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)

SSIGE

Springer

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.

More information about this series at http://www.springer.com/series/15140

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)

Springer

Editors
Mohamed Shehata
EHE-Consulting Group in the Middle East
Cairo, Egypt

Fernanda Rodrigues
University of Aveiro
Aveiro, Portugal

ISSN 2366-3405 ISSN 2366-3413 (electronic)
Sustainable Civil Infrastructures
ISBN 978-3-030-01904-4 ISBN 978-3-030-01905-1 (eBook)
https://doi.org/10.1007/978-3-030-01905-1

Library of Congress Control Number: 2018957410

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Contents

Risks Affecting the Delivery of Construction Projects in Egypt: Identifying, Assessing and Response

Ahmed Mohammed Abdelalim(✉)

Faculty of Engineering at Mataria, Helwan University,
P.O. Box 11718, Cairo, Egypt
dr.ahmed.abdelalim@gmail.com

Abstract. The construction industry is often considered a risky business due to its complexity and strategic nature. It involves numerous project stakeholders and internal and external factors, which lead to enormous risks. Due to the massive risk factors and the widespread changes in the Egyptian construction sector over the last decade, risk in construction has been the object of great attention. The main objective of this paper is to identify and assess the significant risks in the Egypt construction industry based on their risk rating (impact and probability). The paper also compares effective risk management techniques to cope with risks associated with construction activities and to implement the projects in accordance with project objectives. Using a carefully-selected set of 77 attributes, this research first identified the key factors impacting delay in Egyptian construction industry and then established the relationship between the critical attributes for assessing the impacts of these factors. A questionnaire was carried out then extensive personal interviews were conducted to form the basis of this research. The factor analysis technique is used to examine the significance of the risk factors in addition to the AHP and simulation techniques. The three techniques used to assess risks were compared and evaluated using three case studies. From the factor analysis, most critical factors of construction risks were identified as: (1) lack of experience; (2) lack of owners' commitment; (3) lack of clarity in project scope; (4) Egyptian economic crises; (5) lack of contractor's commitment; and (6) Inefficient site management. The paper also suggests the risk response strategies for each type of identified risk.

Keywords: Risk management · Construction projects · Factor analysis
AHP · Simualtion

1 Introduction

Risk analysis and management are important parts of the decision making process in a construction company. The construction industry and its clients are widely associated with a high degree of risk due to the nature of construction business activities, processes, environment and organization. Risk in construction has been highly considered because of time delays and cost overruns associated with construction projects.

M. Shehata and F. Rodrigues (Eds.): GeoMEast 2018, SUCI, pp. 125–154, 2019.
https://doi.org/10.1007/978-3-030-01905-1_7

The main objective of this research is to identify and assess the significant risks in Egypt construction industry based on their risk rating (impact and probability). A comprehensive literature survey was conducted to build up general background knowledge of risk factors in construction projects and particular attention was paid to summarise the previous research findings. A construction industry survey was conducted through a questionnaire amongst contractors, consultants and owners. A total of 73 responses were received. Descriptive Statistical analysis was executed to analyse the responses and present the findings from the survey. The research compares effective risk assessment techniques through case studies to cope with risks associated with construction activities and to implement the projects in accordance with project objectives.

Different risk assessment techniques are evaluated by running case studies from building construction projects comparing Analytic Hierarchy Process (AHP) analysis and Crystal Ball software with the descriptive statistics. The comparison was conducted through three case studies from construction projects. The analysis of Case Study (1) revealed that there is a variation in cost as actual cost increased from the budgeted cost with 9.26% and the predicted cost increased from the budgeted cost by 6.76%–10.52%. Similarily Case Study (2) results revealed that there is a variation in cost as actual cost increased from the budgeted cost with 147.67% and the predicted cost increased by 143.84% to 154.59%. For Case Study (3); there is a variation in cost as actual cost increased from the budgeted cost with 10% and the predicted cost increased by 9.89%–11.70%. Finally, the comparison results found that the prediction of actual cost using different techniques was different.

2 Risk Definition and Causes of Risks

2.1 Risk Definition

Risk management is essential to construction activities in minimizing losses and enhancing profitability. In general, Risk management is a systematic process to define, analyze and respond to system's risk. It's a decision making process enables the organization to exploit the opportunities by increasing the probability and frequency period of desired occurrences and decreasing the negative consequences of undesired occurrences. The PMBOK-6th 2017, summarizes the management of risks into five sequential levels respectively are; Risk Management Planning, Risk Identification, Risk Analysis, Risk Response Planning and Auditing the Risk Management Performance, these processes encounter procedural steps to be accomplished (Smith 1999). The process of RM can be broken down into three essential components, they are risk identification, risk analysis, and risk responses. The construction industry is widely associated with a high degree of risk due to the nature of construction business activities, processes, environment and organization.

There were many different attempts to define risk, among which was that risk is "the potential for unwanted or negative consequences of an event or activity" (Rowe 1977).

Risk can also be generally recognized among those within the construction industry as the phenomenon of continually facing a variety of situations involving many unknown, unexpected, frequently undesirable and often unpredictable factors (Fong 1987). But the latter definition of risk tends to ignore its double- edged nature, which was recognized in defining risk as "the chance of something happening that will have an impact on objectives; may have a positive or negative impact" (AS/NZS 4360 2004).

This paper aims at identifying the top major risks regardless of their nature of impact, through considering the probability of their occurrence and their impact or magnitude of the consequences.

2.2 Egyptian Studies

Several articles have discussed the causes of risk and delays in construction projects; some studies identified the main causes of risk and ranked them, while other studies discussed the analysis methods and the proposed ways to mitigate them. Studies in Egypt were incorporated in this study to compile a list of risk factors. (Amer 1994), studied the major delay causes for construction projects which they are: poor contract management, unrealistic scheduling, lack of owner's financing/payment for completing work, design modifications during construction, and shortages in materials such as cement and steel. Abd El- Razek 2008, considered several delay causes in construction projects in Egypt as; financing by the contractor during construction, delays in contractor's payment by the owner, design changes by owner or his agent during construction, partial payments during construction, and non-utilization of professional construction/contract management. Marzouk 2014, stated that Finance and payments of completed work by owner, variation orders of scope by the owner during construction, effects of subsurface conditions, Low productivity level of labors and Ineffective planning and scheduling of the project were the most five delay causes of construction projects in Egypt. Aziz 2013 ranked factors perceived to affect delays factors and according to their importance level on delay, especially in the last decade. The data were analyzed using Relative Importance Index (RII) and the most important factors were: Delay in progress payments (Funding problems), Different tactical patterns for bribes, Shortage of equipment, Ineffective project planning and scheduling, poor site management and supervision. Khodir 2015, Identified the latest top major risk probabilities in construction projects in Egypt, according to political and economic variables between the time period Jan 2011 and Jan 2013 and then suggested a group of risk response strategies that suit each of the identified key risks. Currency price changes, new tax rates, Lack of fuel, unsecured roads, Official changes, Workers' strikes and Fire risk were the most important risk factors. Marzouk 2014, studied delays that relate to engineering factors which arise due to design development, workshop drawings, and change then he developed a knowledge based expert system for assessing the engineering related delay claims. Further studies have been conducted in the MENA region and internationaly to investigate the most common risks in construction industry, they have been studied and summarized during the questionnaire design, [11–20]. Table 1 summarizes the ranking of the most important risk factors affecting construction projects in Egypt due to recent researching works.

