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COSTING THE HEALTH AND SAFETY IN THE EGYPTIAN BUILDING CONSTRUCTION PROJECTS

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تعد الحوادث و الإصابات في مواقع الإنشاء من المشكلات الرئيسية على الصعيد المحلى والعالمي، ومن المعروف أن تفاصيل خطة السلامة والأمن الصناعي لا تكتب بالتفاصيل والوضوح الكافي في عقود المشاريع أو المواصفات القياسية الحكومية أو في أي مكان آخر مقارنة بالتفاصيل والوضوح الذي تكتب به بنود الأعمال في مقايسة الأعمال الخاصة بالمشاريع كما يتم التنويه عن خطة السلامة ومسئولية سلامة العاملين وسلامة المعدات بصورة عامة في التعاقدات الخاصة بالمشاريع الإنشائية وبدون ذكر أية تفاصيل أخرى سوي أن المقاول هو المسئول عن سلامة جميع العاملين بالموقع.
كان الهدف من هذا البحث هو محاولة تقديم نهج جديد يمكن أن يقيس و يحدد تكلفة تطبيق تعليمات السلامة و الأمن الصناعي في مشاريع الإسكان بمصر.
لم تصمم هذه الرسالة لتبتكر خططا استراتيجية جديدة أو برامجا تنفيذية جديدة لإجراءات السلامة و الأمن الصناعي بالموقع كما لم تقترح أي نوع من أنواع التوعية بالسلامة والصحة المهنية بل كان تركيز الرسالة حول الطرق المعتمدة و المتبعة حاليا في مجال السلامة فيما يخص صناعة الإنشاءات و التزمت هذة الدراسة بحساب تكلفة تطبيق تعليمات السلامة و الأمن الصناعي بمشاريع الإسكان في مصر، ولم تأخذ في الاعتبار تأثير هذه التكلفة على كلٍ من القيمة المالية للتعاقد أو صيغة العقود التنفيذية للمشروع وعلى الرغم من أن مشاريع الإسكان كانت هي محور الدراسة بهذة الرسالة فإن المنهج المتبع يمكن أن يطبق على جميع أنواع المشاريع المختلفة.
تم تصميم البرنامج الحسابي، وكان متوسط نسبة تطبيق خطة السلامة والأمن الصناعي لإنشاء المشاريع السكنية هى 1.22% حسب نتائج البرنامج. ولاعتماد نتائج البرنامج تم مقارنة النسب المحسوبة من البرنامج مع النسب المقررة من أبحاث سابقة في مجال السلامة وكانت نتائج البرنامج مقبولة ويمكن الاعتماد عليها في تقدير تكلفة تطبيق خطة السلامة والأمن الصناعي.
التطوير الناجح للبرنامج الحسابي المستخدم فى البحث قد يساعد المقاولين على معرفة تكلفة تطبيق خطة السلامة والأمن الصناعي في مرحلة العطاءات وهى مرحلة مبكرة تساهم في تقدير قيمة مقايسة الأعمال بدقة أكبر. و بناءً على النتائج ايضا فإن البرنامج يمكن أن يحسب قيمة تكلفة خطة السلامة والأمن الصناعي أثناء التنفيذ بناءً على دقة البيانات المستخدمة في البرنامج وكلما كانت البيانات المستخدمة واقعية وأقرب للحقيقة كانت نتائج البرنامج أكثر دقة وأقرب للواقع ونوصى باجراء ابحاث اخرى لتطوير البرنامج المستخدم.

ABSTRACT:

This study described the steps followed in developing an integrated model designed to estimate the cost of health and safety during construction of residential projects in Egypt. The intention of developing this model was to help owners, investors, and engineers to generate an idea about the desired safety budget needed to complete the proposed project before the actual start of the construction and during the bidding stage. This paper represents three case studies in which the health and safety costs for the construction project came to approximately 1.22% of the total cost of the budget. Although the size of the sample was not large, the results were supportive of the other studies, and indicated that the

findings, in general, can be applied to a variety of project settings. The model can provide users with the option to modify the cost of any elements needed in health and safety from the detailed list that was entered in the model; and to implement all necessary adjustments in an easy and efficient way, by changing the elements values associated with the health and safety. On the other hand, this model was designed to be easy to use and flexible and it executes necessary calculations in a quick and accurate way.

Keywords: Health and Safety, Building Project, Model Cost

INTRODUCTION

The construction industry is well known for its complexities and inefficiencies in dealing with human safety and construction processes. The industry itself has been notorious for its high casualty records over many years. According to reports published by the Construction Industry Institute (CII), injuries and fatalities occur in the construction industry at a rate more than 50% higher than all other industries, (Kartam and Bouz 1998).

