Prioritizing of Risk Factors by using Failure Mode and Effect Analysis in the Iraqi Construction Industry

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Received on:21/2/2016 & Accepted on:21/4/2016

ABSTRACT

The main aim of the study is to demonstrate the qualitative risk analysis method by using failure mode and effect analysis (FMEA) in the construction industry in Iraq .The questionnaires considered as an important method of gathering field information about the risk management in the Iraqi construction industry .The numbers of the questionnaire forms which was distributed between the private and state sectors were 75 forms which consider the sample size. A total numbers of 69 forms from the distributed forms were returned with a returning percentage of (92%). Results show that 21.15% of the the risk factors are categorized as a Low risks. Also, a percentage of 44.23% shows that gathered risks factors of the construction projects are categorized as Moderate risks while a percentage of 21.15% are classified as major risk factors .Also, a percentage of 13.46% are classified as significant risk factors .Extreme risk factors are found to be only 0% from the data obtained by analyzing the questionnaire results.

Keyword: Risk management, qualitative r, Failure mode, effect analysis (FMEA), priority.

INTRODUCTION

Construction industry always have different types of challenge that may affect the main project goals . Meeting these objectives (time, cost, quality safety requirements).They are considered the essential performance measurement to assess construction projects, therefore managing project risks are considered as a valuable tool to achieve project objectives. [5] FMEA was the first used for military operations purposes back in 1949, [2]. In 1963 it has been proposed by NASA for reliability requirements. Since that time till now it is considered as an important technique for system risk management and safety [1].Failure mode and effects analysis can be defined as techniques for identifying and eliminating the possible causes of failure and prioritize potential failures within the projects. This needs disciplined and sequential method to achieve effective assessment to the products objectives. FMEA involves establishing the modes of failure and the effects of failure on a objectives This will insure that all kinds of failure modes are identified and ranked according to their priorities [6].

FMEA is widely used as a risk qualitative assessment approach, it

Could be used as a design tool to systematically analyze postulated component failures and define the total impact on the project objectives. Failure at low levels could cause big failure on higher levels [8].

FMEA main components can be summarized as follows [6] :

1-Likelihood of occurrence (L) : it is the probability of specific types of failure mode to be occur .A likelihood scale described in table 1,

Table1: FMEA likelihood scale

Rank	Failure likelihood	Severity of effect	Detection processes
5	Frequent	Maximum severity -failure lead to the end of the open-innovation process.	Extremely unlick- management processes will almost certainly not detect the potential failure before it occurs
4	Reasonably probable	Very high severity -open innovation network performance severity affected. Members very dissatisfied. Network member will be able to correct the failure with some constraints.	Remote likelihood- management process more likely will not detect the existence of the potential failure before it occurs
3	Occasional	Moderate-reduced performance with gradual performance degradation. Network members dissatisfied. Network member will be able to correct the failure with some constraints.	Moderate - management process may detect the existence of the potential failure before it occurs
2	Remote	Minor- network members will probably notice the effect .it is considered negligible	High - management process have a good chance of detecting the potential failure before it occurs
1	Extremely unlikely	Very slight- insignificant / negligible effect.	Very high - management process almost certainly will detect the potential failure before it occurs

2-Severity (S) – it is the impact of the failure mode on the project objectives.
3- Detection (D) - It is the ability to identify potential failure modes before failure occurrence this is before the unwanted impact actually does occur. In another word it means how detectable is the failure while something is still could be done
4- Risk Priority Number (RPN): it used to define the priority of the failure by giving them a numerical number, RPN can be calculated from the mathematical relation below:
RPN = Failure Likelihood x Severity x Detection.
As shown In the table 2 each range of RPN will give different type of risk categories starting from low risks up to moderate then major and significant and end up to extreme risk factors .

Table 2: The RPN ranking guidelines

RPN	Risk category
90-125	extreme
60-89	Significant
40-59	major
18-39	Moderate
1-17	low

Research Importance

1-It provide an independent view of the project technical risk factors which can be helpful to support decisions and enable more efficient and effective management tool

2-This study highlights on the prioritizing both of the technical and organizational risk factors in the Iraqi construction industry in order to take the effective actions (response plans) once the risk been identified and ranked .

