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Research Article

Diagnosing the Causes of Failure in the Construction Sector Using Root Cause Analysis Technique

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The aim of this study is identifying and diagnosing the causes of construction project failure by using different project management process groups. These groups were initiation process group, planning process group, design process group, contract process group, executing and monitoring process group, and close process group. Also, the relative importance of the causes of construction project failure was investigated. Three techniques were used in this study: Ishikawa diagrams, Pareto diagrams, and 5-why techniques. The results were generally identified and diagnosed thirty-five causes of the construction project failure; however, only twenty-three of the causes were the most important. The majority of causes (thirteen causes) were obtained by using executing and monitoring project management process group. Seven causes were obtained by using contract project management process group. In addition, fewer causes (only three causes) were obtained by using initiation project management process group.

1. Introduction

Many construction projects suffer from poor design and from inconsistent time and cost management. This situation has led to rethinking of the industry's performance and how it could be improved [1]. Consistent cost and time overruns of public works projects are not the best use of taxpayer money. In the current economic downturn where tax revenues are lagging, they are particularly detrimental. In the public sector, money spent on project change orders and increased construction time reduces the number and size of the projects that can be completed during any given fiscal year. Various reasons for construction cost and schedule overruns in any project include design error, inadequate scope, weather, project changes, and underestimating the time needed to complete the project. Items omitted from the engineer's estimate of the projects due to design errors or inadequate scope frequently result in change orders, which increase cost as well as time of delivery. Underestimating the construction time is detrimental because another important project may be delayed from going to bid until the current project is completed. Many public projects are extensions of previous ones, and inaccuracies in estimating project cost and construction time can result in improper sequencing of related projects or phasing within projects, thus delaying much needed improvements [2].

The Iraqi construction sector faced a number of obstacles and problems which prevent the application of project management methodologies in the construction projects. Most of the construction projects failure occurred as a result of the overtaking of planned implementation duration, the poor estimation of the budget, and the poor implementation quality of the project. This study identified and diagnosed the causes that contributed to the construction projects failure, in construction companies in Iraq, via the perspective of contractors, project managers, and their relationship with some variables. In this paper, the author tried to use a number of innovative tools for problems and obstacles diagnosing in the construction projects and then put suggestions to make a simple application for one of the project management methodologies.

2. Study Problem

The problem of this study focused on identifying the application obstacles of a project management methodology, in construction companies in Iraq, via the perspective of contractors, project managers, and their relationship with some variables. The importance of this study can be summarized as follows:

(1) It provides a true vision of the difficulties that can be faced by the stakeholders (project managers, contractors, suppliers, and owner) when applying the methodology of project management in both the construction projects and construction companies.

(2) It attempts to overcome these obstacles and reduce them.

(3) It makes recommendations for the decision-makers to determine what the stakeholders need from the international methodologies in the construction projects.

(4) It encourages the researchers to conduct further studies and then integrate them with the results obtained from the current study.

3. Study Objectives

The objectives of this study can be summarized as follows:

(1) Identifying and diagnosing the causes of construction project failure by using different project management process groups (initiation process group, planning process group, design process group, contract process group, executing and monitoring process group, and close process group).

(2) Determining the relative importance of the causes of construction project failure.

(3) Calculating the relative importance of each project management process group of the construction project.

(4) Supplying logical solutions that have helpful roles in implementation of an international project management methodology in the Iraqi construction sector.

4. Study Limits

The limitations of this study can be specified as follows:

(1) Time limits: the gathering data were implemented in 2015.

(2) Spatial limits: this study was conducted depending on construction companies operating in the Iraqi construction sector.

5. Study Methodology

In order to achieve the objectives presented in this study, a two-step study methodology was adopted as follows:

(1) Comprehensive survey.

(2) Data gathering and results analysis.

The author used the same procedure that was followed by Al-Zwainy et al. [3] for exploring the comprehensive survey. The comprehensive survey was collected via previous studies from local and international journal papers, research reports, conference proceedings, theses, dissertations, and Internet publications.

