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DEVELOPING FRAMEWORK FOR SAFETY ANALYSIS AND RISK ASSESSMENT IN CONSTRUCTION SITE ENVIRONMENT IN JORDAN

RAZVOJ OKVIRA ZA ANALIZU BEZBEDNOSTI I PROCENU RIZIKA U OKRUŽENJU TIPA GRADILIŠTA U JORDANU

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Keywords
- construction site
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- risk matrix
- severity index
- injuries
- T-score
- TRIR

Abstract

Construction projects involve many types of health and injury risks across life of project. A safety plan needs to be designed based on different stages of construction and requires specific needs for each risk type. The core to the successful safety plan is having comprehensive assessment of risk sources and mitigation actions.

A great majority of construction SMEs (Small and Medium Enterprises) are not familiar with risk assessment concepts and methods. Many small and medium construction businesses have difficulty in finding qualified personnel or time to design a safety plan. The goal of this study is to demonstrate a case of designing a safety plan for a real construction project in Jordan.

We show detailed application of conducting a work safety plan and a detailed risk assessment. The studied case presents a robust application of risk assessment in a construction project that can guide small and medium scale construction projects in building sound safety plan. Tables are prepared containing the activities and their hazards and determining the probability and severity of the risk in order to determine the level of risk, which is average (6-12), the precautionary measures and methods of control are then developed and the risk assessment is carried out again until the level of risk reaches a low and acceptable value (2-4). The discussed method is found to be user friendly, and the SMEs found it easy to update their risk strategies during various construction stages in their projects.

We conclude that the hazard rate degree is 27% low, 65% medium, and 8% high. The activities have a level risk that varies from medium to high, so it is mandatory to follow the safety instructions and the monitoring and continuous inspection to reduce accidents and work injuries.

Ključne reči
- lokacija gradilišta
- analiza zaštite na radu
- matrica rizika
- indeks težine povrede
- povrede
- T skor
- TRIR

Izvod

Građevinski projekti podrazumevaju više tipova zdravstvenih rizika i rizika povreda tokom izvođenja radova. Potrebno je razviti plan zaštite na radu u različitim fazama izgradnje, sa specifičnim potrebama za svaki tip rizika. Srž uspešnog plana zaštite na radu je u posedovanju sveobuhvatnih izvora za procenu i postupaka za ublažavanje rizika.

Većina građevinskih MSP (Malih i srednjih preduzeća) nisu upoznati sa koncepcijom procene rizika i metoda. Mnoge manje i srednje građevinske firme imaju poteškoća u nalaženju kvalifikovanog osoblja ili vremena za razvoj plana zaštite. Cilj rada je u predstavljanju razvoja plana zaštite na realnom građevinskom projektu u Jordanu.

Prikazana je detaljna primena u izvođenju plana zaštite na radu i detaljna procena rizika. Proučena studija slučaja je zapravo vešta primena procene rizika, data kao uputstvo manjim i srednjim građevinskim projektima radi izvođenja uspešnog plana zaštite na radu. Formirane su tabele aktivnosti sa njihovim rizicima, u kojima se određuje verovatnoća i težina rizika radi određivanja nivoa rizika, koji je prosečan (6-12), a zatim se razvijaju mere predostrožnosti i postupci za kontrolu i ponavlja se procena rizika sve dok se ne postigne niska i prihvatljiva vrednost nivoa rizika (2-4). Diskutovani postupak se pokazuje kao lak za korišćenje, a MSP je jednostavno da ažuriraju svoje strategije rizika u raznim fazama izvođenja građevinskih projekata.

Zaključujemo da je stepen rizika povreda 27% nizak, 65% srednji i 8% visok. Aktivnosti imaju nivo rizika koji se menja od srednjeg ka visokom, i stoga je obavezno ispoštovati instrukcije za zaštitu na radu, kao i praćenje i neprekidnu inspekciju, radi smanjenja nesrećnih slučajeva i povreda na radu.

INTRODUCTION

Construction industry involves activities that have various hazards. The implementation of standard occupational health and safety is not high across all construction projects in Jordan. There is a large fraction of projects composed of small and medium residential buildings conducted by non-safety trained workers and contractors, /1-3/.

In the Middle East region, there are limited studies that focus on occupational safety plan and success of its implementation. Jannadi and Bu-Khamsin, and Huang and Hinze /12-13/ conducted a questionnaire survey and interviews in industrial contractors in the Eastern Province of Saudi Arabia. Authors interviewed construction safety officials and 72% of the companies participated in this survey were the general building construction companies, /13/.

In another study, Wilson and Koehn /8/ suggested that proper safety actions vary significantly with type of project and surrounding environment. Also, project size is important because larger projects are better organised, whereas small to medium firms do not have the capacity to design and monitor a solid safety program, /6/.

