

the same rate in Ireland. The authors recommended immediate reassessment of the health and safety policies and measures implemented by the construction companies in Morocco through targeting the root causes of the problem starting from the management level.

Phoya (2012) performed a more comprehensive assessment of two construction sites in Tanzania. The research commenced with a pilot study, where interviews with site managers were conducted and surveys were taken by workers on site. The main aim of the pilot study is to perform a general evaluation of the status of health and safety in the construction industry in the country. Thereafter, a deeper analysis was carried out to understand natures of the projects, their risk assessment process, communication tools and channels, controls, legislation systems, organizational structures, nature of individuals and work environments. Through studying these factors in conjunction with the health and safety data collected in the pilot study, the author was able to provide specific recommendations to both projects in order to enhance health and safety awareness, systems and records.

Pathak and Jha (2015) used a more complex method for assessment through analytic hierarchy process (AHP) through compiling a three level of health and safety attributes and performing a pairwise comparison between them by thirty construction companies in India. The first level of attributes were policy, process, personnel, and incentives, followed by fourteen attributes in the second level and forty-five attributes in the third level. The results of the research showed that policy is the most important health and safety attribute in the construction industry, followed by processes, personnel, and incentives, respectively. Further ranking was also implemented to the second and third levels of attributes highlighting more specific aspects of each main attribute through its relative importance and contribution to health and safety in construction.

Another study used a hybrid multi-criteria decision-making method in order to create an assessment tool for health and safety in construction demolition works. The research used quality function deployment (QFD) with analytic network process (ANP) in order to create priorities for construction risks based on their importance. Through identifying the set of activities taking place during demolition works, the

authors were able to identify the associated risks with each activity. A relationship matrix between the health and safety risks was constructed and evaluated by field specialists. The evaluation provided a priority for health and safety risks during one of the most common parts of many projects. Nonetheless, the real outcome of this study is the ability to identify the risks in construction works based on their importance and the possibility to apply this technique to more complex projects, which can assist site managers to strategize their health and safety measures (Fauzey, et al., 2015).

A more simplified assessment method using relative importance and comparison between attributes is used by Kadiri, et al. (2014). The authors used a questionnaire in order to compile the causes of construction accidents from construction companies in Nigeria. Using seventy questionnaires, twenty-five factors that affect health and safety in construction sites were collected. Moreover, the factors were ordered based on their relative importance, where the top three factors were lack of attention by supervisors, irresponsible and careless actions, and poor health and safety awareness by the managers. These results unveiled the huge issue in health and safety leadership in Nigerian companies. Although the authors used a simple method, such research assessment strategies are beneficial in finding major issues in health and safety in the construction industry.

3. METHODOLOGY

3.1 Methodology Design

A structured approach is adopted in the research in order to ensure a sequenced development. The study is developed through three main stages: research planning, theoretical framework and method design, and implementation and final outcomes, as shown in Figure 3.1.

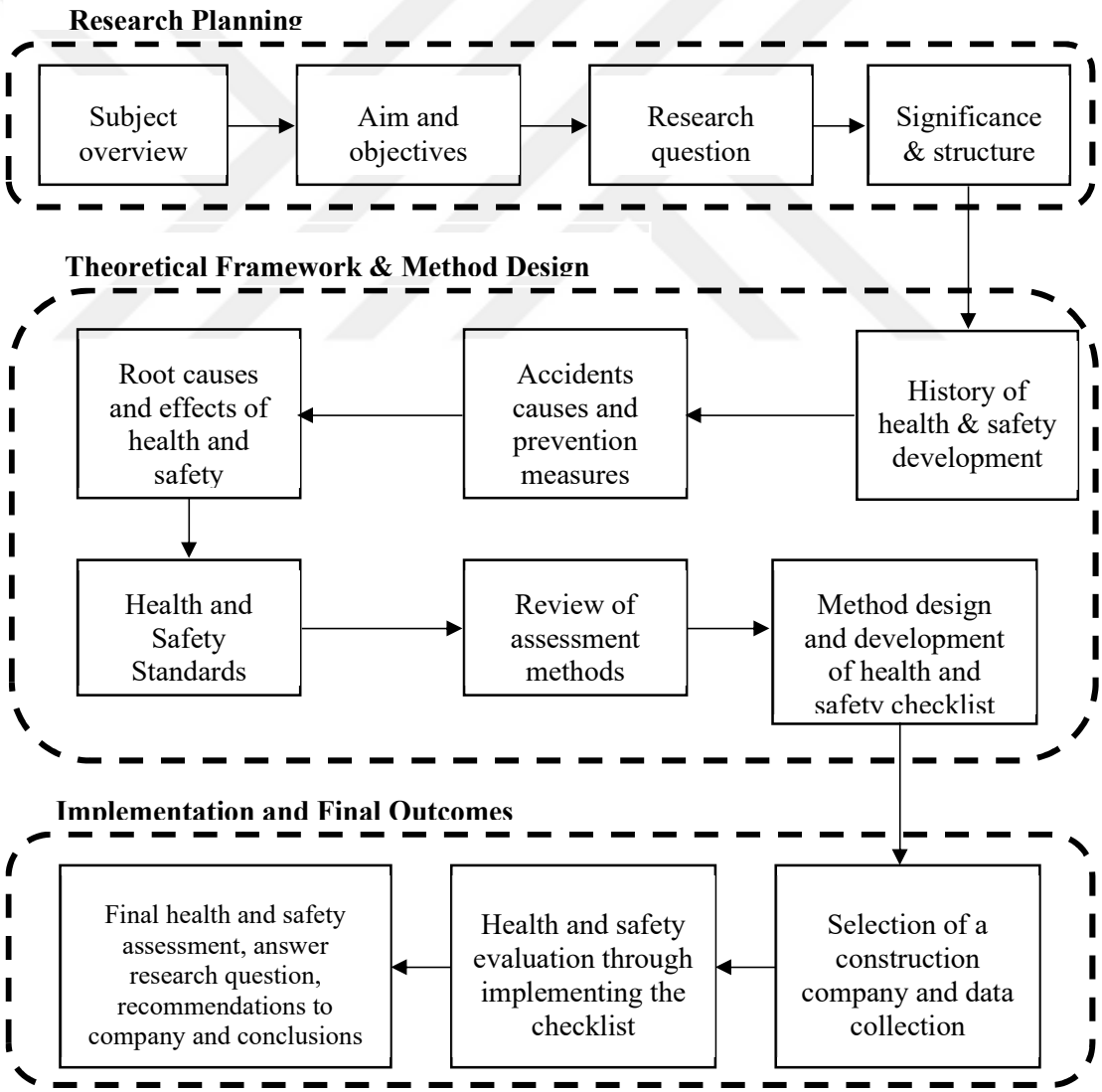

Figure 3.1: Flowchart of research and method design

In the planning stage, the researcher carried out a general knowledge review of the literature, specified the aims and objectives of the study, structured the research question and detailed the significance and structure of the research in order to highlight its contribution to the literature.

Health and safety evaluation methods are classified and refined to develop a health and safety assessment checklist is developed from the different standards in order to suit the nature of the construction project and its activities.

Health and safety at any given construction company or project can be assessed through several indicators and methods. Depending on the objectives of the assessment, a few or all indicators can be included in the evaluation. Through the review performed in the previous chapter that different health and safety indicators are considered, as well as several levels of assessment complexity. There are three main dimensions within various indicators can be used in health and safety evaluation in construction projects:

- Health and safety records: the types and frequency of accidents, in addition to their severity and impact, are key indicators for the success of health and safety planning, risk assessments and measures on site. Other indicators can be added, such as cost of accidents and lost manhours, which give further understanding of the effect of the occurred accidents on construction operations and project controls.
- Company and project health and safety plan: a general occupational health and safety plan is a standard requirement from all companies, especially the ones operating the construction sector. However, a more specific health and safety plan can be developed for each project undertaken by the company in order to consider the special measures and processes based on project activities and requirements. Health and safety plans are assessed based on their comprehensiveness, detailed measures, and enforcement on the project.
- Implementation of health and safety precautions and measures: for each type of construction activity, there are specific health and safety requirements that need to be implemented depending on its nature and the tools used during performing it. Additionally, there are general health and safety measures that

always need to be enforced within the premises of the construction site, such as PPE.

In the literature, authors considered different types of methods to evaluate these health and safety dimensions. The choice of indicators varied between different methods based on their level of detailing. Some authors provided preliminary assessments through understanding the general levels of availability and enforcement of one or more of these dimensions. Nonetheless, a more detailed approach was adopted through developing a set of specific key indicators and using more complex methodologies, e.g. MCDM, to determine their importance or impact on health and safety in the construction industry. Studies also differed based on the level of implementation. While some studies assessed health and safety for the construction sector on the country level, other studies chose specific construction companies for the evaluation and comparison.

The methods of evaluation differed between studies between subjective and objective formulation of the indicators. Subjective evaluations mainly measure the opinions and perceptions of construction employees and experts towards specific aspects of health and safety, which provides an understanding for the researcher on the importance and level of enforcement of health and safety measures on the project. The results of the subjective evaluation are considered important; however, they do not provide an actual measurement of health and safety. The objective evaluations are more solid in terms of outcome as it measures the indicators through numbers and actual facts that can be compared to with previous or future assessments, as well as evaluations that are carried out in other companies, sectors or countries.

In the current research, the three dimensions of health and safety assessment are included, and an objective measurement method is used. Health and safety records over the past 5 years, the most updates general and specific health and safety plans, and actual health and safety measures on site are used. Further details on the developed checklist are provided in the next section.