6. Data Collection and Results Analysis

In order to identify and analyse the root causes for failure of the construction project and explore the problems which prevent the application of project management methodologies in the construction projects by the public institutions (Ministry of Construction and Housing) in Iraq, a survey research approach was adopted and this approach was used because of its advantage of rapid approach in data collection.

A survey research approach was adopted in this study to identify and analyse the main causes of the construction project failure. Also, this approach was used to explore the problems that prevent the application of project management methodologies in the construction projects done by the public institutions (Ministry of Construction and Housing) in Iraq.

The collection of data and information related to project management problems is a difficult task; this is because of the property information of each construction firm. In this study, the brainstorm approach was adopted, in addition to ten experts who were basically selected depending on their experience and qualification. Through the brainstorm approach, personal contact, by using the website, was made with stakeholders (project managers, contractors, suppliers, and owner). This approach deduced the main causes of the failure of construction project in different project management process groups (initiation process, planning process, design process, contract process, executing and monitoring process, and close process), as shown in Table 1.

In order to quantify and analyse the data as well as calculate the Arithmetic Mean (AM), the author used the statistical technique as mentioned by Al-Zwainy et al. [4]. The Arithmetic Mean (AM) and the impact degree can be shown in Table 2.

Problems solution is one of the most important processes in PMM domain. For an effective management methodology, it is very important to identify the "root causes" and "main causes" of the problem. The root cause(s) can be only found if there is a proper understanding of the process with a good experience of the innovative tools and techniques use. Six sigma tools were used as parts of the problem-solving management in the PMM domain. This study also tried to bridge the gap and showcase how the problem management can be done in more effective way by using innovative tools and techniques.

There are several tools of creative thinking such as fishbone diagrams, mind mapping, Pareto analysis, brainstorming, nominal group technique, metaphorical thinking, and why analysis. The author focused on three techniques as follows:

(A) Ishikawa diagrams.

Table 1: Main causes of the failure of construction project in project management process groups.

Project Management Process Groups	Symbols	Main Causes	Symbols
Initiation Process Group	S1	Companies lack of understanding of the population and demographic changes for construction projects	S11
		Strategic location of the project was not selected well	S12
		No database to study the projects feasibility	S13
Planning Process Group	S2	Lack of experience in the field of planning	S21
		Failure to provide a scheme with sums allocated to the project accurately	S22
		Inaccuracy of the bill of quantities	S23
		Executive companies not interesting well with schedule program	S24
Design Process Group	S3	Many designs are inaccurate; therefore designers make adjustments continuously	S31
		Employer requirements were constantly changing	S32
		There were not reconnaissance surveys in the work site	S33
		Brainstorming was bad between architectural designer style and owner in order to reach the desired design	S34
Contract Process Group	S4	Weak ability of the contractors and inaccurate information because of the unavailable database	S41
		information provided by some contractors is inaccurate in bidding or contracting phase due to lack of databases about contractors	S42
		subcontractors were inefficient	S43
		A large positive or negative discrepancy between the bidding price of contractors and the cost guessed by the employer	S45
		Delay in signing the contract for a long time after the referral by the authorities related to the signature	S45
		Lack of the specialists for the bidding analysis committees, and lack of clarity of the approval controls to trade-off between the companies	S46
		Lack of precise criteria for referral and therefore referral to the lowest price	S47
Executing & Monitoring Process Group	S5	General conditions of the civil engineering do not apply to all the fields	S51
		Inefficient residents, engineers, and supervisors in the projects	S52
		Inefficient Executing companies	S53
		Inefficiency of staff in spite of the development in the construction industry	S54
		Monopoly (making the tests in one laboratory)	S55
		Adoption of the general contracting method continuously in spite of problems caused by unsuitability circumstances of the country	S56
		Security conditions in some areas of the country and political or tribal interference	S57
		Holidays and events that reduce the work days per year as well as the weather conditions	S58
		Monitoring and controlling projects were done without using modern software	S59
		Time schedule was not updated regularly and continuously	S510
		Large number of the regular and frequent field visits for propaganda or advertising purposes	S511
		Occurrence of many change orders during construction – executing	S512
		Delays cash flow for contractors	S513
Close Process Group	S6	Problems in the calculations and measurement	S61
		Delay penalties	S62
		Leniency with the executing company if there is a defect in the executed projects and no reaction is taken for the defect diagnosing	S63
		Slow progress in the formation of technical committees	S64

(B) Pareto diagrams.