3-Poor researches and studies in applying effective methods and tools for project risk management in Iraq, beside the poor implementation of the risk management plans which required more attention .

4-The result of this study might be useful implications for developing tool and techniques in construction projects risk

Management in Iraq which can be a rich source for both of the academic and field sectors.

5- Helping in building historical data for future studies.

RESEARCH METHODOLOGY

1- Data Collecting :

The researcher gathered the required data needed for the study in this case the data are the construction contracts from both sectors state and private .Around 30 construction contract were collected from the archive of the following Iraqi Ministries(Ministry of electricity , Ministry of higher education and scientific research and Ministry of Construction & Housing). Table 3 shows the gathered Technical risk factors from the construction industry in Iraq.

Table 3 : The technical risk factors in Iraqi construction industry

1	Reduce the quality of work in order to meet the dead lines
2	Importing materials does not match the engineering specifications
3	Lack of understanding of the drawings and specifications
4	The completion of the design is held by a non-efficient design office
5	adding new work items which considered important and necessary to completion the work
6	The work conflicted between other contractors used by the same employer
7	delays and technical problems with the sub-contractors ,
8	site survey is inaccurate
9	delay in approving the drawings from the consultant board
10	design change risk
11	Lack of expert consultants to solve engineering problems during implementation phase
12	Poor implementation and mismatch the Specifications
13	change in the specifications and the quality of the materials that been mentioned in the contract documents

14	The difference between the actual and contractual quantities
15	The bill of quantities based on incorrect estimation
16	Implementation of the foundation on the basis of the former one built since dozen of years
17	mistakes in the layout belong to the surveyor hired by the contractor
18	Executing additional laboratory test which is not included in the contract form and it's not the responsibility of the contractor to perform it .
19	Mismatch designs architectural, mechanical… etc
20	The lack of plans for the network services: electrical, water pipe lines..etc) which cause problems while excavations
21	Inaccuracies in determining the work quantities
22	Rebar diameters specified in the plans does not exist in the local market.
23	the result of soil density test does not match the required degree of compaction
24	monopoly of the construction materials required for Execution the work
25	The deviations in the axes of columns as well as the different elevations
26	the Contractor start pouring before the results arrival of laboratory testing for the construction materials
27	The delay in the completion of designs
28	Spacing between rebar does not match the Codes and Standards.
29	Difference in plans and contract documents.

Table 4 shows the gathered organizational risk factors from the construction industry in Iraq.

Table: 4 The organizational risk factors in Iraqi construction industry

1	using new equipment without proper training
2 3	The difficulty of obtaining licenses and work authorizations.
3	Lack of documentation of change orders
4	no area for Construction debris

5	problems in resource management
6	Delay in starting the work
7	internal problems between the contractor team
8	Religious holidays and sudden occasions
9	Precast concrete plants are far away from the construction site
10	disagreement between the contractor and the employer
11	The disagreement about the contractor payments after withdrawal the work from him
12	Lack of space within the site
13	The disagreement about the periods and the amounts awarded
14	the contractor delay in taking over the site because the lack of site preparation
15	changes in the methods of management
16	the contractor has a lack of an integrated engineering staff and always rely on his own experiences
17	the delay in both of implementation the work and providing the work progress report
18	delay in making the decisions from the engineer about approving the plans presented by the contractor and process for performing laboratory tests for the construction materials
19	The late arrival of the test results for Construction materials
20	termination of contract by the employer
21	Urgent selection of bids
22	Fluctuating of productivity for machines and labor
23	The risk of delayed results of concrete efficiency test for the foundation

2- The Questionnaires forms:

The main Questionnaires is concerned with the investigation the status of risk management in the construction industry in Iraq? after that the listing of the technical and organizational risk factors actions were taken .Once the risk factors are listed from the available data Basically each forms contain risk factors, impact of each risk on the project goals ,likelihood of occurrence and the risk priority number(RPN).After preparing Questionnaires forms it is important to select the sample size ,which can be defined as a process of making and obtaining the selections .one of the most frequent asked question is what is the sample size that needed to be used in the current research ? Statically the response to this question is at least 30 subjects, however there is a chance that a sample size with 30 subject will not be adequate [9], [4].In this research a total number of 75 forms of questioners were conducted as a sample size. Table 5describes the formula of the Questioners sheets.