In Egypt, the concept of improving safety in construction sites has only started to be developed in recent years. Every year, many construction site workers are killed or injured as a result of their work, others suffer ill health. Therefore, the importance of health and safety has come, (Ho, D., Ahmed, S., Kwan, J., and Ming, F. 2000).

The optimum financial resourcing of health and safety is marginalized by competitive tendering, which does not ensure an equitable basis for estimating and bidding because generally, there are no detailed items included for health and safety in contract documents such as Bills of Quantities, (Smallwood, J. and Emuze, *F. 2014).*

The objective of this study is to introduce a novel approach that clarifies the cost of applying safety regulations in constructing of building projects in Egypt.

The paper will first go through a detailed description of health and safety parameters and safety regulations during construction. Second, a questionnaire was care-fully designed to select the health and safety parameters that relate to constructing residential projects in Egypt. Then, all data were analyzed and built in formula tables, alternatives of the safety plan for the site and labors, component of safety's facilities in the project, techniques of controlling the safety, types of expected hazards and tools needed to apply the safety in the workplace. Next, a simple-to-use spreadsheet model was created to determine the cost of applying the safety plan functioned in factors such as number of labors, area of the project, the volume of work needed and types of equipment used. Finally, the result of applying the created model in three residential projects to calculate the ratio of applying safety plan cost to the tender price.

This study does not try to propose any new safety strategy, program, or awareness system. Rather, it focuses on the current methods used by safety officials in the industry. The scope of this study covers the cost of applying the health and safety regulation in the building projects without taking into account the effect of that cost in the tender price or the contracting formula.

Although housing projects are considered in this study, the approach is general and can easily be adapted on other types of project.

Detailed Safety Plan of Construction

The key to achieving healthy and safe working conditions is to ensure that health and safety issues are planned, organized, controlled, monitored and reviewed.

This part of paper discusses ten sections that may provide the demand for safe, as shown in Table-1, healthy and comfort working environment in constructing building projects by collecting data and information from past researchers, published books, articles and journals that contributed to the construction health and safety design and management. Safety plan regulations are related into building projects referred to *Saudi Aramco Construction Safety Manual 1993*, and *Arab Contractors Safety Manual 2005*.

Table-1 Detailed Safety Plan of Construction

Section	Sub-Section
1- Setting up the Site	• **Site Layout Design.** • **Site Accommodation.** • **Adequate Access Roads.** • **Project Signs.** • **On-Site Vehicle Vs. pedestrian Paths.** • **Site Illumination.**
2- Welfare Facilities	• **Medical Facilities/Suppliers.** • **Designated Smoking Areas.** • **Toilet Facilities/Sanitation.** • **Eating Facilities.**
3- PPE	• **Head Protection.** • **Eye and Face Protection.** • **Hand Protection.** • **Foot Protection.** • **Hearing Protection.**
4- Fire Prevention	• **Water-Type Fire Extinguisher.** • **Carbon-Dioxide Type Extinguisher** • **Dry-Chemical Type Extinguisher**
5- Excavation	• **Shoring Protective Systems.** • **Inspection.** • **Clearance.** • **Access and Egress.**
6- Scaffolding	• **Foundations.** • **Posts.** • **Runners.** • **Bearers.** • **Board-Bearers.** • **Bracing.** • **Ties.** • **Platform Units.** • **Guardrail Systems** • **Access.**
7- Concrete Formwork	• **Vertical Slip Forms.** • **Tube and Coupler Shoring.**
8- Crane and Lifting Devices	• **Competent Persons.** • **Crane Operations** • **Safe Working Load (SWL).** • **Wire Rope.** • **Damaged Slings.** • **Hooks.** • **Shackles.** • **Rigger.** • **Overhead Power-Lines.** • **Pre-List Operation Checklist.**
9- Electrical	• **Temporary Installation** • **Hand Tools and Lighting**
10- Heavy Equipment	• **General Requirements** • **Dumpers and Dump Trucks** • **Graders, Dozers, Scrapers, Loaders and Mini loaders** • **Fork-Lift Trucks**

Questionnaire Composition

The questionnaire was used for the purpose of collecting data and information experienced people in the field. Thus, field visits were made to different contractors in Egypt. The discussions were collected and studied carefully in order to develop the questionnaire format. Also, the literature review established the basis of the questionnaire development. Some questionnaire forms which were appropriate to this study from other studies were reviewed. This investigation was necessary to ensure that the structured questionnaire covers the full dimensions of the subject. At the same time, it allowed the researcher to know how to deal with various interviewing situations and to improve the questioning process.