Table 1. Risk ranking according to previous studies in Egypt

Author	Abd El-Razek et al. (2008)	Aziz (2012)	Aziz (2013)	Marzouk et al. (2012)	Khodeir et al. (2015)
1	Financing by contractor during construction	Lowest bidding procurement method owner originated	Delay in progress payments (funding problems)	payments of completed work by owner	Currency fluctuation
2	Delays in contractor's payment by owner	Additional work owner originated	Different tactics patterns for bribes	Variation orders owner during construction	Change in taxation/new tax rates
3	Design changes by owner or his agent during construction	Bureaucracy in bidding/tendering method owner originated	Shortage of equipment	Effects of subsurface conditions (e.g., soil..)	Change energy cost/lack of fuel
4	Partial payments during construction	Wrong method of cost estimation	Ineffective project planning and scheduling	Low productivity level of labors	Safety/unsecure roads
5	Non-utilization of professional construction/contractual management	Funding problems owner originated	Poor site management and supervision	Ineffective planning and scheduling of project	Official changes
6	Slow delivery of materials	Inaccurate cost estimation Designer originated	Poor financial control on site	Difficulties in financing project by contractor	Workers' strikes
7	Miss-Coordination between various parties (contractor, subcontractor, owner, consultant) working on the project	Mode of financing and payment for completed work by owner	Rework due to errors	Type of project bidding and award (negotiation, lowest bidder)	Fire risk
8	Slowness of the owner decision making process	Unexpected ground conditions miscellaneous	Selecting inappropriate contractors	Shortage of construction materials in market	Bad communications between stakeholders
9	The relationship between different subcontractors' schedules	Inflation miscellaneous	Sudden failures actions	Late approval of design documents by owner	Poor documentations
10	Preparation of shop drawings and material samples	Fluctuation in prices of raw materials	Inadequate planning	Unqualified workforce	Poor project planning and control
11	Lack of database in estimating activity duration and resources	Inadequate planning owner originated	Incompetent project team		Owner hesitation about design
12	Shortage in construction materials	Poor contract management owner originated	Inadequate contractor experience		Lack of decision making
13	Poor organization of the contractor or consultant	Unstable cost of manufactured materials miscellaneous	Frequent equipment breakdowns		Poor material management and planning

(*continued*)

Table 1. (*continued*)

Author	Abd El-Razek et al. (2008)	Aziz (2012)	Aziz (2013)	Marzouk et al. (2012)	Khodeir et al. (2015)
14	Controlling subcontractors by main contractor in the execution of work	Scope changes/ inadequate pre-contract study designer originated	Global financial crisis		Poor equipment management & planning
15	Changes in materials types and specifications during construction	Inadequate site investigations contractor originated	Complexity of project (project type, project scale, etc.)		Poor labor planning
16	Obtaining permits from municipality	Inappropriate government policies miscellaneous	Legal disputes between project participants		Replacement of consultant
17	Waiting for approval of shop drawings and material samples	Inappropriate preconstruction study designer originated	Change orders		Increased material waste
18	Poor labor productivity	Inappropriate contractual procedure Owner originated	Inappropriate construction methods		Force majeure
19	Errors committed due to lack of experience	Inappropriate contractors owner originated	Unqualified/inadequate experienced labor		Geo-technical risks
20	Design errors/incomplete made by designers	Shortening in project period by owner	Conflicts between joint-ownership		New governmental acts or legislations

3 Research Objectives

The main objective of this research is to identify and assess the latest top major risk factors that affected construction projects in Egypt. This was fulfilled through obtaining feedback from different practitioners on the different aspects of risk management that aimed at:

- Construct a general risk register that includes the most common risks facing the construction contractors using heuristic data gathering.
- Based on the probability of occurrence and impact of each risk, ranking is conducted using qualitative risk assessment techniques. The purpose of the ranking is to highlight the risky areas and obtain the priority list of project risks.
- Set up a risk profile; quantitative assessment/response actions.
- Analyze the relationship of these factors and thereby enhance understanding of construction risk factors.

4 Research Methodology

To achieve the study objectives, the following procedure was carried out

- Review literature research to examine previous research and identify the gaps in current knowledge.
- Explore initial list of risk variables that deem important and affecting construction projects through literature review and experts' interviews.
- Conduct a questionnaire survey to assess the probability and the impact of the identified variables on construction projects in Egypt.
- Rank these risk factors using first procedure descriptive statistics based upon the feedback of the questionnaire survey.
- Suggest a strategy to manage risk for each type of identified risk depending on the questionnaire results.
- Collect historical data records for previous projects and prepare these data. Conduct Exploratory Factor Analysis (EFA) by using principal component analysis with VARIMAX rotation through Statistical Package for the Social Sciences (IBM-SPSS- V.23) software to isolate statistical variables that influence the risk factors and are named group (B); and define latent variables.

The sequence of work is illustrated in Fig. 1.

The first step was to identify risks in construction projects. This was done primarily through literature review. A comprehensive list of 77 risks was developed based on previous studies; (Marzouk 2008, Al-Khalil and Al-Ghafly 1999, Assaf and Al-Hejji 1995, 2006, Doloi 2012, Aziz and Remon 2013, Faridi et al. 2006, Abuwarda and Zinab 2016, Gündüz et al. 2013 and Sambasivan 2006). A questionnaire was then structured to get the perceptions of construction experts in Egypt. The questionnaire consisted of two sections. The first section was intended to gather information about the respondents' profile. The second section was intended to get the perception on the rating of each risk and the suggestion of the suitable risk response strategy. Each risk had three questions;

- The first question relates to the probability of the risk event occurring on construction projects. The respondents were asked to choose between rare, low, moderate, high and very high.
- The second question refers to the consequence on project objectives once the risk event occurs.
- The third question relates to the practical actions for managing these risks.

The survey presents seventy-seven (77) factors. These factors were classified into four (4) major categories based on the previous studies and the Egyptian code of project management. Every category extracted to minor categories as explained in Table 2:

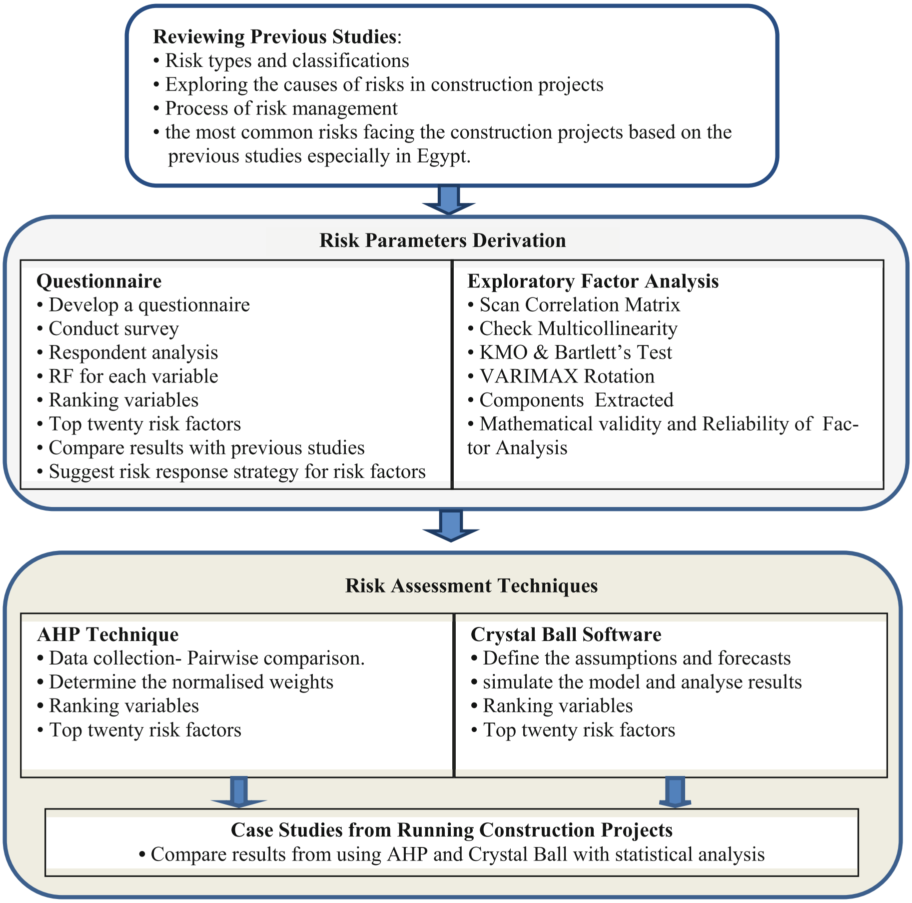

Fig. 1. Research methodology

4.1 Respondent's Profile

The questionnaire survey forms were distributed to construction professionals associated with Egyptian construction industry. The completed responses were collected either personally, or received through regular postal mails, e-mails, and faxes. Out of 100 distributed questionnaires, 73 have returned complete and used in the analysis. The following charts summarize the respondents' profile as illustrated in Fig. 2.

