Sustainable Civil Infrastructures

Mohamed Shehata
Fernanda Rodrigues *Editors*

Project Management and BIM for Sustainable Modern Cities

Proceedings of the 2nd GeoMEast International Congress and Exhibition on Sustainable Civil Infrastructures, Egypt 2018 – The Official International Congress of the Soil-Structure Interaction Group in Egypt (SSIGE)

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Sustainable Civil Infrastructures

Sustainable Infrastructure impacts our well-being and day-to-day lives. The infrastructures we are building today will shape our lives tomorrow. The complex and diverse nature of the impacts due to weather extremes on transportation and civil infrastructures can be seen in our roadways, bridges, and buildings. Extreme summer temperatures, droughts, flash floods, and rising numbers of freeze-thaw cycles pose challenges for civil infrastructure and can endanger public safety. We constantly hear how civil infrastructures need constant attention, preservation, and upgrading. Such improvements and developments would obviously benefit from our desired book series that provide sustainable engineering materials and designs. The economic impact is huge and much research has been conducted worldwide. The future holds many opportunities, not only for researchers in a given country, but also for the worldwide field engineers who apply and implement these technologies. We believe that no approach can succeed if it does not unite the efforts of various engineering disciplines from all over the world under one umbrella to offer a beacon of modern solutions to the global infrastructure. Experts from the various engineering disciplines around the globe will participate in this series, including: Geotechnical, Geological, Geoscience, Petroleum, Structural, Transportation, Bridge, Infrastructure, Energy, Architectural, Chemical and Materials, and other related Engineering disciplines.

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Contents

Implementing an Occupancy Sensor Lighting Control System in a University Lab Classroom 1
Lonny Simonian and Mitchell Packard

Urban Regeneration and Resilience: Evaluating the Impact of Regeneration Projects on Social Resilience in Glasgow's Sighthill 10
Yasser Majdi Khaldi

Strategic Assessment for the Sustainable Combined Sewer Overflow Problem in Peoria, Illinois, USA 54
Amir Al-Khafaji, Jim Ardis, and Scott Reeise

Sustainable and Green Solutions to The City of Peoria Combined Sewer Overflow Problems 69
Amir Al-Khafaji, Jim Ardis, Scott Reeise, and Patrick Urich

Long-Term Strategies for Sustainable Funding of Infrastructure in the USA 87
Amir Al-Khafaji, Dan Meckes, and Dan Gallagher

Strategies for Sustainable Funding of Infrastructure in Illinois, USA 106
Amir Al-Khafaji, Dan Meckes, and Dan Gallagher

Risks Affecting the Delivery of Construction Projects in Egypt: Identifying, Assessing and Response 125
Ahmed Mohammed Abdelalim

RIAM; A Developed Risk Impact Assessment Model for Risk Factors Affecting Large Construction Projects 155
Ahmed Mohammed Abdelalim

Perception of Consultants and Contractors to Performance Factors of Construction Projects 179
Ayodeji E. Oke, Clinton O. Aigbavboa, and Khosi Mohapeloa

Utilization of Project Management Tools for Construction Project Success 190
Sihle Gogela, Ayodeji E. Oke, and Clinton O. Aigbavboa

Text and Information Analytics for Fully Automated Energy Code Checking 196
Peng Zhou and Nora El-Gohary

Integrating BIM-Based Simulation Technique for Sustainable Building Design 209
Ahmed Mohammed Abdelalim and Yasser Abo.elsaud

Smart and Connected Infrastructure Through Sustainable Urban Management: Balancing Economic Development and Environmental Protection Goals 239
Ahmed Abukhater

Understanding Marine Geo-Technical Engineering, Gas Hydrate Energy Release and the Role of External Stimuli 249
J. Rajaraman and S. Narasimha Rao

Author Index 269

RIAM; A Developed Risk Impact Assessment Model for Risk Factors Affecting Large Construction Projects

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Abstract. Cost saving and time performance are usually essential to all parties who are involved in a construction project, i.e. owner, contractor, subcontractor, etc. The main causes of disputes in construction projects involve delay and failure to complete the work in the specified cost and time frame. The delivery time of a project is a key factor for the owner in terms of cost as much as it is for the contractor. Unexpected increase in cost and delays in construction projects is caused by owner, contractor and environments. In which several types of risk factors may occur concurrently. The effect of cost overrun and schedule overrun do not only influence the construction industry, but the overall economy as well. Even though construction project increasing in cost and schedule have received extensive attention of researchers, but because of continuous changes and development in the field, the study considered of increasing demand to the construction industry, in addition to risk strategy and plan analysis. In order to meet the deadline of a project and due to the complex nature of construction projects, cost and scheduling should be flexible enough to accommodate changes without negatively affecting the overall project cost and duration. As such, the objectives of the presented research in this paper are to identify, study, and assess the effect of the factors that affect cost and time contingency. Data are collected from the biggest sixteen construction companies in Egypt. The collected data, output charts and analysis spreadsheets will be used for development of computerized built model with the identification abbreviation "Risk Impact Assessment Model"; ***RIAM***.

Keywords: Risk assessment · Cost overrun · Schedule overrun
Likelihood · Probability · Scale · Modeling

1 Introduction

Risk management has become an essential requirement for construction projects. The risk management process includes Hazard identification, Risk assessment and Risk control. Risk is assessed by Qualitative Methods and Quantitative Methods. Risk management is the systematic process of identifying, analyzing, and responding to project risk, it includes maximizing the probability and consequences of positive attributes and minimizing the probability and consequences of attributes adverse to

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project objectives. Project Risk is an uncertain event or condition that, if occurs, has a positive or negative effect on a project's objectives. Components of risk are an event that may or may not happen, the probability of the occurrence of that event and the impact of the occurrence of that event. There are many sources of uncertainty in construction projects, which include the performance of construction parties, resources availability, environmental conditions, involvement of other parties, contractual relations, etc. As a result of these sources, construction projects may face problems that cause delay(s) in the project completion time [1].

The key success indicators of construction management system(s) include completing the project with cost and time, within the planned budget and duration, and within the required quality, safety, and environmental limits. These goals are interrelated where each of them is affected and affected by the others. An accurate cost estimating and scheduling should be sought in order to meet the overall budget and time deadlines of a project. Time contingency is used to guarantee the completion time of either an activity or a project [2]. Due to the unique nature of construction projects, cost overrun and schedule overrun uncertainty are essential for true budget and scheduling, which should be flexible enough to accommodate changes without negatively affecting the overall cost and duration. It is also essential to allocate a contingency value to both cost and time [3].

Yet, there are situations where there could be delays in activities, whether they are within the critical path or not, which result in a delay in the overall project duration. These delays will consequently have a negative impact on the quality, budget, and might be the safety of a project. Therefore, estimating cost and time contingencies are seen as a prime factor in achieving a successful construction project. Although several industrial sectors developed and used software for estimating time and cost contingencies in order to minimize delays and avoid being over budget, yet limited efforts are reported in the literature in the area of predicting time contingency in construction projects. The overall objectives of the presented research in this paper are: 1. to identify and study the factors that affect cost overrun and schedule overrun; 2. to develop a probability distribution chart for likelihood, cost impact and schedule impact; and 3. to quantify the risk assessment impact on cost and schedule. See Figs. 1, 2 and 3. Strategies for Negative

Rank	Descriptor	Description	Probability
Very high	Almost Certain	Even chance	> 50%
High	Likely	One in every 4 projects	> 25%
Moderate	Possible	One in every 10 projects	>10%
Low	Unlikely	One in every 20 projects	>5%
Very low	Rare	Less than 1 in every 20 projects	< 5%

Fig. 1. Probability matrix

Rank	Schedule	Cost	Safety	Quality
Very high	>3 months	>$10 million	Fatality	>10 %
High	2-3 months	$ 5-10 million	Severe injury	5-10 %
Moderate	1-2 months	$ 2-5 million	Medical treatment	3-5 %
Low	2-4 weeks	$1-2 million	First Aid	1-3 %
Very low	< 2 weeks	< $1 million	No injury	<1 %

Fig. 2. Impact matrix

Fig. 3. Strategies for negative risks

Risks or Threats are Avoid, Transfer, Mitigate or Accept. On the other hand Strategies for Positive Risks or Opportunities are Exploit, Enhance or Accept.

2 Background

Delays have an adverse impact on project success in terms of time, cost, quality and safety [1]. Time-delays and cost overruns are among the most common phenomena in the construction industry [4]. Therefore, planners and schedulers have used time contingency to guarantee the completion time of either an activity or a project [2]. The easiest and safest way to build a time contingency is to extend the project end date to a point where there is a comfortable amount of positive float, which may not be cost effective or acceptable to the client. However, it might not also be acceptable to proceed on a project with a zero float plan [5]. There is no standard definition of contingency in which it could imply different meanings to estimators, contractors, and owners' organizations [6]. Contingency is probably the most misunderstood, misinterpreted, and misapplied word in project execution [7]. It is an amount of money or time (or other resources) added to the base estimated amount to achieve a specific confidence level or allow for changes where experience shows obligation [8]. It can also be defined as the budget that is set aside to cope with uncertainties during construction [3] or the amount of money/time needed above the estimate to reduce the risk of overruns of project objectives to an acceptable level within the organization [9]. [10] Identified two major categories of contingency for construction projects:

1. Design contingency—it addresses the changes during the design process for factors, such as incomplete scope definition and inaccuracy of estimating methods as well as data [11].
2. Construction contingency—it addresses the changes during a construction process. Under a traditional procurement arrangement, the contract typically contains a variation clause(s) to allow for changes and provide a mechanism for determining and valuing variations.