Sampling Approach

The sample survey was selected from the Egyptian Federation for Construction & Building Contractors. The first three grades that were qualified and registered in the Egyptian Federation for Construction and Building Contractors in Cairo only, second or third grade was considered as large companies and would have a chance to participate. The method of sampling used was random sampling. Random numbers were used to select the sample contractors from the contractor list prepared by the Egyptian Federation for Construction & Building Contractors.

Model Description

The overall model was developed in four stages, as shown in Figure-1, first stage is data input, in this stage user have to enter some required data from his project and these data are given symbols in order to use them in stage three as mathematical equations. Second stage is database of unit price which are tables defining the cost of all materials per unit that will be used in the project. Third stage is analysis, in this stage the model will calculate the cost of health and safety of the project according to the project data given by the user. Forth stage is output & reports, in this stage the user will find a detailed report that explains the cost of health and safety expected in that project according to the input data and database of unit price which were given before.

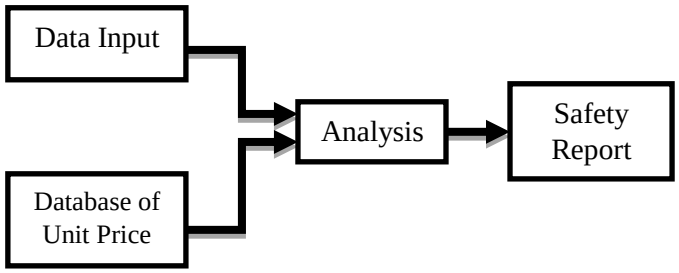

Figure-1: Flow Chart of Model Processes

Data Input: The inputs of the proposed model are considered the main factors that have a high impact on the cost of applying health and safety regulation during the construction project. Unit Price Database: All materials and tools used for safety in the site are dragged in tables. These tables define and describe all units and their prices for every material and tool. These tables used in the model as a temporary database however, the user can modify all prices or keep them in their default values. Analysis: Equations & relations between data input that mentioned previously and safety regulations during construction.

Projects' Data for Case Study

The developed model in the previous chapter can be applied to a three residential projects. Project's name, tender price cost and contract duration for each project is shown in Table-2.

Table-2 Projects' Information

#	Project Name	Area (m^2)	Contract Duration (month)	Tender Price (L.E)
#1	Student Housing	6415	6	29,333,291
#2	Al-Fatth Project	83850	36	76,144,295
#3	Social Housing	15300	18	42,500,000

Results:

Using the student housing project data in the developed model to compute the cost of applying health and safety during construction, the expected cost of health and safety during the construction was 310,590 L.E. The model classified the cost into seven sections, personal protective equipment (PPE) had the major cost with 57% of the safety cost, toilets represented 16% of the safety cost, while extra safety component in scaffolds represented 11%, medical services are 8%, fire prevention extinguisher cost 4% and finally both of site illumination and signs are represented 2% for each. The summary results of safety cost are presented in Table-3 and illustrated in Figure-2 where 100% of the Total Safety cost was equal to 1.06% of the project's total tender price.

Table-3 Expected Health and Safety Expenses, Project #1

Safety Items	Item Cost		Item Percent
PPE	L.E	175,789	57 %
Medical Service	L.E	24,931	8 %
Toilets	L.E	50,400	16 %
Signs	L.E	5,011	2 %
Illumination	L.E	7,920	2 %
Scaffolds	L.E	34,609	11 %
Fire Prevention	L.E	11,930	4 %
Total Safety cost	L.E	**310,590**	**100%**