(C) 5-why technique.

(A) Ishikawa Diagrams. The cause and effect analysis technique was devised by Professor Kaoru Ishikawa, a pioneer of quality management, in 1960s. This tool was then published in book in 1990, "Introduction to Quality Control". the diagrams are known as Ishikawa diagrams or fishbone diagrams because the completed diagram looks like the skeleton of fish [5].

Table 2: Number of frequencies and arithmetic mean for main causes.

Variable	Observed Frequency					AM
	10	**30**	**50**	**70**	**90**	
S11	2	11	21	34	18	62.79
S12	3	7	19	30	27	66.51
S13	1	6	6	33	40	74.41
S21	0	3	4	44	34	74.76
S22	2	7	9	47	21	68.13
S23	1	6	9	38	32	71.86
S24	0	1	4	39	42	78.37
S31	1	4	3	38	40	76.04
S32	3	8	13	27	35	69.30
S33	1	7	15	37	26	68.60
S34	1	12	20	37	16	62.79
S41	0	2	6	28	50	79.30
S42	2	2	3	36	42	75.93
S43	0	0	1	24	60	82.90
S44	1	2	10	40	33	73.72
S45	1	14	18	33	19	62.20
S46	0	8	20	34	24	67.20
S47	0	4	10	24	48	76.97
S51	0	8	15	30	33	70.46
S52	2	1	19	25	39	72.79
S53	0	2	4	32	48	79.30
S54	0	3	6	46	31	74.41
S55	0	12	15	35	23	65.46
S56	0	10	15	42	19	66.27
S57	0	2	2	24	58	82.09
S58	2	6	8	31	38	71.97
S59	1	10	8	41	24	66.74
S510	1	6	15	44	20	67.67
S511	2	10	25	28	21	63.02
S512	1	4	10	39	32	72.55
S513	0	7	12	35	32	71.39
S61	1	12	16	40	16	62.90
S62	1	8	18	40	18	64.76
S63	1	6	9	35	35	72.55
S64	1	10	7	42	25	68.02

This tool is used to come up with new ideas like the brainstorming but with more balanced way. The cause and effect diagram offers a structural approach for the research to obtain possible causes(s) of the problem. This tool helps to organize the problem-solving efforts by identifying the categories of factors that can cause problems. This tool is usually used after the Pareto or brainstorming sessions to organize the generated ideas [6].

Although this tool was developed as a quality control tool, it can be just used to discover the root cause of the problem and the application failure of the project management methodology in the Iraqi construction sector.

The possible reasons for this problem can be identified as follows:

(1) Identify the main problem, write it in a box, and then draw an arrow pointing towards it. In this study the main problem is the failure of PMM application in Iraqi construction sector. It is possible to think about the problem in detail like what the problem is, and when and where the problem occurs in process management groups and different ten management areas.

(2) Diagnose the major factors and draw six branches of the large arrow to represent the main categories (process management groups) as a potential cause, as shown in Table 1.

(3) Use the brainstorm to identify all the possible causes of the problem in each of the main causes and explore each one to identify more specific causes; the information is shown in Table 1 and presented in Figure 1.

(4) The diagram analysis. In this stage, a diagram showing all the possible causes of the problem (the application failure of the project management methodology in Iraqi construction sector) should be provided. Once the fishbone is complete, understanding all the main causes of the problem can be achieved, as shown in Figure 1.