There are many definitions for contingency in the literature; most of them focused on cost contingency. Contingency has different meanings to different people. Despite its importance, estimating time contingency was not thoroughly addressed in the literature. Prior to reviewing the estimating methods for project contingency, there are different attributes that affect contingency. [12] Identified 55 factors affecting the performance of project schedule. They observed seven factors that have the most significant impact on schedule outcome and divide them into two main categories. The first category included factors that encompassed the capability to improve performance level, such as owner's competence as well as commitment and conflict among project members. The second included factors that tended to retain the schedule at its existing level, such as coordination among project members, lack of knowledge and skills for the project managers, hostile socioeconomic environment, and uncertainty in selecting project members/team. In addition, [3] indicated that the effect of change orders increased the original cost and schedule since they modified the original contract. [13] Presented a methodology that incorporated network analysis and duration uncertainty in the project time analysis. They studied the effect of various factors on time contingency using a linear equation. There are many factors that impact time contingency in which it is not only important to identify these factors, but assess their impact on the project duration as well. Most engineers, planners, and agencies relied on their experience to estimate cost and time contingencies [3, 13, 14, 15]. The contractor's contingency was represented as a fixed percentage of the contract value [16] or as a percentage of total project cost or duration [3]. The completion date of a project was often missed due to uncertain events in which their impact was difficult to predict because of the uniqueness of construction projects.

Schedule contingency analysis is the process of identifying and evaluating contingency factors, present or anticipated, and determining both the probability and impact of identified contingency factors [17]. It is a preliminary step in establishing a schedule and time control strategy, which is intended to increase the probability of desired outcome while minimizing risk factors [12].

3 Factors Affecting Cost Overrun and Schedule Overrun

Based on literature and the opinion of practitioners/Expert through fifty nine questionnaires, several imperative factors that affect cost and time contingency are identified and studied. They are divided into four major criteria: (A) Site conditions, (B) Resources, (C) Project parties and (D) Project features related factors. Table 1 shows the detail of these main criteria and their factors. Site conditions include environmental, Subsurface and Site location. Resources include Labor, Equipment and Material. On the other hand, project parties cover Owner, Engineering and Design, Contractor and Project management. In addition Project features cover Financial, Political and schedule sub-criteria. The detail attributes/risk factors related to each subcriterion are shown in Table 1. It is quite clear that the identified criteria and factors effectively contribute to the uncertainty in construction project cost and scheduling, which in turns, impact the assessment of cost and schedule overruns. In the present research, these factors are considered in predicting project budget and time contingencies.

Table 1. Factors affecting cost and schedule overruns

Criteria	Sub-criterion	Attributes/risk factor
Site conditions	Environmental	Earthquake
		Precipitation/flood
		Unpredicted Weather conditions
		Pollution
	Subsurface	Unexpected Surface conditions
		Archeological survey done
		Geo-technical investigation
	Site location	Construction area (rural/urban)
		Access conditions
		On-site congestion
		Delay in permits and licenses
		Security requirements
		Safety regulation
		Differing site conditions
Resources	Labor	Labor skills level
		Labor availability
		Drop in Labor productivity
		Labor accidents
		Human resource planning
		Working hours restrictions
	Equipment	Equipment quality
		Equipment breakdown
		Equipment maintenance
		Equipment malfunctions
	Material	Material delivery
		Material storage
		Material theft and damage
		Material procurement
		Nonconforming material
		Material monopoly
		Nominated vendors
Project parties	Owner	Owner type
		Management strategy
		Organization structure
		Work/labor permits
		On-site access
	Engineering and design	Team experience
		Project goal
		Complexity of design
		Ad-hoc consultants
		A design error

(*continued*)

Table 1. (*continued*)

Criteria	Sub-criterion	Attributes/risk factor
Project parties cont.	Contractor	Contractor pre-qualified
		New technology
		Defective work
		Rework
		Number of subcontractors
		Contractor Reputation
		Nominated sub-contractors
		Number of current projects
	Project management	Management experience
		Owner quality assurance
		Scope definition
		Quality control process
		Type of contract
		Availability of variations
Project features	Financial	Type of Funds
		Fluctuation in prices
		Invoices delay
		Change in currency rate
		Owner financial capacity
		Progress payment
		Rate of interest
		Tax rate
		Foreign currency
		Project size
	Political	Bribery and corruption
		Wars and revolutions
		Military coup
		Changes in laws and regulations
	Schedule	Fast track schedule
		Project duration

4 Research Methodology

Figure 4 shows the detailed steps utilized to perform the various activities of the present research. Factors that affect cost and schedule overruns are identified and discussed using literature review and expert opinion. A questionnaire survey is conducted to collect the impact of each factor. The research methodology is performed using probability distribution developed by crystal ball software. The collected data through questionnaires will be used to illustrate the minimum, mean, maximum and standard deviation values.

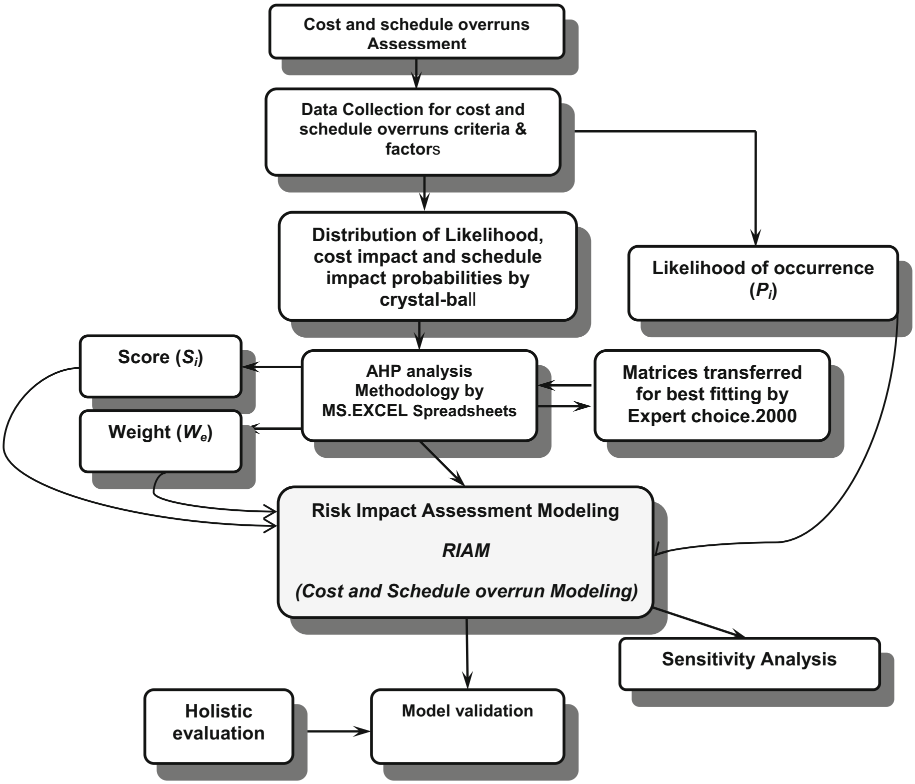


Fig. 4. Research methodology flow chart

The output charts developed by crystal ball software will be divided into three stages, the first one illustrates the probability distribution per each attribute likelihood [Pi], the second stage will concern the cost impact probability distribution either for attributes which will be defined as [weight Wi], or concerning the sub-criterion itself, which will be defined as [Score Si], furthermore the third stage will reflect the schedule impact probability distribution either for attributes/risk factor or for the sub-criterions themselves as described previously. These data will be used by AHP based simulation modeling, which will be described in detail in another paper. As illustrated in Fig. 4, the upper steps will be done in this paper, on the other hand the lower part of the flow chart includes AHP analysis will be illustrated in detail in another paper which can be considered as a complementary part of the present paper, [18].