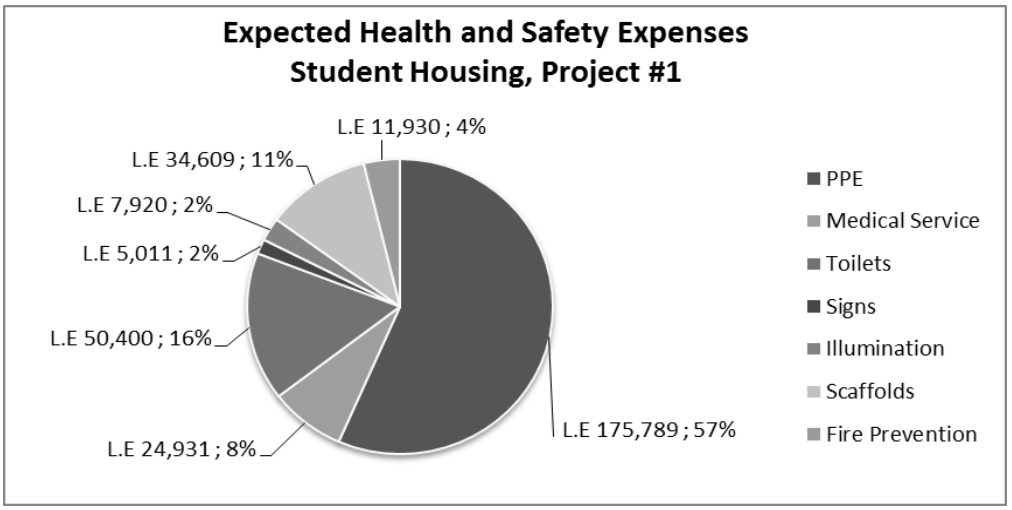

Figure-2 Expected Health and Safety Expenses, Project #1

According to the results of the developed model in project #1, the safety cost was 310,590 L.E which was equal to 1.06% of the project's total tender price. This ratio have suggested to be acceptable and within range according to previous researches conducted in costing of safety, such as *Wells and Hawkins*, *2009* and *Smallwood and Emuze*, *2014*.

Using Al-Fatth (5) project data in the developed model to compute the cost of applying health and safety during construction, the expected cost of health and safety during the construction was 985,442 L.E. The model classified the cost into seven sections, Toilets had the major cost with 38% of the safety cost, Personal Protective Equipment (PPE) represented 23% of the safety cost, while both of medical services and extra safety component in scaffolds represented 14%, fire prevention extinguisher cost 6% and finally both of site illumination and signs are represented 2% and 3% respectively. The summary results of safety cost are presented in Table-4 and illustrated in Figure-3. where100% of the Total Safety cost was equal to 1.29% of the project's total tender price.

Table-4 Expected Health and Safety Expenses, Project #2

Safety Items	Item Cost		Item Percent
PPE	L.E	226,270	23 %
Medical Service	L.E	139,612	14 %
Toilets	L.E	378,000	38 %
Signs	L.E	24,909	3 %
Illumination	L.E	20,448	2 %
Scaffolds	L.E	139,993	14 %
Fire Prevention	L.E	56,210	6 %
Total Safety Cost	**L.E**	**985,442**	**100%**

According to the result of the developed model in project #2, the safety cost was 985,442 L.E which was equal to 1.29% of the project's total tender price. This ratio have suggested to be acceptable and within range according to previous researches conducted in costing of safety, such as *Wells and Hawkins, 2009* and *Smallwood and Emuze, 2014*.