Table 2. Categorized factors that cause delay in construction projects

No.	Major category	Category	ID	No.
1	Project life-cycle category	Feasibility and strategy stage	01:07	7
		Tendering and contract stage	08:12	5
		Construction stage	13:18	6
		Testing, handover and guarantee stage	19:20	2
2	Project parties	Owner related factors	21:28	8
		Contractor related factors	29:32	4
		Consultant related factors	33:35	3
		Project management related factors	36:42	7
3	Resources	Project site related factors	43:48	6
		Equipment related factors	49:58	10
		Labor related factors	59:63	5
4	External	Environmental related factors	64:67	4
		Financial related factors	68:72	5
		Regulation related factors	73:77	5

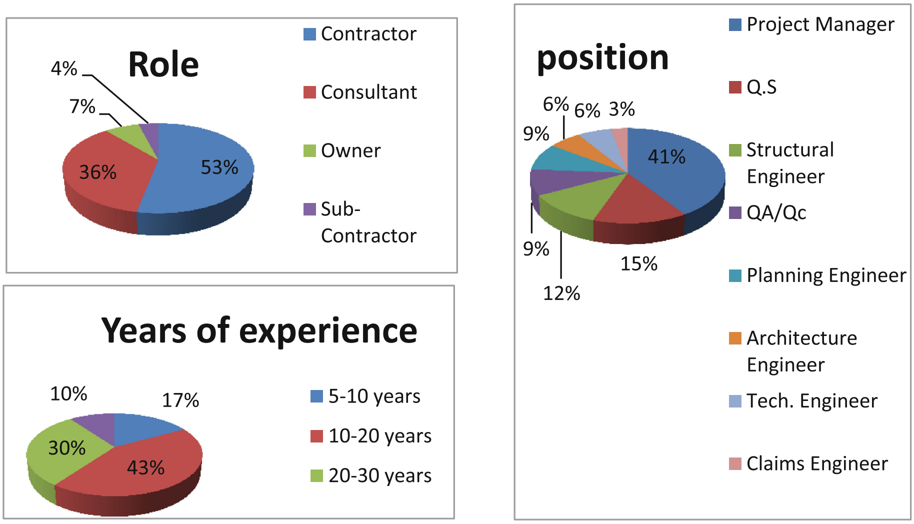

Fig. 2. Respondents' profile

4.2 Data Analysis Approach

The experts were requested to judge two attributes of each risk: the probability of occurrence, denoted by (P), and the degree of consequence, denoted by (C). The risk factor or index, denoted by (RF), is the function of these two attributes, Eqs. (1) and (2):

$$Risk\,Factor;\; RF = P * C \tag{1}$$

$$Risk\,Factor;\; RF = (P + C) - (P * C) \tag{2}$$

The first form is common in some forms of risk analysis, but the second is better because it identifies items with high likelihoods or high consequences or both, so the chance of high consequence but low likelihood items being ignored is reduced greatly (Cooper 2005; Khodier et al. 2015). In this research, the two equations were used to rank the variables to compare the results and choose the most realistic one.

The three variables (RF), (P) and (C) are all measured numerically. The respondents judged the Probability of occurrence using the five-level judgment scale of: very high, high, medium, low and rare. The same scale was also applied to the degree of consequence of the risk.

To apply the model, the opinion judgment scale was converted into numerical scales. The "very high" took a value of 0.9, and the "high," "medium," "low" and "rare" took values of 0.7, 0.5, 0.3 and 0.1 respectively, while the consequence numerical scale was the "very high" took a value of 0.8, and the "high," "medium," "low" and "rare" took values of 0.4, 0.2, 0.1 and 0.05 respectively as the per the risk impact scale involved in the (PMBOK-6th 2017).

4.3 Findings of the Survey

The attributes ranked using the two equations; attribute with highest RF or rank 1 indicates that it has the maximum risk impact while the attribute with lowest rank indicates that it has the least impact on construction projects (Table 3). The Risk responses were associated with the questionnaire to get expert judgement.

Table 3. Overall risk significant factors, with highly significant risks highlighted.

ID	Description	P × C		(P + C) − (P * C)		Response
		RF	Rank	RF	Rank	
R1	Improper project feasibility study	0.16	26	0.64	36	Avoid
R2	Scope changes arising from redesign and extensive variations	0.12	54	0.58	57	Mitigate
R3	Inappropriate overall organizational structure linking to the project	0.14	39	0.62	42	Mitigate
R4	Insufficient data collection and survey before design	0.13	47	0.60	51	Avoid
R5	Lack of design team experience in construction projects	0.18	18	0.67	20	Mitigate
R6	Mistakes and delays in producing design documents	0.13	46	0.65	27	Mitigate
R7	The technical specifications of the project is not achieved	0.14	38	0.62	41	Mitigate

(*continued*)

Table 3. (*continued*)

ID	Description	P × C		(P + C) − (P * C)		Response
		RF	Rank	RF	Rank	
R8	Improper type of project bidding and award (negotiation, lowest bidder)	0.13	50	0.59	55	Avoid
R9	Inadequate quality/ambiguity of contract documents	0.13	52	0.60	50	Avoid
R10	Inadequate definition of substantial completion and responsibilities	0.13	49	0.60	49	Avoid
R11	Improper risk allocation over parties in contract	0.13	43	0.64	38	Mitigate
R12	Ineffective delay penalties	0.11	62	0.56	63	Avoid
R13	Delay in the project scheduling	0.26	2	0.79	2	Mitigate
R14	Lack of the contractor's commitment to safety rules and regulations	0.22	7	0.75	4	Mitigate
R15	Work suspensions owing to conflicts	0.11	61	0.56	66	accept
R16	Delay in performing inspection and testing	0.10	66	0.57	60	Mitigate
R17	Lack of the contractor's commitment to maintenance and repair of defects that appear during the contractual warranty period	0.10	70	0.56	65	transfer
R18	Unrealistic inspection and testing methods proposed in contract	0.14	41	0.61	46	Mitigate
R19	Non-payment of all dues contractors and reported the final insurance or what is left of it to him	0.09	72	0.54	72	Avoid
R20	Delay in performing final inspection and certification by a third party	0.11	60	0.57	59	Avoid
R21	Owner Type	0.16	23	0.67	22	accept
R22	Owner's financial problems	0.26	3	0.76	3	Avoid
R23	Delays in contractor's progress payment (of completed work) by owner	0.22	6	0.72	8	Mitigate
R24	Delay to furnish and deliver the site to the contractor	0.11	59	0.58	58	Mitigate
R25	Delay in settlement of contractor's claim by the owner	0.18	19	0.70	13	Mitigate
R26	Suspension of work by owner	0.15	33	0.63	39	Avoid
R27	Slow decision making by owner	0.19	11	0.69	15	Mitigate
R28	Variation orders/changes of scope by the owner during construction	0.19	12	0.72	9	Mitigate
R29	Inadequate contractor experience	0.13	44	0.61	47	Avoid
R30	Un-use of advanced engineering design software and modern equipments	0.13	51	0.61	44	Mitigate
R31	Shortage of sub-contractors	0.13	48	0.60	53	Mitigate
R32	Conflicts between contractors and sub-contractors	0.18	20	0.70	14	Mitigate
R33	Inadequate experience of consultant	0.19	14	0.69	17	Avoid

(*continued*)

Table 3. (*continued*)