A survey was conducted by Hassanein and Hanna /20/ about efficiency of safety measures application in the Egyptian construction industry. Authors concluded that safety programs organised by Egypt contractors are less formal and the accident insurance costs are fixed irrespective of the contractor’s safety performance, /19/.

Assessment of the risks in work environment is the core of safety management, /1/. Job location Safety Analysis (JSA) is a practical method for identifying, evaluating, and controlling risks in work procedures, /2/. There are significant differences in risk sources between construction sites and industrial facilities which indicates importance of showing elaborate application to future construction projects.

Projects for construction are dynamic. Many unique factors characterise them - such as frequent rotations of the work team, exposure to weather conditions, high proportions of unskilled and temporary workers. Construction sites, unlike other production facilities, undergo changes in topography, topology, and work conditions throughout the duration of the projects. These features make it harder to manage construction site safety than to manage factory setting. A comprehensive approach is needed to identify hazards and risks, enhance safety, and prevent accidents.

The facilitating risk assessment process in construction projects using occupational safety risk assessment is the core of safety practices, /24/. Protection measures should be taken against identified risks at the workplace zones.

The need for safety awareness among construction industry workers is recognised, /6/. The high cost is associated with work related injuries like workers compensation, insurance premium, time loss, indirect costs of injuries, and litigation, /7/.

There are several factors responsible for accidents on construction sites. Previous studies about causes of accidents conducted occupational safety examination. Studies show 40% of construction fatalities are caused by falls, 8.4% are struck by objects, 1.4% are caught in between incidents, and 8.5% are electrocution, /8/.

There are several actions that can be adopted to implement labour safety. Management laws and regulations are designed to set standard procedures and guidelines to be implemented.

Gunduz and Laitinen /23/ developed a 10-step safety procedure for small/medium construction projects. Tixier et al. /25/ used univariate and bivariate nonparametric stochastic safety risk generators based on kernel density estimators and copulas.

Choe and Henshaw /2/ compared safety risk of different construction trades in terms of common hazard types, sources of injuries, and safety risk quantification models by occupations, which affects risk assessment.

The purpose of a Job Safety Analysis (JSA) program is to mitigate or eliminate hazards associated with performing specific job tasks. The JSA manages worker exposure to workplace hazards safely by providing a tool for identifying, evaluating, discussing, mitigating and documenting potential hazards and appropriate control measures. JSA is vital to the overall safety of project, it sets safety actions across all project tasks which have highly variable safety measures.

The process of JSA for a construction site involves breaking down the activities into individual tasks, identifying potential hazards for each task, risk assessment to determine the likelihood and severity of each hazard, and developing preventative measures aimed at eliminating each hazard. Job-related injuries and fatalities often occur because the employees are not properly trained for safety.

The paper focuses on application of SRA for a selected construction project. The study includes physical visits at different construction phases, collecting the data and feedback regarding number of workers, total work hours, and work shifts from construction site workers using questionnaires. Information pertaining to the number of accidents taking place on construction sites, cause for the accidents, and type of injuries suffered by the workers is collected and examined.

In this research we analyse construction site safety and conduct comprehensive risk assessment for a representative construction project in Jordan. The following steps are followed: map hazards zones and number of workers exposed, conducting job hazard analysis for each phase of the construction project. Also, we identify the appropriate control action consistent with the safety regulation. We design the risk matrix upon existing hazards or risks to determine required controls and the level of risk for each zone and process within the construction site.

Case study overview

The considered project is the construction of residential Towers in Abdali, Amman, Jordan. The work includes construction activities: steel framework, concrete adding and curing, masonry, landscaping, and finishing works. The project involves six floors below- and 35 above ground.

The residential tower consists of various types of apartments (1B, 2B and 3B), as well as 6 levels of underground parking and related service areas. The ground floor area consists of management offices, entrance hall, retail shops, gymnasium facilities, and external works with a total area of about 51 442 m^2. The project is located in the Abdali area next to the parliament building, where the number of employees is currently approximately 350 employees and is one of several projects being established in this area. The project started on September 1, 2018 and the work is still underway. The construction of the main tower and other buildings and adjacent squares is also being carried out. Figure 1 shows the final form of the project and Fig. 2 shows concrete casting for ground beams and walls reinforcement.

Figure 1. The final form of the project.

Figure 2. Concrete casting for ground beams and walls reinforcement.

Risks identification

The definition of Hazard Identification by OSHA is part of the process used to evaluate hazards. The term often used to describe the full process is risk assessment, /3/.

The Occupational Safety Administration identifies and classifies the hazards in the workplace environment as the first step. A review of these hazards and the development of the recommended controls is given according to international specifications and standards using the following hazard identification and control form, /10/.

Table 1. Sample of hazard identification and recommended controls.

