Modelling Risks of Road Construction in Real Estate Projects

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Abstract – *Roads projects suffer many risks through their construction, this paper aims to identify the key risks that confront the construction of road projects in Egypt. A structural questionnaire with forty factors extracted from previous studies was developed to this purpose. The questionnaire includes the probability and the impact of each risk factor. The relative importance index for each factor was calculated by multiplying the probability and the impact of each factor. The data was analysed by using IBM SPSS software. We created a model of the factors affecting the construction of road projects in Egypt. We observed and monitored the risks in real estate for ten projects for the road construction. According to the analysis of the results from the questionnaire and the results from real estate, we found that 95.4 % of the projects will be finished according to the risk estimators.*

***Key Words*: road construction; risk assessment; risk factors; real estate; statistical analysis.**

1. INTRODUCTION

Egypt started executing many projects as a part of an ambitious overall development plan which will extend for several years. This development plan is considered as a pillar of the sustainable development strategy. The development plan is divided into many branches including agricultural area expansion projects, industrial projects, housing projects, and infrastructure development projects. Road network is the backbone of the land transportation network that provides the accessibility for the required mobility to support economic growth and promote social activities.

It's obvious that roads construction projects like other heavy construction projects faced lots and lots of risks due to many political and economic decisions related to the currency exchange rate. Those risks resulted in cost and time overruns on most of these projects. The lack of risk management in Egyptian road construction projects is due to lack of data and information about risks in Egypt as most of the researches done in the risk management field has covered projects in East Asia, the United States, and Europe.

2. LITERATURE REVIEW

To find out the risk factors of the road construction projects in Egypt we first must know the nature and the stages of road construction projects and understand what risk means and how to manage it. Noseer, (2006) stated that the road construction project like any other project goes through several steps. The road construction projects are always dynamic, complex, unique, and involving multiple feedback processes. Road construction projects involve multi works items with many details. A lot of parties are either directly or indirectly involved in the construction project, and their interests may be positively or negatively affected because of the project execution or project completion. Participants with various experience and skills typically have different interests and expectations. This naturally creates problems and confusion for even the most experienced project managers and to have a successful project, it's a must to have enough project management [1]. Richman, (2002) defined project management as a set of principles, methods, and techniques that people use to effectively plan and control project work [2].

Road construction projects differ from other kinds of construction projects that it extends for long distances. This means variable geological conditions, surface levels, environmental characteristics, and human activities. Accordingly, many risk factors surround the road construction project that we must deal with wisely.

Larson & Gray (2015) defined risk as an uncertain event that if it happened, it will have a negative or positive effect on the scope, cost, schedule, or quality. So, to face project risks we must carry out a systematic process of planning for, identifying, analyzing, responding to, and monitoring project risks which are known as "Risk management". Since the 50s of the 20th century and till now the field of project management in general, including of course the discipline of risk management has been under the spotlight of researchers due to the major importance of this field [3].

Ibrahim (2009) focused in his research on risk management in airport construction projects in Egypt as he created a questionnaire to find out the probability of occurrence, the impact and the response strategy for (190) risk factor categorized under (15) risk group; environmental, Geotechnical, project management, area conditions, political and governmental, design, construction, financial, subcontractors generated risks, owner risks, labor risks, material risks, equipment risks, contractual and illegal risks, and project delivery method risks [4].

Waghmare and Pimplikar (2012) studied risk factors affecting road construction project as a part of the feasibility of project investment by using a questionnaire with (49) risk factor included into (8) aspect. These aspects were marketing, technical and technological, political, regulatory and policy, social and cultural, environmental and city planning, financial and economic. They used a risk probability matrix followed by financial analysis for the feasibility study and sensitivity analysis. They found that feasibility study analysis with calculating risk factors causes a decrease in investment feasibility parameters. They also found that risk factors that have the highest influence on the construction project are those having relation with the economic and financial aspect [5].

Diab et al., (2012) analysed and evaluated through their research the different risk drivers in highway construction projects in the US using a probability/impact questionnaire survey consists of (31) significant risk drivers that were grouped into five broad categories; project scope, right of way, utility conflicts, architectural/engineering (A/E) services, and project construction management. Risk drivers were identified from previous studies, were chosen, analyzed, and evaluated for their study. They found that 80% of respondents indicated that a risk assessment was important for highway construction projects [6].