ID	Description	P × C		(P + C) − (P * C)		Response
		RF	Rank	RF	Rank	
R34	Delay in approving shop drawings and sample materials	0.15	30	0.66	25	Mitigate
R35	Conflicts between consultant and contractor	0.16	27	0.64	32	Avoid
R36	Poor site management and supervision	0.22	8	0.72	7	Mitigate
R37	Lack of communication between the parties	0.16	28	0.65	26	Mitigate
R38	Change in key staffing throughout the project	0.15	32	0.64	37	Avoid
R39	Ineffective planning of project	0.28	1	0.80	1	Mitigate
R40	Shortcoming of the measure and value process	0.17	22	0.67	23	Mitigate
R41	Lack of human resources planning	0.15	34	0.65	28	Mitigate
R42	Poor quality assurance/control	0.16	25	0.67	21	Mitigate
R43	Restricted access at the site	0.08	77	0.53	75	Accept
R44	Lack of protection on a construction site	0.14	42	0.61	45	Mitigate
R45	Unavailability of utilities in the site or Delay in providing services from utilities such as (water, etc.)	0.14	40	0.62	43	Mitigate
R46	Effects of subsurface conditions (e.g., soil, high water table, etc.)	0.17	21	0.66	24	Avoid
R47	Traffic control and restriction at job site	0.11	58	0.56	64	Mitigate
R48	Effect of social and cultural condition	0.09	73	0.54	71	Accept
R49	Shortage of construction materials, equipment and labors in market	0.16	29	0.64	35	Mitigate
R50	Improper storage of materials leading to damage	0.11	63	0.57	62	Mitigate
R51	Thefts done on site	0.10	69	0.54	73	Avoid
R52	Damage of sorted materials	0.10	67	0.55	70	Mitigate
R53	Delay in material delivery	0.22	5	0.74	5	Mitigate
R54	Changes in material types and specifications during construction	0.16	24	0.65	31	Avoid
R55	Change in material prices or price escalation due to monopoly	0.18	15	0.68	18	Accept
R56	Delay in material delivery	0.15	31	0.65	30	Mitigate
R57	Low efficiency of equipment	0.11	57	0.59	54	Mitigate
R58	Delay in equipment delivery	0.12	53	0.60	52	Transfer
R59	Unqualified workforce	0.18	17	0.69	16	Mitigate
R60	Shortage of labors	0.13	45	0.61	48	Mitigate
R61	Low productivity level of labors	0.15	36	0.64	34	Mitigate
R62	Labor injuries on site	0.09	75	0.53	74	Mitigate
R63	Labor strikes due to revolutions	0.11	64	0.55	68	Avoid
R64	Force Majeure as war, revolution, riot, strike, and earthquake, etc.	0.10	68	0.64	33	Accept

(*continued*)

Table 3. (*continued*)

ID	Description	P × C		(P + C) − (P * C)		Response
		RF	Rank	RF	Rank	
R65	Weather effect (hot, rain, etc.)	0.11	65	0.55	67	Accept
R66	pollution due to work	0.10	71	0.53	76	Avoid
R67	Archaeological area	0.08	76	0.55	69	Avoid
R68	Fluctuations in cost/currency	0.22	4	0.73	6	Share
R69	Delay in approval of completed work by client	0.20	10	0.71	12	Mitigate
R70	Financing by contractor during construction	0.21	9	0.71	11	Mitigate
R71	Delays in the owner advanced payment	0.09	74	0.52	77	Avoid
R72	Insufficient data collection and survey before design	0.18	16	0.68	19	Avoid
R73	Slow permit by government/municipality	0.12	55	0.58	56	Mitigate
R74	Delay in performing final inspection and certification by a third party	0.15	35	0.62	40	Avoid
R75	Incessant variation order	0.15	37	0.65	29	Mitigate
R76	Changes in government regulations and laws	0.12	56	0.57	61	Accept
R77	Wars and Revolutions	0.19	13	0.71	10	Accept

The top 20 risk factors affecting construction project in Egypt are bolded in Table 2, it seems to be the same results from the different analysis with different ranking; Conflicts between. Ineffective planning of project, Delay in the project scheduling and Owner's financial problems are the first, second and the third factors with high probability and high consequence on projects.

4.4 Ranking Top Major Risks

By analyzing the top risks from Table 2 using the two equations mentioned before, it is obvious that risk factors related to project management have the highest impact in the construction projects in Egypt followed by factors related to the owner, financial, consultant and construction stage. The other categories ranked as shown in Fig. 3 starting from the risk with highest risk impact.

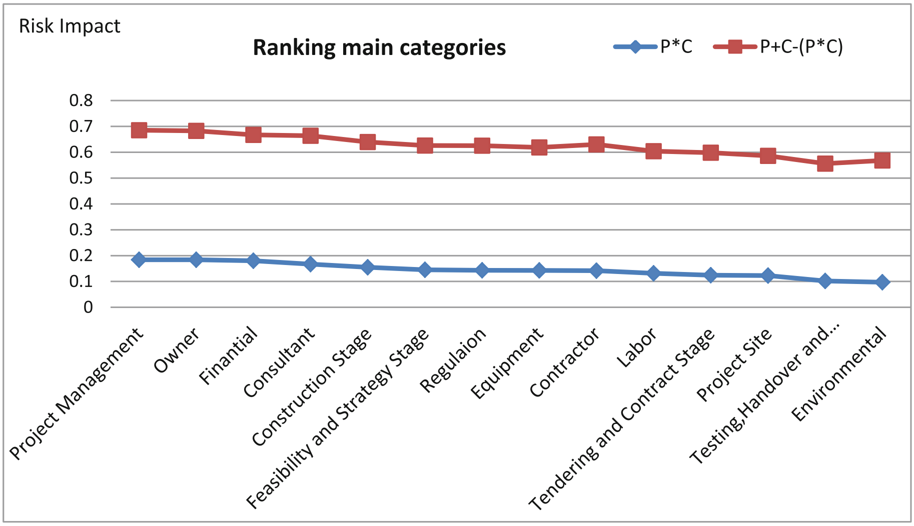

Fig. 3. Ranking main categories

5 Comparative Study

It was essential to correlate similar studies for Egypt and synchronize them to do the comparative study so that each significant cause reflects the most representative cause of delays and risk for construction projects in Egypt. This was necessary because each researcher had identified the attributes based on the local conditions and the prevailing problems. The comparative study depends on the following researches' work; (Abd El-Razek et al. 2008, Aziz 2013, Marzouk et al. 2008, Khodeir et al. 2014, and Aziz 2012). Table 4 represents the top twenty risk factors concluded from this study and its comparison with the top attributes in the other researches.

Table 4. Ranking of the 20 most significant risk factors in Egypt and their correspondings in the other researches in Egypt

Rank	Author	[7]	[31]	[21]	[8]	[9]
	Year	2008	2012	2013	2013	2014
1	Ineffective planning of project		11	10	5	
2	Insufficient project scheduling			3	5	
3	Owner's financial problems		5		6	
4	Fluctuations in cost/currency		9			1
5	Delay in material delivery	5				
6	Delays in contractor's progress payment (of completed work) by owner	2		1	1	

(*continued*)

Table 4. (*continued*)

Rank	Author	[7]	[31]	[21]	[8]	[9]
	Year	2008	2012	2013	2013	2014
7	Lack of the contractor's commitment to safety rules and regulations					
8	Poor site management and supervision	6		5		
9	Financing by contractor during construction	1				
10	Delay in approval of completed work by client					
11	Slow decision making by owner	7				
12	Variation orders/changes of scope by the owner during construction	3	14		2	
13	Strikes and revolutions					6
14	Inadequate experience of consultant	4	19	12		
15	Change in material prices or price escalation due to monopoly		10			
16	Insufficient data collection and survey before design		15			
17	Unqualified workforce			19	10	
18	Shortage of construction materials, equipment and labors in market			3	8	
19	Delay in settlement of contractor's claim by the owner					
20	Conflicts between contractors and sub-contractors					

It is observed that only three factors have no ranking in the studies, and the other 17 attributes considered being one of the most important attributes affecting construction projects in Egypt. This result emphasized the current research findings.

6 Suggested Risk Response Strategies

In the third part of the questionnaire, the experts suggest suitable risk response strategies for the identified key risks. The results depend on the most likely suggestion from the 73 respondents, Table 2. The strategies include negative risk responses, such as avoidance, transfer, sharing, mitigation and passive acceptance as illustrated in Fig. 4.

Fig. 4. Risk response strategies (Cooper 2005)

7 Factor Analysis

Factor analysis is a powerful statistical technique that aims at providing greater insight among numerous correlated, but seemingly unrelated variables into a much fewer underlying factors (Doloi 2009). In order to evaluate the adequacy of the survey data for factor analysis, Kaiser–Meyer–Olkin (KMO) test and Bartlett's test were conducted, Field 2005. The value of KMO represents the ratio of the squared correlation between variables to the squared partial correlation between variables. It varies from 0 to 1. A value close to 1 indicates that the pattern of correlations is relatively compact and hence factor analysis should give distinct and reliable results, Field 2005. A minimum value of 0.5 has been suggested, Kaiser 1974. In this research of the 77 attributes, a total of 40 attributes was selected based on the highest risk factors extracted from the descriptive statistics analysis depending on the two equations. After deleting the repetitive attributes, only 20 attributes remained. The KMO value of the selected 20 variables is 0.634 which is deemed good for this study. In order to test the null hypothesis that the correlation matrix is an identical matrix, the principal component analysis requires the probability associated with Bartlett's Test to be less than the level of significance (Zhang 2005). The probability associated with the Bartlett test is < 0.001, which satisfies this requirement as shown in Table 5.

