A Proposed Methodology for Managing Risks in Construction Industry in EGYPT

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Abstract: **Risk management in construction industry is one of the important processes of construction management to achieve project objectives and minimize potential risks . Construction projects have been distinguished from other projects in different industries by their uniqueness and complexity. Many types of construction industry in EGYPT were studied such as infrastructure, public buildings, housing projects and power station projects, these kinds of projects have a huge development due the increasing demand for such kind . Risk factors affecting negatively this industry are attributed to many sources as these risks cause cost overrun and/or schedule delay in many construction projects.**

The purpose of this research is to achieve and propose an integrated and coherent methodology that may help in determining risk factors related industrial projects , qualitative same quantitative assessment , using advanced questionnaire tools & surveying techniques that help in proposing an approach to improve and develop risk management processes , mitigate threats , maximize response influence , alerting & advising stake holders to insure project success and overcome obstacles with the lowest expected losses .

In this research many steps were conducted starting by literature review , identifying the risk factors and sources using extensive survey through experts representing huge companies in construction fields . Then an a questionnaire was designed & distributed to prioritize these factors regarding their probability and consequences on both time and cost. According to their relative important index , a statistical analysis for all collected data was carried out using (Statistical Package for the Social Sciences) SPSS Ver.23 software , Reliability Analysis , (Cronbach's alpha coefficient) , Person correlation ,T test, and ANOVA analysis, to find out the effect of all independent variables on dependent variables .In parallel an extensive survey was conducted to collect data of 32 real existing mega projects during last ten years with a total budget of 330 billion EGP. These data includes real indications , impacts and deviations regarding the main parameters adopted in this research , time & cost , then a forecasting model was developed using Crystal Ball software ver. 11.1.2.4 , the entire range of results possible for a given situation with a specified confidence levels by studying the top 20 risk factors affecting time and cost and their impacts on the case studies of projects with the highest schedule and cost deviations . The results were compared and the main findings were very close to the actual results as the actual time deviation average for the real projects is 33% while the software prediction is 31% & the actual cost deviation average for the real projects is 28.5% while the software prediction is 27% . Finally a survey was distributed to experts to identify the most effective responses for these risks. The result was adding 78 new responses by the respondents beside the original questionnaire 80 responses .

Keywords: **Risk assessment , qualitative , quantitative , schedule deviation , cost deviation , probability, impact , relative important index , response planning , simulation , forecasting , statistical analysis.**

1. GENERAL INTRODUCTION

The construction industry is one of the most dynamic, risky, challenging and strict. Construction projects are particularly subjected to more risks than other ones, because of their complexity, various components, inputs, outputs, financial problems and conflicts among parties. Moreover, they require many people with different skills, using equipment, applying many technologies and the coordination of wide range of activities.

Moreover, there are many types of construction industry in EGYPT, some of these types will be studied deeply in this research. These types of projects like infrastructure (Roads, Bridges, & Waste water treatment plants), public buildings (Airports , Banks, Malls & Religious buildings), housing projects (Hotels, Compounds & Resorts) and power projects (Power Plant, Solar plant, Oil & Gas plants), industry has a huge flourishment and development in EGYPT as the important need for these projects to increase investments and to continue improvement plans.

Unexpected increase in cost and delays in construction projects are caused by owners, contractors, environments, etc. in which several types of risk factors may occur concurrently. The effect of cost overrun and schedule delay do not only influence the construction industry but the overall economy as well. **(A. M.Abdel-Alim, et.al 2017)**

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 **(Faridi and El-Sayegh 2006)**.

These factors have led the construction industry to seek alternative strategies to mitigate negative risks & minimize their consequences and exploit opportunities & maximize their consequences. Risks causes cost overrun and/or schedule delay in many construction projects. In addition, risks can affect productivity, performance, quality and scope of construction projects.

A significant problem is poor communications in construction project, incomplete and inconsistent, thus, project participants do not have a shared understanding of the risks that threaten the project. Consequently, they are unable to implement effective early-warning measures and mitigating strategies to adequately deal with problems resulting from decisions taken elsewhere in the chain. It is believed that, the development of assessment of risks will enhance the response strategies .

Actually , a methodology for managing risks in construction industry in EGYPT is recommended to be discussed , studied and validated in real projects life cycles as per represented in this research .

2. PROBLEM DEFINITIONS

In construction projects there are many risk sources and factors affect projects success and objectives , many researchers studied construction risks in EGYPT in all its related processes starting from risk identification till risk monitoring . But in this research we need to reveal a wide view and focus on a complete methodology for managing risks in EGYPT by conducting extensive meetings , surveys and questionnaires to extract all real data which will help in complete an applicable method for managing these risks . Also , depending on real case studies and huge existing projects this research will reveal an important results which will help in managing risks smoothly and propose responses effectively .

2.1Gaps In The Literature

After reviewing many previous researches , few of them were focusing on a complete methodology for managing risks , as some focus on only risk identification , others focus on using expert systems for response planning and many of researches conducted only one survey / questionnaire to enhance their data collection . In this research three questionnaire were distributed to an experts with a high managerial levels in huge construction companies in EGYPT , many soft wares were used to examine and analyze the collected data , ending by proposing a variety of real and effective risk response strategies .

2.2 Research Objectives

The research aims to many objectives which may summarized as follow :

➢ Construct a general risk register that includes the most frequent 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 ranking is to highlight the risky areas and obtain the priority list of project risks.
- Assess the methods of risk identification techniques in construction industry.
- Setting up a well-defined risk profile, qualitative & quantitative assessment.
- Conducting an extensive survey for 32 real existing projects constructed during past 15 years to study and analyze any schedule or cost deviations , reasons and adopted responses planning
- Propose a comprehensive scientific methodology applicable for various types of construction projects and useful in developing risk management & controlling process.

3. LITERATURE REVIEW

Many different approaches to risk classification have been recommended in the literature (Tah & Carr, 2001); (Zavadskas, Turskis, & Tamosaitiene, 2010); (El-sayegh, 2008); (Baloi & Price, 2003). Review of the literature shows that there is a lack of an accepted method of risk classification among professionals in the construction industry. Zayed, et al., (2008) suggested a hierarchy level of classification based on macro and micro levels as shown in Figures 1 A & B.