3.2 Health and Safety Assessment Checklist and Limitations

For the implementation of construction health and safety assessment, a comprehensive checklist is developed based on the three main dimensions of health and safety and the requirements of health and safety regulations and standards on the domestic and international levels. The health and safety standards that are considered for this evaluation are the ISO 45001:2018, OSHA guidelines and ISGÜM/ ILO requirements. The template of the developed health and safety checklist is provided in Appendix A, which shows the format used to collect data from the participating companies for assessment. All dimensions and indicators are judged using an objective method based on numbers and actual levels of inclusion and implementation. Therefore, the outcomes of this assessment serve the main aim of the research by providing a compliance evaluation against domestic and international health and safety standards. The results of the evaluation should also provide an effective comparison tool within other companies in the sector, as well as an indication of the levels of health and safety within the current operations, systems and process adopted by the construction company.

The developed health and safety checklist is divided into four main sections, as provided in the following sections. The maximum points shown in each section is based on the perfect score a construction company can achieve on the developed checklist.

3.2.1. Section A of the H&S Checklist

This section records operational data on projects values in US dollars, deployed manpower and total manhours in the past five years from 2015 until 2019. It is structured as shown in Table.3.1.

Table 3.1: Section A of H&S Checklist – operational data

Section A: Operational Data	**2019**	**2018**	**2017**	**2016**	**2015**
Total projects' value (M USD)					
Deployed Manpower					
Total worked manhour (A1)					

3.2.2. Section B of the H&S Checklist

Section B records data using health and safety records such as, numbers of minor, moderate, and severe injuries, and fatalities. Cost of health and safety accidents and lost manhours due to these accidents. All provided data are for the past five years from 2015 to 2019. The number of specialized health and safety employees are indicated for the same period, including safety managers, safety officers, fire Marshalls and first-aid-trained personnel. Other indicators are used such as number of performed health and safety trainings in each year, number of personnel receiving health and safety inductions and trainings and frequency of health and safety risk assessment evaluations. It is structured as shown in Table 3.2.

Table 3.2: Section B of H&S Checklist – health and safety records

Section B: Health and Safety Records	**2019**	**2018**	**2017**	**2016**	**2015**
Number of minor injury accidents (B1)					
Number of moderate injury accidents (B2)					
Number of severe injury accidents (B3)					
Number of fatalities (B4)					
Cost of H&S accidents					
Lost manhours caused by accidents					
Total number of H&S employees					
Safety managers (no.)					
Safety officers (no.)					
Trained fire marshals					
Trained first aid personnel					
Number of performed H&S trainings					
Total H&S inductions performed					
Number of H&S risk assessments					

Based on the collected data, the incident rates are for each incident type is calculated through the equation developed by OSHA, which is also known as OSHA TCIR/ TRIR equation. The equation is modified as Equation 3.1 to suite the difference in working hours between the different countries:

$$Incident\ rate = \frac{5000\ x\ number\ of\ incidents\ x\ WH}{Total\ MH} \quad (3.1)$$

Where,

WH is the standard working hours worked by each employee (in Turkey it is 45 hours per week, while in Afghanistan, it is 48 hours per week)

Total MH is the total manhours worked by all employees in a specific year

The number 5000 is the product of 50 working weeks per year by 100 for the calculation of the rate per 100 employees.

Table 3.3: Section B of H&S checklist – OSHA TCIR/ TRIR calculations

OSHA TCIR/TRIR Points Calculation					
WH = employee weekly working hours Points guide (20 = below average; 10 = average; 0 = above average) Minor average = 2.4 to 2.6 Moderate average = 0.35 to 0.40 Severe average = 0.045 to 0.050 Fatality average = 0.0045 to 0.0050	2019	2018	2017	2016	2015
$Minor\ Rate = \frac{5000\ x\ B1\ x\ WH}{A1}$					
$Moderate\ Rate = \frac{5000\ x\ B2\ x\ WH}{A1}$					
$Severe\ Rate = \frac{5000\ x\ B3\ x\ WH}{A1}$					
$Fatality\ Rate = \frac{5000\ x\ B4\ x\ WH}{A1}$					
Total points per year					
Average total points (max. 80 points)					

3.2.3. Section C of the H&S Checklist

Section C assigns points based on the availability of general and specific health and safety plans for the participating companies. Thereafter, the sections of the health and safety plan are evaluated based on a four-point scale: 0 points for not available sections, 1 point for basic sections with some structures, systems, precautions and measures, 2 points for detailed sections with structures, systems, precautionary requirements and measures, and 3 points for very detailed sections with extraordinary structures, systems, precautionary requirements and measures. The structure of the evaluation is carried out as shown in Table 3.4.

Table 3.4: Section C of H&S checklist – H&S plan assessment

Section C: Health and Safety plan	**Total Points (max. 69 points)**				
Evaluation of the following sections of the company's H&S plan	0 (N/A)	1 (Basic)	2 (Detailed)	3 (E/O)	Points
Purpose and scope of H&S plan					
H&S management structure, systems, and contact information					
Evaluation processes and systems					
H&S planning and risk assessments					
Competency, awareness, and training					
H&S document control					
H&S performance measurement and monitoring					
Records management					
Accident investigation procedures and precautions					
Emergency plans					
Permit systems					
Personal Protective Equipment (PPE)					
Machinery and vehicles					
Personal transportation within the construction site					
Communication of health and safety hazards					
Confined spaces					
First aid and medical management					
Noise hazards					
Fall protection					
Respiratory hazards					
Infections and diseases					
Ergonomics					
Radiation					

3.2.4. Section D of H&S Checklist

Section D evaluates activities and aspects on the construction site based on the availability of health and safety measures on the participating company projects, which are evaluated through a field investigation. Health and safety measures are evaluated based on a four-point scale: 0 points for not available measures, 1 point for basic/ low measures, 2 points for adequate measures, and 3 points for extraordinary measures. The structure of the evaluation is carried out as shown in Table 3.5.

Table 3.5: Section D of H&S checklist - implementation

Sections D: Implementation of H&S requirements	**Total points (max. 60 points)**				
Evaluation of the following according to site investigation	0 (N/A)	1 (Basic)	2 (adequate)	3 (E/O)	Points
Personal protective equipment (PPE)					
Housekeeping					
Cable management					
Material storage					
Signage systems and safety tags					
Presence of H&S officers on site					
Ramps and elevations					
Ladders and scaffoldings					
Vertical transportation (temporary)					
Hand tools					
Machinery and vehicles					
Working at heights (Persons and objects)					
Site personnel communication					
Electrical works (electrocution)					
Mechanical works (impact, pressure, heat, noise)					
Working in confined spaces					
First aid kits					
Medical facilities					
Chemical and radiation hazards					
Temporary structures					

3.2.5 Final Evaluation

The scores collected from the sections A, B, C and D are finally added to calculate the total earned points where the maximum score can be 209 points. Table 3.6 shows the maximum points that can be earned by the evaluated construction company based on the constructed checklist. Moreover, the legend provides an interpretation of the achieved score by the firm and a guidance towards the necessary actions to be taken.

Table 3.6: Legend for score interpretation and suggested action

FINAL RESULTS	
TOTAL EARNED POINTS (max. 209 points)	
LEGEND 114 and below: Unacceptable health and safety level (immediate intervention required at all aspects) 115 to 124: Weak health and safety level (enhancements to several aspects is required urgently) 125 to 134: Acceptable health and safety level (A few or several aspects need to be enhanced) 135 to 144: Good health and safety level (A few aspects need to be enhanced in the next operational year) 145 to 159: Excellent health and safety level (H&S level to be maintained and further improvement can be achieved) 160 and above : Extraordinary health and safety level (H&S level to be maintained)	

3.2.6 Limitations and Challenges of the Method

The limitations and challenges that can be faced during the assessment include the availability of the required data by the developed health and safety checklist. Moreover, accessibility to the projects of the participating companies is necessary in order to perform a complete evaluation, which can be hindered by bureaucratic or political reasons. The accuracy of the evaluation outcomes can also depend on the transparency of the participating companies and their cooperation with the researcher. Despite the mentioned limitations, it is intended to perform the most comprehensive assessment as required by the checklist through clarifying them to the participating companies to create rapport and consensus on the objectives of the study. Additionally, the identity of the participating companies is kept confidential for better fulfilment of the research aim.

4. IMPLEMENTATION AND RESULTS

This chapter introduces the selected construction firms in terms of their characteristics, health and safety planning and the implementation of H&S on their projects. The approach used for the assessment is conducted as per the designed methodology and the structured health and safety checklist presented in Appendix A. The evaluation adopts a comprehensive approach that takes into consideration the safety records, safety planning measures and documentation, and the actual status of health and safety on a project site through a field investigation. The business names of the companies are kept confidential, while the focus is to apply the structured health and safety checklist in a systematic manner. However, a brief introduction is provided about each firm to illustrate their magnitude and potential in the industry.

An example of an accident is provided for discussion and analysis of its costs. The accident cost is calculated according to the following formula:

$$\text{Total cost} = \text{Direct cost} + \text{Indirect cost}$$

This simple formula would work well for tangible items such as equipment and materials, however, not everything is as simple as it seems. There are intangible costs (ones that cannot touch or even sometimes precisely monetarize) such as:

- Damage of reputation
- Workforce morale decline
- Rumours resulting in adverse publicity

4.1 Compliance with Health and Safety Checklist

4.1.1 Firm A (Turkey)

The first organization selected for the study is from Turkey, firm A. The firm is one of the country's construction giants boasting 12 major residential projects in Istanbul alone. Starting as a construction material shop in Esenyurt, Istanbul in 1990, it has become one of the construction sector dominators providing housing for 60,000 people in 30 years. Their consistent growth and professional crew have built 15,000 houses on a land of 1,500,000 m^2 totally. The quality of their projects ranges from middle to high and offers what can be called "affordable housing".

Firm A employs over 2500 office and site workers. In the case study, the focus is given to the larger number of site employees (around 2000) as this is where most of the slip and fall job-related accidents happen, i.e. building sites. Figure 4.1 provides two examples of the ongoing and completed projects for firm A. As shown by the examples, Firm A operates on a grand scale, which on the other hand unfortunately provides a lot of opportunity for work related accidents, in our case, namely slip and fall. Firm A has 12 projects in Esenyurt/Beylikduzu area.