Table 5. KMO and Bartlett's test

Kaiser-Meyer-Olkin	Measure of sampling adequacy	0.634
Bartlett's test	Approx. Chi-Square	413.152
	df	190
	Sig.	.000

7.1 Extracted Components

The principal components analysis, PCA, is adopted to reduce the highly correlated project attributes into a smaller number of risk factors. As stated above, the factor analysis was performed on the selected 20 attributes and principal components (factors) were extracted as shown in Table 7. These principal components were extracted by specifying the minimum initial Eigen value of 1.0. A screen plot to graph the Eigen values against the number of total components was generated in the data reduction process, Field 2005. The first six components, which cumulatively explain 72.1% of the total variances as shown in Table 6, have been kept and other components that accounted for less than 27.9% were dropped. The variables that were grouped into factors were given new headings according to its relationship meaning:

- Factor 1: Lack of experience
- Factor 2: Lack of owners' commitment
- Factor 3: Lack of clarity in project scope
- Factor 4: Egyptian economic crises
- Factor 5: Lack of contractor's commitment
- Factor 6: Inefficient site management

Table 6. Factor analysis-component extracted

ID	Descriptions of factors and the attributes	Factor loading	Variance explained
Factor 1: Lack of experience			*15.792%*
R33	Inadequate experience of consultant	.838	
R36	Poor site management and supervision	.730	
R5	Lack of design team experience in construction projects	.719	
R25	Delay in settlement of contractor's claim by the owner	.655	
R39	Ineffective planning of project	.591	
R77	Strikes and revolutions	.553	
Factor 2:Lack of owners' commitment			*14.495%*
R59	Unqualified workforce	.821	
R23	Delays in contractor's progress payment (of completed work) by owner	.774	
R22	Owner's financial problems	.713	
R27	Slow decision making by owner	.697	
Factor 3: Lack of clarity in project scope			*10.869%*
R28	Variation orders/changes of scope by the owner during construction	.820	
R13	Delay in the project scheduling	.543	
Factor 4: Egyptian economic crises			*10.595%*
R55	Change in material prices or price escalation due to monopoly	.791	
R68	Fluctuations in cost/currency	.774	
Factor 5: Lack of contractors commitment			*10.203%*
R13	Delay in the project scheduling	.533	
R14	Lack of the contractor's commitment to safety rules and regulations	.533	
Factor 6: Inefficient site management			*10.146%*
R69	Delay in approval of completed work by client	.769	
R53	Delay in material delivery	.727	
R72	Insufficient data collection and survey before design	.572	
R70	Financing by contractor during construction	.557	

8 Mathematical Validity of Factor Analysis

8.1 Validity

Validity analysis examines whether what is expected to be measured is truly measured, Zhang 2005, i.e. whether the attributes grouped under a certain factor (or component) in the data reduction process collectively explain the same measure within the target dimensions. If the attributes truly explain the measure of the factor identified in the factor analysis, they should significantly correlate with one another. By taking the Pearson correlation (r), it can be interpreted the amount by which the two variables affect one another. Using the SPSS, the Pearson bivariate correlation analysis was performed to examine the relationships between the measured attributes within all the six extracted factors as listed in Table 7. Table 7 shows the correlations between the attributes in factors 1 to 6. Pearson bivariate correlations are greater than 0.4 in most of the cases among different attributes in all the factors. From these results, factors formed in factor analysis contain attributes which are related.

Table 7. Correlation matrix for the attributes

Factor 1

	R33	R36	R5	R25	R39	R77
R33	1	.611	.516	.506	.425	.354
R36	.611	1	.439	.665	.457	.159
R5	.516	.439	1	.430	.301	.293
R25	.506	.665	.430	1	.574	.214
R39	.425	.457	.301	.574	1	.114
R77	.354	.159	.293	.214	.114	1

Factor 2

	R59	R23	R22	R27
R59	1	.573	.398	.507
R23	.573	1	.460	.458
R22	.398	.460	1	.510
R27	.507	.458	.510	1

Factor 3

	R28	R13
R28	1	.489
R13	.489	1

Factor 4

	R55	R68
R55	1	.701
R68	.701	1

Factor 5

	R13	R14
R13	1	.532
R14	.532	1

Factor 6

	R69	R53	R72	R70
R69	1	.293	.428	.425
R53	.293	1	.254	.415
R72	.428	.254	1	.477
R70	.425	.415	.477	1

8.2 Reliability

Reliability is an important measure to ensure the consistency of the construct over time (i.e. consistency of measured attributes and scale), Cronbach's alpha test was performed on entire data as well as attributes in each factor which are shown in Table 8. The value of Cα could be anywhere in the range of 0 to 1, where a higher value denotes the greater internal consistency and vice versa.

The value of Cα is inflated by a large number of variables, so there is no set interpretation as to what is an acceptable limit, Zhang 2005. However, a rule of thumb applies to most situations with the following ranges: $C\alpha > 0.9$ denotes excellent, $0.9 > C\alpha > 0.8$ as good, $0.8 > C\alpha > 0.7$ as acceptable, $0.7 > C\alpha > 0.6$ as questionable, $0.6 > C\alpha > 0.5$ as poor and $0.5 > C\alpha$ denotes unacceptable, Doloi 2009. The value of Cα for all attributes calculated is 0.859 which is considered to be good.

Table 8. Reliability Cronbach's alpha for the attributes.

Attributes Cronbach's alpha (Cα)	Attributes Cronbach's alpha (Cα)
Attributes in factor 1	0.801
Attributes in factor 2	0.774
Attributes in factor 3	0.652
Attributes in factor 4	0.821
Attributes in factor 5	0.692
Attributes in factor 6	0.712
All attributes selected for factor analysis	0.859

Table 8 shows the values of the Cronbach's alpha (Cα) for the attributes under each factor and the results indicate a good overall reliability and internal consistency of the measured attributes in the analysis.

9 Ranking of Risk Factors According to AHP Technique

In order to adapt the AHP methodology, the first step is to arrange the elements of the decision problem in the form of a hierarchy. Figure 5 summarizes the concequence of conducting AHP Technique. A top down approach has been adopted in formulating the AHP model for this research. A hierarchy that consists of four levels, and descends from the general to the more particular was developed. The top level is the overall goal of the decision, followed by the decision criteria which impact the goal directly in the second level. The sub-criteria level comes next against the alternatives to be evaluated at the lowest level. The goal of this decision problem is the ranking of the risk factors affecting construction projects in Egypt and assigning the top twenty risk factors. This objective can be achieved by considering four strategic criteria, namely project life cycle, project parties, resources and external related factors, which form the second level in the hierarchy. The third level of the hierarchy contains the sub-criteria which were already before. The criteria and sub-criteria used in the hierarchy can be assessed using the AHP approach of pairwise comparison of elements in each level with respect to every parent element located one level above. Local priorities result directly from pairwise comparisons of the sub-criteria with respect to the criteria, while global priorities result from the multiplication of criteria and sub-criteria priorities. For instance, a set of global priority weights is produced for each of the sub-criteria by multiplying local weights of the sub-criteria with weights of all the parent elements above it. The local priorities define a share of a given decision-making element in reaching the goal at the upper level, where the global priorities of a given level represent in turn the share of each element in reaching the main goal, which is the ranking of the top twenty risk factors affecting construction projects in Egypt. After building the hierarchy, next is the pairwise comparisons phase. Hence, from the hierarchy shown in Fig. 6, there are 92 sets of pairwise comparison matrices, one for the criteria with respect to the goal, 14 for the sub-criteria with respect to each criterion, and 77 for the risk factors with respect to each of the sub-criteria. Table 9 illustrates the ranking of the top risk factors according to global weight using AHP technique. Figure 7 shows the ranking of the categories according to AHP assessment.