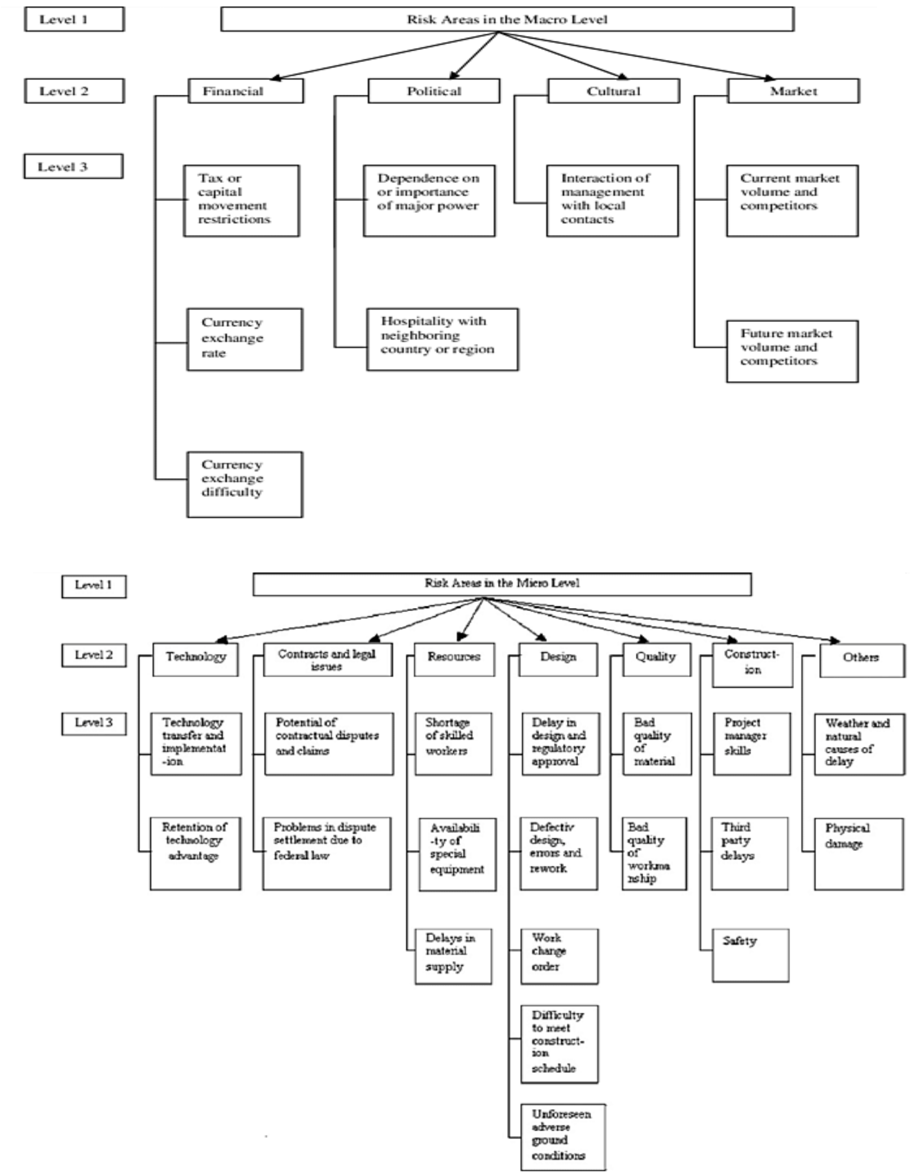


Figure 1 A & B: Hierarchy of risk classification in the macro & Micro level (Zayed, Amer, & Pan, 2008)

However, Tah and Carr (2001) suggested a two level hierarchy classification of project risks. The two levels are external and internal risks. Flanagan and Norman suggested three ways of classifying risk: based on consequence, type, and impact of risk. Chapman (2006) grouped risks into four subsets (environment, industry, client and project). Shen-fa and Xiao (2009) classified project risks into six groups in accordance with the nature of the risks, i.e. financial, legal, management, market, policy and political, as well as technical risks.

Another classification of project risk is pure risk versus speculative risk. Pure risk involves situations that can only end in a loss. For example, the risk of an accident or earthquake is a pure risk. Speculative risks on the other hand are situations that might end in a loss or a gain. For example, the risks of change in exchange rate or scope change are speculative risks. Speculative risks are dynamic and changing while pure risks are more static due to their nature. Insurance deals with only pure risks and not speculative risks. Zavadskas et al. (2010) suggested three levels for project risk classification (external, project, and internal levels) along with the source of each level as shown in Figure 3.

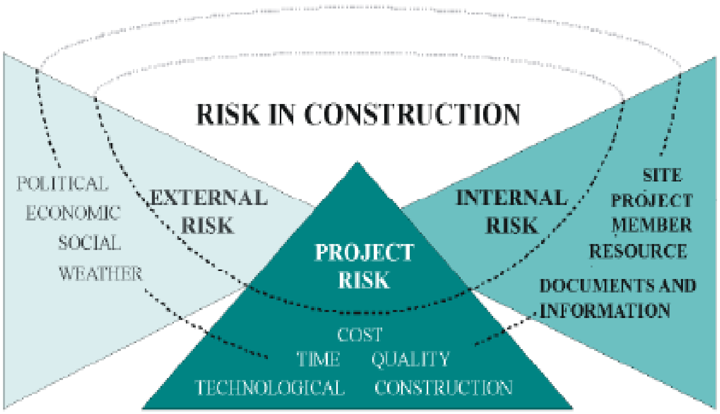


Figure 3: Risk Classification By Level (Zavadskas, Turskis, & Tamosaitiene, 2010)

Regarding Egyptian studies , (A. M. Abdelalim 2019) summarized the ranking of the most important risk factors affecting construction projects in Egypt due to recent researching works as per table 1 . He conducted several articles which 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.