(B) Pareto Diagram. Pareto analysis is a technique for focusing the attention on the most important problem areas. The Pareto concept, named after the nineteenth-century Italian economist Vilfredo Pareto, consists of a few relative factors that generally account for a large percentage of the total cases (e.g., complaints, defects, and problems). The idea is to classify the cases according to the degree of importance as well as to focus on the most important problem solutions, leaving the less important [6]. The basic concept of Pareto analysis is the data arrangement in a descending order. The diagram can be used with or without a cumulative curve which represents the percentage sum of the vertical bars in the Pareto diagram [7].

The author is the first researcher who used the Pareto diagram in the project management methodology (PMM) to diagnose the deviation causes in six project management process groups. Relative importance (RI%) for main causes in project management process groups was shown in Table 3. The contract process group had highest relative importance, 17.6%; however, the close process group had the lowest relative importance, 15.4%. Figure 2 shows the Pareto diagram prepared depending on the information provided in Table 3 and Figure 1.

From Pareto chart, it can be concluded that planning process group (S2), contract process group (S4), and executing and monitoring process group (S5) constituted 80% of the problem. It can be said that by targeting these 3 top causes, 80% of the problem can be resolved.

The author followed the same procedure in diagnosing the problems in the project management process groups using the fish bone and Pareto chart, as follows:

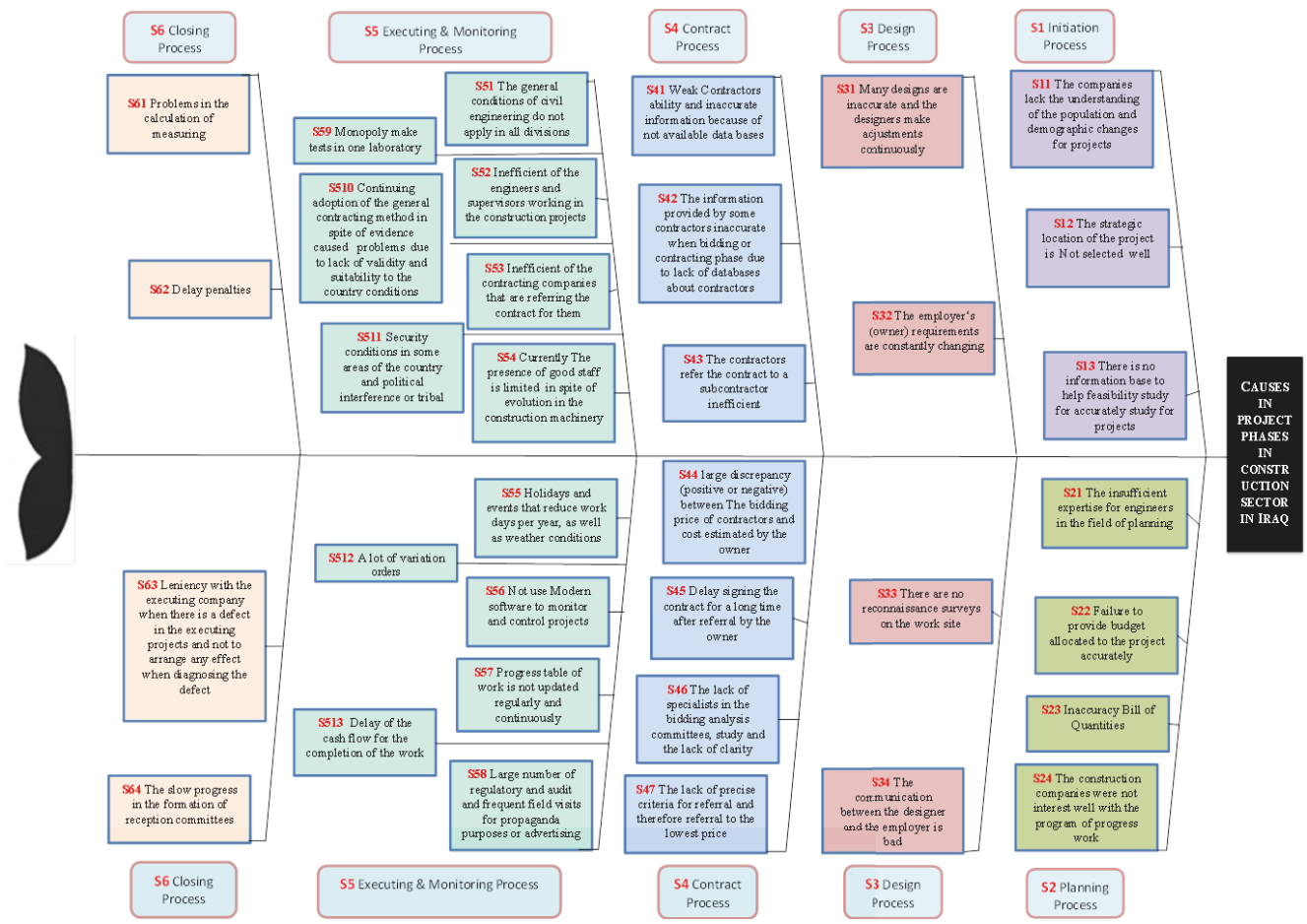

Figure 1: Ishikawa diagrams.

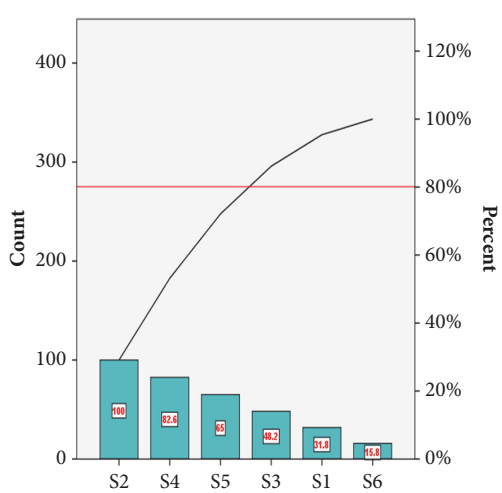

Figure 2: Pareto chart for all the processes.

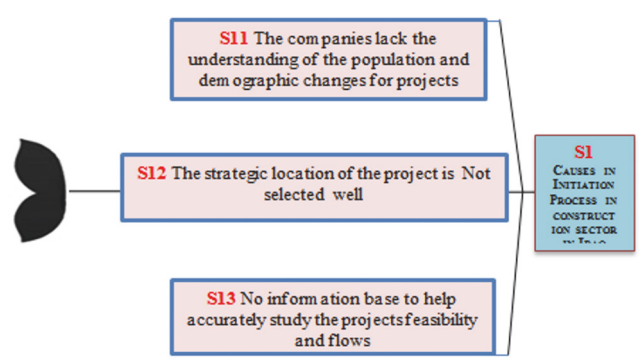

Figure 3: Fishbone diagram for project initiation management process group.

Firstly, in the project initiation management process group, it was observed that there was a problem in the Iraqi construction sector. For example, the companies had too poor understanding to achieve the population's requirements and demographics' changes for the projects. Also, the selection of the strategic location of the project was inappropriate. In addition, there was no helpful database for the feasibility studies of the projects. These causes highly influenced the performance of construction projects. The problems of the initiation process group can be explained in Table 4. Figure 3 shows the fishbone diagram for initiation process group.

Table 3: Main causes weight, relative importance, and rank.