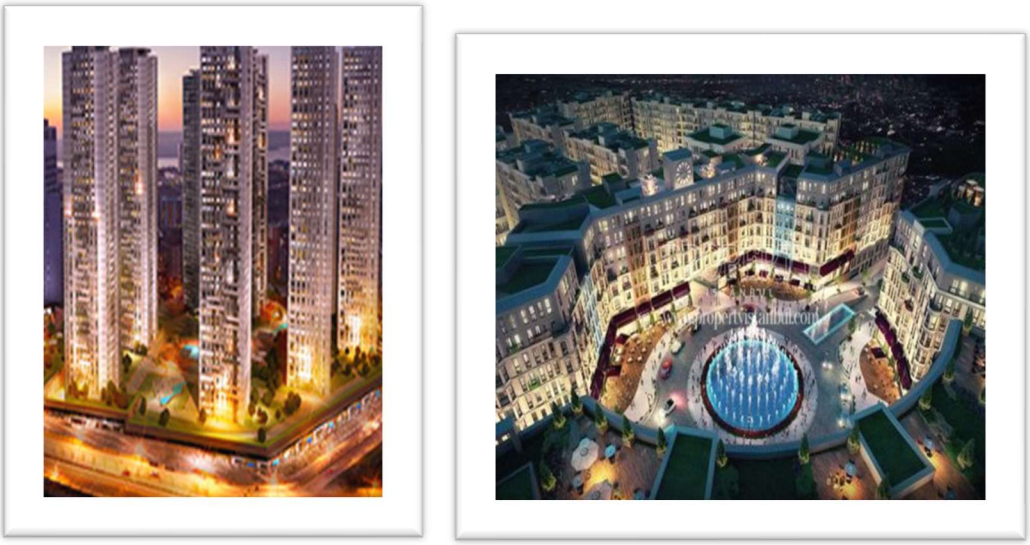

Figure 4.1: Example of projects of Firm A (Resource: participating firm)

For our case study, NLOGO is chosen (commenced in 2014), Esenyurt's highest rising residential tower blocks. The project is being constructed on a total area of 310,000 m2, boast 7 high rise towers, offering 2,500 residences, 59 commercial units, 2 open swimming pools, children's playgrounds, perimeter cycling and walking tracks as well as closed gym areas (for both male and female). Due to the current economic situation its completion has been delayed; it is partially occupied with ongoing work on 3 towers.

Based on the health and safety records, the company's safety plans and the field investigation of one of Firm A's projects. The health and safety assessment checklist is used to evaluate the overall status of health and safety in the company. Data were obtained based on a) records and numbers as provided by the company's safety manager b) safety manual of the company c) site visit to a single site from each company selected randomly.

As shown in Table 4.1, the three main sections of evaluation are A&B, C and D. Firm A scored 60 points based on their safety records, 32 points based on their safety plan, and 40 points based on their implementation of health and safety in the investigated project. The total points accumulated are 132 points, which means that the status of health and safety for Firm A is considered acceptable. However, there are several aspects that need to be monitored, reviewed, and enhanced in order to elevate the health and safety status of the company. The OSHA TCIR/ TRIR is calculated based on 45 working hours per week per employee as per the Turkish working standards in construction.

Table 4.1: Construction Health and Safety Assessment Checklist for firm A

Section A: Operational Data	**2019**	**2018**	**2017**	**2016**	**2015**
Total projects' value (M USD)	30	37	34	29	36
Deployed Manpower	2511	2622	2589	2366	2328
Total worked manhour (A1)	45.4 M	47.4 M	42.3 M	41.2 M	39.8 M

Section B: **Health and Safety Records**	**2019**	**2018**	**2017**	**2016**	**2015**
Number of minor injury accidents (B1)	219	232	202	226	454
Number of moderate injury accidents (B2)	26	40	37	39	63
Number of severe injury accidents (B3)	15	11	9	6	23
Number of fatalities (B4)	1	0	0	0	0
Cost of H&S accidents ($)	322 K	121 K	143 K	117 K	265 K
Lost manhours caused by accidents	2756	2440	2033	2310	2916
Total number of H&S employees	13	12	14	15	9
Safety managers (no.)	2	2	2	2	1
Safety officers (no.)	11	10	12	13	8
Trained fire marshals	83	70	51	48	23
Trained first aid personnel	49	51	46	33	12
Number of performed H&S trainings	9	8	10	12	4
Total H&S inductions performed	415	397	402	458	264
Number of H&S risk assessments	46	48	51	58	18
OSHA TCIR/TRIR Points Calculation					
WH = employee weekly working hours Points guide (20 = below average; 10 = average; 0 = above average) Minor average = 2.4 to 2.6 Moderate average = 0.35 to 0.40 Severe average = 0.045 to 0.050 Fatality average = 0.0045 to 0.0050	**2019**	**2018**	**2017**	**2016**	**2015**
$Minor\ Rate = \frac{5000\ x\ B1\ x\ WH}{A1}$	1.085	1.101	1.074	1.234	2.567
$Moderate\ Rate = \frac{5000\ x\ B2\ x\ WH}{A1}$	0.129	0.190	0.197	0.213	0.356
$Severe\ Rate = \frac{5000\ x\ B3\ x\ WH}{A1}$	0.074	0.052	0.048	0.033	0.130
$Fatality\ Rate = \frac{5000\ x\ B4\ x\ WH}{A1}$	0.0049	0	0	0	0
Total points per year	50	60	70	80	40

Average total points (max. 80 points)	**60**				
Section C: Health and Safety plan	**Total Points (max. 69 points)**				**32**
Evaluation of the following sections of the company's H&S plan	0 (N/A)	1 (Basic)	2 (Detailed)	3 (E/O)	Points
Purpose and scope of H&S plan			●		2
H&S management structure, systems, and contact information				●	3
Evaluation processes and systems			●		2
H&S planning and risk assessments			●		2
Competency, awareness, and training		●			1
H&S document control		●			1
H&S performance measurement and monitoring			●		2
Records management			●		2
Accident investigation procedures and precautions			●		2
Emergency plans			●		2
Permit systems		●			1
Personal Protective Equipment (PPE)			●		2
Machinery and vehicles		●			1
Personal transportation within the construction site	●				0
Communication of health and safety hazards	●				0
Confined spaces		●			1
First aid and medical management			●		2
Noise hazards		●			1
Fall protection			●		2

Respiratory hazards		●			1
Infections and diseases		●			1
Ergonomics	●				0
Radiation		●			1
Sections D: **Implementation of H&S requirements**	**Total points (max. 60 points)**				**40**
Evaluation of the following according to site investigation	0 (N/A)	1 (Basic)	2 (adequate)	3 (E/O)	Points
Personal protective equipment (PPE)			●		2
Housekeeping				●	3
Cable management			●		2
Material storage				●	3
Signage systems and safety tags				●	3
Presence of H&S officers on site			●		2
Ramps and elevations			●		2
Ladders and scaffoldings			●		2
Vertical transportation (temporary)			●		2
Hand tools			●		2
Machinery and vehicles		●			1
Working at heights (Persons and objects)		●			1
Site personnel communication		●			1
Electrical works (electrocution)			●		2
Mechanical works (impact, pressure, heat, noise)			●		2
Working in confined spaces		●			1
First aid kits				●	3
Medical facilities				●	3
Chemical and radiation hazards		●			1
Temporary structures			●		2

FINAL RESULTS	
TOTAL EARNED POINTS (max. 209 points)	**132 (Acceptable)**
LEGEND 114 and below: Unacceptable health and safety level (immediate intervention required at all aspects) 115 to 124: Weak health and safety level (enhancements to several aspects is required urgently) 125 to 134: Acceptable health and safety level (A few or several aspects need to be enhanced) 135 to 144: Good health and safety level (A few aspects need to be enhanced in the next operational year) 145 to 159: Excellent health and safety level (H&S level to be maintained and further improvement can be achieved) 160 and above : Extraordinary health and safety level (H&S level to be maintained)	

4.1.2 Firm B (Afghanistan)

Firm B was founded in Dubai UAE in 2003 and in Kabul Afghanistan in 2009 has been involved in projects in Infrastructure works, Construction of site offices and facilities, Landscaping and Building and works. This company is highly reputable for its profound construction work in the United Arab Emirates and has completed projects in Infrastructure including Road Constructions. Dynamic highly qualified Civil, Structure Design, Road Design and Electrical Engineers have been the key behind our success in the construction field for the last eleven years. Firm B is benefited by an experienced and innovative team of technical personnel and dedicated leaders. This company is highly reputable for its profound construction work in the United Arab Emirates & Afghanistan and has completed a number of projects in Infrastructure including Construction, Buildings, MV& LV Distribution Network and Road works. Firm B has been a major hand in the development of the Projects in Township, Parks, and Luxury Villas.

Firm B employs a total of around 500 employees and has a strict policy of HSE procedures in place on each of its sites. Below is an extract of the HSE plan and what has to be observed before/when entering a construction site:

- All staff must sign in at security gate before entering site
- Alteration to working concerning people authorized to gain access to site.

- Stipulate that all portable electrical equipment must be 110 V and all repairs undertaken by a competent trained person.
- Stipulates vehicles will carry first aid provisions and trained staff and numbers of first aid personnel will be in line with local laws.
- Must provide training certificates before work Commences.
- Safety officers Hard Hats and High vest colours to be determine.

The above list is not exhaustive and prevents/protects staff from injuries in case an accident takes place. Should these precautions be observed, the damage should be brought to a minimum.

Based on the health and safety records, the company's safety plans and the field investigation of one of Firm B's projects. The health and safety assessment checklist is used to evaluate the overall status of health and safety in the company. Data were obtained based on a) records and numbers as provided by the company's safety manager b) safety manual of the company c) site visit to a single site from each company selected randomly.