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*)

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

4. RESEARCH METHODOLOGY

Figure 7 represents the sequence of conducting research, many phases were maintained to come up with reliable results. This research demonstrates extensive literature review survey for past researches in the area of risk management in construction projects , risk definitions & types , risk identification , qualitative risk analysis , quantitative risk analysis and risk response planning & implementation .

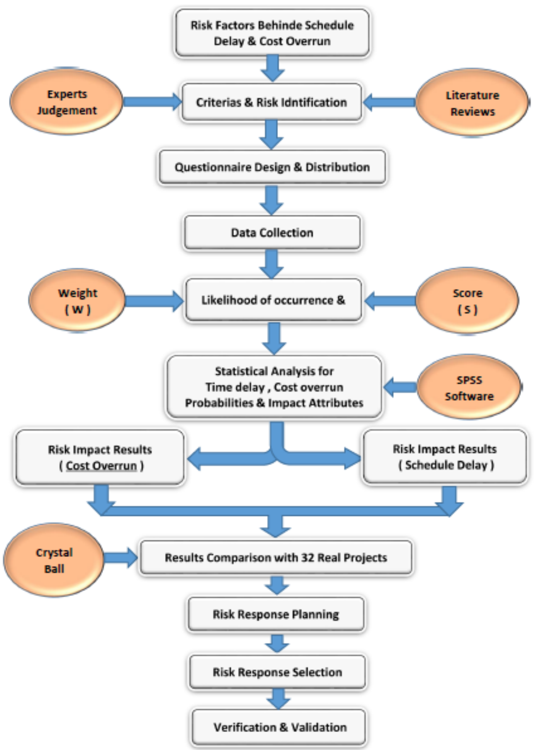


Figure 4: Research Methodology

4.1 Questionnaire Design

A questionnaire containing the sixty-six selected attributes was developed and reviewed by 20 experts (experience more than 30 years in construction projects) to check whether the selected attributes represent all kinds of risks associated with schedule and cost overruns for large construction projects in the Egyptian environment.

The purpose of such questionnaire is to select the most important ones (See Appendix A for copy of this questionnaire). During this process, the experts were encouraged to come up with new attributes that they find to be important and have great influence on schedule delay and cost overruns. New attributes have been added to the list providing they have enough potential to affect the schedule and cost overruns. Attributes that were found to be of weak or no influence were eliminated from the list as per the below table 2 showing the distributed 66 risk factors are.

The survey was designed to collect the following sections :

- Risk Attribute Probability of Occurrence
- Risk Consequence on Schedule
- Risk Consequence on Cost

Table 2: – Risk Category and Attributes in Egyptian Construction Market

Item	Risk type in the construction industry in EGYPT	Risk Probability					
		Rare	Unlikely	Moderate	Likely	Almost Certain	RII
Category 1 : Geotechnical risk							
1.1	Unexpected surface conditions						
1.2	Archeological survey						
1.3	Geo-technical history / Consultant						
Category 2 : Engineering and Design risk							
2.1	Unqualified engineering / design team						
2.2	Unclear Project Scope & Definition						
2.3	Unclear Design specifications						
2.4	Poor coordination between all related design parties						
2.5	Design changes during construction						
2.6	Owner hesitated requirements in design process						
2.7	Unrealistic fast track schedule						
2.8	Non-readiness of engineering before starting site work						
Category 3 : Material risk							
3.1	Late Material delivery						
3.2	Bad Material storage						
3.3	Organization Weak procurement Cycle						
3.4	Defective Material						
3.5	Material damage / waste						
Category 4 : Equipment risk							
4.1	Critical imported spare parts						
4.2	Low Equipment quality/productivity						
4.3	Insufficient equipment storage						
4.4	Repetitive Equipment failure						
4.5	Poor Equipment maintenance						
4.6	Equipment damage						
4.7	Theft of equipment and tools						
Category 5 : Labor risk							
5.1	Unskilled labor						
5.2	Labor unavailability						
5.3	Labor low productivity						
5.4	Labor strikes						
5.5	Skilled labor high wage scales						
5.6	Poor labor resource planning						

Category 6 : Environment risk							
6.1	Non-compliance with environmental laws						
6.2	Unpredicted Climatic Changes						
6.3	Precipitation & Humidity						
6.4	Earthquakes						
Category 7 : Contractor risk							
7.1	Poor Contractor pre-qualifications						
7.2	Insufficient financial / funding						
7.3	Lack of ability and experience						
7.4	Bad selection for subcontractors						
7.5	Poor Quality / Rework						
Category 8 : Project control system risk							
8.1	Project control team low experiences						
8.2	Lack of Project management standards / soft wares						
8.3	Bad quality assurance procedures						
8.4	Tight contractual project duration						
8.5	Unclear scope definition						
8.6	Bad commitment to schedule						
8.7	Poor project control process						
8.8	Poor resources planning						
8.9	Poor major equipment management plan						
8.1	Bad quality control						
8.11	Un-controlled change order						
Category 9 : Owner risk							
9.1	Owner type / Reputation						
9.2	Owner financial stability						
9.3	Lack of decision making process						
9.4	Repetitive payments delay						
Category 10 : Area Conditions risk							
10.1	Difficulties to erect temporary facilities.						
10.2	Unavailability of labor living needs						
10.3	Safety regulations & restrictions						
10.4	Hard traffic flow						
10.5	Obstructions due to site congestion						
10.6	Traffic permits and approvals						
10.7	Poor intensive security						
10.8	Working hours restrictions						
10.9	Poor Existing & temporary facilities						
Category 11 : Political / Economical risk							
11.1	Potential of riots & disturbances						
11.2	Changes in laws and regulations						
11.3	Monetary Inflation						
11.4	Rises of taxes rates						
11.5	Import / Export restrictions						
11.6	Stability of governmental						

The above table containing risk attributes was designed also to show consequences on both time & cost .

4.2 Sample Size

Some methods were adopted to determine population and sample size as there are several approaches for determining the sample size. These approaches may include (small & large population approach , using equations and applying formulas , imitating a sample size of similar studies , using published tables) .