Sharaf and Abdel Wahab (2015) identified the most significant risk factors affecting highway construction project in Egypt as a set of (12) risk groups consisting of (73) risks were selected and a questionnaire survey was conducted to determine the likelihood and consequences of the identified risks. Then, a software application was developed using MATLAB to facilitate risk evaluation of highway projects. By analyzing the 40 respondent forms they found that the risk factors arise from the owner side and the most vital risk factor is the delay the decision making. A fuzzy logic model was developed to evaluate project risk [7].

El-Sayegh and Mansour research (2015) was interested in the risks associated with highway construction projects in the United Arab Emirates (UAE). Thirty-three risks were identified through detailed literature review and categorized into six categories; technical, site, commercial, political, environmental and socioeconomic factors. A questionnaire was developed to solicit the opinion of construction professionals as to the probability and impact of those risks in addition to their proper allocation. Fifty-one questionnaires were completed and analyzed. The priority of each risk was calculated by multiplying the probability with the impact for each risk. The relative importance index (RII) for the risk priority was calculated based on all responses for each risk. The most vital risks were quality and integrity of design, inefficient planning, delays in expropriations, unexpected ground utilities and delays in approvals. Internal project risks are found to be more significant than external risks due to the political, economic and cultural stability in the UAE [8].

Bhosale et al., (2018) in their paper had a target to study the current risk management practices in road construction projects in India and find a suitable analytical approach to evaluate risk management practices in road construction projects. In addition to validating risk management maturity model (RMMM) using case study and survey. By studying various analytical approaches, they concluded that the maturity model is one of the best tools for evaluating risk management practices as it is very practical [9].

3. METHODOLOGY

The first step was identifying the risk factors of roads construction projects. By reviewing the previous researches and studies in the field of risk management, we obtained a long list of risk factors which was reviewed and filtered by removing redundancy, repeated factors and factors unrelated to road construction projects.

Then we consulted experts in the fields of both management and roads to alter the filtered risk factors list. The output of the consulting process was a list of forty risk factors and table (1) presents the identified risk factors along with the sources from literature. After that, we created a hybrid categorization system that depends on the steps of the road construction project and depends on the usually used categorizing system (monetary, human, etc.). We divided the forty risk factors into six main categories which are the stages of road construction project in additional to general circumstances category which included risk factors that don't affect the project specifically but the country, the region or the whole world and those ten categories are; feasibility and preliminary studies stage (F), design stage (D), bidding stage (B), construction stage [monetary (C), management and staff (M), equipment and materials (E), Site features (S) and Others (O)], running and maintenance stage (R), and general circumstances (G).

Table -1: Risk Factors

Code	Risk Factor	Source
F1	Prolonged consultation on route, structure, natural environment and heritage issues.	Sato et al., 2005 [10], Smith et al., 2006 [11], Caltrans, 2007 [12].
F2	Incomplete or erroneous primary surveying	Smith et al., 2006 [11], Caltrans, 2007 [12], diab et al., 2012 [6].
F3	Incomplete or erroneous geological condition study	Sato et al., 2005 [10], zayed et al., 2008 [13], Caltrans, 2007 [12], Ibrahim, 2009 [4], diab et al., 2012 [6]
D1	Design Errors and Omissions	Richman, 2002 [2], Smith et al., 2006 [11], zayed et al., 2008 [13], Caltrans, 2007 [12], Ibrahim, 2009 [4], Banaitiene and Banaitis, 2012 [14], diab et al., 2012 [6]