5 Development of Data and Charts

5.1 Introduction

Cost and schedule overruns analysis are defined in this research as the process of identifying and evaluating contingency factors, present or anticipated, and determining the cost and schedule overruns indexes. In order to assess these indexes, some steps are utilized to perform the intended analysis. These steps are discussed further in the following sections. The questionnaires have been developed to evaluate the probability of attributes in addition to attributes cost impact and schedule impact, these questionnaires cover a lot of attributes/risk factors from literature to allocate various categories as per environmental and financial effects which had covered by 65 factors and increased up to 70 factors by practitioners advice, These added factors are equipment malfunctions, ad-hoc consultants, availability of variations, owner financial capacity and tax rate. The data have been mentioned in Excel spreadsheets to determine the min., max., mean values in addition to standard deviation, the evaluated weights have been transformed into percentages using (PMBOK® Guide- 5th edition) chapter-11 scales. The probability distribution of likelihood of occurrence, cost impact and schedule impact has been developed using Oracle crystal ball Release 11.1.2.3 software, these charts will be used in the graphical mode mentioned in the development model as discussed later, and on the other hand the user can use the numerical mode simply. Table 1 and Figs. 5, 6, 7 illustrated the set of attributes. The spreadsheets will be used to present the heat maps and tornado charts as mentioned in the paper.

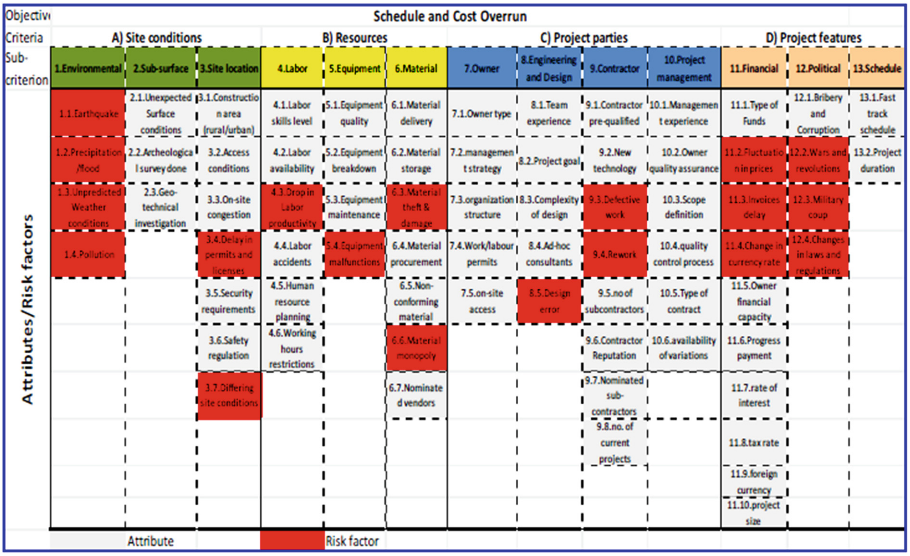


Fig. 5. Summary of risk attributes.

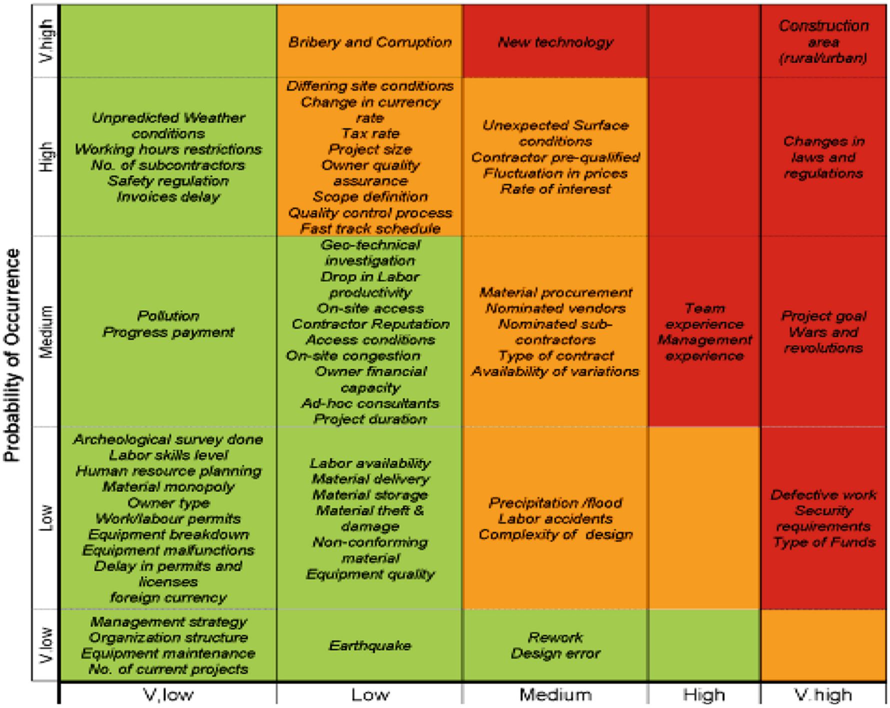


Fig. 6. Heat map concerning attributes cost impact.

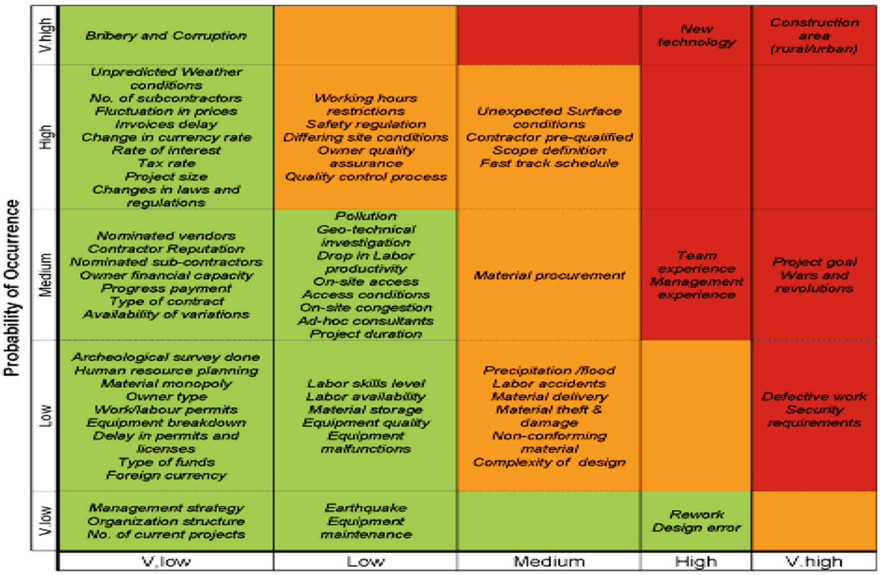


Fig. 7. Heat map concerning attributes schedule impact.

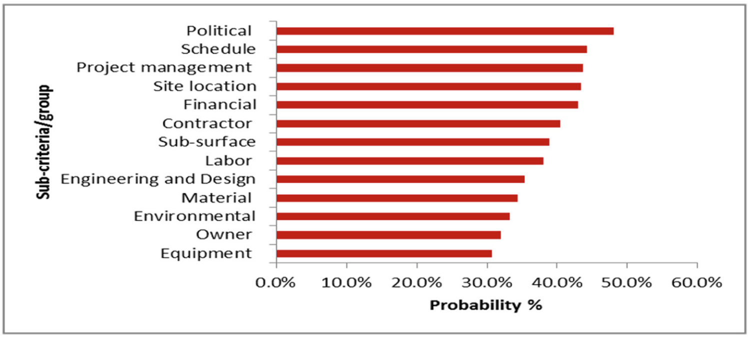


Fig. 8. Attributes probability of occurrence tornado chart (for sub-criterions).

5.2 Data Collection and Probability Distribution

The questionnaires have been prepared in Arabic language and English language to be simply filled; the sheets have been distributed in three evaluated portions, the first one concerning the probability of occurring of attribute, the second portion assigned for attribute cost impact and the third portion assigned for attribute schedule impact. The evaluation category is spread to five levels, very low = 1, low = 2, moderate = 3, high = 4 and very high = 5. To change the previous ranks into numerical scales (PMBOK® Guide) – Fifth Edition chapter-11 will be utilized, MS. Excel 2010 has been used to develop spreadsheets to present the collection data and calculate the mean, minimum and maximum values in addition to the standard divisions, Oracle® Crystal Ball Release 11.1.2.3 software will be used for representing the probability distribution for all attributes as same as the probability distribution of sub-criterions themselves, referred to (PMBOK® Guide) some distributions are frequently used as per Beta, triangular and lognormal distribution.

Data are collected through one mean questionnaire and structured interviews to collect information on case study projects. A survey is conducted in the form of a questionnaire to collect projects risk factors and its probability in addition to its cost and schedule overruns from the construction firms in Egypt. The questionnaire is designed using the significant factors identified by literature and experts as shown in Table 1.

The questionnaire includes three parts. Part one includes the respondent personal general information, i.e. years of experience, total value of completed works, type of company partnership, type of the projects, project duration. Otherwise part two includes the identified attributes probability of occurrence, cost impact and schedule overrun. Part three includes any additional attributes have been added by practitioner. In order to facilitate the answers of reviewers, a scale from 1 to 5 is used, using a scale range as mentioned above.

Physical and telephone interviews are conducted with senior managers of sixteen companies, which are located in Egypt, or located outside Egypt but have some projects here. The surveyed companies have experience history ranges from 15 to 60 years in the construction industry.