(Hair, 1995) stated that “it is generally agreed that the minimum sample for appropriate use for statistical analysis is equal to or greater than 5 times of the independent variables, but not less than” 100” $P \geq 100$ and $P \geq 5X$ (where X is equal to number of variables). This research has 60 variables, so the sample size for this study is $X = 5x60 = 300$, so the number of accepted sample size according to this approach is ranged from 100 to 300. according to equation no. 1

$$SS = \frac{Z^2 \times p\,(1-p)}{e^2} \qquad \text{Equation 1}$$

Where, SS= (sample size)

Z= confidence level (the number of standard deviations a given proportion is away from the mean). Z value (e.g. 1.64 for 0.9495 ≈95% confidence level)

p= percentage picking a choice, expressed as a decimal (0.50 used for sample -size needed)

$$SS = \frac{(1.64^2 \times 0.5\,(1-0.5)}{(0.08^2)} = 100$$

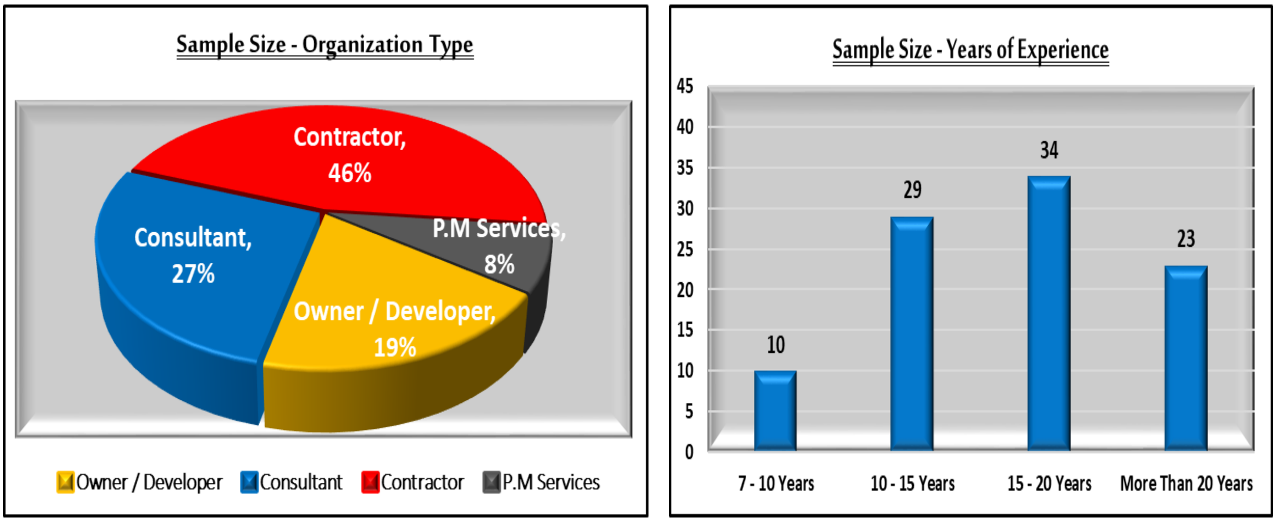
Another equation used for Correction with finite population,

$$SS\ new = \frac{SS}{\{1 + (SS - 1)/pop\}}$$

So that:

$$SS\ new = \frac{100}{\{1 + (100 - 1)/670{,}000\}} = 99 \approx 100$$

Actually, the questionnaire was sent and discussed with 121 engineers (52 by email & 69 by direct interviews) , 108 feedbacks have been received , eight of them were neglected due to sequential choices or uncompleted answers and data. As per the below figures 8,9 which illustrates respondents characteristics :



Figures 5 A, B: – Respondents Profile

4.3 Data Collection & Analysis

In order to carry out the study, many steps were used to analyze the survey results.

- Rank the factors after calculating their RII.
- Analysis of factors to improve the validity of the study hypotheses by conducting Reliability Analysis (Cronbach's alpha coefficient) .
- Analyze the factors by calculating Person correlation, to find out their correlation strength .

➢ Conduct T test, and ANOVA analysis, to find out the effect of all independent variables (Organization type , Organization size, experience years) on dependent variables (the significant factors of probability , time impact & cost impact) .

4.3.1 Ranking Risk Factors

The Relative Importance Index (RII) is used to rank factors and to explore importance levels. As per table 4.6 which indicates the Factors Importance Index Levels for attributes probabilities , time impact & cost impact.

To calculate the classification factor it will be as indicated in table 4.6

Where : X = the smallest index , Y = the highest index , D = difference between highest RII & smallest RII as per below table 3 .

Table 3: – Relative Importance Index (RII) Ranking

(Probability)	Importance		Rare	Unlikely	Moderate	Likely	Almost Certain
	From		Upto20%	20%	40%	60%	Morethan80%
	To			40%	60%	80%	
	RII Value	From	X	X+2D+1	X+4D+1	X+6D	X+8D+1
		To	X+2D	X+4D	X+6D	X+8D	Y
(Cost & Time Impact)	Importance		Insignificant	Low	Moderate	High	Very High
	From		Upto20%	20%	40%	60%	Morethan80%
	To			40%	60%	80%	
	RII Value	From	X	X+2D+2	X+4D+2	X+6D	X+8D+2
		To	X+2D	X+4D	X+6D	X+8D	Y

4.3.2 Reliability analysis

The assessment of Scale Reliability is a measurement of the internal consistency of the constructed items in this research, in order to evaluate the reliability of each factor Cronbach's alpha coefficient and item total correlation is used, the value of Cronbach's alpha for acceptable reliability is 0.8, and any factor which have the value of Corrected Item-Total Correlation below 0.3 would be considered rejected (Kien, 2012). The analysis shows that Cronbach's Alpha value of all factors is (0.966) which is higher than 0.8 (Table 4).