Type of Hazard	Control Measures			Update		
	Existing Controls	Hazard Ranking	Recommended Controls	Due Date	Assigned to	Completion Date
Physical						
Lightning	Provide the number of searchlights and lamps on the floors Maintenance of searchlights	Low				
Noise	Wearing PPE Awareness and training Hand Tool Maintenance	Medium	Noise Measuring Replace the old tools Preventive maintenance Rotate workers and give breaks to workers			
Vibration	Health Check workers on these machines periodically Rotate workers	Low	Provide Special PPE Vibration Measuring			
Heat	Wearing PPE Reduce time work	Medium	Awareness and training Organize working hours Provide Special PPE			
Radiation	Use work permit Wearing PPE					
Chemical						
Solid Material Dust	Wearing mask against dust Suction system Awareness and training	Medium				
Flammable Liquids	No smoking Provide SDS Awareness Check and maintenance for tanks	Medium				
Gases	Operate vehicles, cars and winches only at work time Preventive maintenance Awareness and training	Medium	Substitution Provide SDS Labeling dangerous material			

From Table 1 we can conclude that the hazard rate degree is 27% low, 65% medium, and 8% high.

The control methods used in the site are monitored and recommendations are made for proposed methods of control. The hazard control hierarchy is applied, starting with the elimination of hazards, the use of engineering and administrative methods, personal protective equipment, safety signals and others.

METHODOLOGY OF JOB SAFETY ANALYSIS

The definition of job safety analysis (JSA) or job hazard analysis (JHA) by OSHA is a technique that focuses on job tasks as a way to identify hazards before they occur /10, 11/. It focuses on the relationship between the worker, the task, the tools, and work environment. Ideally, after identification of potential hazards, protection steps to eliminate or reduce them to an acceptable risk level are drafted /14, 15/.

Job safety analysis (JSA) is the second step in risk management that is to be conducted to ensure that work procedures implement designated safety measures in job operation, /9/.

In a JSA, each basic step of the work is to identify potential hazards and set the appropriate safety actions. JSA conducted for all hazardous work activities includes precautions and requirements such as fire, potential environmental hazards. The construction project tasks have been broken down into tasks, identifying the hazards, the consequences of the risks, identifying the affected persons, establishing control measures and determining the responsibility of each task. Finally, after the analysis, risk levels for activities are identified as low, medium, and high, /4, 5, 16-18/.

The job safety analysis JSA is conducted for the following 13 important jobs. These tasks are recognised in the European site safety analysis framework /21, 22/.

a) Project activities break down

Table 2. Identified construction tasks considered for safety actions.

	Construction Task
1	Survey works
2	Grouting works
3	Steel structure
4	Concrete surface repair
5	Working at heights : installation of steel grating
6	Manual excavation
7	Mechanical excavation
8	Lifting operations
9	Installation of electrical equipment
10	Transportation of heavy equipment
11	Working at heights

b) Risks identification per activity

Detailed risk analysis is conducted for all identified activities in Table 2. We show tables for surveying task (Tables 3 and 4).

Table 3. Sample of safety analysis sheet for surveying task.

JSA Title: 1		**SURVEY WORKS**			**Date:**	
Project Name:			**Project No:**		**Work Location:**	
Permit/s Required: (circle below)		**Additional PPE Requirements:** (list on pre-start)		**Permit/s Required: (circle below)**		
	Confined Space Entry					
	Vehicle					
	Excavation					
	Radiography					
	Hot Work					
	Cold Work					
	Test Certificates					
		1 Safety shoes, Helmet & Vest				
		1. Safety goggles				
		2. Gloves as applicable				
		3. Vest				
Potential Environmental Hazards (Circle below)		**Hazardous Materials** (attach SDS)		**Fire/Emergency Equipment Requirements** (e.g. fire extinguisher, rescue gear etc)		
	Air Pollution (dust) Fumes	MSDS for cement / epoxy grouting mixture				
X	Spills to ground					
X	Noise					
	Soil erosion					
X	Spills to water					
	Hazards to flora and fauna					
	Electrical	X	Chemical	X	Light/Dark/Visibility	Other Comments
	Pressure (air, water, gas)		Heat/Cold	X	Dust and/or fume	Conduct tool box talk Proper housekeeping Simultaneous operations
	Mechanical (crush points)		Ignition Sources		Other Trades	
X	Manual Handling	X	Ground Condition	X	Wind	

Table 4. Safety actions identified for surveying task.

Steps	Task/Activity	Hazard	Affected Person	Risk Consequence	Solution/Control Measure Mitigation	Procedure / Control	Responsible Person
1	Pre - Work	Getting lost in the area Driving Inadequate lightning Equipment Failure	Supervisor Foreman	Dizziness	Ensure and obtain clearance certificate Ensure the equipment in good condition Not driving in bad condition	C	Supervisor / Foreman
2	Manual Handling/Transportation of survey equipment	Tripping ,Falls Equipment are not safe	Drivers	Back Strain	Wear safety hat, gloves & shoes Install warning signs Barricade the area	D	Supervisor / Foreman
3	Location, alignment, and obtain elevation	Slips, Trips, and fall	Workers	Struck- by Run over	Use the correct equipment Watch around Inspected equipment	I	Supervisor / Foreman

In Tables 5 and 6 we show grouting task hazard identification and protection actions.