Table 5: The components of Failure Mode and Effects analysis template 'adopted from [3].

PROJECT NAME:				DATE :	
Failure mode	Failure classification	(A) Likelihood of the occurrence	(B) Severity of the consequence	(C) Detection of failure	PRN= (A)*(B)* (C)
Risk description	Categorization of the risk	probability that a specific failure mode, to occur	Effect for a given failure mode.	This is before the un wanted impact actually does occur .in another word it means how detectable the failure is while something Is still could be done.	Its shows which risk are important than the other

3-Distrubution the Questioners forms:

Around 75 of the Questioners Forms were distributed to (mid to seniors) engineers, a number of 69 forms from the distributed forms were returned with a returning percentage of (92%)..table 6 shows the names of the engineering firms and organizations that been selected to complete the questionnaire process .the numbers of responds are also listed below .The closed questionnaire process targeted both the state and private sectors.

Table (6): Number of Respondents and their Organizations.

No	Organization	No. of respondents
1	Al-Mansour Contracting Company/ Ministry of Construction and Housing	7
2	Ministry of Higher Education and Scientific Research	6
3	Al-Rasheed Contracting Company/Ministry of Construction and Housing	8
4	AL-Mutasim state company for construction contracts./ Ministry of Construction and Housing Ministry of Construction and housing	8
5	Ashur Contracting Company/Ministry of Construction and Housing	6
6	The Ministry of Electricity / Directorate of power transmission projects	2

7	Hammurabi Contracting Company/ Ministry of Construction and Housing	6
8	National Center for Engineering consultations/ Ministry of Construction and Housing Ministry of Construction and Housing	6
9	AL-Farouq construction contracting company /Ministry of Construction and Housing	8
10	Private Sector (private contracting companies and consultation offices)	12
Total	69	

Discussion the Questionnaire Findings

In order to simplify the results of the questionnaire form the analysis process consist of two main parts: Part **one**: personal qualifications analysis.

It is designed to reflect the features and characteristics of the research study sample.

Fig.(1) shows the percentage of the selected sample major study field .the fig indicate that the biggest percentage was civil engineering field with a (52.1%) while the architecture engineering field goes with (30.43%) . and for the other engineering fields which are mechanical ,water resource ,electrical and others are (7.27%) , (5.79%) ,(2.89%) and (1.44%) respectively .

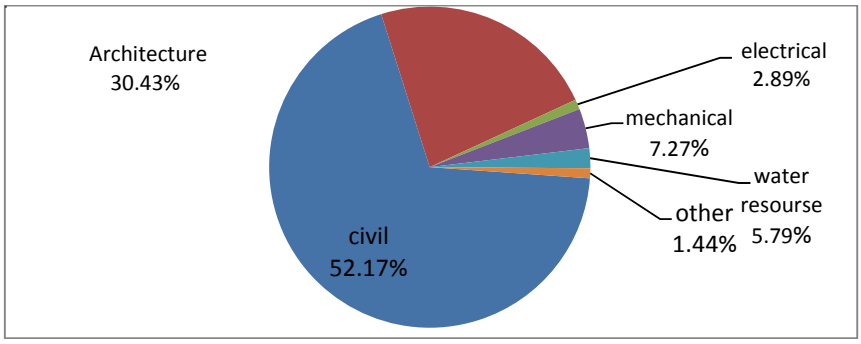

Figure. (1) : The research sample engineering specialization

Fig. (2) describes the functional position of the research sample who fill out the questionnaire forms , a percentage of 54% was a project engineers, while a percentage less percentage for contractors with a 22% was a . Site engineers and a total percentage of 13% of the research sample .A percentage of 7% represents the consultant engineers. Finally the remaining percentage are 4% witch represent the owners.