Table 4: - Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.966	0.966	240

4.2.3 Chi-Square Test

The (Chi-Square) test is conducted to configure the relation between the independent ordinal variables years of experience , type of organization and size of Organization . It reflects the relation between every couple of ordinal variables. (Tables 5) present the results. As the result found statically significance relations are between (years of experience / size of Organization) and (type of organization / size of Organization) .

Table 5:- Chi-Square Test Results

Couple independent ordinal variables		Pearson Chi-Square Asymp. Sig. (2-sided)
Years of experience	Type of organization	.404
Years of experience	Size of organization	.001
Size of organization	Type of organization	.001

4.2.4 Pearson Correlation

The pearson correlation were applied 3 times by using SPSS Rev.23, the first one was on the highest risk attributes probability which were classified in (Almost certain & Likely) , these risk attributes are 34 , the direction of the relations between them will was identified . The second one was on the highest risk attributes time impact which were classified in (Almost certain & Likely) , these risk attributes are 34 , the direction of the relations between them was identified , while the third one The second one was on the highest risk attributes cost impact which were classified in (Almost certain & Likely) , these risk attributes are 32 , the direction of the relations between them was identified . (All detailed results are presented in appendix C)

4.2.5 T Test

The T test is used to study the effect of one independent factor on dependent variables, it is conducted by studying differences between (Means), Independent-Sample T Test used for conducting T test, and the test parameters are:

1-Test Variables (dependent variables): All significant factors of risk attributes probability , time impact & cost impact .

2-Grouping Variables (independent factors): Years of experience , organization type & organization size.

Also this test was applied 3 times , the first was on one independent factor which is years of experience & on one dependent variables which are risk probabilities . The second was on another independent factor which is organization type & on one dependent variables which are risk attributes time impact , while the third was on another independent factor which is organization size & on one dependent variables which are risk attributes cost impact . As below tables 6,7,8 respectively .

Table 6: - Independent Samples Test for Factor R 7.2

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Insufficient financial / funding	Equal variances assumed	.010	.922	-.036	35	.972	-.01190	.33094	-.68374	.65993
	Equal variances not assumed			-.036	13.514	.972	-.01190	.33156	-.72543	.70162

Table 7: - Independent Samples Test for Factor R 9.2

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Owner financial stability	Equal variances assumed	.340	.565	-1.805	25	.083	-.51974	.28789	-1.11265	.07318
	Equal variances not assumed			-2.086	18.754	.051	-.51974	.24921	-1.04181	.00233

Table 8: - Independent Samples Test for Factor R 8.7

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Poor project control process	Equal variances assumed	.283	.596	.622	98	.535	.13333	.21442	-.29217	.55884
	Equal variances not assumed			.619	82.203	.538	.13333	.21556	-.29546	.56213

4.3.6 Analysis of Variances (ANOVA)

ANOVA test is conducted to study whether there are any significant differences between Means, it is used to study the effect of one independent factor or more on dependent variables, for this study One-Way ANOVA it is used to examine the effect of independent factors (years of experiences , organization size and organization type) on the top ranked significant factors of risk attributes (probability , time impact & cost impact) , before proceeding with (One– Way ANOVA) analysis we should first study homogeneity of variables for independent variable using Levene statistic test which is conducted to check the homogeneity of variances, if any variable Levene value less than 0.05, then ANOVA analysis cannot be conducted for this variable, Appendix C presents Levene statistic and ANOVA analysis values for all conducted tests & tables.

For the first test , it was conducted between one independent factor which is organization type & on all top ranked dependent variables (34) which are risk attributes probabilities , it was indicated that all Sig are higher than $\alpha = 0.05$, which means that there are no statistically significant differences between Means of these risk attributes probabilities according to independent factor (Type of organization) . The second test was conducted between one independent factor which is organization Size & on all top ranked dependent variables (29) which are risk attributes time impact , it was indicated that all Sig are higher than $\alpha = 0.05$, which means that there are no statistically significant differences between Means of these risk attributes time impact according to independent factor (Size of organization). The third test was conducted between one independent factor which is years of experience & on all top ranked dependent variables (32) which are risk attributes cost impact , it was indicated that all Sig are higher than $\alpha = 0.05$ except for 16 risk attributes which were (C8.11 Un-controlled change order , C3.5 Material damage / waste , C2.5 Design changes during construction , C8.8 Poor resources planning , C8.9 Poor major equipment management plan , C8.7 Poor project control process , C5.6 Poor labor resource planning , C8.5 Repetitive project scope changes , C4.2 Low Equipment quality / productivity , C3.3 Organization Weak procurement Cycle , C5.5 Skilled labor high wage scales , C8.1 Project control team low experiences , C5.3 Labor low productivity , C10.9 Poor Existing & temporary facilities , C2.4 Poor coordination between all related design parties , C4.7 Theft of equipment and tools) , it means that there are a statistically significant differences between Means of these risk attributes cost impact according to independent factor (Years of experience) .

5. CASE STUDIES ANALYSIS – REAL 32 CONSTRUCTION PROJECTS

About 32 real existing projects were considered the core study of this research , the total amount of these projects exceeded 340 billion EGP . Moreover , in order to achieve better results and more accurate data , these project samples were selected to cover a long time period of mega projects construction in EGYPT . The mentioned projects were constructed during the last 15 years to insure and compare whether risk attributes were changed during this long period or not and to insure that real data were conducted and adopted in this research .Some criteria were determined to identify a selective mega project with complex components and variety of its types , these criteria are as follow :

i. Classification of projects respondents (Owner , Contractor , Consultant , P.M)

ii. Targeting projects with budget greater than 250 Million EGP .