As shown in Table 4.2, the three main sections of evaluation are A&B, C and D. Firm B scored 54 points based on their safety records, 33 points based on their safety plan, and 32 points based on their implementation of health and safety in the investigated project. The total points accumulated are 119 points, which means that the status of health and safety for Firm B is considered weak. From the obtained results, it can be confirmed that there are multiple issues that need to be monitored, reviewed, and enhanced in order to elevate the health and safety status of the company to an acceptable status. The OSHA TCIR/ TRIR is calculated based on 48 working hours per week per employee as per the Afghani working standards in construction.

Table 4.2: Construction Health and Safety Assessment Checklist for firm B

Section A: Operational Data	**2019**	**2018**	**2017**	**2016**	**2015**
Total projects' value (M USD)	5.86	5.64	3.26	7.22	6.73
Deployed Manpower	504	532	516	611	598
Total worked manhour (A1)	12.3 M	16.9 M	15.1 M	20.6 M	18.2 M

Section B: **Health and Safety Records**	**2019**	**2018**	**2017**	**2016**	**2015**
Number of minor injury accidents (B1)	72	64	79	117	98
Number of moderate injury accidents (B2)	20	16	12	18	25
Number of severe injury accidents (B3)	7	2	14	20	19
Number of fatalities (B4)	0	1	0	0	1
Cost of H&S accidents ($)	56.6 K	72.1 K	86.1 K	96.9 K	92.6 K
Lost manhours caused by accidents	665	702	736	922	886
Total number of H&S employees	4	4	3	4	2
Safety managers (no.)	1	1	1	1	1
Safety officers (no.)	3	3	2	3	1
Trained fire marshals	9	10	8	8	6
Trained first aid personnel	7	5	3	4	2
Number of performed H&S trainings	2	2	2	1	1
Total H&S inductions performed	26	55	49	129	72
Number of H&S risk assessments	12	12	12	4	4
OSHA TCIR/TRIR Points Calculation					
WH = employee weekly working hours Points guide (20 = below average; 10 = average; 0 = above average) Minor average = 2.4 to 2.6 Moderate average = 0.35 to 0.40 Severe average = 0.045 to 0.050 Fatality average = 0.0045 to 0.0050	**2019**	**2018**	**2017**	**2016**	**2015**
$Minor\ Rate = \frac{5000\ x\ B1\ x\ WH}{A1}$	1.405	0.909	1.256	1.363	1.292
$Moderate\ Rate = \frac{5000\ x\ B2\ x\ WH}{A1}$	0.390	0.227	0.191	0.210	0.330
$Severe\ Rate = \frac{5000\ x\ B3\ x\ WH}{A1}$	0.137	0.028	0.223	0.233	0.251
$Fatality\ Rate = \frac{5000\ x\ B4\ x\ WH}{A1}$	0	0.014	0	0	0.013
Total points per year	40	60	60	60	50

Average total points (max. 80 points)	**54**				
Section C: Health and Safety plan	**Total Points (max. 69 points)**				**33**
Evaluation of the following sections of the company's H&S plan	0 (N/A)	1 (Basic)	2 (Detailed)	3 (E/O)	Points
Purpose and scope of H&S plan		●			1
H&S management structure, systems, and contact information		●			1
Evaluation processes and systems			●		2
H&S planning and risk assessments		●			1
Competency, awareness, and training		●			1
H&S document control		●			1
H&S performance measurement and monitoring			●		2
Records management			●		2
Accident investigation procedures and precautions				●	3
Emergency plans			●		2
Permit systems		●			1
Personal Protective Equipment (PPE)				●	3
Machinery and vehicles		●			1
Personal transportation within the construction site		●			1
Communication of health and safety hazards		●			1
Confined spaces		●			1
First aid and medical management				●	3
Noise hazards		●			1
Fall protection			●		2

Respiratory hazards			●		2
Infections and diseases		●			1
Ergonomics	●				0
Radiation	●				0
Sections D: **Implementation of H&S requirements**	**Total points (max. 60 points)**				**32**
Evaluation of the following according to site investigation	0 (N/A)	1 (Basic)	2 (adequate)	3 (E/O)	Points
Personal protective equipment (PPE)			●		2
Housekeeping			●		2
Cable management			●		2
Material storage				●	3
Signage systems and safety tags		●			1
Presence of H&S officers on site		●			1
Ramps and elevations			●		2
Ladders and scaffoldings				●	3
Vertical transportation (temporary)			●		2
Hand tools		●			1
Machinery and vehicles			●		2
Working at heights (Persons and objects)			●		2
Site personnel communication		●			1
Electrical works (electrocution)		●			1
Mechanical works (impact, pressure, heat, noise)		●			1
Working in confined spaces		●			1
First aid kits		●			1
Medical facilities			●		2
Chemical and radiation hazards		●			1
Temporary structures		●			1

FINAL RESULTS	
TOTAL EARNED POINTS (max. 209 points)	**119 (Weak)**

LEGEND

114 and below: Unacceptable health and safety level (immediate intervention required at all aspects)

115 to 124: Weak health and safety level (enhancements to several aspects is required urgently)

125 to 134: Acceptable health and safety level (A few or several aspects need to be enhanced)

135 to 144: Good health and safety level (A few aspects need to be enhanced in the next operational year)

145 to 159: Excellent health and safety level (H&S level to be maintained and further improvement can be achieved)

160 and above : Extraordinary health and safety level (H&S level to be maintained)

4.2 Comparative Analysis and Discussion

Following the review of health and safety profiles of both companies it is apparent that Firm A has better health and safety performance than Firm B. Firm A has scored total points of 132, while Firm B aggregated 119 points. The two firms are one classification category away from each other and both companies need further enhancements to their health and safety parameters with different extents. It is also beneficial to compare the OSHA TCIR/ TRIR rates in order to see the issues based on the safety records in the past five years. As shown in Figure 4.2, both firms achieved good rates of minor injury incidents, while Firm A had achieved rates lower than Firm B in 2016, 2017 and 2019. As illustrated by the chart, Firm A have reduced their minor injury significantly after a high year in 2015, while Firm B is maintaining their performance within a certain range.

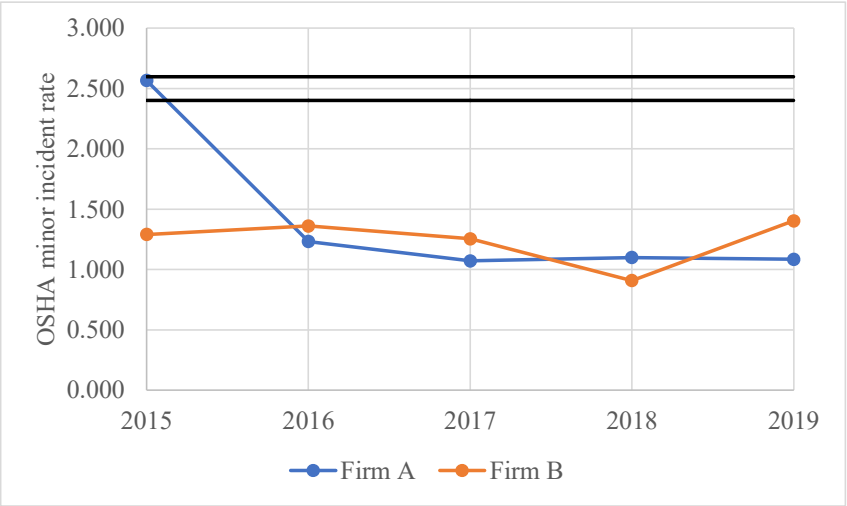

Figure 4.2: Comparison between Firms A and B based on minor incident rates between 2015 and 2019

As shown in Figure 4.3, both firms achieved good rates of moderate injury incidents, while Firm A had achieved rates lower than Firm B in 2018 and 2019. Firm A have reduced their moderate injury rate significantly after a high year in 2015 and the rate was reduced further significantly in 2019. Firm B reduced the same rate between 2015 and 2016; however, the rate increased significantly in 2019 but remained within the average range of moderate injury.

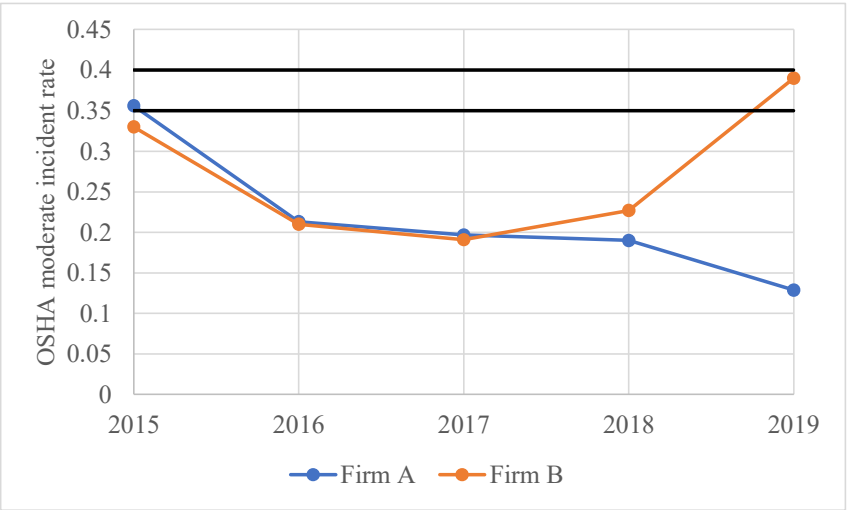

Figure 4.3: Comparison between Firms A and B based on moderate incident rates between 2015 and 2019

For severe injury rates, Figure 4.4 shows the comparison between firms A and B, with the black lines highlighting the minimum and maximum of the average range. Both companies have exceeded the normal range in at least three years, while Firm A have achieved better severe injury rates than Firm B in most years. The high rates of severe injuries in both companies in comparison to the normal rates can be attributed to the nature of the construction activities that caused the injuries. High risk activities, such as falling and confinement, need to be further investigated for each firm in order to develop the most suitable mitigation plan. Furthermore, the fatality rates shown in Figure 4.5 reflect a similar rate for Firm B mostly. The increase in severe injury incident can be an indicator to increase the probability of fatalities. Nonetheless, Firm A was able to maintain a better fatality rate profile, which was mostly below or within the average range.