No	Code: Project Management Process Groups	Code: Main Causes	Weights of Main Causes	Average Weights of Main Causes	Relative Importance RI%	Rank
1	S1	S11	62.79	68	16	5th
2		S12	66.51			
3		S13	74.41			
1	S2	S21	74.76	73.28	17.4	2nd
2		S22	68.13			
3		S23	71.86			
4		S24	78.37			
1	S3	S31	76.04	69.18	16.4	4th
2		S32	69.30			
3		S33	68.60			
4		S34	62.79			
1	S4	S41	79.30	74.03	17.6	1st
2		S42	75.93			
3		S43	82.90			
4		S44	73.72			
5		S45	62.20			
6		S46	67.20			
7		S47	76.97			
1	S5	S51	70.46	71.08	16.8	3rd
2		S52	72.79			
3		S53	79.30			
4		S54	74.41			
5		S55	65.46			
6		S56	66.27			
7		S57	82.09			
8		S58	71.97			
9		S59	66.74			
10		S510	67.67			
11		S511	63.02			
12		S512	72.55			
13		S513	71.39			
1	S6	S61	62.90	67.06	15.8	6th
2		S62	64.76			
3		S63	72.55			
4		S64	68.02			
	$\sum$			422.63	100%	

Figure 4 shows the Pareto chart for the rank of the failure causes in initiation process group.

Secondly, in the project planning management process group, the problem causes can be summarized as follows:

(i) Insufficient experience of the engineers in the planning field.

(ii) Failure in accurately providing the project with the allocated budget.

(iii) Inaccuracy of the quantities bill.

(iv) The construction companies were not well interested in the program of work progress.

These causes had a high effect on the Iraqi construction sector. Table 5 represents the relative importance and rank of the causes in project planning management process group. Figure 5 shows the fishbone diagram of the project planning management process group. Figure 6 shows the Pareto chart where the cause (S24) had the first rank as a relative importance by 26.67% individually and by 100% cumulatively.

Table 4: Main causes weights, relative importance, and rank for project initiation management process group.

Code		Weights of Secondary Causes	RI%	Rank
Main Causes	Secondary Causes			
S1	S11	62.79	30.8	3rd
	S12	66.51	32.7	2nd
	S13	74.41	36.5	1st
∑		203.71	100	

Table 5: Main causes weights, relative importance, and rank for project planning management process group.

Code		Weights Of Secondary Causes	RI%	Rank
Main Causes	Secondary Causes			
S2	S21	74.76	25.46	2nd
	S22	68.13	23.2	4th
	S23	71.86	24.47	3rd
	S24	78.37	26.69	1st
∑		293.61	100	

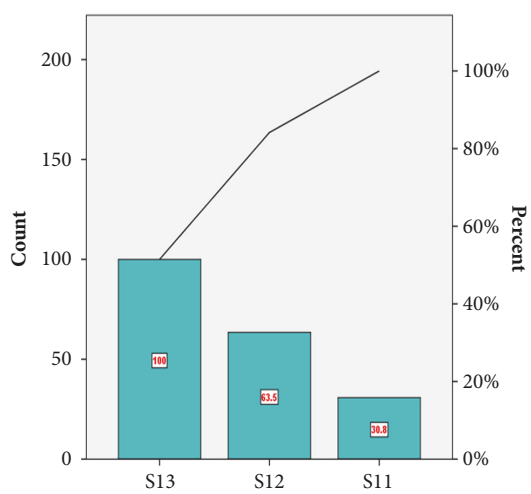

Figure 4: Pareto chart for project initiation management process group.

Thirdly, in the project design management process group, the causes were as follows:

(i) Many designs were inaccurate and the designers made continuous adjustments.

(ii) The employer's (owner's) requirements were constantly changing.

(iii) There were no reconnaissance surveys in the work site.

(iv) The communication between the designer and the employer was not good.

These causes had an influence on the desired designs in the Iraqi construction sector. Table 6 represents the relative importance and rank of the causes in project design management process group. Figures 7 and 8 show the fishbone diagram and Pareto chart for the project design management process group, respectively.

Table 6: Main causes weights, relative importance, and rank for project design management process group.