D2	Design process takes longer than anticipated	Sato et al., 2005 [10], zayed et al., 2008 [13], Banaitiene and Banaitis, 2012 [14]
B1	Scope is underestimated	Heerkens, 2002 [15], Caltrans, 2007 [12], Sharaf and Abdelwahab, 2015 [7]
B2	Project duration underestimated	Heerkens, 2002 [15], Caltrans, 2007 [12], Ibrahim, 2009 [4]
B3	Price underestimated	Horine, 2009 [16]
B4	Unrealistic or aggressive performance standards	Horine, 2009 [16], Ibrahim, 2009 [4]
C1	No cost control	Richman, 2002 [2], Sharaf and Abdelwahab, 2015 [7]
C2	Cash flow problems	Richman, 2002 [2], Heerkens, 2002 [15], Sato et al., 2005 [10], Caltrans, 2007 [12], Horine, 2009 [16], Ibrahim, 2009 [4]
M1	Change in management or priorities	Richman, 2002 [2], Heerkens, 2002 [15], Caltrans, 2007 [12]
M2	Misallocation and mismanagement of resources.	Horine, 2009 [16], Ibrahim, 2009 [4]
M3	Estimating and/or scheduling errors	Caltrans, 2007 [12] Horine, 2009 [16], Banaitiene and Banaitis, 2012 [14]
M4	Lack of coordination/communication between staff	Richman, 2002 [2], Heerkens, 2002 [15], Caltrans, 2007 [12], Horine, 2009 [16], El-Sayegh and Mansour, 2015 [8]
M5	Inadequate risk management.	Horine, 2009 [16]
M6	Poor leadership.	Horine, 2009 [16], Ibrahim, 2009 [4], Sharaf and Abdelwahab, 2015 [7]
M7	Labor shortages.	zayed et al., 2008 [13], Caltrans, 2007 [12], Horine, 2009 [16], Ibrahim, 2009 [4], Sharaf and Abdelwahab, 2015 [7]
M8	Lack of experience.	Richman, 2002 [2], Caltrans, 2007 [12], Horine, 2009 [16], Ibrahim, 2009 [4], Sharaf and Abdelwahab, 2015 [7]
M9	Surveying error	Richman, 2002 [2], Ibrahim, 2009 [4], Sharaf and Abdelwahab, 2015 [7]
M10	Poor Quality Assurance / Quality Control (QA/QC).	Ibrahim, 2009 [4], diab et al., 2012 [6], Sharaf and Abdelwahab, 2015 [7]
E1	Availability	Richman, 2002 [2], Heerkens, 2002 [15], Fewings, 2005 [17], zayed et al., 2008 [13], Ibrahim, 2009 [4], diab et al., 2012 [6], Sharaf and Abdelwahab, 2015 [7]
E2	Condition of equipment	Ibrahim, 2009 [4], Sharaf and Abdelwahab, 2015 [7]
E3	Maintenance	Fewings, 2005 [17], (Ibrahim, 2009) Sharaf and Abdelwahab, 2015 [7]
E4	Poor material reliability	Heerkens, 2002 [15], zayed et al., 2008 [13], Ibrahim, 2009 [4]
E5	Inadequate contingency reserve.	Horine, 2009 [16], Ibrahim, 2009 [4]
S1	New discovery of buried cultural assets or paleontology findings	Sato et al., 2005 [10], Caltrans, 2007 [12]
S2	Utilities damage during construction	Smith et al., 2006 [11], Caltrans, 2007 [12], Ibrahim, 2009 [4], diab et al., 2012 [6]
O1	Delayed permits due to prolonged coordination and consultation with the organizations concerned	Heerkens, 2002 [15], Sato et al., 2005 [10], Smith et al., 2006 [11], Horine, 2009 [16], Ibrahim, 2009 [4], diab et al., 2012 [6], Sharaf and Abdelwahab, 2015 [7]
O2	Consultant, Suppliers and Subcontractors reliability and experience	Heerkens, 2002 [15], Smith et al., 2006 [11], Caltrans, 2007 [12], Ibrahim, 2009 [4], Sharaf and Abdelwahab, 2015 [7]
O3	Project scope and objectives change	Heerkens, 2002 [15], Smith et al., 2006 [11], Caltrans, 2007 [12], Horine, 2009 [16], Ibrahim, 2009 [4], diab et al., 2012 [6]
O4	Technological Innovation	Fewings, 2005 [17], Sato et al., 2005 [10], zayed et al., 2008 [13]
O5	Pressure to deliver project on an accelerated schedule	Caltrans, 2007 [12]
R1	Handing over committee notes	Sato et al., 2005 [10]
R2	Accidental damage (landslide, etc.)	Sato et al., 2005 [10]
R3	Post opening increase of the traffic volume	Sato et al., 2005 [10]
G1	Force majeure (war, revolution, earthquake, typhoon, etc.)	Heerkens, 2002 [15], Sato et al., 2005 [10], Smith et al., 2006 [11], Ibrahim, 2009 [4], Sharaf and Abdelwahab, 2015 [7], El-Sayegh and Mansour, 2015 [8]
G2	Influences of increasing in taxes policy	(Ibrahim, 2009) waghmare and pimplikar, 2012 [5], Banaitiene and Banaitis, 2012 [14], Sharaf and Abdelwahab, 2015 [7]
G3	Inflation and deflation	Richman, 2002 [2], Heerkens, 2002 [15], Sato et al., 2005 [10], Horine, 2009 [16], Ibrahim, 2009 [4], Sharaf and Abdelwahab, 2015 [7]

In the second step we put the risk factors in a structural questionnaire form with five degrees of occurrence probability and five degrees of impact on the project as whole (very low, low, moderate, high and very high) in additional to a cover page which contains an introduction to the questionnaire and some personal information for the respondent including the years of experience in road projects and the current company.