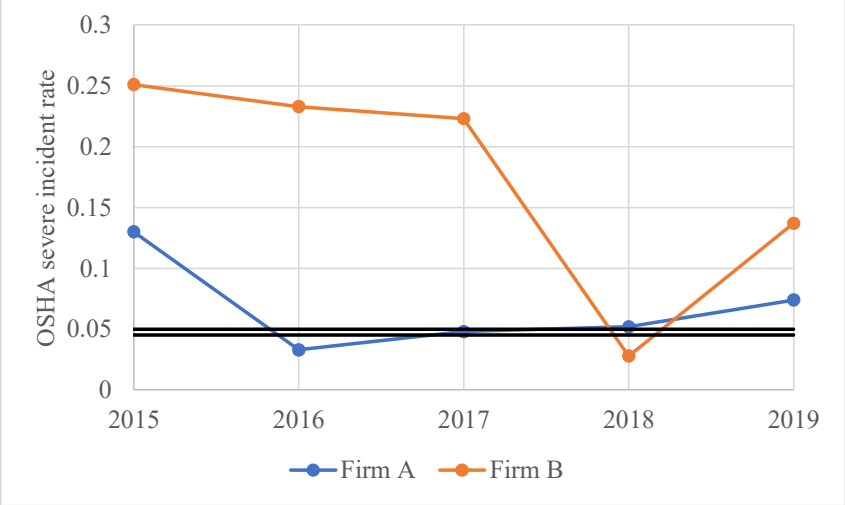

Figure 4.4: Comparison between Firms A and B based on severe incident rates between 2015 and 2019

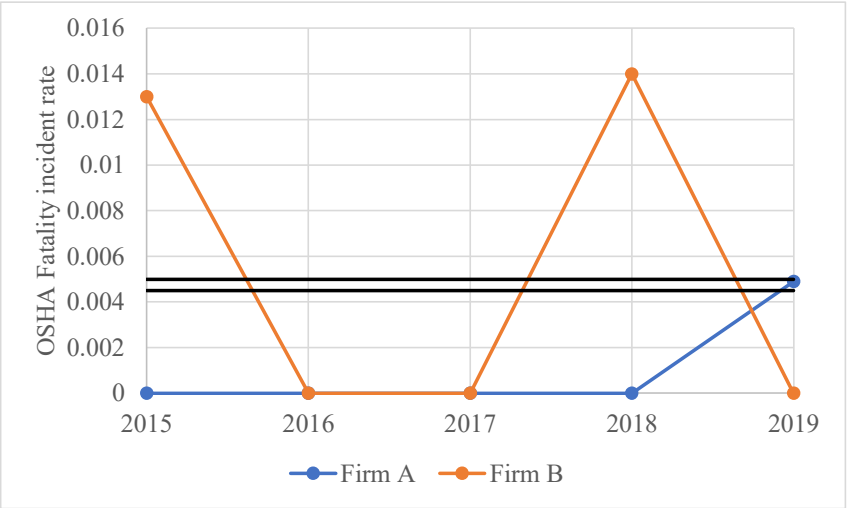

Figure 4.5: Comparison between Firms A and B based on fatality rates between 2015 and 2019

Additionally, two example accidents are analysed in the case studies (one for each company) in order to understand the processes and implementation of the health and safety plan on actual cases. These two accidents and their cost analysis were added as examples of the processes, systems and estimation that were carried out by each company. The accidents are analyzed as part of the field investigation that is required as per the developed checklist. A field investigation is carried out to complete the assessment on section D of the checklist. Since the field investigation involved only one site at one time visit, the accidents were meant to create a balance between the visit observations and the type of accidents that occur in each company and their causes. I believe the review of accidents was necessary to have a more clear vision of the actual conditions at site, as well as the effectiveness of the H&S plan provided by each company. The accidents were not considered directly in the assessment; however, they were reviewed in order to create a clearer vision of the actual site conditions and the implementation of H&S plans. This step is meant to balance the fact that the assessment was performed based on a one time visit to one site.

For Firm A, an example of a recent health and safety accident is given from the NLOGO project. The accident is a severe multilevel slip and fall accident involving a machine and human caused by lack of preventive measures and general disobedience of HSE rules and regulations. For legal purposes the name of the person involved is

not disclosed (the name Burak is a fictional name and not the actual name of the involved person). All the facts have been gathered from the site management and photos used are from a private archive of a site employee which makes it extremely valuable in terms of authenticity.

The incident took place on a sunny afternoon at 2.15 PM on October 3rd, 2019. It involved 29-year-old Bobcat Telescopic Handler (BTH T35) operator, Burak (name changed for legal purposes), who had been recently employed by the company and had just completed his two-week Telescopic Handler training course. At the time of the incident, Burak drove an 3.5-ton capacity Telescopic Handler into the building site. He picked up a 1.5-ton pallet of bricks. The site does not have designated traffic lanes for either industrial trucks or vehicles. Burak drove his Telescopic Handler (further referred to as BTH) straight across the yard's unmarked lanes towards the 5-floor building due to become a commercial unit block. At the time of the incident, two other construction workers were on the fourth floor, ready to receive the load, also not wearing any PPE. Figure 4.6 shows the area where the example accident took place.

Figure 4.6: The location of example accident of firm A

The machine on the picture is the T35.130SLP is a 13 m Telescopic Handler with 3.5 tons max lifting capacity. The cost of this machine is $76,000. A robust design and high-end features make it particularly suitable for load lifting light loads (in construction terms) to low heights.

It is observed from the specification description that the arm range of the machine and the height are almost identical, 13 meters, which makes it extremely unsafe and unstable during the process.

- A close attention should have been given to the way this machine is stationed.
- There are no safety barriers in case of a roll-back.
- The machine and its operator are practically insecure, prone to a 10-meter fall in case anything goes wrong.
- The height of the building and the length of the lifting arm are incompatible.
- There are no safety regulators or any personnel to supervise or alert the operator about safety distance from the edge.

Due to the high lifting angle, short telescopic arm (for this specific purpose) and no protective barriers, the BTH has rolled back and collapsed 10 meters down to the concrete floor. The BTH operator was pronounced dead at the spot. He was not wearing any PPE and did not take any precautions to secure the vehicle in case of any roll-back.

Falls from more than 4 meters usually result in a trip to the emergency room, but even these can cause serious head injuries, internal organ injuries and spine injuries incompatible with life. Below is a list of injuries sustained by Burak, one of which, namely the *head injury was* fatal.

- Broken bones.
- Knee damage.
- Shoulder dislocations
- Spine damage.
- Fatal head injury which was the main cause of death.
- Cuts and bruises.

If the HSE rules and regulations were strictly followed and implemented, there would have been a chance to avoid this accident. Measures that have been actually taken to ensure that this type of accident does not occur again are also reviewed.

The below list of precautions is a global standard and is a must in any HSE manual, and is not restricted to the company discussed:

- Damage/sliding/rolling back or deterioration of the equipment caused by wet, abrasive or corrosive environments as well as lack of safety barriers
- Trying to move weights that are too heavy and exceed the load limit of the machine
- Equipment failure
- Untrained workers planning the lift or using the equipment
- People being struck by moving parts of the machinery or by things falling

Factors that *should* be considered:

- What are you lifting?
- How heavy is it?
- Where is its centre of gravity?
- How will you attach it to the lifting machinery?
- Who is in control of the lift?
- What are the safe limits of the equipment?
- Could you rehearse the lift if necessary?

Safe lifting needs to be thoughtfully planned by a competent person, appropriately supervised and carried out safely.

Strict DON'Ts

- exceed the safe working load of machinery or accessories like chains, slings and grabs. Remember that the load in the legs of a sling increases as the angle between the legs increases
- lift a load if you doubt its weight or the adequacy of the equipment

Whenever a load lifting operation is taking place, the following *must* be observed:

- Conduct a visual inspection of the equipment.
- Conduct a visual inspection of site conditions and potential hazards.
- Ensure the stability zone of the equipment.
- Ensure stabilizers are fully deployed.
- Ensure all safety devices are in place.

As observed from the photo, none of the above were observed. This accident could have been avoided along with the accident costs, both direct and indirect.

Cost of the accident:

As mentioned before earlier, the formula for calculating accident costs is as follows:

Total **cost** = Direct **cost** + Indirect **cost**

In case of Buraks fatal accident, the total costs were settled by the company with the family of the deceased on a mutual agreement of avoiding a long and tedious lawsuit. The costs were calculated taking into consideration the family's financial situation and the fact of Burak being the sole breadwinner.

It is extremely difficult to obtain this kind of information as it is not public and scarcely available. A lot of it is concealed from the public and companies vigorously guard such information to avoid damage of their business reputation. Also, unlike Europe (for example), the settlements are on a much more personal level and in many cases do no go to the court of law.

Monetary *direct* costs can be calculated as follows:

- The cost of the machine (BTH) is $76,000
- Damage to the surroundings and building was around $7,000
- Settlement amount was divided into two parts – the family was given 2 two-bedroom apartments in the NLOGO project (exempt from monthly charges) with the total market value of around $130,000 and a lump sum amount of 250,000 Turkish Lira which at the time of the accident was around $45,000.
- The total *monetary cost* to the company was $268,000 which converted to Turkish Lira (October 2019 exchange rate) is around 1,500,000 Turkish Lira. It may not seem a lot but taking into consideration the minimum salary of a Turkish citizen of 2,243 Turkish Lira ($396) the amount equates to 668 minimum salaries or 55 years of employment at that rate.