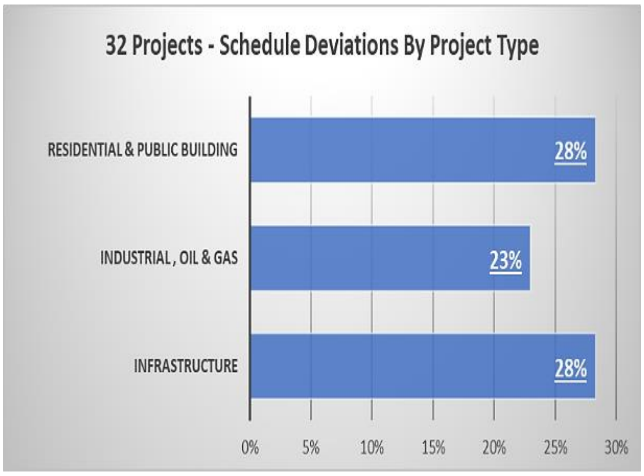
iii. Targeting projects with total duration greater than one year .

iv. Sampling variety of project types (Infra. , oil & Gas , industrial , residential)

v. Sampling the major key players of the project (Project managers , construction managers , planners , cost controllers , contract administrators , cost budgeting)

Chapter 5 include the targeted samples of the 32 projects which met the above mentioned criteria , some of these projects had a clear risk management plan and other projects did not have . These data were recorded and analyzed to extract the actual deviations happened for both time & cost in these projects .

Some characteristics were extracted as per the below figures 6,7,8 & 9



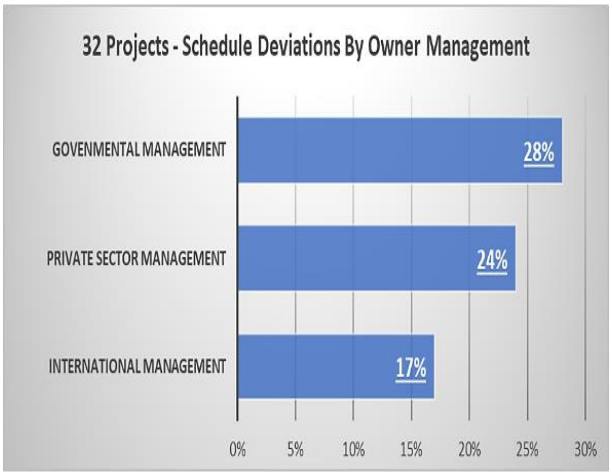
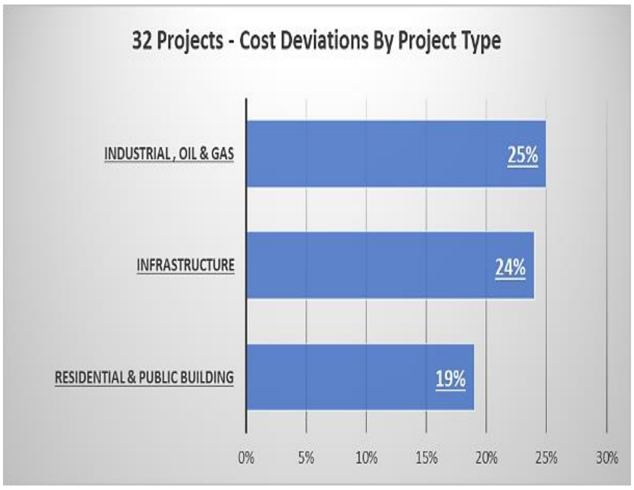


Figure 6: Schedule Deviations By Project Type / Figure 7: Schedule Deviations By Project Owner



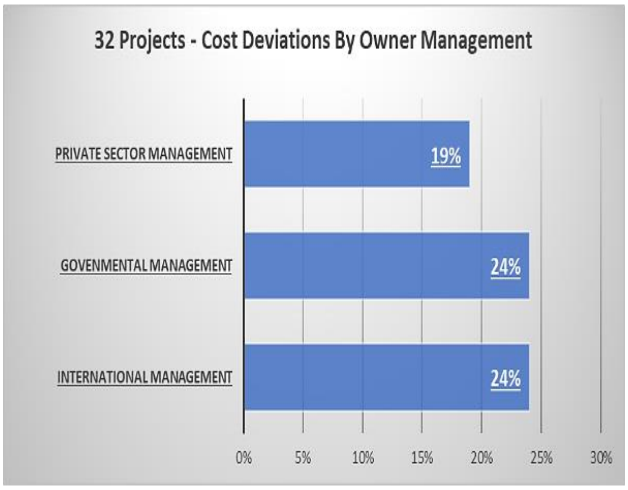


Figure 8: Cost Deviations By Project Type / Figure 9: Cost Deviations By Project Owner

5.1 Extracting Top 10 Project with Highest Time Deviations

As per the collected data , the top 10 projects had the highest time deviations will be indicated in chapter 5 , The average schedule variances / deviations identified in these projects is 33 % , the below figure 10 shows these top ten projects and the average deviations for all .

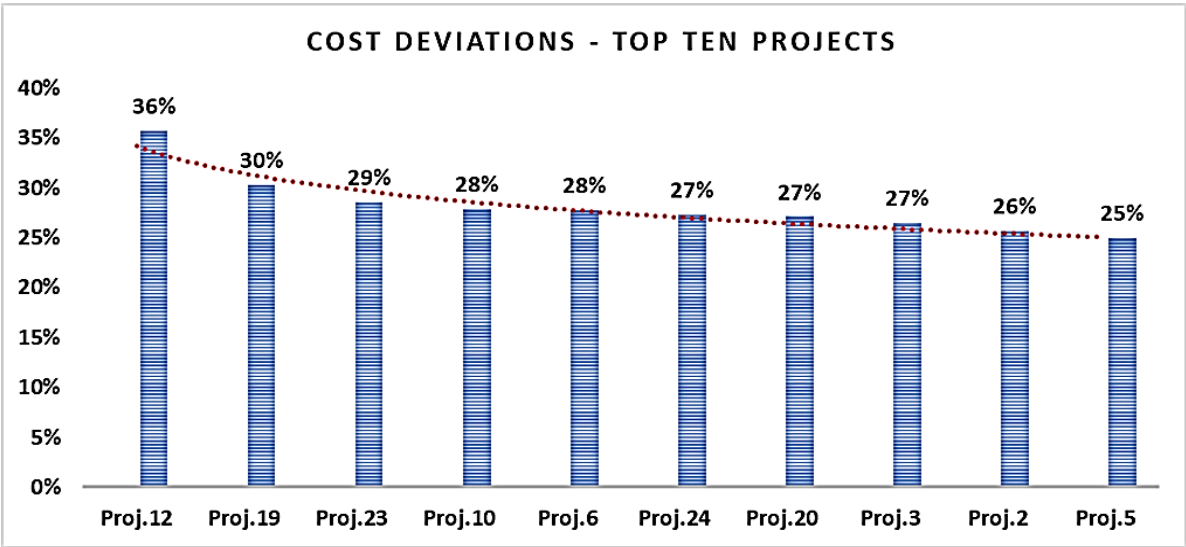


Figure 10: Top 10 Projects – Schedule Deviation Average

5.2 Extracting Top 10 Project with Highest Cost Deviations

As per the collected data , the top 10 projects had the highest time deviations will be indicated in chapter 5 , The average cost variances / deviations identified in these projects is 28.5 % , the below figure (11) shows these top 10 projects and the average deviations for all .