Two hundred road engineers were asked to fill the questionnaire. The sample of respondents was various experience, from both private and public sector companies and various subspecialties (site – technical office – laboratory – contracts – management). Out of the two hundred questionnaires, only 160 forms were completely answered. Table (2) shows the sorting of the respondents according to ranges of experience years while table (3) shows the company of the respondents.

Table -2: Respondents Experience Profile

Experience (yrs.)	No. of respondents
Less than 5 years	67
5:10	53
11:15	15
16:20	10
More than 20 years	15

Table -3: Respondents' Employer Profile

Company	No. of respondents
General Nile Company for Roads and Bridges	76
Arab Contractors	22
General Nile Company for Roads Construction	14
Egyptian Company for Self-Maintenance	10
SAMCO	9
PETROJET	7
Rawafed Al-Toroq	4
General Nile Company for Desert Roads	3
Others	15

In the third step, the 160 questionnaires were analyzed by the Statistical Package for the Social Sciences software (IBM SPSS). In order to get a ranked list of risk factors there are many methods like frequency index method (F.I) which depends on the probability of occurrence of risk factor, severity index method (S.I) which depends on impact of occurrence of the risk factor, importance index (IMPI) which results from the multiplication of frequency and severity indices and there is the relative importance index method (RII) which we are going to apply in our research. (Rajgor et al., 2016) [18].

4. ANALYSIS AND RESULTS

4.1. Reliability and Validity

After inserting the data to the SPSS program, we started by the reliability analysis using the Cronbach's alpha method to check the reliability and the validity of the questionnaire of the risk factors. The value of reliability according to Cronbach's alpha method should be more than (0.6) otherwise the factor should be eliminated to increase the overall questionnaire reliability (Field, 2013) [19]. Table (4) shows the reliability of each risk category and it was found that the overall questionnaire reliability equals (0.923) which is highly accepted.

Table -4: Risk Categories Reliability

Category	Reliability
Feasibility and Preliminary studies	0.625
Design	0.441
Bidding	0.647
Monetary	0.642
management & site staff	0.83
equipment & materials	0.743
site features	0.667
Others	0.738
Running and Maintenance	0.633
General Circumstances	0.723

It also showed that if we eliminated the design group from the questionnaire, the questionnaire overall reliability would be higher. It's recommended to eliminate the factor “Inadequate contingency reserve” from equipment and material category and the “Force majeure” risk factor from general circumstances category to increase the reliability of those two risk factors categories.

4.2. Risk Factors Ranking

The value of each risk factor is calculated by multiplying its impact by its occurrence probability. These values are gathered for the 160 forms and for each risk factor in the questionnaire and analyzed using Relative Importance Index Technique (RII) which states that:

$$RII = \sum W / (A * N) \quad (1)$$

Where; (W): the weight given to each factor by the respondents, (A): the highest weight, (N): the total number of sample forms. According to the relative importance index (RII) the risk factors affecting roads construction projects in Egypt was ranked as shown in table (5).

Table -5: Ranking Risk Factors

Rank	Risk Factor	RII
1	Cash flow problems	0.8350
2	Pressure to deliver project on an accelerated schedule	0.8238
3	Poor leadership.	0.8025
4	Post opening increase of the traffic volume	0.7950
5	Price underestimated	0.7950
6	Force majeure (war, revolution, earthquake, typhoon, etc.)	0.7925
7	Foreign currency availability and exchange rate	0.7850
8	Project duration underestimated	0.7850
9	Availability (materials & equipment)	0.7838