Indirect costs are all the "uninsured" additional costs associated with an accident. What is important to realize is that indirect costs are usually much greater than direct costs: From 2-10 times as expensive.

- Delay of completion date
- Training replacement employee
- Accident investigation and implementation of corrective measures
- Lost productivity
- Repairs of damaged equipment and property
- Costs associated with lower employee morale and absenteeism

Speaking of this accident in particular the indirect cost mentioned above are all applicable. It is difficult to estimate the exact amount of indirect costs due to lack of information available and shared but instead the rules and regulations put in place to avoid such (and similar) accidents in the future is further investigated.

HSE Compliance is a cloud based EHS (environmental health and safety) compliance management solution that helps businesses across various industries to manage on-site risks and regulatory monitoring.

Firm A is an important part of the economy in Istanbul and is often seen as one of the leaders on the construction market. Owing to its relatively labour-intensive nature, construction works provide opportunities for employment for a wide range of people skilled, semi-skilled and unskilled. Despite its importance, construction industries are considered risky with frequent and high accidents rates and ill-health problems to workers, practitioners and end users.

In the past 5 years, Firm A's safety record was almost immaculate with minor day to day common injuries such as trips, slips and one level falls occurring by items on the construction site. Even though compliance level was not high, things managed to stay on a low level when it came to work related injuries.

As strict measures for health and safety were taken following the accident, the site management have put in place a set of extremely strict rules following the fatal accident. Not following the rules will result in immediate dismissal and a negative reference for those at fault.

- All operations involving technical equipment and machinery are to be supervised by foremen
- CCTV has been put in place to maintain and record rule compliance

- Extra training has been given to staff
- PPE to be worn always when on site, even if no jobs are being performed
- Reports to be filed out documenting all activities and jobs carried out even if no accidents (minor or major) have occurred.
- On-going training sessions for all employees (including those not directly involved in construction work such as security and service staff) are now held monthly.

In the past 5 years there were no lethal accidents in Firm A on any of its building sites, except for the mentioned example. There were minor work-related accidents which were settled directly with the victims. Safety procedures were not implemented as required which has resulted in general disregard to safety rules and regulation and has become a general practice. The incident described above has shown that such things cannot be left to chance. Further recommendations are provided in the next chapter based on the health and safety assessment.

For Firm B, a particular accident of Pressure Tank Explosion at Ferdaws Jawad Batching Plant is discussed.

A batch plant or batching plant is a device that combines various ingredients to form concrete. This mixture is then discharged into a ready-mix truck (also known as a concrete transport truck). Water is then added to the mix in the truck and mixed during transport to the job site. Figure 4.7 shows the batching plant used by Firm B.

Figure 4.7: Batching Plant (Kabul, Afghanistan) operated by Firm B

Let us look at the safety risks and operational hazards of a Batching Plant to give us a broader picture of how the site operates.

An urgent issue nowadays, which the company should concern with a due regard in their daily operation, is health and safety at work. It is essential that human life safety should be given the unquestioned priority during any building process. In this regard, people are searching for new solutions involving all their expertise, cutting edge technologies and advanced methods of minimizing risk factors which endanger workers 'health.

The Health and Safety policy applied across Firm B is aimed to:

- Comply with all the applicable legislation in this field and improve the company's health and safety stewardship towards industry best practice
- Ensure that their employees and contractors respect the Firm B's health and safety imperatives
- Ensure that their companies provide a healthy and safe workplace for their employees and contractors, and take due care of all customers and visitors at their locations
- Require all their company employees and contractors to work in a safe manner as mandated by law and industry best practice

The most common causes of accidents are slips, trip and falls, injury by falling and moving objects and improper manual handling. With additional care and attention by all, many of these accidents are preventable. The main goal is zero fatality and zero accident level. Due to the nature and the volume of the company's operation activities, these are extremely challenging goals. They will continue to require substantial management and time, and all the appropriate resources will be directed to this area to promote Firm B's advance towards those targets. The strategic plan is currently being implemented in order to eliminate fatalities.

One cannot overestimate the importance of work safety in the concrete industry. For instance, the frequency of accidents is about 50 –60 per million working hours, and on building sites it amounts to almost 85 accidents per million working hours.

Differences in safety levels are quite high. Accidents at work result in significant direct and indirect costs. Different estimates show that the actual costs make up 2 to 4 times the amount of statutory accident insurance fee. The total cost of accidents may result in the company`s wage bill increases by 10 percent.

It is important to point out that increasing safety level at workplace always requires additional funds to be raised. However, the economic factors alone which are mentioned above are sufficient to justify the importance of safety activities. A safe working environment is usually a highly effective working environment. Typical injury categories and ages (Kletz, 2000):

- Plant Operators (39%) and General Operatives (33%) are the most injury prone.
- 30-39 is the most injury prone age range (33%), followed by 20-29 (25%), and 40-49 (24%)

The Accident: Accident Report

Date of Occurrence: 22 June 2015 Time of Incident: 1010H

Location: Ferdaws Jawad Batching Plant

Type of Incident/Accident: Pressure Tank Explosion

Detailed Description of the Incident/Accident:

A group of workers from a subsidiary of Firm B was busy pouring powdered materials into the “Pressure Tank” for making cement on or about 1010H, this date, after dropping the remaining powder one of the worker tried to closed the upper valve cover but after a few seconds the said pressure tank explodes vertically around 1 meter high causing 2 pieces of galvanized iron roof to be ripped off while the others tried to scamper for safety. No injuries were reported except for some dust splinters that went into the eyes of 2 workers resulting to red eyes. They were sent to a nearby hospital for further treatment and evaluation.

Responses/Immediate Actions:

- Stop the work immediately and called the PM, Safety Officer and Foreman of Firm B for information.
- Informed Trojan Safety Officer/Safety Manager about the incident
- Conducted immediate Toolbox Talk by their Safety Officer to prevent re-occurrence.
- Conducted an immediate investigation as to the cause of explosion.

Root Causes of Accident:

- Heat temperature inside the pressure tank exceeded causing the cover to explode.
- Failure to use PPE's like safety goggles, dust mask and hand gloves while working on activity.
- Hazardous machine without temperature control gauge for safety.
- No Supervisor/Foreman attending to worker during the operation.
- Poorly maintained equipment.
- Lack of training for all workers during the operation.
- Lack of instruction procedures on how to operate said machine/equipment.

Water storage tanks for cement & concrete batching plants should be protected with backflow prevention through the use of an 'air gap'. These are typically built on the water tanks themselves using what is called a weir or an interrupter or by means of a separate air gap. Figure 4.8 is a diagram of the basic function of an air gap with weir overflow. In our case, due to poor maintenance and general disregard to working equipment's functionality, the backflow pipe was blocked, thus putting extra pressure on the tank which has resulted in steam accumulation and explosion as the end result.

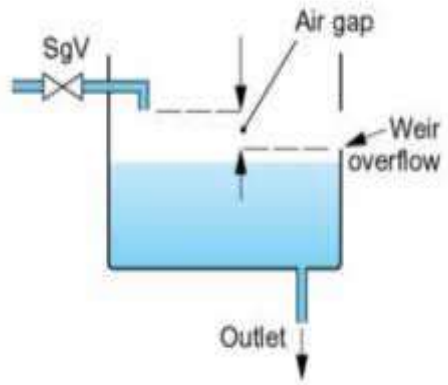

Figure 4.8: A simplified diagram of how a backflow function prevents excess pressure in the tank.

Preventive/Control Measures:

- Proper PPE's to be worn during the activity (Helmet, goggles, Dust Mask, Hand gloves)
- Toolbox talk explaining to workers the do's and don'ts of said equipment.
- Proper or adequate training to all workers doing said activity.
- Installation of "Temperature Control Gauge" for safety check.
- Full supervision of foreman/supervision until completion of activity.

Figure 4.9: Pictures of the accident site of Firm B

As observed from the above pictures, it was not a major accident in term of human victims, however, damage was cause to the batching plant which has resulted in work being brought to a halt and two site workers had to be sent for medical check-up.

As mentioned earlier, the formula for calculating accident costs is as follows:

Total cost = Direct cost + Indirect cost

Monetary *direct* costs can be calculated as follows:

- The cost of the damaged equipment is $13,500
- Damage to the surroundings and structures $2,000
- Treatment costs and compensations for injured workers $3,000
- The total *monetary cost* to the company was $18,500. The amount may seem insignificant; however, such operational incidents may cost the company and the production higher accumulated amounts, if health and safety measures are not taken.

Indirect costs are all the "uninsured" additional costs associated with an accident. What is important to realize is that indirect costs are usually much greater than direct costs: From 2-10 times as expensive.

- Training replacement employee
- Accident investigation and implementation of corrective measures
- Lost productivity of the plant
- Repairs of damaged equipment and property
- Costs associated with lower employee morale and absenteeism

The total indirect costs were estimated at $15,300

The total incident cost is $33,800

In this incident, the indirect cost mentioned above are all applicable. It is difficult to estimate the exact amount of indirect costs due to lack of information available and shared but instead the rules and regulations put in place to avoid such (and similar) accidents in the future are further investigated

HSE Compliance is a cloud based EHS (environmental health and safety) compliance management solution that helps businesses across various industries to manage on-site risks and regulatory monitoring.

Based on the review of the example accidents from the two companies, it can be observed that the accident types and the response of the firms is compatible with the finding with the performed health and safety evaluation and analysis. For Firm A, it can be seen that the use of machinery imposes a high health and safety risk on the construction activities and the personnel of the company. Therefore, the analysis based on field observations pointed out several short comings in the operation of machinery and vehicles around the site, as well as the communication between the machinery and moving personnel around the site. Further theoretical and practical trainings are required for all personnel on the communication signals and site mobilization techniques that need to be used through carrying out the day-to-day activities. The analysis that followed the accident reflect a good level of health and safety system implementation, which led to carrying out proper investigations and measures to prevent the occurrence of this type of accidents in the future.