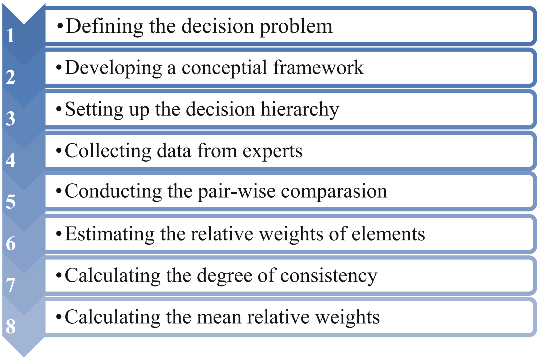

Fig. 5. AHP- processes.

10 Ranking of Risk Factors Using Crystal Ball Simulation Technique

Crystal Ball is an easy-to-use simulation program that helps to analyse the risks and uncertainties associated with Microsoft Excel spread sheet models. To use Crystal Ball, the following steps must be performed as shown in Fig. 8. Table 10 shows priority list of the top twenty project risks according to 90% confidence level. The ranking is according to the two formulas; [P * C] and [P + C− (PC)]. Using the two formulas gives the same results; expect the two risk factors; Force Majeure (R64) and conflicts between contractors and sub-contractors (R32) are added according to the second formula. The output charts and statistics data developed by crystal ball software are depending on the three probability distribution; uniform, triangular and custom distribution. The results show that using the different charts for assumption, are almost consistent and give the same top twenty project risks with different priorities.

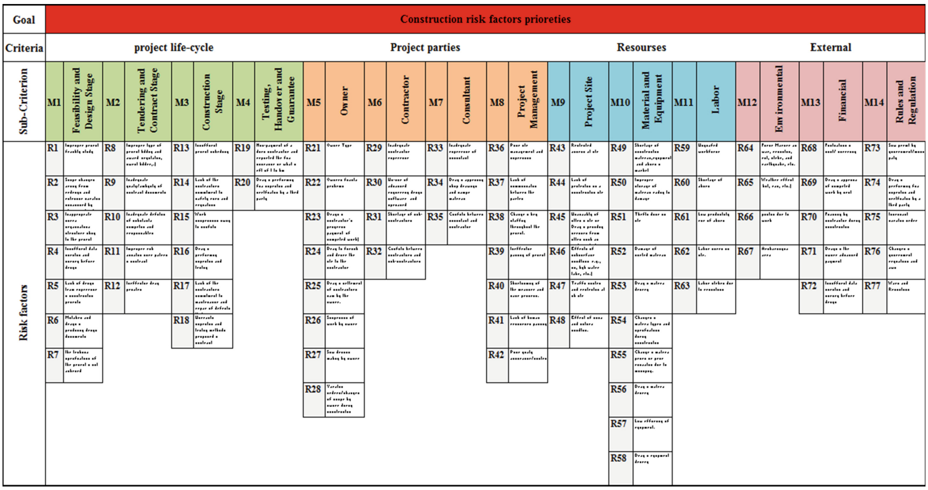

Fig. 6. AHP hierarchy for risk factors affecting construction projects in Egypt

Table 9. Top twenty risk factors using AHP assessment

Rank	ID	Description	Global weight
1	R22	Owner's financial problems	0.0614
2	R39	Ineffective planning of project	0.0564
3	R33	Inadequate experience of consultant	0.0528
4	R36	Poor site management and supervision	0.0506
5	R68	Fluctuations in cost/currency	0.0498
6	R23	Delays in contractor's progress payment (of completed work) by owner	0.0429
7	R40	Shortcoming of the measure and value process	0.0351
8	R13	Insufficient project scheduling	0.0308
9	R69	Delay in approval of completed work by client	0.0296
10	R35	Conflicts between consultant and contractor	0.0291
11	R27	Slow decision making by owner	0.0246
12	R14	Lack of the contractor's commitment to safety rules and regulations	0.0233
13	R1	Improper project feasibility study	0.0229
14	R5	Lack of design team experience in construction projects	0.0224
15	R70	Financing by contractor during construction	0.0210
16	R77	Loss due to Egyptian revolutions	0.0205
17	R28	Variation orders/changes of scope by owner during construction	0.0204
18	R42	Poor quality assurance/control	0.0192
19	R34	Delay in approving shop drawings and sample materials	0.0161
20	R74	Delay in performing final inspection and certification by a third party	0.0156

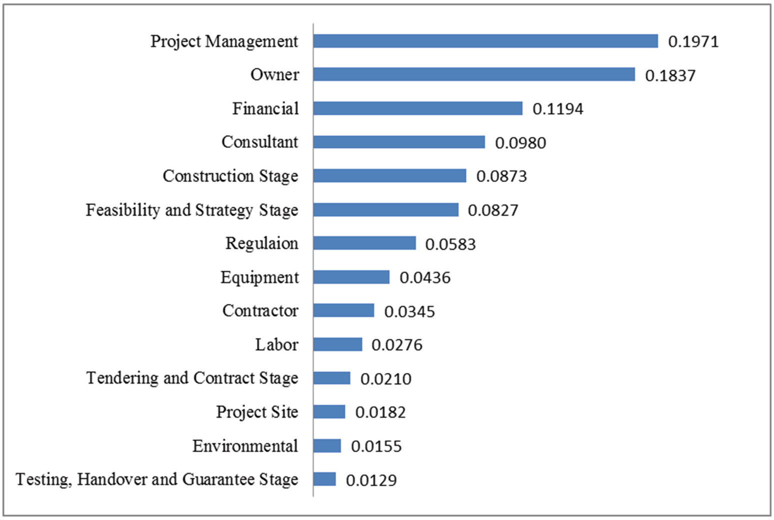

Fig. 7. Ranking of the categories according to AHP assessment

1 • Build a Microsoft® Excel® spreadsheet to model the relationships
2 • Define assumption for probabilistic variables
3 • Define the forecast cells, that is, the output variables of interest.
4 • Set the number of replications.
5 • Run the simulation.
6 • Simulate the model and analyze the outputs
7 • Report results and make decisions

Fig. 8. Model steps development in Crystal Ball.

Table 10. Priority list of project risks (90% confidence level)

No.	ID	Forecast formula [P*C]	Risk factor	ID	Forecast formula [P + C − (PC)]	Risk factor
		Risk description			Risk description	
1	R39	Ineffective planning of project	0.41	R39	Ineffective planning of project	0.83
2	R22	Owner's financial problems	0.4	R22	Owner's financial problems	0.81
3	R13	Insufficient project scheduling	0.36	R14	Lack of the contractor's commitment to safety rules and regulations	0.81
4	R14	Lack of the contractor's commitment to safety rules and regulations	0.35	R13	Insufficient project scheduling	0.8
5	R23	Delays in contractor's progress payment (of completed work) by owner	0.34	R36	Poor site management and supervision	0.8
6	R36	Poor site management and supervision	0.34	R28	Variation orders/changes of scope by owner during construction	0.78
7	R53	Delay in material delivery	0.33	R68	Fluctuations in cost/currency	0.77
8	R68	Fluctuations in cost/currency	0.33	R55	Change in material prices or price escalation due to monopoly	0.77
9	R70	Financing by contractor during construction	0.31	R23	Delays in contractor's progress payment (of completed work) by owner	0.76
10	R77	Loss due to Egyptian Revolutions	0.31	R77	Loss due to Egyptian Revolutions	0.76

(*continued*)

Table 10. (*continued*)

No.	ID	Forecast formula [P*C] Risk description	Risk factor	ID	Forecast formula [P + C – (PC)] Risk description	Risk factor
11	R55	Change in material prices or price escalation due to monopoly	0.31	R25	Delay in settlement of contractor's claim by the owner	0.74
12	R28	Variation orders/changes of scope by owner during construction	0.3	R53	Delay in material delivery	0.74
13	R27	Slow decision making by owner	0.3	R46	Effects of subsurface conditions	0.74
14	R69	Delay in approval of completed work by client	0.29	R33	Inadequate experience of consultant	0.73
15	R33	Inadequate experience of consultant	0.29	R69	Delay in approval of completed work by client	0.73
16	R25	Delay in settlement of contractor's claim by the owner	0.29	R70	Financing by contractor during construction	0.73
17	R46	Effects of subsurface conditions	0.29	R64	Force Majeure	0.72
18	R72	Insufficient data collection and survey before design	0.28	R27	Slow decision making by owner	0.72
19	R5	Shortage of construction materials, equipment and labours in market	0.28	R72	Design errors/incomplete made by designers	0.72
20	R59	Unqualified workforce	0.28	R32	Conflicts between contractors and sub-contractors	0.72

11 Comparasion of Using Different Risk Assessment Techniques

Comparing the top 20 risk factors affecting construction projects in Egypt from the result of using different risk assessment techniques are summarises in Table 11. Thirteen factors from the twenty risk factors are existing in the three risk assessment techniques.