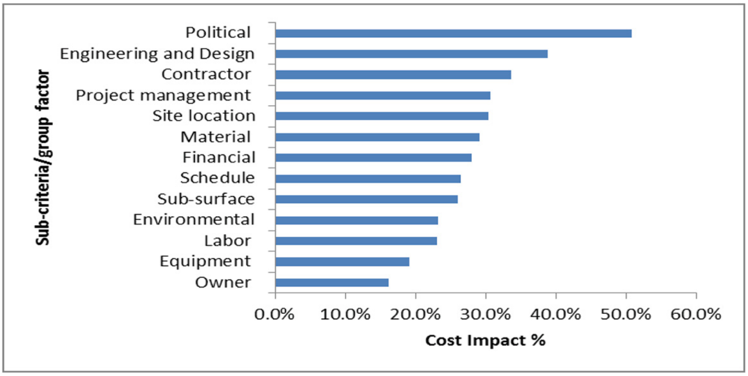


Fig. 9. Tornado chart for sub-criterions cost impact.

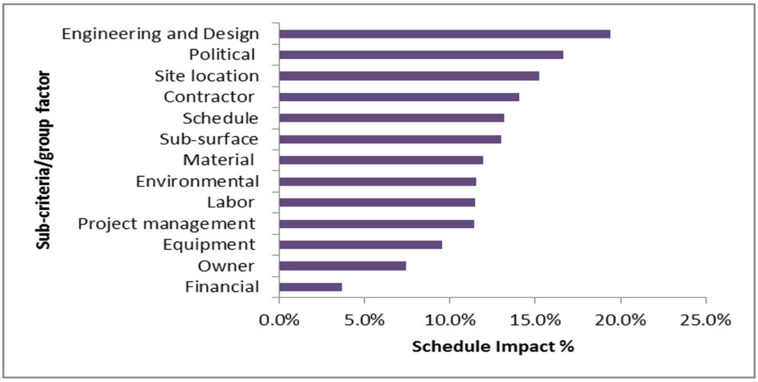


Fig. 10. Tornado chart for sub-criteria schedule impact.

The said companies work in variety of projects, such as pipelines, tanks, refineries, infrastructure, silos …etc. The variety of companies' type is taken into consideration as per national/international huge companies, construction firms, consultants and insurance group. 38 feedbacks have been received, 5 have been rejected due to shortage data, the type of contact engineers are 3 consultants, 4 project managers, 6 construction managers, 4 planners, 7 cost estimators, 1 contract administrator, 1 insurance engineer and 7 site engineers. The budget values of projects that run by the interviewed managers range from $25 up to $500 Million US dollars and the durations range from 6 months up to 3 years. Three case study projects are selected to test the robustness of developed model.

Some figures concerning tornado charts and probability distribution have been illustrated as samples, due to limited space all charts and figures can't be illustrated.

The sample charts mentioned in Figs. 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20 will be used as a part of model structure named RIAM which has been built by the same author and described in another paper titled "Quantitative Risk Assessment in Construction Projects Using AHP-ANP Simulation Based Techniques".

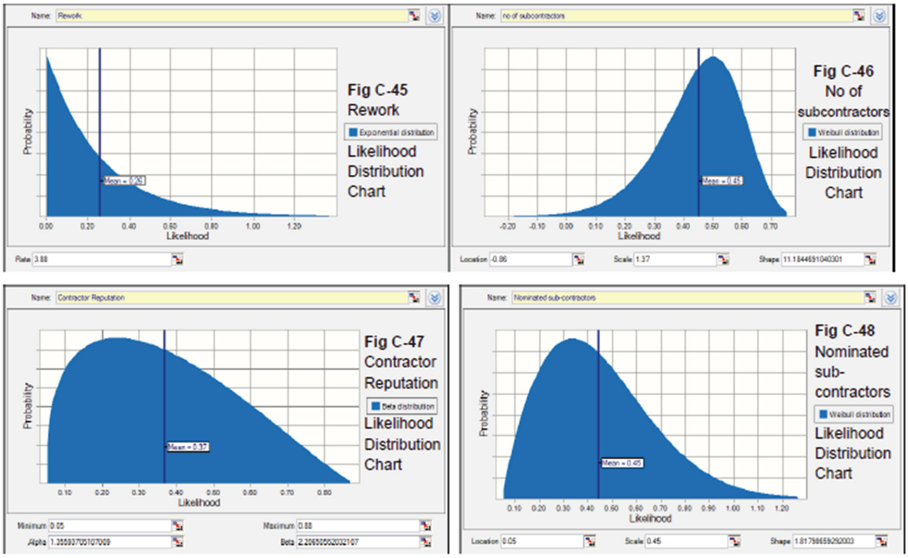


Fig. 11. Likelihood probability distribution charts for some contractor's related factors.

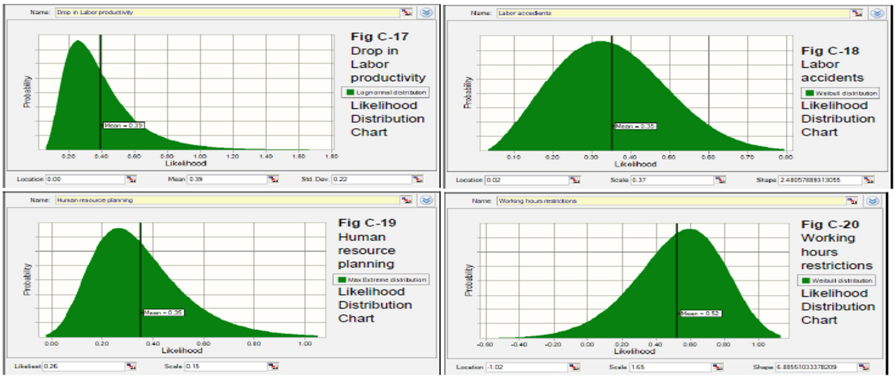


Fig. 12. Likelihood probability distribution charts for some labors' related factors.

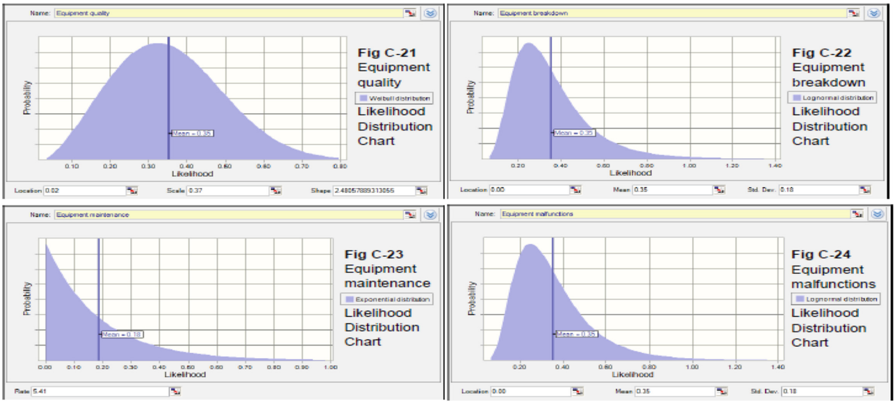


Fig. 13. Likelihood probability distribution charts for some equipment related factors.

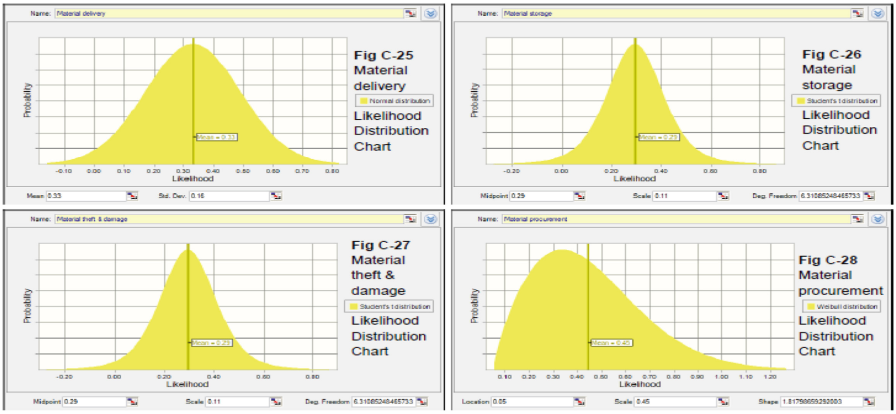


Fig. 14. Likelihood probability distribution charts for some materials related factors.