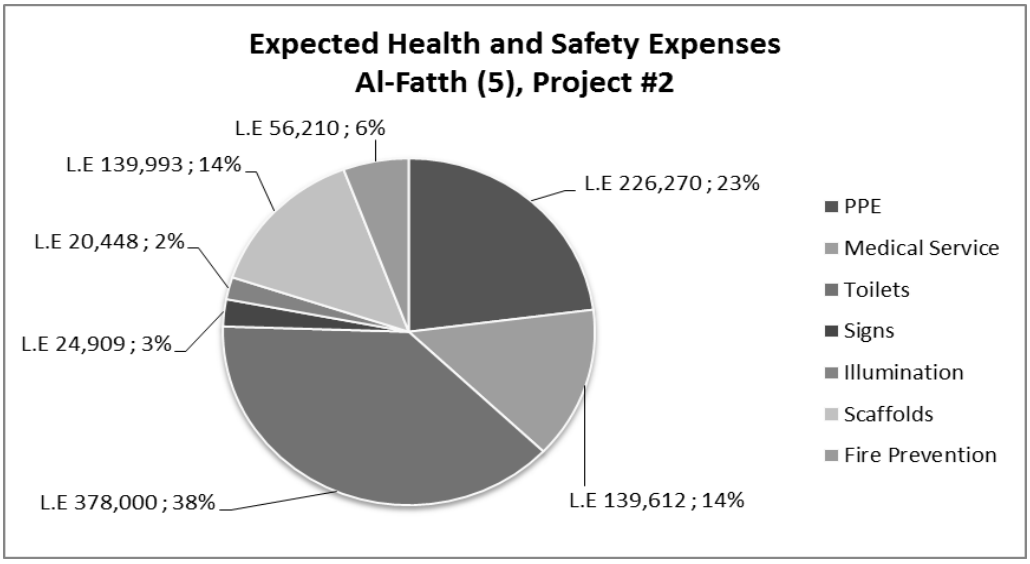

Figure-3 Expected Health and Safety Expenses, Project #2

Using Social Housing project data in the developed model to compute the cost of applying health and safety during construction, the expected cost of health and safety during the construction was 551,250 L.E. The model has classifies the cost into seven sections, Toilets has the major cost with 27% of the safety cost, Personal Protective Equipment (PPE) represent 36% of the safety cost, while extra safety component in scaffolds represent 11%, medical services are 13%, fire prevention extinguisher cost 6% and finally both of site illumination and signs are represent 4% and 3% respectively. The summary results of safety cost are presented in Table-5and illustrated in Figure-4. where100% of the Total Safety cost was equal to 1.30% of the project's total tender price.

Table-5 Expected Health and Safety Expenses, Project #3

Safety Items	Item Cost	Item Percent
PPE	L.E 197,390	36 %
Medical Service	L.E 70,765	13 %
Toilets	L.E 151,200	27 %
Signs	L.E 17,218	3 %
Illumination	L.E 20,160	4 %

11 %	L.E	60,988	Scaffolds
6 %	L.E	33,530	Fire Prevention
100%	**L.E**	**551,250**	**Total Safety Cost**

According to the result of the developed model in project #3, the safety cost was 551,250 L.E which was equal to 1.30% of the project's total tender price. This ratio have suggested to be acceptable and within range according to previous researches conducted in costing of safety, such as *Wells and Hawkins, 2009* and *Smallwood and Emuze, 2014*.

The developed model has the following advantages:

1. It has the ability to expect the cost of health and safety needed through construction of residential projects at the project's bidding stage.
2. It is easy, user friendly, flexible and executes quick calculations.
3. It generates professional output reports in a quick and efficient way.

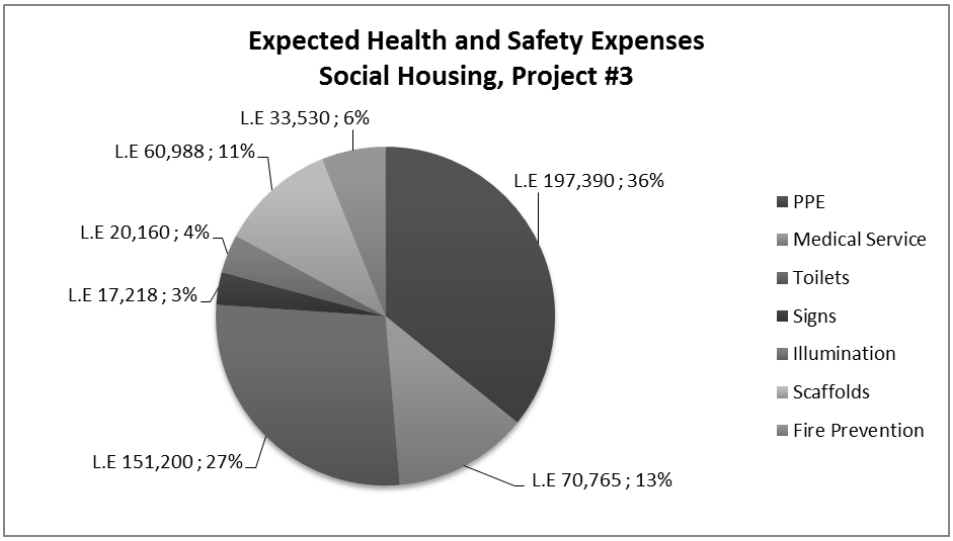

Figure-4 Expected Health and Safety Expenses, Project #3

Limitation of the Developed Model

The model can be used for estimating the direct cost needed during the construction of residential building projects in Egypt. General contractors cannot use this model to prepare safety cost estimate of any other type of projects.

Moreover, the model does not execute any adjustment for the daily number of labors (man-power) which is considered as constant number during the construction.

Recommendations for Future Expansion

Despite the ability of the developed model to generate conceptual estimates for the cost of health and safety for building projects, the model can be enhanced by adding the following features:

1. Include more equations to adjust the duration of each activity entered in the model to generate the optimum number of labors during the construction of the project.
2. Incorporate the effect of health and safety cost in the total cost of the project.
3. Generate a written form in project contracts for detailed health and safety roles involved in constructing residential projects.
4. Integrate the model with 3D modeling by using the Building Information Modeling concepts.

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