Table 5. Sample safety analysis sheet for grouting works.

<table>
<tr><td colspan="2">JSA Title: 2</td><td colspan="3">GROUTING WORKS</td><td>Date:</td><td></td></tr>
<tr><td colspan="2">Project Name:</td><td></td><td>Project No:</td><td></td><td>Work Location:</td><td></td></tr>
<tr><td colspan="2">Permit/s Required: (circle below)</td><td colspan="3" rowspan="8">Additional PPE Requirements:
(list on pre-start)</td><td colspan="2" rowspan="8">Special Tools or Equipment Required
(e.g. gas detection, fall protection, ventilation fans, lighting, high pressure water blasting, scaffolding etc)</td></tr>
<tr><td></td><td>Confined Space Entry</td></tr>
<tr><td></td><td>Vehicle</td></tr>
<tr><td></td><td>Excavation</td></tr>
<tr><td></td><td>Radiography</td></tr>
<tr><td></td><td>Hot Work</td></tr>
<tr><td></td><td>Cold Work</td></tr>
<tr><td></td><td>Test Certificates</td></tr>
<tr><td colspan="2"></td><td colspan="3">1. Safety shoes, Helmet & Vest</td><td colspan="2">1. Full body harness if working at more than 2 meters height</td></tr>
<tr><td colspan="2"></td><td colspan="3">2. Safety goggles</td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td colspan="3">3. Gloves as applicable</td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td colspan="3">4. Vest</td><td colspan="2"></td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="2">Potential Environmental Hazards (Circle below)</td><td colspan="3">Hazardous Materials
(attach SDS)</td><td colspan="2">Fire/Emergency Equipment Requirements
(e.g. fire extinguisher, rescue gear etc)</td></tr>
<tr><td></td><td>Air Pollution (dust) Fumes</td><td colspan="3">MSDS for cement / epoxy grouting mixture</td><td colspan="2"></td></tr>
<tr><td>X</td><td>Spills to ground</td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td></td><td>Noise</td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td></td><td>Soil erosion</td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td>X</td><td>Spills to water</td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td>X</td><td>Hazards to flora and fauna</td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="7"></td></tr>
<tr><td></td><td>Electrical</td><td>X</td><td>Chemical</td><td></td><td>Light/Dark/Visibility</td><td>Other Comments</td></tr>
<tr><td></td><td>Pressure (air, water, gas)</td><td></td><td>Heat/Cold</td><td></td><td>Dust and/or fume</td><td rowspan="3">Conduct tool box talk
Proper housekeeping
Simultaneous operations</td></tr>
<tr><td></td><td>Mechanical (crush points)</td><td></td><td>Ignition Sources</td><td></td><td>Other Trades</td></tr>
<tr><td>X</td><td>Manual Handling</td><td></td><td>Ground Condition</td><td></td><td>Wind</td></tr>
</table>

Table 6. Safety actions identified for grouting task.

Steps	**Task/Activity**	**Hazard**	**Affected Person**	**Risk Consequence**	**n/Control Measure Mitigation**	**Procedure / Control**	**esponsible Person**
1	Mixing Concrete	Exposure to cement and dust Defective Electrical Mixer Noise from the mixer while in operation	Supervisor Foreman Workers	Skin Disease, irritation, eye injury Electrocution, electric shock Noise induced hearing illness	Wear safety gloves & eye protection Proper Maintenance & inspection prior to use. Wear ear plug / ear protection	D	Supervisor / Foreman
2	Laying Bricks	Falling bricks while laying		Hit injury / personal injury	Wear safety hat, gloves & shoes Install warning signs Barricade the area	I	Supervisor / Foreman
3	Working at height	Fall from height / equipment / bricks fall		Personal injury / Equipment damage	Use only certified scaffolding, ensure toe-boards properly fitted, install warning signs.	W	Supervisor / Foreman

c) Risks classification

The risk assessment is the process where one can identify hazards, analyse, or evaluate the risk associated with that hazard, and determine appropriate ways to control the hazard (OSHA, 2015), /10, 23/.

First step is to establish risk-rating system according to jobs and activities in the project as follows.

Severity						
	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		Likelihood				

Figure 3. Risk rating system (risk matrix).

The value of risk level varies from 1 to 25, the risk ranking and explanation are shown in Table 7.

Table 7. Risk level classification classes.

Low	Moderate	High
1-4	5- 12	15 - 25

Safety action types are defined in Table 8.

Table 8. Recommended procedures and controls.

A	Preventive maintenance
C	Quality Control Process
D	Special Purpose Equipment / Supplies
E	Emergency Management Plan
I	Inspection
M	Environmental Design / Modification
P	Operating Procedure
S	Staff Training
W	Work Permit System

Detailed description of risk assessment grade is shown in Table 9.