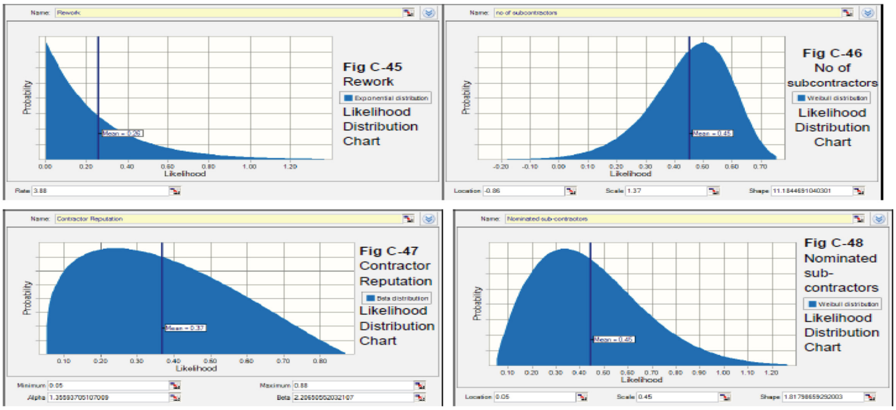


Fig. 15. Likelihood probability distribution charts for some subcontractors' related factors.

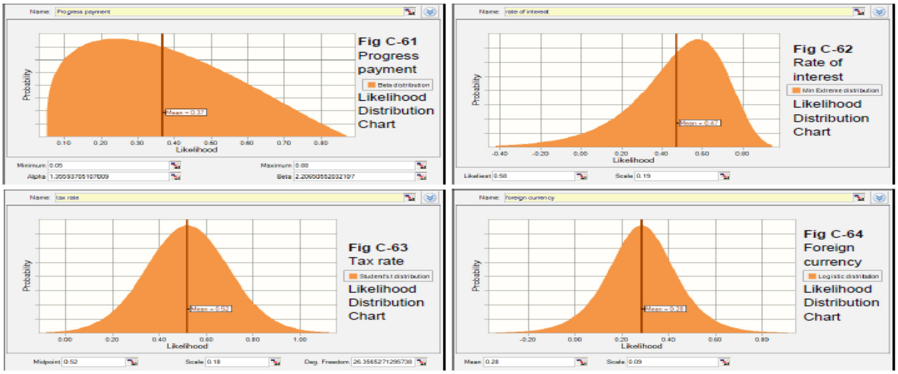


Fig. 16. Likelihood probability distribution charts for some financial related factors.

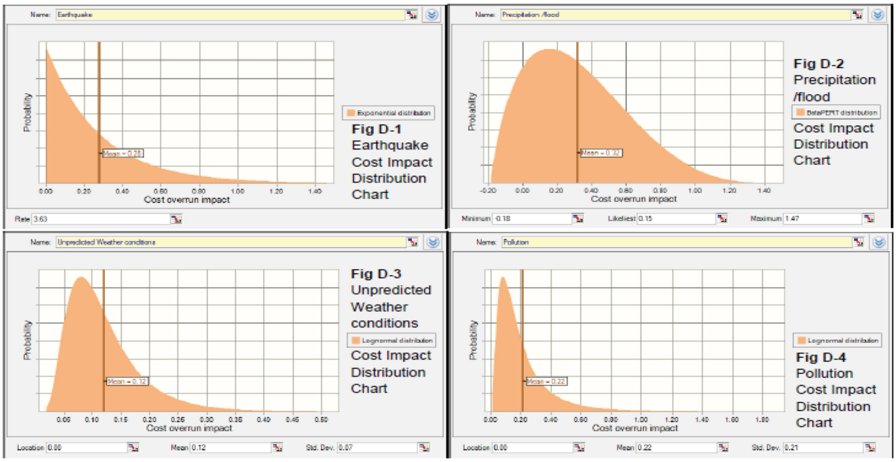


Fig. 17. Cost impact probability distribution charts for some environmental related factors.

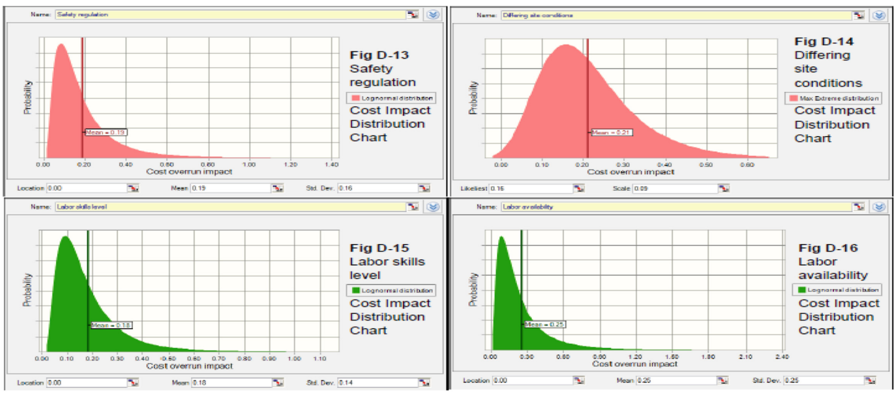


Fig. 18. Cost impact probability distribution charts for some labors'/site related factors.

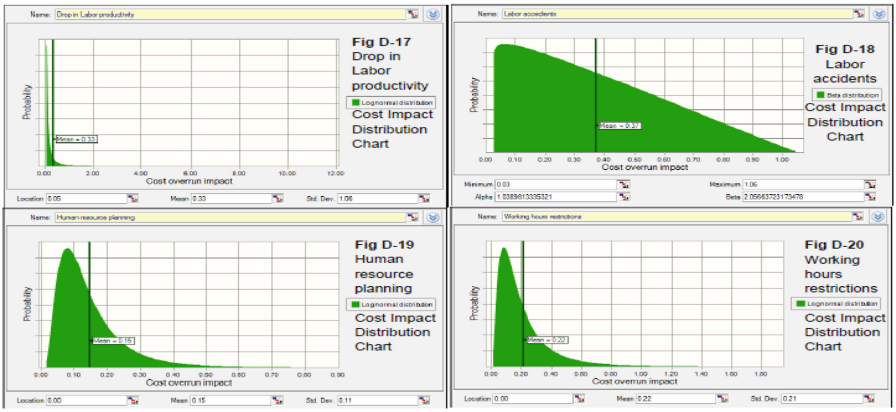


Fig. 19. Cost impact probability distribution charts for other labors' related factors.

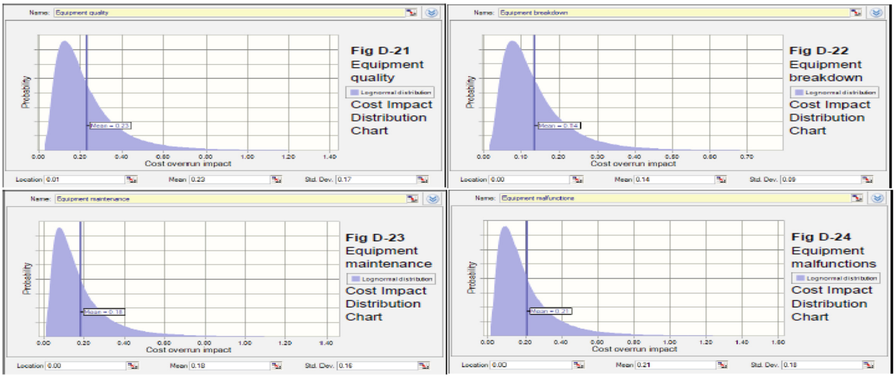


Fig. 20. Cost impact probability distribution charts for some equipment's related factors.

6 Implementation of Cost and Schedule Overruns Assessment Model

The above explained steps are utilized in implementing the developed model and performing the intended analysis, Table 2 will brief the collected data using mean values for probability of occurrence, score of sub-criterion and weight of attributes, this table is repeated another two times, one based on minimum values and the other one based on maximum values. These data will be illustrated to calculate the optimistic and the pessimistic overruns to help the top management to decide the right decision for cost and time contingency percentages.

For risk response, if the attribute impact will be avoided, the proposed value will be taken equal to zero, if the action will be accepted, the proposed value will be taken as same as its original value, if the action is mitigated, the proposed value will be reduced to its half value, if it's transferred, 12% only of its initial value will be taken.