10	Surveying error	0.7788
11	Inflation and deflation	0.7788
12	Utilities damage during construction	0.7700
13	Condition of equipment	0.7700
14	Design Errors and Omissions	0.7675
15	Misallocation and mismanagement of resources	0.7663
16	Maintenance (equipment)	0.7613
17	Accidental damage (landslide, etc.)	0.7575
18	Incomplete or erroneous primary surveying	0.7575
19	Incomplete or erroneous geological condition study	0.7550
20	No cost control	0.7500
21	Delayed permits due to prolonged coordination and consultation with the organizations concerned	0.7475
22	Lack of coordination/communication between staff	0.7413
23	Labor shortages	0.7350
24	Influences of increasing in taxes policy	0.7338
25	Poor Quality Assurance/Quality Control (QA/QC).	0.7325
26	Inadequate contingency reserve	0.7313
27	Lack of experience (management & site staff)	0.7288
28	Consultant, Suppliers and Subcontractors reliability and experience	0.7250
29	Poor material reliability	0.7238
30	Inadequate risk management.	0.7200
31	Estimating and/or scheduling errors	0.7138
32	Scope is underestimated	0.7113
33	Change in management or priorities	0.7013
34	New discovery of buried cultural assets or paleontology findings	0.6975
35	Unrealistic or aggressive performance standards	0.6963
36	Project scope and objectives change	0.6863
37	Handing over committee notes	0.6750
38	Design process takes longer than anticipated	0.6600
39	Prolonged consultation on route, structure, natural environment and heritage issues.	0.6575
40	Technological Innovation	0.6288

4.3. Correlation Analysis

We made correlation analysis to find out how far the risk factors related to the project overall risk and it was found that the all (40) risk factors are correlated to project risk with significance value equals zero. The lowest value of correlation was (0.401) for the risk factor “Change in management or priorities” and the highest value of correlation was (0.896) for the risk factor “cash flow problems”.

4.4. Regression Analysis

The questionnaire in this paper was based on dividing risk factors into ten independent groups and to get an equation that connects the ten groups with the overall project risk, we applied the regression analysis to the collected data. The results showed that (R=0.674) which is a moderately reliable result if (R) value is more than (0.6). The regression analysis also showed that to achieve the regression model equation the value of (F) was (13849) with a significance of zero value which indicates that there is a significant relationship between the ten variables (risk factors groups) and the overall project risk. The regression analysis ended up giving the following regression model.

$$RISK = 0.471 + 0.158\,(F) + 0.149\,(D) + 0.167\,(B) + 0.149\,(C) + 0.129\,(M) + 0.024(E) - 0.079\,(S) + 0.095(O) + 0.105\,(R) + 0.149\,(G) \quad (2)$$

Where; the feasibility and preliminary studies (F), design (D), bidding (B), monetary (C), management and staff (M), equipment and materials (E), Site features (S), Others (O), running and maintenance (R), general circumstances (G).

4.5. Chi-Square test

By applying (Chi-Square) test using Pearson's method on both company name and experience years' ranges it was found that the significance equals (0.199) which is more than (0.05) and that means that there is no relationship or dependency between company name and experience years' ranges.

4.6. ANOVA test

We applied (ANOVA) test on the gathered data to find out if the mean value of answers would change by changing the experience years' ranges and if the mean value of answers would change according to the respondent’s company. The results showed significant values more than (0.05) which proved that there is no difference in mean values according to either the company or the experience years' ranges.

4.7. Overall risk

The overall risk (OR) was calculated from the probability and impact of the risk factors of the 160 respondent forms. Where the overall risk of the project equal to the summation of the mean risk of each factor.

$$OR = \sum_{i=1}^{m} \sum_{j=1}^{N} (P_{ij} * S_{ij})/N \quad (3)$$

Where; OR is the overall risk of the project, m is the number of risk factors in this research m equal to 40, N is the total number of respondents in this study N equal to 160, P_{ij} is the probability of risk i for respondent j and S_{ij} is the severity of risk i for respondent j. so the overall risk in this research was 496.

5. RISK IN REAL ESTATE

In this research, the authors observed ten projects in Egypt. Each risk of the forty risk factors was monitored if the risk did not occur it take a value of zero while if the risk happened the risk was given a value according to its impact. The risk value was 1 for the very low, 2 for low, 3 for medium, 4 for high and 5 for very high. The overall risk was calculated by summation the value of each risk factor.

It is shown from the table (6), only one out of ten projects were finished with 255 overall risk value while five projects were finished with 305 overall risk and all the ten projects were finished with 560 overall risk value. Hence, we can calculate the percentage of the accomplished projects by dividing the cumulated finished projects over the total projects. Table (6) shows the overall risk for each case study and the percentage of the accumulated finished projects.