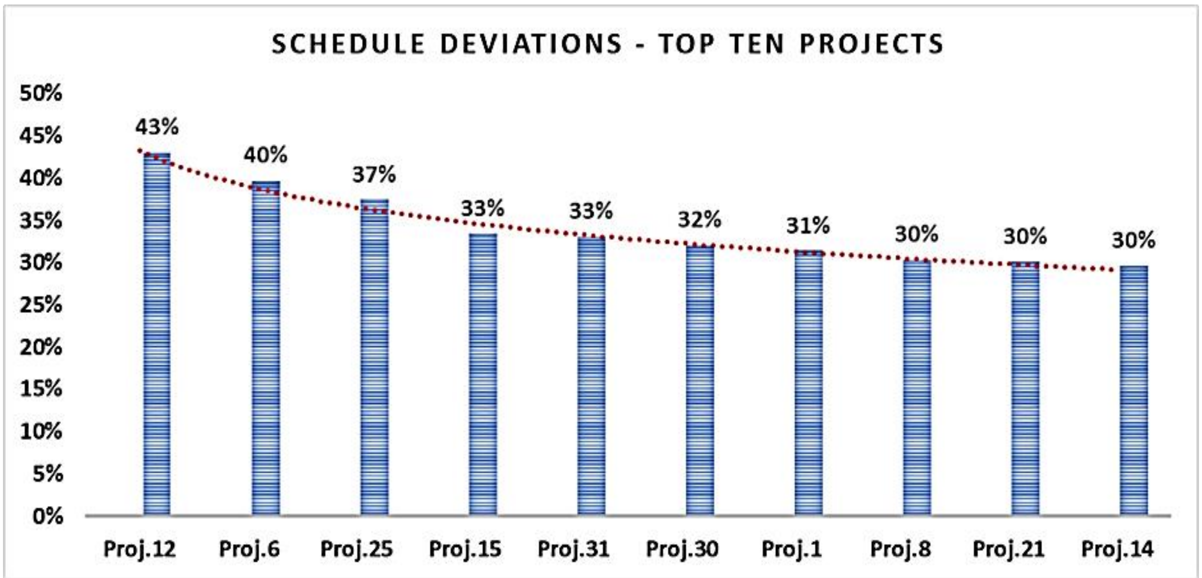


Figure 11: Top 10 Projects – Cost Deviation Average

6. SIMULATION, FORECASTING & ANALYZING DATA USING CRYSTAL BALL

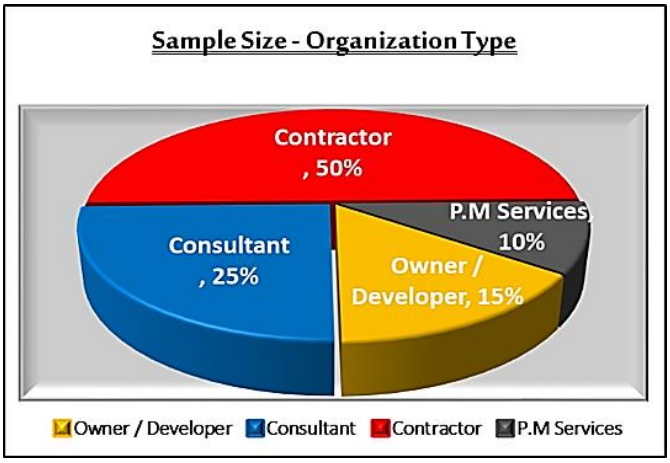
After extracting the top 20 risk factors affecting time & the top 20 risk factors affecting cost , A predictive modeling, forecasting, simulation, and optimization will be implemented using Crystal Ball software ver. 11.1.2.4 .Then , making a comparison between data results from crystal ball predictions & the real existing data from the projects case study . For the time impact after testing and validation , the results of simulation on 10,000 trials shows that the increase of the total duration should be between 1% to 31% based on confidence levels between 0% and 95% and the duration increase of 20% was noticed at 82% confidence level. While for the cost impact after testing and validation , the results of simulation on 10,000 trials shows that the increase of the total duration should be between 1% to 27% based on confidence levels between 0% and 95% and the cost increase of 20% was noticed at 82% confidence level.

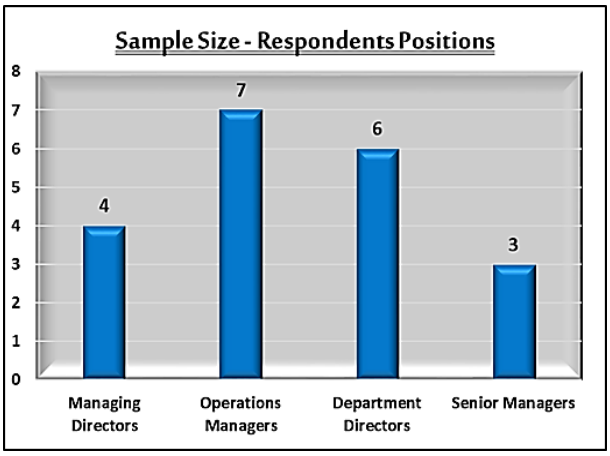
7. RISK RESPONSE STRATEGIES & IMPLEMENTATION

The final section in this research is to prepare and implement a strong risk response strategy & risk implementation , an extensive survey and questionnaire was developed as the top 20 risk factors affecting time & cost were identified also proposed responses were selected , developed and conveyed to an experts in the construction field as a separate questionnaire to assess the efficiency of the proposed risk response strategies for these top risk factors .