Table 2. Probability of occurrence, local weight of attributes impact and score of sub-criteria impact using mean values

Sub-criterion cost score/ schedule score (S_i)	Attributes/risk factor	Attribute Probability of occurrence (P_i)	Attribute cost impact local weight (W_i)	Proposed mean cost overrun% $S_i \times W_i \times P_i$	Cost Risk response	Planned mean cost overrun %	Attribute schedule impact local weight (W_i)	Proposed mean schedule overrun% $S_i \times W_i \times P_i$	Schedule Risk response	Planned mean schedule overrun %
Material	Material delivery	33.03	8.90	0.16	transfer	0.02	6.50	0.11	accept	0.11
5.4%/5%	Material storage	29.39	17.60	0.28	accept	0.28	13.10	0.19	avoid	0.00
	Material theft & damage	29.39	9.80	0.16	transfer	0.02	6.50	0.10	accept	0.10
	Material procurement	43.94	2.50	0.06	mitigate	0.03	3.30	0.07	accept	0.07
	Non-conforming material	29.39	9.80	0.16	avoid	0.00	6.50	0.10	accept	0.10
	Material monopoly	31.21	49.00	0.83	avoid	0.00	39.30	0.61	avoid	0.00
	Nominated vendors	43.94	2.40	0.06	avoid	0.00	24.80	0.54	avoid	0.00
Owner	Owner type	33.03	42.00	3.15	avoid	0.00	46.20	2.33	avoid	0.00
22.7%/15.3%	management strategy	25.76	14.00	0.82	accept	0.82	11.50	0.45	avoid	0.00
	organization structure	25.76	14.00	0.82	accept	0.82	11.50	0.45	avoid	0.00
	Work/labour permits	33.03	28.00	2.10	avoid	0.00	23.10	1.17	accept	1.17
	on-site access	42.12	2.00	0.19	mitigate	0.10	7.70	0.50	mitigate	0.25
Engineering	Team experience	40.30	10.80	0.09	avoid	0.00	13.30	0.10	accept	0.10
and Design	Project goal	36.67	2.70	0.02	mitigate	0.01	6.70	0.05	mitigate	0.02
2%/1.9%	Complexity of design	33.03	15.10	0.10	avoid	0.00	26.70	0.17	avoid	0.00
	Ad-hoc consultants	40.91	60.50	0.50	avoid	0.00	40.00	0.31	avoid	0.00
	Design error	25.76	10.80	0.06	transfer	0.01	13.30	0.07	accept	0.07
Contractor	Contractor pre-qualified	51.82	5.20	0.06	avoid	0.00	6.50	0.14	avoid	0.00
2.4%/4.1%	New technology	59.70	5.20	0.07	avoid	0.00	6.50	0.16	avoid	0.00
	Defective work	34.85	1.30	0.01	accept	0.01	2.20	0.03	accept	0.03
	Rework	25.76	5.20	0.03	accept	0.03	6.50	0.07	accept	0.07
	no of subcontractors	45.15	26.10	0.28	accept	0.28	11.10	0.21	avoid	0.00
	Contractor Reputation	36.67	23.90	0.21	avoid	0.00	30.90	0.46	avoid	0.00
	Nominated sub-contractors	43.94	6.80	0.07	avoid	0.00	25.90	0.47	avoid	0.00
	no. of current projects	25.76	26.10	0.16	avoid	0.00	10.30	0.11	avoid	0.00
Project	Management experience	40.30	2.40	0.03	avoid	0.00	1.60	0.05	accept	0.05
Environmental	Earthquake	16.67	9.00	0.17	avoid	0.00	14.30	0.19	avoid	0.00
11.3%/8.1%	Precipitation /flood	29.39	3.30	0.11	avoid	0.00	6.80	0.16	avoid	0.00
	Unpredicted Weather conditions	46.36	76.70	4.02	mitigate	2.01	59.10	2.22	mitigate	1.11
	Pollution	40.30	10.90	0.50	accept	0.50	19.80	0.65	accept	0.65
Sub-surface	Unexpected Surface conditions	48.18	14.90	0.62	accept	0.62	15.90	0.38	accept	0.38
8.6%/5%	Archeological survey done	27.58	74.50	1.77	mitigate	0.88	63.60	0.88	avoid	0.00
	Geo-technical investigation	40.91	10.60	0.37	mitigate	0.19	20.60	0.42	avoid	0.00
Site location	Construction area (rural/urban)	57.27	1.40	0.03	mitigate	0.01	3.30	0.08	mitigate	0.04
3.2%/4.1%	Access conditions	40.30	7.20	0.09	mitigate	0.05	10.10	0.17	mitigate	0.08
	On-site congestion	42.12	7.20	0.10	mitigate	0.05	11.10	0.19	mitigate	0.10
	Delay in permits and licenses	33.03	36.90	0.39	accept	0.39	35.50	0.48	accept	0.48
	Security requirements	34.85	3.20	0.04	accept	0.04	5.60	0.08	avoid	0.00
	Safety regulation	50.00	28.80	0.46	accept	0.46	22.40	0.46	avoid	0.00
	Differing site conditions	46.36	15.20	0.23	accept	0.23	12.00	0.23	avoid	0.00
Labor	Labor skills level	34.85	29.40	1.24	accept	1.24	25.50	0.72	avoid	0.00
12.1%/8.1%	Labor availability	33.03	6.80	0.27	accept	0.27	6.40	0.17	avoid	0.00
	Drop in Labor productivity	38.48	8.90	0.41	mitigate	0.21	12.80	0.40	mitigate	0.20
	Labor accidents	34.85	1.80	0.08	transfer	0.01	4.30	0.12	accept	0.12
	Human resource planning	34.85	44.30	1.87	avoid	0.00	38.30	1.08	avoid	0.00
	Working hours restrictions	52.42	8.90	0.56	avoid	0.00	12.80	0.54	accept	0.54
Equipment	Equipment quality	34.85	10.00	0.60	avoid	0.00	14.30	0.57	avoid	0.00
17.1%/11.5%	Equipment breakdown	34.85	50.20	2.99	mitigate	1.50	42.90	1.72	mitigate	0.86
	Equipment maintenance	18.48	29.80	0.94	mitigate	0.47	28.60	0.61	mitigate	0.30
	Equipment malfunctions	34.85	10.00	0.60	transfer	0.07	14.30	0.57	accept	0.57
management	Owner quality assurance	46.36	31.20	0.42	accept	0.42	5.80	0.22	avoid	0.00
2.9%/8.1%	Scope definition	46.36	10.40	0.14	avoid	0.00	49.40	1.86	avoid	0.00
	quality control process	46.36	40.50	0.54	accept	0.54	5.80	0.22	avoid	0.00
	Type of contract	38.48	7.40	0.08	accept	0.08	23.00	0.72	avoid	0.00
	availability of variations	44.55	8.10	0.10	avoid	0.00	14.40	0.52	avoid	0.00
Financial	Type of Funds	29.39	0.70	0.01	transfer	0.00	5.90	0.37	transfer	0.04
4.1%/21.6%	Fluctuation in prices	48.18	1.70	0.03	accept	0.03	11.80	1.23	avoid	0.00
	Invoices delay	50.00	18.70	0.38	accept	0.38	5.90	0.64	avoid	0.00
	Change in currency rate	51.82	3.30	0.07	accept	0.07	11.80	1.32	avoid	0.00
	Owner financial capacity	36.67	8.60	0.13	accept	0.13	11.80	0.93	avoid	0.00
	Progress payment	36.67	10.40	0.16	accept	0.16	11.80	0.93	avoid	0.00
	rate of interest	48.18	1.60	0.03	accept	0.03	11.80	1.23	avoid	0.00
	tax rate	51.82	3.30	0.07	mitigate	0.04	11.80	1.32	avoid	0.00
	foreign currency	29.39	46.30	0.56	mitigate	0.28	5.90	0.37	avoid	0.00
	project size	48.18	5.50	0.11	mitigate	0.05	11.80	1.23	avoid	0.00
Political	Bribery and Corruption	63.33	77.10	0.29	accept	0.29	56.60	0.90	avoid	0.00
0.6%/2.5%	Wars and revolutions	42.12	9.20	0.02	avoid	0.00	11.80	0.12	avoid	0.00
	Military coup	33.03	4.60	0.01	avoid	0.00	5.90	0.05	avoid	0.00
	Changes in laws and regulations	53.64	9.20	0.03	transfer	0.00	25.80	0.35	avoid	0.00
Schedule	Fast track schedule	51.82	25.00	1.00	avoid	0.00	33.30	0.78	accept	0.78
7.7%/4.5%	Project duration	36.67	75.00	2.12	accept	2.12	66.70	1.10	accept	1.10
100%	Summation			35.2%		16.2%		38.5%		9.5%

7 Implementation of the Proposed Model; Riam

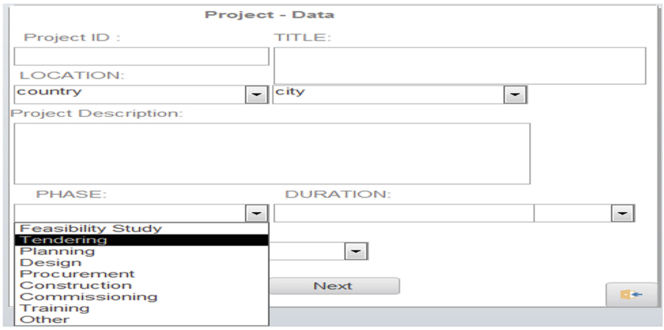
This SECTION presents the steps for developing a computerized system (RIAM) to quantify the risks associated with schedule and cost concerning construction projects. The system will be developed by Microsoft® Visual Basic ™ programming language and Microsoft Access. The RIAM - model will be run through three software, Microsoft Excel and Crystal ball in addition to Expert Choice 2000.

- This model is designed to be flexible and easy to use. It does not require previous knowledge of the above mentioned programs. Thus RIAM-model overcomes the deficiencies of previous risk analysis and quantification tools in being complicated, non-flexible, and time consuming. A computerized system (RIAM) will be used for risk assessment and risk strategy (plan) for project attributes as mentioned in Fig. 4 above. Figure 21a illustrates the front page of running the model.
- As per Fig. 21b, the user will insert brief of the project which will be assessed. The data can be allocated either by writing or using the arrows attached.