Technical guide to help assess risk in work site activities is shown in Table 10.

An example of hazards analysis is shown in Table 9. The risk matrix is designed based on the nature of the hazards and it gives the probability of occurrence of the hazard. The risk level of the activities in the project is then determined and the value of each level of risk is defined as low, medium or high level. In the last column, the matrix includes quantitative and qualitative description to guide workers. For all designated tasks, the Tables are prepared containing the activities and their hazards and determining the probability and severity of the risk in order to determine the level of risk, which is average (6-12). The precautionary measures and methods of control are then developed, and the risk assessment is carried out again until the level of risk reaches a low and acceptable value (2-4).

For the Abdali project we calculate risk for all tasks identified in Table 2. We show a sample of risk assessment for Raft foundation in Table 11.

Table 9. Severity assessment explanation guide.

LIKELIHOOD ASSESSMENT EXPLANATION GUIDE			
SEVERITY EVALUATION GUIDE			
DAMAGE	DESCRIPTION (ASSET DAMAGE)	RESULT (ENVIRONMENTAL DAMAGE)	Assessment
More than one release of poisonous gas	Extensive damage. For example, the explosion caused the plant closed.	High amount of leakage affecting public spaces, environmental disaster, for example, leakage to groundwater wells	5
Single Dead or permanent disability example release of carcinogen item	Heavy damage a certain part of the plant remains disabled for example, condenser fire	High amount of leakage for example, fuel leakage resulting from failure to comply with the rules	4
Severe injuries, lost time accident > 3 days. Example fall from high	Local damage. Partial closure of a portion of the plant or plants.	Local leakage resulting from failure to comply with the rules of the construction sites example chemical leak in the rain water drainage lines	3
Small / serious injury. such as chemicals, back or leg injuries..	Little damage. Parts replacement. such as a pump or compressor failure.	Minor leaks that will not create public concerns example condenser leakage from road tankers	2
Minor injuries. First Aid cases. such as cutting fingers.	minimum cost of equipment outages do not cause trouble for example, failure of seals	Unspreading light leaks example leakage of chemical barrels	1

Table 10. Likelihood assessment explanation guide.

Likelihood Guide	Assessment
Definitive occurrence The damage to be arisen from the hazard is the condition that even it is certain no control precaution is taken and/or any of following factors is valid. Hazard can cause national or town health problems such as cholera epidemics Subject to same hazard all the time for example noise level more than 85 dB Failure to accept the occupational safety for example failure to adhere to work permit rules	5
Very possible If the control precautions depend on the person used in every opportunity (for example personal protective equipment, work permit procedure) damage is very possible. Lack of training and control is more than one of this factor	4
Possible If the control precautions depend on the person used in every opportunity (for example moveable gas detectors, work permit procedures) damage is possible. the one or more factors as described in the training and control providing condition and possibly definitive hazard.	3
Can happen If control precautions are not depending on the operator damage can occur (for example pressure safe valve). It is absence of maintenance system or control system controlling the check precautions. Other factors including the hazard, injuries, diseases or, Dangerous condition exposing to many numbers of persons.	2
Probably If there is maintenance and check system, or training is repeated regularly, the damages explained in the probable section should be minimized in probability. Many minor injuries, health problems or condition expose to more than one person.	1

d) Work safety analysis calculations

The purpose of this part is to provide a practical and uniform method for recording and measuring incidents and employee injuries occurring on the job. Incident and injury rates will be compiled in accordance with the Occupational Safety and Health Administration (OSHA).

The objectives of safety analysis are to assess compliance with legal requirements (tasks of safety committee and supervisor, analyse injuries and accidents, update safety actions, estimate the cost of accidents.

Injuries and accidents are reported during project's life. This information is used in safety analysis. The following metrics are calculated /24, 25/.

– *Frequency Rate* (FR) is defined as the number of work injuries that led to absence, which occurred during one year on the basis of the work capacity of 200 000 person.

$$\mathrm{FR} = \frac{\text{number of injuries that led to absence} \times 200000}{\text{total man-hours worked}}, \quad (1)$$

where: total man-hours worked = no. of workers × no. of working days × no. of daily working hours.

– *Severity Rate* (SR) is defined as the number of days of absence due to injuries within one year on the basis of the work capacity of one million people.

$$\mathrm{SR} = \frac{\text{no. of days absent because of injuries} \times 1000000}{\text{total man-hours worked}}. \quad (2)$$

The FR and SR calculating method varies from country to country. In all these calculations, minor injuries or first-aid incidents involving few human-hours lost are not considered.

– *Absence Rate* AR (SPF): After analysing FR and SR, a new definition for AR used in Jordan is devised, it is the ratio of the rate of severity to the frequency.

Table 11. Risk assessment matrix for Raft Foundation.