For Firm B, the example accident reflects the highest health and safety risks that are present in the projects of the company, which are mechanical activities and working in confined spaces. The performed health and safety evaluation shows that the implementation of health and safety measures on project sites need to be further enforced through better contingency plans for this type of activities. Moreover, the firm is required to provide its personnel with task-specific health and safety trainings for the potential risks imposed by mechanical works and confined spaces. The analysis of the example accident showed a weak level of health and safety planning on site, which requires further inputs for health and safety experts, i.e. safety manager. The analysis presented in this report is enhanced through the input of the research. However, it is necessary for Firm B to develop stronger health and safety plans and systems that can cope up with the high risks imposed by the performed activities.

The magnitude of operations and firm size can be an affecting factor in the ability to develop health and safety tools, systems and procedures, as well as enforcing

them on company projects, which is a factor that can be studied in further research. Furthermore, the answers to the research questions are discussed as follows:

Q1: What are the health and safety standards and regulations that are imposed on the construction sector in Turkey and Afghanistan?

In Turkey, construction firms adopt the health and safety standards imposed by the Labour Health and Occupational Safety Centre (ISGÜM), which is based on the cooperation between Turkey and International Labour organization (ILO). ISGÜM provides variety of services in training, testing and quality control that support its purpose of maintaining and monitoring health and safety in the country. Furthermore, the agency provides health and safety principles and guidelines to construction, industrial and mining companies that include requirements on environment, personal and task health and safety (ISGÜM, 2019).

In Afghanistan, construction firms adopt the health and safety standards given by OSHA and integrated by ISO standards. The International Organization for Standardization (ISO) provides a few codes for occupational health and safety, which can be applied to construction and industrial companies and projects. ISO 45001:2018 is a set of health and safety requirements, which is an update to the ISO 18001:2007. The ISO 45001 is a comprehensive occupational health and safety system that provides an integrated approach with the organization's plan, empowers the engagement of all employees and ensures the integration of health and safety into the business process (NSF, 2018). Moreover, OSHA have issued their requirements that include instructions on PPE, machinery and vehicle operations, violence in the workplace, surfaces' safety, hazard communication, safety of energy sources, confined spaces, first aid requirements, hearing at site, fall protection, respiratory protection, bloodborne pathogens, ergonomics, radiation, electrical safety, protection during incident investigation, employee assistance, medical management, decontamination and field staff exposure monitoring. For each of these sections, the instructions provide definitions, scopes, responsibilities and procedures to be followed during the planning and the execution of the construction operations (OSHA, 2011).

Q2: How does the systems and process adopted by the organization consider the health and safety standards and regulations? i.e. Health and safety manual of the organization.

Both companies consider health and safety standards and regulations throughout their operations. In the planning stage, the companies developed health and safety plans with different coverage and detailing of the requirements. These safety plans allow the companies to share the requirements within their employees in order to develop expectation and adequate implementation and monitoring mechanisms. Furthermore, the project sites show that both companies give attention to the requirements of health and safety standards, with different extents that are discussed in the comparison analysis. The implementation of health and safety standards is apparent through the field visits performed as part of the current studies. Both firms record and analyse incidents in a systematic manner and impose health and safety standards in every possible detail on their projects and employees.

Q3: What is the perception of the organization towards the necessity and importance of health and safety standards and regulations?

Through the discussions performed with responsible safety staff and the actual observations to projects' sites, it is evident that both companies give a great importance to health and safety standards and regulations requirements. Both companies realize the impact of incidents on their schedules, budgets, and human powers. Therefore, they implement health and safety standards, and monitor their outcomes in order to minimize losses and analyse their current strategies.

Q4: How are the health and safety standards and regulations adopted by the organization implemented in reality?

Through the performed analysis, the Turkish firm (Firm A) scored 40 out of 60 points on implementation, while the Afghani firm (Firm B) scored 32 points. The level of health and safety implementation at Firm A is considered at a high moderate level, which should be enhanced through addressing the several points that they scored low

on, such as machinery and vehicles, site personnel communication, and working in confined spaces. By focusing on these points, the firm will be able to enhance their level of health and safety implementation. For Firm B, the level of health and safety implementation is considered at a low moderate level. The same strategy can be followed by focusing on their weak points, such as hand tools and mechanical works. However, the number of weak points is more at Firm B than firm A.

Q5: Is there a significant difference between the two companies operating in different countries? If so, what are these differences?

Table 4.3 provides a comparison between the analysis outcomes for Firm A and Firm B. In the comparison based on the incident rate calculations, both firms have minor incident rates that are below the average, despite the one record within the average of Firm A in 2015. Both firms A and B had their moderate incident rates within or below the average in the last five years. Severe incident rates show that Firm B had numbers that exceeded the average in four out of the past five years and with very significant deviations from the normal range, while Firm B exceeded the average slightly in two out of the five years and had a significant deviation in 2015. Firm B had very high fatality rates in 2015 and 2018, while Firm A kept their rates within or below the average. The results are reflected in the point system of the H&S checklist, where firm A averaged 60 points and Firm B averaged 54 points.

In the health and safety plan assessment, both companies were deemed equal on 13 out of the 23 evaluated points. Firm A had better evaluation on 4 points and Firm B had better evaluation on 6 points, which led to Firm B achieving a better score on this section: 33 for B and 32 for A. In the health and safety implementation assessment, both companies were deemed equal on 8 out of the 20 evaluated points. Firm A had better evaluation on 9 points and Firm B had better evaluation on 3 points, which led to Firm A achieving a better score on this section: 32 for B and 40 for A. While the safety plans for both companies can be considered acceptable with the need for enhancements on specific sections, Firm B is required to work on implementing and enforcing health and safety standard and regulations with a greater extent and urgency

than Firm A, which is also reflected in the section and overall scores of both companies.

Table 4.3: Comparative analysis between Firm A and Firm B

OSHA TCIR/TRIR Points Calculation						
WH = employee weekly working hours Points guide (20 = below average; 10 = average; 0 = above average) Minor average = 2.4 to 2.6 Moderate average = 0.35 to 0.40 Severe average = 0.045 to 0.050 Fatality average = 0.0045 to 0.0050		**2019**	**2018**	**2017**	**2016**	**2015**
Minor Rate	Firm A	1.085	1.101	1.074	1.234	2.567
	Firm B	1.405	0.909	1.256	1.363	1.292
Moderate Rate	Firm A	0.129	0.190	0.197	0.213	0.356
	Firm B	0.390	0.227	0.191	0.210	0.330
Severe Rate	Firm A	0.074	0.052	0.048	0.033	0.130
	Firm B	0.137	0.028	0.223	0.233	0.251
Fatality Rate	Firm A	0.0049	0	0	0	0
	Firm B	0	0.014	0	0	0.013
Total points per year	Firm A	50	60	70	80	40
	Firm B	40	60	60	60	50
Average total points (max. 80 points)	**Firm A**	**60**				
	Firm B	**54**				

Section C: **Health and Safety plan**	**Total Points (max. 69 points)**		**Firm A**		**32**
			Firm B		**33**
Evaluation of the following sections of the company's H&S plan	0 (N/A)	1 (Basic)	2 (Detailed)	3 (E/O)	Lead firm
Purpose and scope of H&S plan		B	A		A
H&S management structure, systems, and contact information		B		A	A
Evaluation processes and systems			A/B		=
H&S planning and risk assessments		B	A		A
Competency, awareness, and training		A/B			=
H&S document control		A/B			=
H&S performance measurement and monitoring			A/B		=
Records management			A/B		=
Accident investigation procedures and precautions			A	B	B
Emergency plans			A/B		=
Permit systems		A/B			=
Personal Protective Equipment (PPE)			A	B	B
Machinery and vehicles		A/B			=
Personal transportation within the construction site	A	B			B
Communication of health and safety hazards	A	B			B
Confined spaces		A/B			=
First aid and medical management			A	B	B
Noise hazards		A/B			=
Fall protection			A/B		=
Respiratory hazards		A	B		B
Infections and diseases		A/B			=

Ergonomics	A/B				=
Radiation	B	A			A
Sections D: **Implementation of H&S requirements**	**Total points (max. 60 points)**		**Firm A**		**40**
			Firm B		**32**
Evaluation of the following according to site investigation	0 (N/A)	1 (Basic)	2 (adequate)	3 (E/O)	Lead firm
Personal protective equipment (PPE)			A/B		=
Housekeeping			B	A	A
Cable management			A/B		=
Material storage				A/B	=
Signage systems and safety tags		B		A	A
Presence of H&S officers on site		B	A		A
Ramps and elevations			A/B		=
Ladders and scaffoldings			A	B	B
Vertical transportation (temporary)			A/B		=
Hand tools		B	A		A
Machinery and vehicles		A	B		B
Working at heights (Persons and objects)		A	B		B
Site personnel communication		A/B			=
Electrical works (electrocution)		B	A		A
Mechanical works (impact, pressure, heat, noise)		B	A		A
Working in confined spaces		A/B			=
First aid kits		B		A	A
Medical facilities			B	A	A
Chemical and radiation hazards		A/B			=
Temporary structures		B	A		A

FINAL RESULTS		
TOTAL EARNED POINTS (max. 209 points)	**Firm A**	**132 (Acceptable)**
	Firm B	**119 (Weak)**

LEGEND

114 and below: Unacceptable health and safety level (immediate intervention required at all aspects)

115 to 124: Weak health and safety level (enhancements to several aspects is required urgently)

125 to 134: Acceptable health and safety level (A few or several aspects need to be enhanced)

135 to 144: Good health and safety level (A few aspects need to be enhanced in the next operational year)

145 to 159: Excellent health and safety level (H&S level to be maintained and further improvement can be achieved)

160 and above : Extraordinary health and safety level (H&S level to be maintained)

5. CONCLUSIONS

It is evident that health and safety is one of the most significant domains in construction due to the high rate of incidents and the high risks that are associated with construction activities. The regulations and standards addressed the concerns in health and safety over the past 100 years, leading to their development to ensure better planning and implementation on the project. Since the 1970s, several countries, including the United States, the United Kingdom, and Turkey have put extensive efforts to develop their occupational health and safety requirements, in addition to enforcing them and monitoring their outcomes, which led to a significant decrease in incident and fatality rates.