7.1 User Interfaces and Data Entry

As per Fig. 21c, when the mentioned screen is opened, the user will choose each attribute by ticking the enclosed arrow, a sub - screen will be opened to choose the attribute probability, cost impact and schedule impact. The user can choose the minimum, mean or maximum values easily by either pressing the indicating button or write the fraction in the related field. Taken into confederation that (a) if the user insert any number out of range, it will be rejected; (b) the default values are equal to mean values.

- As referred in Fig. 21d, the lower part of the previous screen will illustrate the user choices through tables of data. In addition, the user can use the right buttons in order to restore the values to their mean values furthermore to transfer data in order to start the analytical hierarchy process AHP for building the relationship matrices.
- As previous, the user can allocate the fractions either numerically or through the graphical solution by illustrating the charts attached with each part of the form presented in Fig. 21d.The normal distribution of probability will be appeared as per Fig. 21e, three buttons are appended with each attribute, one will illustrate the probability normal distribution of attribute likelihood and its button in the upper part, the second chart will consider the probability of cost impact related to its attribute, the button mentioned in the middle portion, on the other hand the schedule impact probability distribution chart will be appeared through the lower button.
- To utilize the allocated data by the user and building the matrices in order to develop the AHP technique, the user will transfer data using the related button as illustrated in Fig. 21c above; RIAM-model will start the analysis and the calculation to form the relationship matrices either between the attributes or between the sub-criterions themselves. With respect of the matrices, RIAM-model will develop the



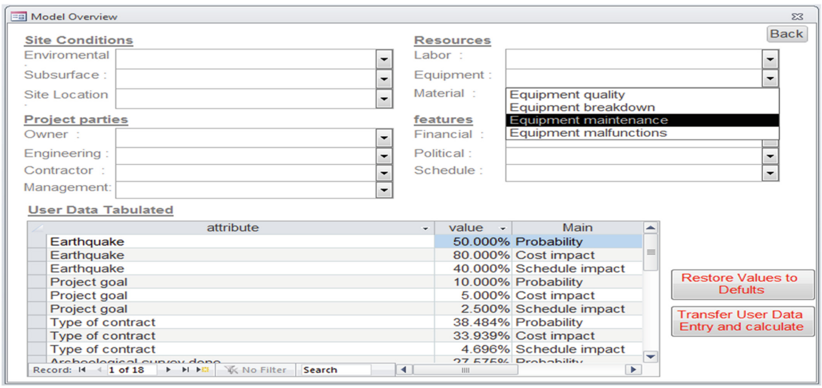
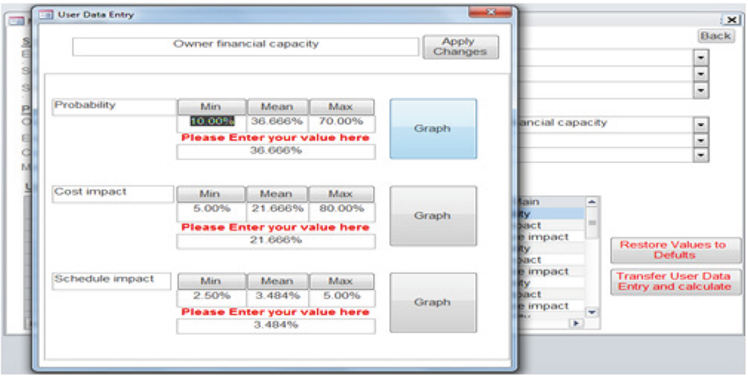


Fig. 21. **a.** Model information screen. **b.** Model information screen. **c.** Model main screen. **d.** User data entry. **e.** The developed charts through graphical solution. **f.** The matrices main screen. **g.** The matrices before best fitting. **h.** The matrices after best fitting. **i.** Risk response screen



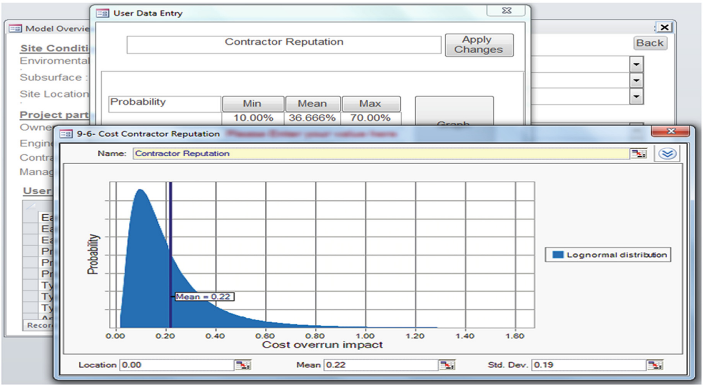
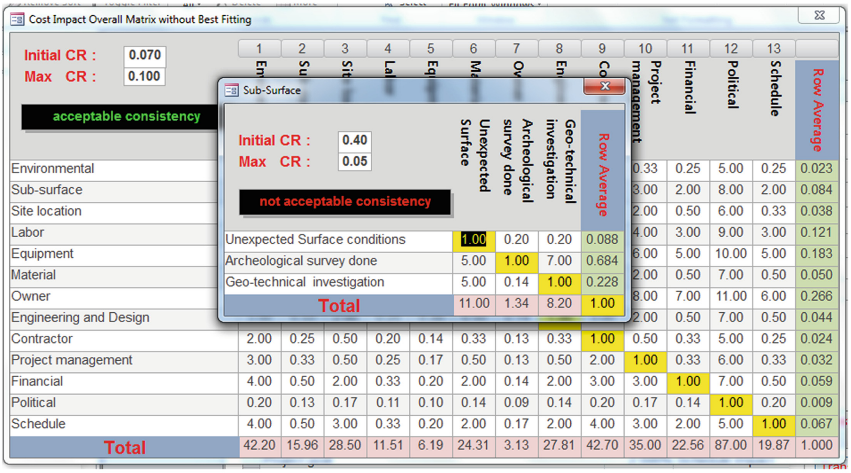
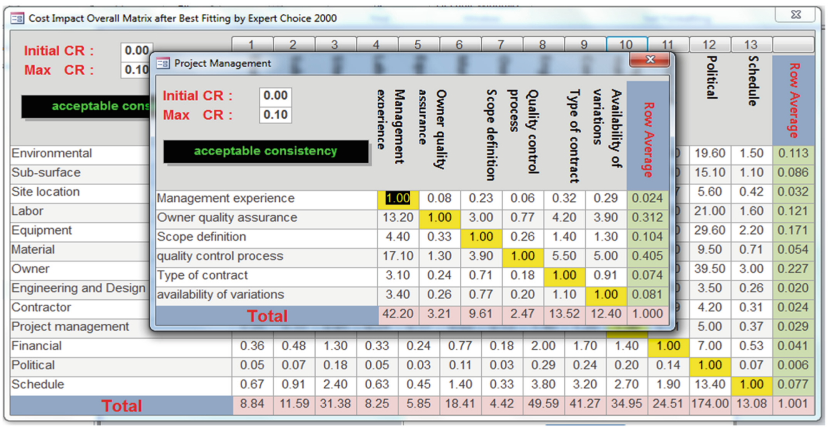


Fig. 21. (*continued*)





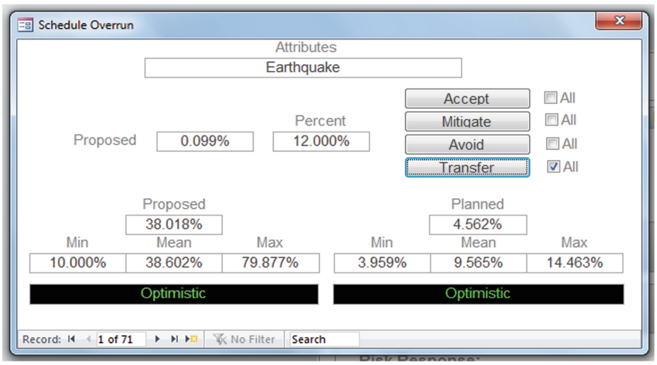


Fig. 21. (*continued*)

row average, the totals, consistency ratio and the maximum consistency. In addition, the model will evaluate the matrix inconsistency if it acceptable, the font color will be green without animation, if it is not acceptable, it will be red color and appeared with animation. Figure 21f will illustrate the main entrance of matrices either for cost impact or concerning schedule impact.

- The user can start his choice by pressing on the overall matrices buttons to present the matrices without best fitting as per the data entry, the overall matrix will be appeared as Fig. 21g and the user can review each sub-criterion matrix by ticking its button above
- In order to enhance matrices inconsistency to reach the optimum value (closed to zero), the model will apply the best fitting iterations typically as per Expert choice 2000 software procedure. These steps will be applied for all main matrices subjected to main criteria themselves in addition to their sub-criterions matrices either with respect of attributes cost impact or attributes schedule impact.
- Furthermore, the revised inconsistency ratio will be appeared at the top part of the screen as indicated in Fig. 21h, the user can check their values equal to zero.
- As per Fig. 21i, the user can choose the response plan related to each attribute either for cost overrun or schedule overruns, the proposed values will indicate the range of output values without risk response which logically will be equal or more than the planned values that indicate the expected plan to affiliate the project risks.