ITEM NO	ACTIVITY	HAZARD		POTENTIAL RISKs	THOSE AFFECTED FROM RISK	RISK ASSESSMENT			PRECAUTIONS		CONTROL RESPONSIBLE	REMAINING RISK		
						PROBABILITY	SEVERITY	RISK RATING				PROBABILITY	SEVERITY	RISK RATING
1	Survey works	1.1	Falling Down	Injuries	Surveyor, assistant	3	3	9	1.1.1	Make sure that excavated area barricaded (hard barrication)	HSE Staff, Engineers, Surveyor	2	2	4
									1.1.2	TBT about falling hazards	HSE Staff			
									1.1.3	Provide mean of protection in case of surveying inside barrication borders	Construction engineers, surveyor			
		1.2	Lifting survey equipment	Back injuries	Surveyor, assistant	3	2	6	1.2.1	Avoid lifting weight exceed 25 kg	HSE Staff, Engineers, Surveyor	1	2	2
									1.2.2	Provide alternative lifting device in case of equipment exceed 25 kg	Construction engineers, surveyor			
									1.2.3	TBT about manual Handling	HSE Staff			
		1.3	Tripping Hazard	Injuries	Surveyor, assistant	3	2	6	1.3.1	Apply daily housekeeping	Site engineer & HSE	2	1	2
									1.3.2	PPE's Specially (eye glass)	HSE Staff, Engineers, Surveyor			
									1.3.3	Coordinate with	HSE Staff, Engineers, Surveyor			

Calculating AR is a reliable and simple tool, which clearly shows the project's safety performance. This formula is easy to calculate and does not depend on the number of employees. The AR is a guide and it gives a benchmark against any safety reference level.

$$AR = \frac{SR}{FR}. \quad (3)$$

– *Frequency-Severity Index* or indicator FSI. FSI includes details of work injury and estimates frequency, severity, and incidence rate of work injuries in worksites. FSI provides a uniform system of recording events associated with injuries and the determination of corrective action. This FSI index is defined as the following:

$$FSI = \sqrt{\frac{2FR \cdot SR}{1000}}. \quad (4)$$

– *Safe-T-Score*. Safe T-Score compares the result of frequency accident in the past with the present, so that it can find the number of accident reduction. The testing method used is the student test,

$$\text{Safe-T-Score} = \frac{\text{accident FR (now)} - \text{accident FR (past)}}{\sqrt{\dfrac{\text{accident FR (past)}}{\text{no. of working hours (20000)}}}}. \quad (5)$$

After calculating this value, compare the results with the following Fig. 4. In Fig. 4 we show Safe-T-score that indicates the trend of safety plan implementation. In general, if the value is positive, the safety situation is getting worse. If the value is negative, the project is heading for better safety. If it is close to +3 it indicates that the current situation is heading towards the worst and the situation is deteriorating. If the value < -3, it indicates improvement in safety state.

– *Total Recordable Injury Rate* (TRIR). The total recordable incident rate is defined as the OSHA incident rate. It is calculated as the number of OSHA recordable incidents the project has had in a year. The 200 000 value is because it is the number of hours that 100 employees, working a 40-hour week, would log in 50 weeks.

$$\text{TRIR} = \frac{\text{total no. of recordable cases} \times 200000}{\text{total man-hours worked}} . \qquad (6)$$

A monthly report is prepared to monitor the state of the project health. A sample report sheet (March 2019) is shown in Fig. 5.

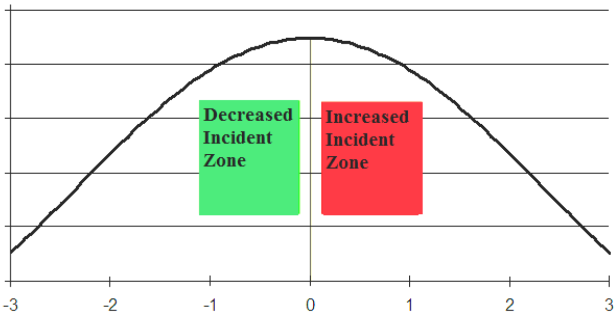

Figure 4. Safety-T-score diagram to assess current project compared to reference.