Table 11. Top 20 risk factors comparison using different risk assessment techniques

No.	Descriptive statistical analysis		Analytic Hierarchy Process (AHP) analysis		Crystal Ball software	
	ID	Description	ID	Description	ID	Description
1	R39	Ineffective planning of project	R22	Owner's financial problems	R39	Ineffective planning of project
2	R13	Insufficient project scheduling	R39	Ineffective planning of project	R22	Owner's financial problems
3	R22	Owner's financial problems	R33	Inadequate experience of consultant	R14	Lack of the contractor's commitment to safety rules and regulations
4	R68	Fluctuations in cost/currency	R36	Poor site management and supervision	R13	Insufficient project scheduling
5	R53	Delay in material delivery	R68	Fluctuations in cost/currency	R36	Poor site management and supervision
6	R23	Delays in contractor's progress payment (of completed work) by owner	R23	Delays in contractor's progress payment (of completed work) by owner	R28	Variation orders/changes of scope by owner during construction
7	R14	Lack of the contractor's commitment to safety rules and regulations	R40	Shortcoming of the measure and value process	R68	Fluctuations in cost/currency
8	R36	Poor site management and supervision	R13	Insufficient project scheduling	R55	Change in material prices or price escalation due to monopoly
9	R70	Financing by contractor during construction	R69	Delay in approval of completed work by client	R23	Delays in contractor's progress payment (of completed work) by owner
10	R69	Delay in approval of completed work by client	R35	Conflicts between consultant and contractor	R77	Loss due to Egyptian Revolutions
11	R27	Slow decision making by owner	R27	Slow decision making by owner	R25	Delay in settlement of contractor's claim by the owner
12	R28	Variation orders/changes of scope by owner during construction	R14	Lack of the contractor's commitment to safety rules and regulations	R53	Delay in material delivery
13	R77	Loss due to Egyptian revolutions	R1	Improper project feasibility study	R46	Effects of subsurface conditions (e.g., soil, high water table, etc.)

(*continued*)

Table 11. (*continued*)

No.	Descriptive statistical analysis		Analytic Hierarchy Process (AHP) analysis		Crystal Ball software	
	ID	Description	ID	Description	ID	Description
14	R33	Inadequate experience of consultant	R5	Lack of design team experience in construction projects	R33	Inadequate experience of consultant
15	R55	Change in material prices or price escalation due to monopoly	R70	Financing by contractor during construction	R69	Delay in approval of completed work by client
16	R72	Design errors/incomplete made by designers	R77	Loss due to Egyptian revolutions	R70	Financing by contractor during construction
17	R59	Unqualified workforce	R28	Variation orders/changes of scope by owner during construction	R64	Force Majeure
18	R49	Shortage of construction materials, equipment and labors in market	R42	Poor quality assurance/control	R27	Slow decision making by owner
19	R25	Delay in settlement of contractor's claim by the owner	R34	Delay in approving shop drawings and sample materials	R72	Design errors/incomplete made by designers
20	R32	Conflicts between contractors and sub-contractors	R74	Delay in performing final inspection and certification by a third party	R32	Conflicts between contractors and sub-contractors

12 Case Studies

Three case studies from construction projects in Egypt are used to analyse and quantify the impact of risks factors using the information collected from the construction professionals. Experts were asked for their opinion about causes of cost variation and the percentage of impact to enable prediction of actual cost of such project before completion. A total of 35 out of 77 critical risk factors were identified as major influencing risk factors on the construction project. Experts gave every risk factor; out of the 77 risk factors; influencing cost overrun factor on the construction project Percentages of each observed risk factors. The Impact ***(d_j)*** of critical risk factors associated with construction projects were used to analyse and identify the possible project cost variation in order compare different risk assessment techniques. The project Cost Variation Coefficient ***(CVC)*** and the Predicted Actual Cost ***(PAC)*** of the three case studies are presented in

12 due to the use of statistical analysis, AHP and Crystal Ball techniques and compared with the actual cost of the projects. From previous analysis of collected data from construction projects field, the planner can predict approximately the construction actual cost of any new construction project before construction using the following equations (Aziz 2013).

$$CVC = 1 + \frac{\sum_{J=5}^{J=1}(dj \times ERII\mathrm{j})}{\sum_{J=5}^{J=1}(ERIIj)} \tag{3}$$

$$PAC = VC \times TBC \tag{4}$$

Where;

- ***CVC***: is the project Cost Variation Coefficient;
- ***$ERII_J$*** (%): is the Equivalent weighted average percentage of Relative Importance Index per Risk Factor;
- ***dj:*** is the percentage of each Risk Factor impact that ranged between (0.00–1.00).
- ***PAV:*** is the Predicted Actual Cost at completion before construction of the studied project;
- ***TBC:*** is the Total Budgeted Cost before construction of the studied project.

From studying and analysing the previous projects, it was found that for Case Study (1); there is a variation in cost as actual cost increased from the budgeted cost with 9.26% and the predicted actual cost increased from the budgeted cost by 6.76% to 10.52%. Similarily, the Case Study (2) results revealed that there is a variation in cost as actual cost increased from the budgeted cost with 147.67% and the predicted actual cost increased from the budgeted cost by 143.84% to 154.59%. For Case Study (3); there is a variation in cost as actual cost increased from the budgeted cost with 10% and the predicted actual cost increased from the budgeted cost by 9.89% to 11.70%. These differences in cost variation ranges resulted from using different risk assessment techniques. The comparison results found that the prediction of actual cost using different techniques was different from the views of the three case studies. The results presented in Table 12 revealed that using different techniques give predicted actual cost almost consistent with max variance from the actual cost less than 8% which is accepted.

Table 12. Summary of case studies' results

No.	Assessment technique			Case study (1) Initial cost = 540,000,000 L.E		Case study (2) Initial cost = 15,000,000 L.E		Case study (3) Initial cost = 43,000,000 L.E	
				CVC %	PAC	CVC %	PAC	CVC %	PAC
				9.26	590,000,000	146.7	37,000,000	10%	47,300,000
1	Statistical Analysis	(P * C)	PERT	7.4	580,016,341	147.4	37,110,253	10.0	47,315,251
2			Mean	6.9	577,030,137	144.5	36,668,471	9.9	47,253,120

(*continued*)

Table 12. (*continued*)

No.	Assessment technique			Case study (1) Initial cost = 540,000,000 L.E		Case study (2) Initial cost = 15,000,000 L.E		Case study (3) Initial cost = 43,000,000 L.E	
				CVC %	PAC	CVC %	PAC	CVC %	PAC
3		(P + C) – (PC)	PERT	7.6		147.5		10.5	47,502,372
4			Mean	6.9	577,423,968	144.8	36,717,300	10.0	47,306,168
5	AHP	(P * C)	PERT	10.5	596,823,728	152.4	37,853,463	11.1	47,779,950
6			Mean	9.7	592,560,969	149.3	37,400,595	11.7	48,031,261
7		(P + C) – (PC)	PERT	10.1	594,399,258	154.6	38,187,996	11.4	47,914,375
8			Mean	10.5	596,823,728	152.4	37,853,463	11.1	47,779,950
9	Crystal Ball		Custom	7.4%	580,000,637	145.9	36,888,180	10.4	47,471,821
10			Normal	7.4%	580,000,637	145.9	36,888,180	10.4	47,471,821
11			Triangular	6.8%	576,478,287	143.8	36,562,187	9.9	47,274,356
Min. and Max CVC %				6.8%	10.5%	143%	154.6%	9.9	11.7

13 Discussion of the Critical Risk Factors

13.1 Factor 1: Lack of Experience

Inadequate experience of the contractor is due to the lack of site management skills of the client. The inexperienced contractor may not be able to cope up with the progress of work or may not understand the complexity of the project leading to misinterpretation and confusion. Inadequate experience of contractor in turn leads to improper management of site and thus cause time overruns. The Poor site management and supervision clearly highlights the lack of coordination between various bureaucratic hierarchies involved in Egyptian construction industry. Efficient site management and effective supervision is one of the vital factors for achieving success in Egyptian projects. Improper planning during the bidding stage is one important reason of risk which is generally overlooked in analysis of construction delays (Doloi 2009). In most of the construction companies, people who apply for bid are different from who actually execute the work. Hence there is a tendency that people who apply for bid tend to be a bit overly optimistic and don't envisage for various practical contingencies.