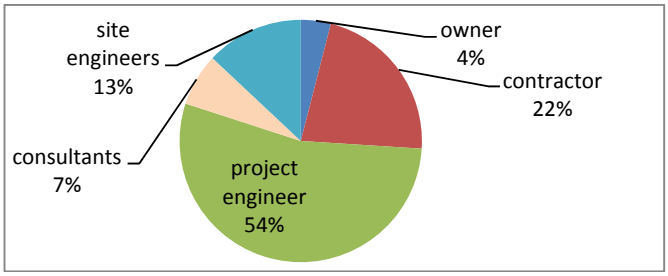

Figure..(2) The functional positions of the research sample.

Fig,(3)shows the percentage of the state sector versus the percentage of the private sector, the highest percentage of 82.60%are for the state sector while the less percentage 17.40% is for the private sector which represents the local and foreign contracting construction companies .witch means the majority of engineers working in the state sector are very high Compared with the engineers working in the private construction firms..

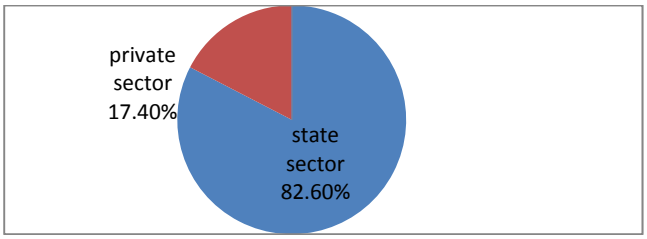

Figure.(3): Percentage of study sample to state and private sectors .

Fig.(4) illustrates the academic certificate level of the research sample size .the highest percentage of 66.67% goes to engineers with Bachelor degree ,while a percentage of 20.28% are for engineers with a master degree. The least percentage are for the engineer with a PHD which is 13.04% from the research sample.

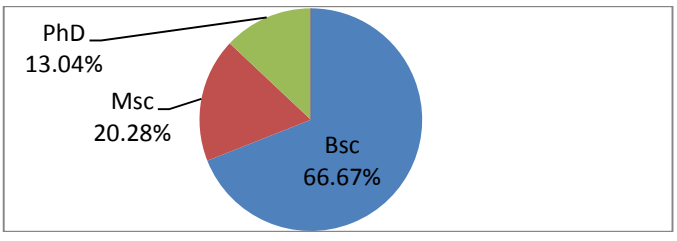

Figure.(4): The academic certificate of the research sample

Fig.(5) shows the years of experience for each individual of the research sample .the largest percentage was to the engineers with over 25 years of experience ,while the percentage of the

engineers with (6-15) years of experience was just 26% . In the other hand the least percentage went to the engineers with (16-25) years of experience with a percentage of 23% from the research sample.

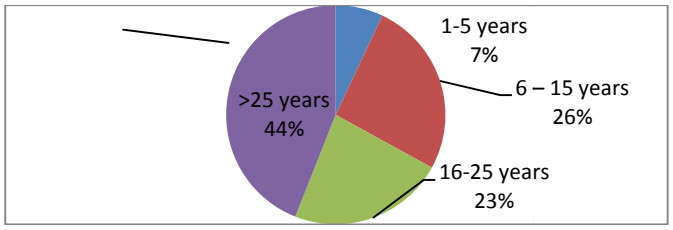

Figure. (5) :Years of Experience of the research sample .

Finally Fig (.6) reflects the percentage of the area of specialization of the research sample, which can be classified between two areas of work, the first one designee's with a percentage of 14% and the second one is the site managers and executors of the work with highest percentage of 86% from the research sample. A question will be generated why these two types of categories? The answer is simple because they are involved 100% in managing the project risk factors from the inceptions of the design to the implementation the work and end up to the maintenance stage .fig (7) highlights of the risk management through design period.