Table -6: Real Estate Overall Risk Value

Case Study No.	The percentage of the accumulated finished projects	Overall risk value
1	0.1	255
2	0.2	280
3	0.3	300
4	0.5	305
5	0.5	305
6	0.6	345
7	0.7	370
8	0.8	380
9	0.9	420
10	1.0	560

The authors analysed the data from the real estate through IBM SPSS for estimating the relation between the percentage of the accumulated finished projects and the overall risk value. A cubic equation was used to estimate the overall risk value. The value of "R" was 0.984 and the significant of ANOVA test was zero. Equation (4) shows this relation.

$$OR = 192 + 716 X - 1488 X^2 + 1123 X^3 \quad (4)$$

Where; OR is the overall risk value and X is the percentage of the accumulated finished projects. Figure (1) shows the relation between the percentage of the accumulated finished projects (x axis) and the overall risk value (y axis). While the overall value extracted from questionnaires was 496. From chart (1), we found that 95.4 % of projects will be finished without additional management reserve.

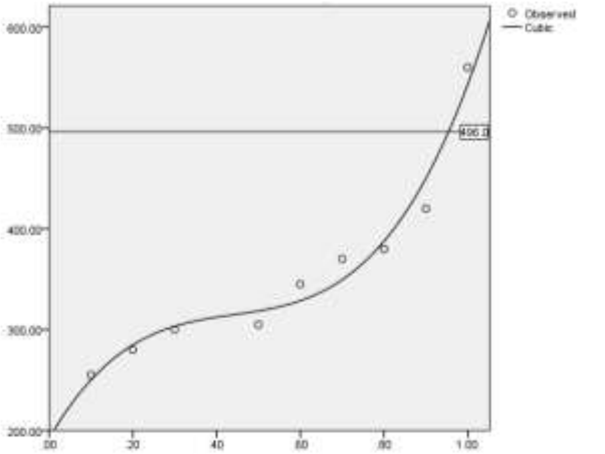

Chart -1: Overall risk value

6. DISCUSSION

Engineers of public sector companies and governmental companies were more cooperative in responding to the questionnaire than private sector companies as the percentage of respondents from private sector companies didn't exceed (15%) of the total respondents. The most effective way to get responses to the questionnaire was by face to face meetings. On the contrary, phone meetings and internet messaging didn't give valuable results. Junior engineers are obviously more familiar with concepts like risk and risk management than senior engineers due to including management in the curriculum of engineering faculties lately.

It wasn't a surprise that (cash flow problems) risk factor at the head of ranking of risk factors in Egypt due to the economic instability of the country which includes the construction of the road involved parties. The effect of the economic situation in Egypt was present in the factor (Foreign currency availability and exchange rate) which came in the 7th place and the factor (Inflation and deflation) that came in the 11th place. In the second place of ranking was the (Pressure to deliver the project on an accelerated schedule) risk factor which coincides with government plan to achieve development in several sectors rapidly.

(Force majeure) risk factor including revolution came 6th in ranking due to the major impact of the 25th of January revolution on all life aspects in Egypt. It's not far from what Zayed et al., 2008 [13] came up with in their research about Chinese highways where political risk came first on the other hand political risk was out of the top ten risks in the UAE highways projects due to El-Sayegh and Mansour, 2015 [8] and (force majeure) was in the 23rd place in ranking in UAE risk list. (Technological Innovation) factor came last in ranking in Egypt on contrary with Zayed et al., 2008 [13] research in China where (emerging technology) came with a high ranking is eye-catching point deserves studying.

7. CONCLUSIONS

In this research, we identified the risk factors that surround the construction of road projects in Egypt. Some of them are of the regular kind of risks like human errors and equipment condition etc. Other risks appeared due to political and economic instability through the last 7 years and are temporary but highly effective for example (force majeure (revolution)) and economic instability related factors like (foreign currency availability and exchange rate). Top five risk factors according to the research are Cash flow problems, Pressure to deliver project on an accelerated schedule, Poor leadership, post opening increase of the traffic volume and Price underestimated. The fact that (Technological Innovation) factor is at the bottom of risk ranking is disturbing as technology is an effective factor in any field and so it should be applied effectively to roads construction in Egypt.

This paper introduces a model for calculating the risk depending on the feasibility and preliminary studies, design, bidding; construction, management and staff, equipment and materials, Site features, others, running and maintenance, general circumstances. The overall value calculated from the questionnaires was 496 this means that 95.4 % of projects will be finished without additional management reserve.

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