According to those 20 expert respondents in the field of construction with at least 30 years of experience , the proposed risk response plans were 80 responses for the top 20 risks for time and cost . The received / collected data from respondents contained another 78 new responses (36 for schedule risks & 42 for cost risks) which considered a very good added value to this survey as most of these risk responses were developed and actually used in real project life cycles according to meeting & calls with respondents as they had confirmed that their added responses were all actually implemented in many construction projects where they were involved in / under their supervision .

The below figures 12 A,B illustrates the characteristics of the respondents profiles .





Figures 12 A,B: – Respondents Organization Type / Current Positions

8. CONCLUSIONS

The study investigate a methodology to manage risks in construction industry in EGYPT through highlighting many previous researches in construction risk management , making a list of attributes which represent common risks associated with schedule and cost overruns . Questionnaire was conducted construction experts in EGYPT to select the most important attributes which are relevant to the study.

Risks were categorized into 11 category including 66 risk attributes affecting time and cost in construction projects . An extensive survey was designed and distributed to indicate the RII for risk attributes time impact & cost impact . Then conducting statistical analysis through using SPSS Ver.23 such as (Reliability analysis , Chi-Square Test , Pearson Correlation , T-Test & ANOVA Test) . According to RII ranking , the top 20 risks impact time & top 20 risks impact cost were determined and tabulated as below tables 9,10 .

Table 9: – Top 20 Risk Factors Affecting Time

Rank	Factor (Time Impact)	Factor No.	Group No.	RII
1	Owner financial instability	9.2	9	0.884
2	Repetitive payments delay	9.4	9	0.87
3	Insufficient financial / funding	7.2	7	0.862
4	Late Material delivery	3.1	3	0.832
5	Un-controlled change order	8.11	8	0.822
6	Bad commitment to schedule	8.6	8	0.802
7	Unrealistic fast track schedule	2.7	2	0.798
8	Lack of ability and experience	7.3	7	0.778
9	Poor resources planning	8.8	8	0.77

10	Organization Weak procurement Cycle	3.3	3	0.762
11	Poor major equipment management plan	8.9	8	0.762
12	Design changes during construction	2.5	2	0.761
13	Labor unavailability	5.2	5	0.761
14	Low Equipment quality/productivity	4.2	4	0.756
15	Bad selection for subcontractors	7.4	7	0.754
16	Lack of decision making process	9.3	9	0.754
17	Poor Contractor pre-qualifications	7.1	7	0.754
18	Poor project control process	8.7	8	0.752
19	Unclear Project Scope & Definition	2.2	2	0.732
20	Monetary Inflation	11.3	11	0.724

Table 10: – Top 20 Risk Factors Affecting Cost

Rank	Factor (Cost Impact)	Factor No.	Group No.	RII
1	Owner financial instability	9.2	9	0.898
2	Repetitive payments delay	9.4	9	0.886
3	Insufficient financial / funding	7.2	7	0.856
4	Un-controlled change order	8.11	8	0.838
5	Monetary Inflation	11.3	11	0.832
6	Material damage / waste	3.5	3	0.808
7	Design changes during construction	2.5	2	0.790
8	Poor resources planning	8.8	8	0.788
9	Poor Quality / Rework	7.5	7	0.778
10	Poor major equipment management plan	8.9	8	0.778
11	Poor project control process	8.7	8	0.776
12	Bad commitment to schedule	8.6	8	0.776
13	Lack of ability and experience	7.3	7	0.772
14	Poor labor resource planning	5.6	5	0.770
15	Unclear Design specifications	2.3	2	0.760
16	Unclear scope definition	8.5	8	0.756
17	Low Equipment quality/productivity	4.2	4	0.756
18	Organization Weak procurement Cycle	3.3	3	0.754
19	Bad Material storage	3.2	3	0.752
20	Skilled labor high wage scales	5.5	5	0.752

Parallel to the above steps , a case study was prepared to validate research results with a real 32 existing projects with a total value of 320 billion EGP . The collected data revealed the actual deviations happened to both time and cost . It was indicated that the average schedule variance for all 32 projects is 26 % and the average cost variance is 22 % while the average schedule variance for top 10 projects is 33 % and the average cost variance is 28.5 %. After that , a prediction model was created using Crystal Ball software ver. 11.1.2.4 to estimate the expected deviations for the top 10 impacted , the results was very close to the actual results from the real projects case studies . As the actual time deviation average for the real projects is 33% while the software prediction is 31% & the actual cost deviation average for the real projects is 28.5% while the software prediction is 27% . Finally , Risk response planning & implementation was applied on the top 20 risk attributes affecting time & top 20 risk attributes affecting cost through an extensive survey which designed & distributed to 20 expert with at least 30 years of experience of the construction field and their positions were (4 managing directors , 7 operations managers , 6 departments directors & 3 senior managers) covering all types of construction organizations. The Questionnaire concluded 80 responses and strategies to deal with expected risks affecting cost / schedule . The respondents of this questionnaire added new valued responses with a total of 78 new response , according to their feedback these responses positively affected the risk factors and actively succeeded in reducing the occurred deviations for both schedule & cost of their construction projects , The collected data is considered a real validation of risk response strategies for construction projects in EGYPT and reflects a strong experiences in dealing with most common risks affect construction projects negatively .

9. RECOMMENDATIONS FOR FUTURE RESEARCHES

This research proposed a risk management methodology for construction industry in EGYPT , future researches may add in depth areas of research like :

1 - Risk monitoring and controlling process should take more attention , development and software creation in order to maintain more effective techniques that could help in that area of risk management .

2 – Create various expert systems using artificial intelligence to cover each process of risk management processes .

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support given by all respondents from various prestigious companies/institutions that made this research possible.

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