AY
HSE Statistics Report

Doc ID: **HSE Monthly Report**
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Rev. No. **1** Rev.Date: **1**
April 2019
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Project Name:	**Abdali Views Project**	Project Start Date:	**20th Sep 2018**
Area:	**Amman - Jordan**	Project finish Date:	**5th Dec 2020**
Location:	**Abdali**	Report Number:	**7**
Project Manager:	**Eng. Farid Thiabat**	Period Ending:	**31-Mar-19**

NO.		DESCRIPTION	LAST PERIOD	THIS PERIOD	TOTAL TO-DATE
0	EMPLOYEE	No. of Employees (overall)	320	25	345
2		No. of Employees (HSE)	9	0	9
3	RECORDABLE CASES	No. of Lost Time Incidents (LTIs)	0	0	0
4		No. of Restricted Work Cases	0	0	0
5		No. Occupational Illnesses	0	0	0
6		No. of Occupational Fatalities	0	0	0
7		No. of Medical Treatment Cases	1	0	1
8		No. of Loss Consciousness Case	0	0	0
9	NON-REC-ORDABLE	No. of First Aid Cases	7	1	8
10		No. of Near Misses	6	1	7
11		No. of Non-Occupational Fatalities	0	0	0
12	INDUCTION / TRAINING	No. of HSE Staff inducted	9	0	9
13		No. of Project Personnel inducted	349	79	438
14		No. of Employees Trained (other than Induction)	255	68	323
15		Total Man-hours for HSE Induction	303	79	382
16		Total Man-hours for Training	150	42	192
17	INSPECTION	No. of HSE Meetings	15	2	17
18		No. of HSE Inspections	136	21	157
19	ENVIRONMENT & SECURITY	No. of Fires	0	0	0
20		No. of Thefts	0	0	0
21		No. of Property Damage	0	0	0
22		No. of Alcohol Intoxication Cases	0	0	0
23		No. of Drugs Abuse Cases	0	0	0
24		No. of Spills/Leaks	0	0	0
25		No. of Chemical Rleases	0	0	0
26	VEHICLES	No. of Vehicles (Group 5 & 9)	41	-8	33
27		No. of Cranes	4	0	4
28		No. of Vehicle Accidents (Group 5 & 9)	0	0	0
29	MAN-HOURS	Total Man-hours Worked (Direct & Indirect)	231,700	78,272	309,972
30		Total Lost Man Days due to LTIs	0	0	0
31		Total Man-hours from Last LTI / Fatality	0	0	0
32	RATES	***LTI Frequency Rate (LTI FR)***	0.00	0.00	0.00
33		***Total Recordable Injury Rate (TRIR)***	0.86	2.55	0.65
34		*Severity Rate*	0.00	0.00	0.00
35		*Mean Duration*	0.00	0.00	0.00

	TYPE	First Aid This period	First Aid To-date	Recordable This period	Recordable To-date
NATURE OF INJURY	Abrasion		2		
	Arc Eye				
	Asphyxiation				
	Blister				
	Burns				
	Contusion		1		
	Cut / wound		2		
	Dislocation				
	Electric shock				
	Foreign Body		1		
	Fracture				
	Laceration				
	Puncture		1		
	Sprain / Strain	1	1		
	Others				1
	TOTAL	1	8		1
BODY PART AFFECTED	Ankle				
	Arm / Forearm				
	Back				
	Chest				
	Ear				
	Eye		1		
	Face				
	Finger		3		
	Foot		2		
	Groin				
	Hand				
	Head/Forehead				
	Internal Organs				
	Knee	1	1		
	Leg (Thigh/Calf)				
	Mouth				
	Neck				
	Shoulder		1		
	Skin				
	Torso				
	Wrist				
	Others				1
	TOTAL	2	8		1
NATURE OF ILLNESS	Allergy				
	Avian Flu				
	Dermatitis				
	Frost Bite				
	Hearing Loss				
	Heat Stress				
	Malaria				
	Poisoning				
	Respiratory				
	Skin inflammation				
	Others				
	TOTAL				

Prepared by:	Ramzi Hjazeen	1/Apr/19
	Name & Signature	***Date***
Checked by:	Ramzi Hjazeen	1/Apr/19
	Name & Signature	***Date***
Approved by:	Eng. Alaa Hamaydeh	1/Apr/19
	Name & Signature	***Date***

INCIDENT RATE CALCULATIONS:

32 LTI Frequency Rate (LTI FR):
No. of Lost Time Injury x 200,000 / Total Man-hours Worked (Item 3)

33 Total Recordable Injury Rate (TRIR):
Total Number of Recordable Cases x 200,000 / Total Man-hours Worked (Items 3+4+5+6+7+8)

34 Severity Rates:
Total Lost Man Days x 200,000 / Total Man-hours Worked (Item 30)

34 Mean Duration:
Total Lost Man Days / No. of Lost Time Injury (Item 30)

Figure 5. Health and safety report for month of March 2019.

Total number of injuries and type are reported per month as shown in Fig. 6.

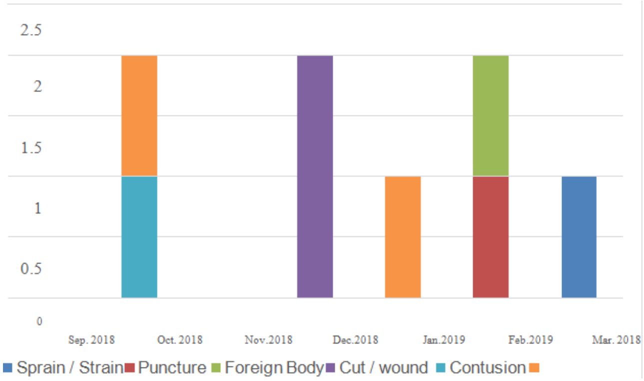

Figure 6. Total number of injuries per each month.