The main aim of this study was to perform a compliance assessment for selected construction organizations based on criteria derived from international health and safety regulations and standards. The methodology section developed an evaluation methodology to ensure a comprehensive illustration of the health and safety status of a construction firm. The developed checklist incorporated company characteristics, health and safety records, health and safety plan and implementation of health and safety requirements on construction sites. A pointing system is developed to balance the three main parts of the checklist, with higher weight given to health and safety records. The index used in the health and safety records' evaluation is based on OSHA TCIR/ TRIR index which provides the incident rate per hundred employees. The planning and implementation sections of the checklist are based on the requirements of OSHA, BSI and LOI. Therefore, the developed health and safety assessment checklist in this research is a comprehensive tool that can provide a status check with specific pitfall diagnosis for quick intervention measures.

5.1 Final Results

Two firms selected for the implementation of the developed health and safety assessment checklist: Firm A from Turkey and Firm B from Afghanistan. The two firms are of different size and capabilities, which can be contributing to the differences

in their results. The developed scoring system has maximum points of 209, with a minimum of 160 points for an extraordinary health and safety performance. Firm A aggregated 60 points based the H&S records, 32 points based on H&S planning and 40 points based on H&S implementation. The total points for Firm A are 132, yielding an acceptable level of health and safety. Firm B aggregated 54 points based on H&S records, 33 points based on H&S planning and 32 points based on H&S implementation. It is apparent that the main contributors to the difference in results between the two firms are H&S records and H&S implementation. The comparison between Firm A and Firm B, with OSHA average incident rate, shows that both firms need to focus their interventions on high risk activities that are leading to severe injuries and fatalities. The assessment provided in the current research provides a more panoramic view of the health and safety status for the construction company, which is more developed and indicating than most of the suggested tools in the literature.

The performed health and safety assessments achieve a comprehensive status check for the H&S in a given construction firm through incorporating H&S data and records, in addition to an evaluation of the health and safety plan of the firm and the actual implementation on their project sites. In addition to the comprehensive nature of the evaluation, it provides a quantified scale for the status of health and safety with details on every aspect as per OSHA, BSI and LOI standards. Such an approach makes it possible to track the specific health and safety issues and take the appropriate correction measures for fast intervention and enhancement of performance.

Through the reviewed methodologies of health and safety assessment in the literature, the developed checklist is superior to the diagnostic approaches like the one demonstrated by Bakeli and Hafidi Alaoui (2018). Moreover, the checklist highlights the field root causes like the application by Phoya (2012) through an advanced assessment of the site health and safety condition in Section D. The scoring system used in the developed check list provide an indication of the health and safety status, similar to Pathak and Jha (2015); however, the scoring is not limited to the safety records, but also extends to the planning and implementation stages for an early diagnosis and intervention.

In the comparison based on the incident rate calculations, both firms have minor incident rates that are below the average, despite the one record within the average of Firm A in 2015. Both firms A and B had their moderate incident rates within or below the average in the last five years. Severe incident rates show that Firm B had numbers that exceeded the average in four out of the past five years and with very significant deviations from the normal range, while Firm B exceeded the average slightly in two out of the five years and had a significant deviation in 2015. Firm B had very high fatality rates in 2015 and 2018, while Firm A kept their rates within or below the average. The results are reflected in the point system of the H&S checklist, where firm A averaged 60 points and Firm B averaged 54 points.

In the health and safety plan assessment, both companies were deemed equal on 13 out of the 23 evaluated points. Firm A had better evaluation on 4 points and Firm B had better evaluation on 6 points, which led to Firm B achieving a better score on this section: 33 for B and 32 for A. In the health and safety implementation assessment, both companies were deemed equal on 8 out of the 20 evaluated points. Firm A had better evaluation on 9 points and Firm B had better evaluation on 3 points, which led to Firm A achieving a better score on this section: 32 for B and 40 for A. While the safety plans for both companies can be considered acceptable with the need for enhancements on specific sections, Firm B is required to work on implementing and enforcing health and safety standard and regulations with a greater extent and urgency than Firm A, which is also reflected in the section and overall scores of both companies.

5.2 Recommendations and Future Research

Both firms are recommended to focus their attention on high risk construction activities that are leading to severe injuries and fatalities. Furthermore, Firm A is recommended to take the following measures in order to be able to achieve the next rank in the scoring system:

- Increase the number of health and safety trainings per year to achieve 2016's record of 12 trainings.

- Increase health and safety risk assessment evaluation and monitoring to a weekly basis with a total of 52 risk assessments per year.
- Enhance the safety plan of the company with more details of training and competency requirements, documents control systems, permit systems, confined spaces, noise hazards, respiratory hazards, infections and diseases and radiation.
- Create and detail sections in the health and safety plan on personal transportation on site, communication hazards and ergonomics.
- More attention to vehicular motions on site and risks that are associated with working at heights.
- Enhance communication between site personnel through specific training on the subject and health and safety demonstrations.
- Enhance safety measures for working in confined spaces by providing extra protection measures and additional exists.

Firm B is recommended to take the following measures in order to achieve the next ranking on the scoring system:

- Increase number of health and safety trainings to increase awareness and education towards site hazards and correction measures.
- Develop the safety plan in sections that achieved basic scoring to include more details and resources for problem solving.
- Develop sections of the safety plan that are currently not available in the safety plan, i.e. ergonomics and radiation.
- Implement better signage systems and increase presence of safety officers on site.
- Enhance communication between site personnel through specific training on site communication and safety activities.
- Enhance safety practices on site for electrical and mechanical works.
- Increase the number of first aid kits on site.
- Ensure better storage for chemicals on site and stability of unattended temporary structures that are under construction.

The future research on the subject should investigate the correlational analysis between the health and safety assessment based on the developed checklist and the company characteristics with the use of several construction firms to increase the reliability of the results.

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APPENDIX A: H&S CHECKLIST TEMPLATE

Construction Health and Safety Assessment Checklist

Section A: Operational Data	**2019**	**2018**	**2017**	**2016**	**2015**
Total projects' value (M USD)					
Deployed Manpower					
Total worked manhour (A1)					
Section B: Health and Safety Records	**2019**	**2018**	**2017**	**2016**	**2015**
Number of minor injury accidents (B1)					
Number of moderate injury accidents (B2)					
Number of severe injury accidents (B3)					
Number of fatalities (B4)					
Cost of H&S accidents					
Lost manhours caused by accidents					
Total number of H&S employees					
Safety managers (no.)					
Safety officers (no.)					
Trained fire marshals					
Trained first aid personnel					
Number of performed H&S trainings					
Total H&S inductions performed					
Number of H&S risk assessments					
OSHA TCIR/TRIR Points Calculation					
WH = employee weekly working hours Points guide (20 = below average; 10 = average; 0 = above average) Minor average = 2.4 to 2.6 Moderate average = 0.35 to 0.40 Severe average = 0.045 to 0.050 Fatality average = 0.0045 to 0.0050	2019	2018	2017	2016	2015
$Minor\ Rate = \frac{5000\ x\ B1\ x\ WH}{A1}$					
$Moderate\ Rate = \frac{5000\ x\ B2\ x\ WH}{A1}$					

$Severe\ Rate = \frac{5000\ x\ B3\ x\ WH}{A1}$					
$Fatality\ Rate = \frac{5000\ x\ B4\ x\ WH}{A1}$					
Total points per year					
Average total points (max. 80 points)					
Section C: Health and Safety plan	**Total Points (max. 69 points)**				
Evaluation of the following sections of the company's H&S plan	0 (N/A)	1 (Basic)	2 (Detailed)	3 (E/O)	Points
Purpose and scope of H&S plan					
H&S management structure, systems, and contact information					
Evaluation processes and systems					
H&S planning and risk assessments					
Competency, awareness, and training					
H&S document control					
H&S performance measurement and monitoring					
Records management					
Accident investigation procedures and precautions					
Emergency plans					
Permit systems					
Personal Protective Equipment (PPE)					
Machinery and vehicles					
Personal transportation within the construction site					
Communication of health and safety hazards					
Confined spaces					
First aid and medical management					
Noise hazards					

Fall protection					
Respiratory hazards					
Infections and diseases					
Ergonomics					
Radiation					
Sections D: Implementation of H&S requirements	**Total points (max. 60 points)**				
Evaluation of the following according to site investigation	0 (N/A)	1 (Basic)	2 (adequate)	3 (E/O)	Points
Personal protective equipment (PPE)					
Housekeeping					
Cable management					
Material storage					
Signage systems and safety tags					
Presence of H&S officers on site					
Ramps and elevations					
Ladders and scaffoldings					
Vertical transportation (temporary)					
Hand tools					
Machinery and vehicles					
Working at heights (Persons and objects)					
Site personnel communication					
Electrical works (electrocution)					
Mechanical works (impact, pressure, heat, noise)					
Working in confined spaces					
First aid kits					
Medical facilities					
Chemical and radiation hazards					
Temporary structures					

FINAL RESULTS	
TOTAL EARNED POINTS (max. 209 points)	

LEGEND
114 and below: Unacceptable health and safety level (immediate intervention required at all aspects)
115 to 124: Weak health and safety level (enhancements to several aspects is required urgently)
125 to 134: Acceptable health and safety level (A few or several aspects need to be enhanced)
135 to 144: Good health and safety level (A few aspects need to be enhanced in the next operational year)
145 to 159: Excellent health and safety level (H&S level to be maintained and further improvement can be achieved)
160 and above : Extraordinary health and safety level (H&S level to be maintained)