Taken into consideration that, (a) the developed graphs have been issued by crystal ball software, (b) all calculations and matrices import from Microsoft Excel spreadsheets developed by the author.

7.2 Validation of RIAM Model

The developed model RIAM is accurate enough for applying the analytical hierarchal analysis, therefore the user can utilize either the Microsoft excel spreadsheets developed by the author or the developed model RIAM which in fact depends mainly on the said spreadsheets, the accuracy of RIAM model with respect to Super-Decisions software is less than $\pm$ 3%. In order to verify the precision of predicted cost contingency and time contingency index using the developed model, data are collected from experts and projects database (closeout reports) regarding the actual cost and delays in their previous construction projects. These data include the actual and planned cost in addition to actual and planned finish dates. There are three huge construction projects will be presented in Table 3 to compare with the developed model as follow:

After then a comparison was carried out to illustrate the results depend on Microsoft Excel spread sheets, Expert choice 2000 software and Super-Decisions software (which developed by (Saaty, 1982) as follows in Table 4.

Table 3. Comparison between three actual projects

Description	Project-1	Project-2	Project-3
Name	Tina-Abu Sultan Gas Pipeline	Port Said East Container Phase-2	Al-Arish – Taba Gas Pipeline
Scope of work	Construction only of 32”/60 km steel PL	EPC of terminal and buildings	Construction only of 36”/254 km steel PL
Client	–	–	–
Type of project	Unit rates	FIDIC, Lump sum	Lump sum
Location	Ismailia	Port said	Sinai
Price in US$	9,728,685	164,869,316	45,269,440
Planned cost	7,958,064	147,887,777	35,672,319
Actual cost	8,772,651	156,834,988	38,533,239
Planned start date	26/9/2005	12/9/2009	31/3/2002
Actual start date	14/9/2005	23/9/2009	13/4/2002
Planned duration (months)	12	32.7 (140 weeks)	12
Actual duration (months)	13.2	34.9	12.8

Table 4. The results comparison between different software.

Description	Microsoft excel	Expert choice 2000	Super-decisions	Accuracy %
Proposed mean cost overrun%	35.1%	35.2%	35.0%	99.7151%
Planned mean cost overrun%	16.2%	16.2%	15.9%	98.1481%
Proposed min cost overrun%	10.0%	10.0%	10.0%	100.0000%
Planned min cost overrun%	4.4%	4.3%	4.4%	100.0000%
Proposed max cost overrun%	73.2%	72.1%	72.8%	99.4536%
Planned max cost overrun%	37.6%	36.3%	37.2%	98.9362%
Proposed mean schedule overrun%	38.6%	38.5%	38.6%	100.0000%
Planned mean schedule overrun%	9.6%	9.5%	9.4%	97.9167%
Proposed min schedule overrun%	10.0%	10.0%	10.0%	100.0000%
Planned min schedule overrun%	4.0%	4.1%	4.0%	100.0000%
Proposed max schedule overrun%	79.9%	79.7%	79.9%	100.0000%
Planned max schedule overrun%	14.5%	14.2%	14.1%	97.2414%
Optimistic cost overrun %	10.3%	10.3%	10.2%	99.0291%
Pessimistic cost overrun %	26.9%	26.3%	26.6%	98.8848%
Using PERT technique cost overrun%	17.8%	17.6%	17.6%	98.8764%
Optimistic schedule overrun %	6.8%	6.8%	6.7%	98.5294%
Pessimistic schedule overrun %	12.0%	11.8%	11.8%	98.3333%
Using PERT technique schedule overrun%	9.4%	9.4%	9.3%	98.9362%

8 Conclusions

Estimating cost and scheduling contingencies are major factors in achieving a successful and realistic budget and schedule for construction projects. In the present research, a survey is sent to many construction companies to identify, qualify study, assess, and quantify the factors that affect budget and time contingency. From Figs. 6 and 7 as presented above, there are some attributes located in the red zone, which reflect greater probability and impact effect of such factors, if the cost estimator takes the impact of those attributes as same as their values, the budget and schedule will increase accordingly, and the tenders may be unsuccessful. Therefore, risk response and risk plan shall be studied and controlled to transfer or mitigate the impact of said factors to another party, such as insurance companies, sub-contractor or the client himself, which enhance the cost and schedule contingencies demand. On the other hand the attributes located in the green zone have little probability and impact, these factors may be neglected or avoid. Applying these results in the region of study, from Figs. 8, 9 and 10 political sub-criteria can be considered as the most probable and impacted factor, on the other hand owner sub-criterion can be considered the lowest probable and impacted factor.

Finally, a developer model is designed to be flexible and easy to use. It does not require previous knowledge of the above mentioned programs. Thus RIAM-model overcomes the deficiencies of previous risk analysis and quantification tools in being complicated, non-flexible, and time consuming. A computerized system (RIAM) will be used for risk assessment and risk strategy (plan) for project attributes as mentioned before.

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Data Availability Statement

All data generated or analyzed during the study are included in the submitted article or supplemental materials files.

References

1. Faridi, A., El-Sayegh, S.: Significant factors causing delay in the UAE construction industry. J. Constr. Manag. Econ. **24**(11), 1167–1176 (2006)
2. Park, M., Peña-Mora, F.: Reliability buffering for construction projects. J. Constr. Eng. Manag. **130**(5), 626–637 (2004)
3. Touran, A.: Calculation of contingency in construction projects. IEEE Trans. Eng. Manag. **50**(2), 135–140 (2003)
4. Koushki, P., Al-Rashid, K., Kartam, N.: Delays and cost increases in the construction of private residential projects in Kuwait. Constr. Manag. Econ. **23**(3), 285–294 (2005)
5. Moselhi, O.: Applied earned value for project control. In: CIB W-65 Conference Proceedings, Trinidad, Wisconsin (1993)

6. Moselhi, O.: Risk assessment and contingency estimating. Trans. Am. Assoc. Cost Eng., p. 22 (1997)
7. Patrascu, A.: Construction Cost Engineering Handbook. Marcel Dekker, New York (1988)
8. AACE: AACE international's risk management dictionary. Cost Eng. **42**(4), 28–31 (2000)
9. PMI: A Gide to the Project Management of Knowledge (PMBOK Guide), 5th edn. Project Management Institute, Pennsylvania (2013)
10. Treasury, H.: CUP Guidance: No. 41—Managing Risk and Contingency for Works Projects. Central Unit on Procurement, London (1993)
11. Clark, F., Lorenzoni, A.: Applied Cost Engineering. CRC Press, Boca Raton (1996)
12. Iyer, K., Jha, K.: Critical factors affecting schedule performance: evidence from Indian construction projects. J. Constr. Eng. Manag. **132**(8), 871–881 (2006)
13. Boskers, N., AbouRizk, S.: Modeling scheduling uncertainty in capital construction projects. In: Proceeding of the Winter Simulation Conference, pp. 1500–1507 (2005)
14. Barraza, G.: Probabilistic estimation and allocation of project time contingency. J. Constr. Eng. Manag. **137**(4), 259–265 (2011)
15. Brinkkemper, S., Lyytinen, K., Welke, R.: Method Engineering: Principles of Method Construction and Tool Support. Kluwer Academic Publishers, Massachusetts (1996)
16. Smith, G., Bohn, C.: Small to medium contractor contingency and assumption of risk. J. Constr. Eng. Manag. **125**(2), 101–108 (1999)
17. Sukumaran, P., Bayraktar, M.E., Hong, T.H., Hastak, M.: Model for analysis of factors affecting construction schedule in highway work zones. J. Transp. Eng. **132**(6), 508–517 (2006)
18. Abdelalim A.M., O.M. Nawawy, Basiouny: Identification and assessment of risk factors Affecting construction projects. HBRC J. (2015)

Author Index

A
Abdelalim, Ahmed Mohammed, 125, 155, 209
Abo.elsaud, Yasser, 209
Abukhater, Ahmed, 239
Aigbavboa, Clinton O., 179, 190
Al-Khafaji, Amir, 54, 69, 87, 106
Ardis, Jim, 54, 69

E
El-Gohary, Nora, 196

G
Gallagher, Dan, 87, 106
Gogela, Sihle, 190

K
Khaldi, Yasser Majdi, 10

M
Meckes, Dan, 87, 106
Mohapeloa, Khosi, 179

N
Narasimha Rao, S., 249

O
Oke, Ayodeji E., 179, 190

P
Packard, Mitchell, 1

R
Rajaraman, J., 249
Reeise, Scott, 54, 69

S
Simonian, Lonny, 1

U
Urich, Patrick, 69

Z
Zhou, Peng, 196

M. Shehata and F. Rodrigues (Eds.): GeoMEast 2018, SUCI, p. 269, 2019.
https://doi.org/10.1007/978-3-030-01905-1