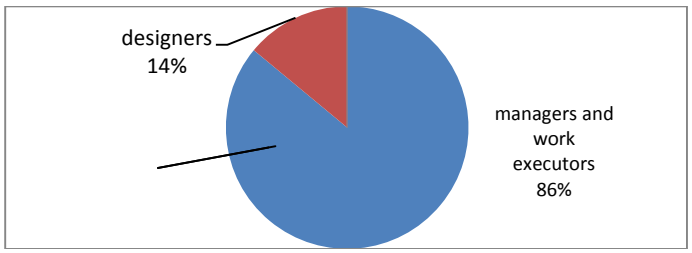

Figure. (6) : The Area of specialization for the research sample .

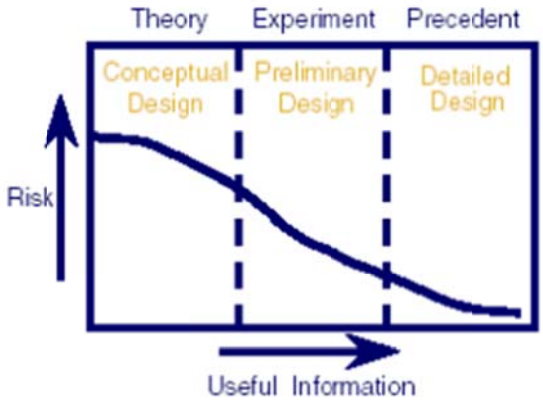

Figure. (7) :The effect of information on risk through time [7].

Part two :after obtaining the data .The analyzing process by using statistical package for social science (SPSS) were conducted .the analysis process focus of obtaining (the likelihood of occurrence for each technical and organizational risk factors .The impact of each risk of on the project goals and the Delectability of the failure mode) and by multiplying all of these factors the result will be the Risk priority number. RPR will fall between certain categories that reflect what the technical failure mode really are. Below are an example to demonstrate the assessment process for one of the technical failure modes.

Failure mode	Type	Likelihood	consequence	Detection of failure	PRN	Risk
change in the specifications and the quality of the materials that been mentioned in the contract documents	Technical	4 (Reasonably probable)	4 (Very high severity)	3 (Moderate)	48	Major

From that it can be realized that RPN =4 X 4 X 3 = 48
And from table 2 the RPN ranking guidelines indicated that 48 falls between the risk categories (40-59) which gives an indication to the major failure mode. Same calculations are applied for the organizational failure modes. All gathered risk factors were analyzed as shown in appendix A.

CONCLUSION

a. studies show that nearly 65% of research sample agreed that the construction projects does not apply any formal approach for managing project risk factors used I the construction sector in the republic of Iraq
b. 72% of the construction projects are uncertain at the beginning of the construction phase with the majority finishing without committing the time and budget frames according to the results obtained from the research questionnaire.
c. The questionnaire was an important source of obtaining the necessary field information's from the parties involved about the reality of the project risk management in Iraq.
d. The study found from both of the technical and organizational failure factors. that there are only 7 Failure modes that are categorized as a significant risk factors .with 11 low and major Failure modes and 23 moderate Failure modes , while the extreme Failure modes were just 0% .
e. Having low failure modes with 21.15% does not mean always neglecting the failure modes .

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APPENDIX

no.	Failure mode	Failure classification	Likelihood	consequence	Detection	PRN	Risk category
1	using new equipment without proper training	Organizational	2	3	2	12	low
2	The difficulty of obtaining licenses and work authorizations .	Organizational	3	3	3	27	Moderate
3	Lack of documentation of change orders	Organizational	2	3	3	18	Moderate
4	no area for Construction debris	Organizational	3	4	1	12	low