13.2 Factor 2: Lack of Owners' Commitment

In case of the unavailability of workforce with the required skill set and hiring of unskilled labor is inevitable, they must be trained properly before putting them at work. Delay in payment to the contractor, which in turn causes financial difficulties. Financial difficulties of contractors have reportedly been one of the important reasons for delay in construction projects (Assaf and Al-Hejji 2006). Slow decision from the owner is due to the lack of proper coordination between owner and consultant or owner and contractor. This occurs when a contractor or consultant fails to make the client understand the time significance of the decision to be taken or the owner's decision is not communicated properly to concerning parties.

13.3 Factor 3: Lack of Clarity in Project Scope

Variation orders/changes of scope clearly come under lack of clarity of project scope by owner and designer. Change in scope of work and variation orders at a later stage delay the project completion due to change in quantities and change in project schedule. It may further delay the project due to unavailability of appropriate spare resources to the contractors. In fact, it results in a complete drain out of the contractor's resources and reduce his capability to follow the time plan. Insufficient scheduling is due to lack of clarity in project scope. Though the unrealistic schedule not only causes time overrun, it also compels contractors for compromising quality of construction leading to mistakes and reworks in construction activities.

13.4 Factor 4: Egyptian Economic Crises

Change in material prices or price escalation due to monopoly and fluctuations in cost/currency are mainly the results of the Egyptian economic crises. It causes increase in all of the project activity cost and cause time overrun and May causes the project to be stopped.

13.5 Factor 5: Lack of Contractor's Commitment

Insufficient scheduling in this factor is due to lack of coordination between client and contractor about the realistic difficulties at the site. Site accidents due to lack of safety measures are due to lack of commitment from both client and contractor towards the project. Site accidents not only harm individuals and consume time, but also it is also observed that productivity of labor reduces significantly after an accident. Time is also wasted in attending to accidents and replacing the injured person by a person with lesser or irrelevant skills. This then relates to the efforts required for training and development. These can be avoided if the client and contractor commit to appropriate safety measures adopted on the site.

13.6 Factor 6: Inefficient Site Management

Delay in approval of completed work by client occurs due to lack of communication between contractor and the approval authority. Lack of communication can be mutual, i.e. either the client is unaware of the completed work or order of approved work is not communicated back to the contractor. Delay in material delivery by vendors shows inefficient site management and the lack of commitment in terms of contractor's procurement planning prior to the construction phase of the project. Ignorance of the lead time for material delivery by the vendors potentially results in material shortage, which has reportedly been one of the significant causes of schedule delay across construction projects.

14 Conclusions

The objective of this research was to identify the main causes of risk that affect construction projects in Egypt. A literature review was conducted to identify the risk factors stipulated in the literature. 73 responses were conducted to identify the most appropriate risk attributes. A compiled list of 77 causes was obtained and subjected to further quantitative evaluation in a questionnaire survey to confirm the causes and identify the most important causes of project risk. The most important causes identified by the survey, and based on statistical analysis, AHP and Simulation techniques were: ineffective planning of the project; delay in the project scheduling; owner's financial problems; fluctuations in cost/ currency; delay in material delivery and delays in contractor's progress payment (of completed work) by owner.

Project management; Owners' related factors; financial and consultants' related factors are the most important categories affecting construction projects

In addition to identifying the top major key risks, the paper also suggests a group of risk response strategies that suit each of the identified key risks. These risks and their equivalent response strategies have been identified to be added. Factor analysis of responses on the project attributes has extracted critical factors; lack of experience; lack of owners' commitment; lack of clarity in project scope; Egyptian economic crises; lack of contractor's commitment; and Inefficient site management are the six critical factors. Validity analysis and reliability analysis confirm the quality of the questionnaire survey and the soundness of the factor analysis.

15 Data Availabilty Statement and Limitations

- All data generated or analyzed during the study are included in the submitted article or supplemental materials files. Data are covering the last decade of the Egyptian construction market and still valid. This research investigated construction projects in general and made no differentiation between international companies joining either Egyptian private sector companies or Egyptian public sector companies. There is a need to investigate such differences in-depth because the two types of Egyptian company have different behaviours and organisational structures. The study focuses on the construction projects in general and the data were collected with this in mind. Therefore determination and ranking the risk factors are generated based on all types of Egyptian construction projects and doesn't consider other types of construction projects such as building construction projects; construction wastewater projects; and road construction projects.

References

Smith, N.J.: Managing Risk in Construction Projects. Blackwell, Oxford (1999)

Rowe, W.D.: An Anatomy of Risk. Wiley, New York (1977)

Fong, S.W.: Risk management. Cost Eng. **25**, 12–16 (1987)

AS/NZS 4360, Australian/New Zealand Standard on Risk Management. Standards, Australia and Standards, New Zealand (2004)

Amer WH. Analysis and evaluation of delays in construction projects in Egypt. MSc. Thesis, Zagazig University, Egypt (1994)

Abd El-Razek, M.E., Bassioni, H.A., Mobarak, A.M.: Causes of delay in building construction projects in Egypt. J. Constr. Eng. Manag. **134**(11), 831–841 (2008)

Marzouk, M.M., El-Rasas, T.I.: Analyzing delay causes in egyptian construction projects. J. Adv. Res. **5**(1), 49–55 (2014)

Khodeir, L.M., Mohamed, A.H.: Identifying the latest risk probabilities affecting construction projects in Egypt according to political and economic variables. From January 2011 to January 2013. HBRC J. **11**(1), 129–135 (2015)

Marzouk, M., El-Dokhmasey, A., El-Said, M.: Assessing construction engineering-related delays: Egyptian perspective. J. Prof. Issusse Eng. Educ. Pract. **134**(3), 315–326 (2008)

Al-Khalil, M., Al-Ghafly, M.: Important causes of delay in public utility projects in Saudi Arabia. J. Constr. Manag. Econ. **17**(5), 647–655 (1999)

Assaf, S., Al-Khalil, M., Hazmi, M.A.: Delay causes in large building construction projects. J. Manag. Eng. ASCE **11**(2), 45–50 (1995)

Assaf, S., Al-Hejji, S.: Delay causes in large construction projects. Int. J. Proj. Manag. **24**(4), 349–357 (2006)

Faridi, A.S., El-Sayegh, S.M.: Significant factors causing delay in the UAE construction industry. Constr. Manag. Econ. **24**(11), 1167–1176 (2006)

Cooper, D.F.: Project Risk Management Guidelines. Wiley, West Sussix (2005)

Aziz, R.F.: Ranking of delay factors in construction projects after egyptian revolution. Alex. Eng. J. **52**(3), 387–406 (2013a)

Doloi, H., et al.: Analyzing factors affecting delays in Indian construction projects. Int. J. Proj. Manag. **30**(4), 479–489 (2012)

Gündüz, M., Nielsen, Y., Özdemir, M.: Quantification of delay factors using the relative importance index method for construction projects in Turkey. J. Manag. Eng. **29**(2), 133–139 (2013). https://doi.org/10.1061/(asce)me.1943-5479.0000129

Doloi, H.: Analysis of pre-qualification criteria in contractor selection and their impacts on project success. Constr. Manag. Econ. **27**(12), 1245–1263 (2009). https://doi.org/10.1080/01446190903394541

Field, A.: Discovering Statistics Using SPSS. Sage, London (2005)

Kaiser, H.F.: An index of factorial simplicity. Psychometrical **39**, 31–36 (1974)

Zhang, X.: Concessionaire's financial capability in developing build-operate-transfer type infrastructure projects. J. Constr. Eng. Manag. **131**(10), 1054–1064 (2005). https://doi.org/10.1061/(ASCE)0733-9364(2005)131:10(1054)

Aziz, R.F.: Factors causing cost variation for constructing wastewater projects in Egypt. Alex. Eng. J. **52**(1), 51–66 (2013b). https://doi.org/10.1016/j.aej.2012.11.004

Author Index

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