A long term report for 6 months is given in Table 12.

Analysing and calculating the TRIR

As shown in Tables 10 and 11 according to the table of HSE statics report one case was recorded in October 2018, so the value of the TRIR has fallen to its lowest level 0.65 in March 2019. TRIR calculation is shown in Table 13.

A plot of TRIR is shown in Fig. 7 indicating drop in injuries which is a good indicator.

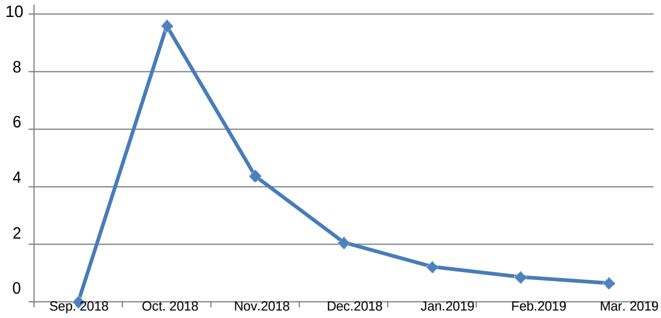

Figure 7. Total Recordable Injury Rate (TRIR) chart.

Table 12. Summary of reported accidents in 6 months period in 2018 for Abdali Towers project.

DATE	TOTAL NO. OF INJURIES	NATURE OF INJURY					
		Abrasion	Contusion	Cut / wound	Foreign Body	Puncture	Sprain / Strain
Sep. 2018	0	0	0	0	0	0	0
Oct. 2018	2	1	1	0	0	0	0
Nov.2018	0	0	0	0	0	0	0
Dec.2018	2	0	0	2	0	0	0
Jan.2019	1	1	0	0	0	0	0
Feb.2019	2	0	0	0	1	1	0
Mar. 2018	1	0	0	0	0	0	1
TOTAL	8	2	1	2	1	1	1

Table 13. TRIR analysis summary for Abdali Tower Project for selected period.

DATE	LAST PERIOD				THIS PERIOD				TOTAL TO - DATE			
	A*	B*	C*	D*	A	B	C	D	A	B	C	D
Sep. 2018	0	0	0	0	54	4846	0	0	54	4846	0	0
Oct. 2018	54	4846	0	0	72	16000	1	12.5	126	20846	1	9.59
Nov.2018	126	20846	1	9.59	91	27140	0	7.36	217	45734	1	4.37
Dec.2018	217	45734	1	4.37	45	50652	0	3.94	262	96386	1	2.07
Jan.2019	262	96386	1	2.07	33	66976	0	2.98	295	163362	1	1.22
Feb.2019	295	163362	1	1.22	25	68338	0	2.92	320	231700	1	0.86
Mar. 2019	320	231700	1	0.86	25	78272	2.55	0	345	309972	1	0.65

A - no. of employees (overall); B - total man-hours worked; C - no. of medical treatment cases; D - total recordable injury rate (TRIR).

RESULTS

The safety analysis of the selected project for a period between 1/9/2018 to 31/3/2019 is conducted. The analysis shows no incident causing work injuries that had one or more lost workdays during that period, minor injuries or first-aid incidents involving few human-hours lost.

Because no injuries resulted in absence from work one day and more, there is no calculated value for FR, SR, AR, Safe-T-Score. The calculated TRIR is a negligible value.

Based on the above calculations, the occupational safety and health status of the project is safe and indicates that occupational safety and health programs are successfully implemented and need to be updated constantly.

CONCLUSION

Detailed safety analysis for construction project in Jordan is conducted. The project has been broken down into tasks, hazards per task are identified. The control measures are determined, and responsible staff type are set for each task.

The risk matrix was designed based on the nature of the hazards. Tables were made for the probability of occurrence of the hazard and the possible consequences. The risk level of the activities in the project was then determined. The value of each level of risk was defined as a low, medium or high level. Putting the necessary interpretations into tables for both the probability and the consequences of the hazard (both quantitatively and qualitatively).

Tables are prepared containing activities and their hazards and determine the probability and severity of risk in order to determine the level of risk, which is average (6-12). Safety measures and methods of control are then developed, and risk assessment is carried out again until the level of risk has reached a low and acceptable value (2-4).

Job Safety Analysis is conducted for all construction site tasks and procedures. JSA conducted for all hazardous work activities includes identifying precautions and safety requirements such as fire, potential environmental hazards and possible hazardous procedures. We conduct Job safety analysis for a construction project site in Jordan. The analysis shows that the hazard rate is 27% low, 65 medium, and 8% high.

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