5	problems in resource management	Organizational	3	4	4	48	major
6	Delay in starting the work	Organizational	3	3	3	27	moderate
7	internal problems between the contractor team	Organizational	2	4	4	32	Moderate
8	Religious holidays and sudden occasions	Organizational	4	3	3	36	Moderate
9	Precast concrete plants are far away from the construction site	Organizational	3	3	2	18	Moderate
10	disagreement between the contractor and the employer	Organizational	3	4	4	48	major
11	The disagreement about the contractor payments after withdrawal the work from him	Organizational	4	3	3	36	Moderate
12	Lack of space within the site	Organizational	2	3	1	6	low
13	The disagreement about the periods and the amounts awarded	Organizational	4	3	3	36	Moderate
14	the contractor delay in taking over the site because the lack of site preparation	Organizational	2	2	2	8	low
15	changes in the methods of management	Organizational	3	2	4	24	Moderate
16	the contractor has a lack of an integrated engineering staff and always rely on his own experiences	Organizational	3	5	4	60	significant
17	the delay in both of implementation the work and providing the work progress report	Organizational	4	5	3	60	significant
18	delay in making the decisions from the engineer about approving the plans presented by the contractor and process for performing laboratory tests for the construction materials	Organizational	2	3	4	24	Moderate
19	The late arrival of the test results for Construction materials	Organizational	3	3	5	45	Major
20	termination of contract by the employer	Organizational	2	3	2	12	Low
21	. Urgent selection of bids	Organizational	2	2	1	4	Low

22	Fluctuating of productivity for machines and labor	Organizational	3	5	3	45	Major
23	The risk of delayed results of concrete efficiency test for the foundation	Organizational	3	3	5	45	Major
24	Reduce the quality of work in order to meet the dead lines	Technical	3	5	4	60	Significant
25	Importing materials does not match the engineering specifications	Technical	3	4	2	24	Moderate
26	Lack of understanding of the drawings and specifications	Technical	3	4	3	36	Moderate
27	The completion of the design is held by a non-efficient design office	Technical	4	4	5	80	Significant
28	adding new work items which considered important and necessary to completion the work	Technical	3	3	2	18	Moderate
29	The work conflicted between other contractors used by the same employer	Technical	2	4	4	32	Moderate
30	delays and technical problems with the sub contractors ,	Technical	3	4	3	36	Moderate
31	site survey is inaccurate	Technical	2	3	3	18	Moderate
32	delay in approving the drawings from the consultant board	Technical	2	2	4	16	low
33	design change risk	Technical	4	5	3	60	Significant
34	Lack of expert consultants to solve engineering problems during implementation phase	Technical	2	4	1	8	Low
35	Poor implementation and mismatch the Specifications	Technical	4	5	2	40	Major
36	change in the specifications and the quality of the materials that been mentioned in the contract documents	Technical	4	4	3	48	Major
37	The difference between the actual and contractual quantities	Technical	3	4	3	36	Moderate
38	The bill of quantities based on incorrect estimation	Technical	3	3	2	18	Moderate

39	Implementation of the foundation on the basis of the former one built since dozen of years	Technical	2	3	3	18	Moderate
40	mistakes in the layout belong to the surveyor hired by the contractor	Technical	2	2	4	16	Low
41	executing additional laboratory test which is not included in the contract form and its not the responsibility of the contractor to perform it .	Technical	3	3	4	36	Moderate
42	Mismatch designs architectural, mechanical… etc	Technical	3	5	3	45	Major
43	The lack of plans for the network services : electrical ,water pipe lines ..etc) which cause problems while excavations	Technical	3	4	3	36	Moderate
44	Inaccuracies in determining the work quantities	Technical	3	3	2	18	Moderate
45	The delay in the completion of designs	Technical	3	4	5	60	Significant
46	the Contractor start pouring before the results arrival of laboratory testing for the construction materials	Technical	2	5	1	10	Low
47	The deviations in the axes of columns as well as the different elevations	Technical	2	4	2	16	Low
48	rebar diameters specified in the plans does not exist in the local market.	Technical	3	3	2	18	Moderate
49	spacing between rebar does not match the Codes and Standards.	Technical	4	4	3	48	Major
50	the result of soil density test does not match the required degree of compaction	Technical	4	5	4	80	Significant
51	monopoly of the construction materials required for Execution the work	Technical	3	4	4	48	Major
52	differences in plans or contract documents	Technical	5	4	2	40	Major