Code		Weights of Secondary Causes	RI%	Rank
Main Causes	Secondary Causes			
S3	S31	76.04	27.47	1st
	S32	69.30	25.04	2nd
	S33	68.60	24.79	3rd
	S34	62.79	22.69	4th
∑		276.73	100	

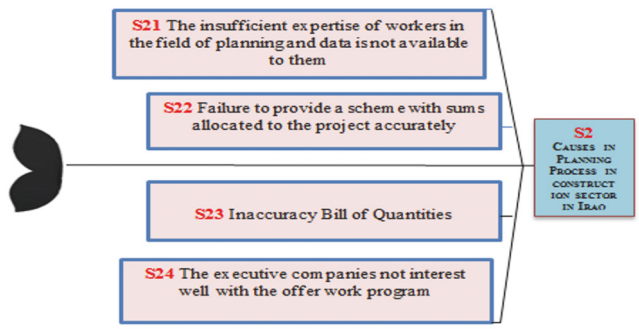

Figure 5: Fishbone diagram of the project planning management process group.

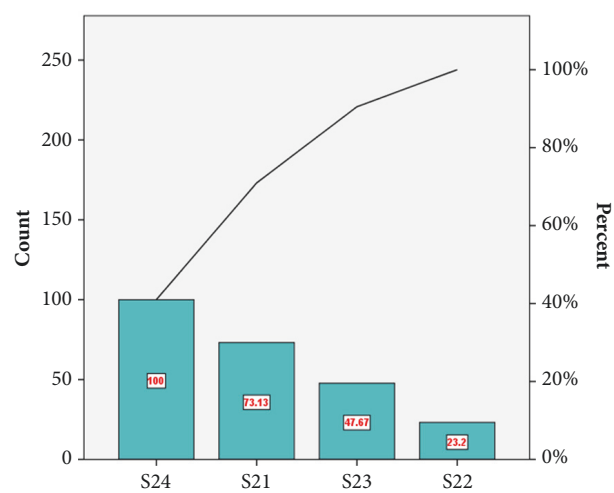

Figure 6: Pareto chart for project planning management process group.

Fourthly, in the project contract management process group, seven causes were identified, as follows:

(i) The weak ability of contractors.

(ii) Inaccurate information provided by some contractors during the bidding or contracting period because of the lack of databases about the contractors.

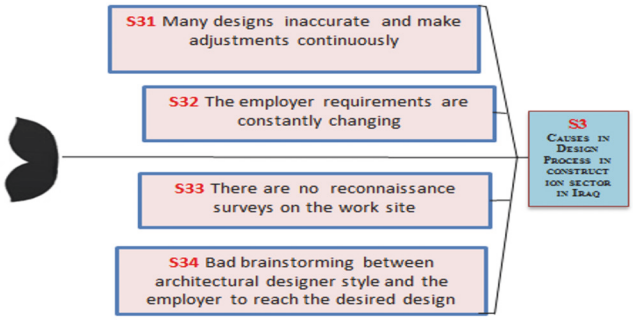

Figure 7: Fishbone diagram for project design management process group.

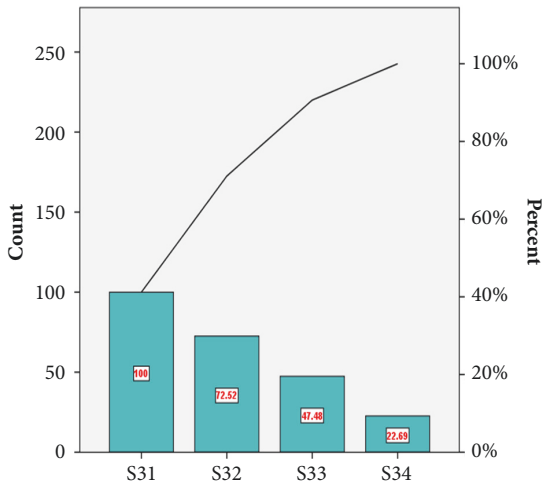

Figure 8: Pareto chart for project design management process group.

(iii) The contractors referring the contract to an inefficient subcontractor.

(iv) Large discrepancy (positive or negative) between the bidding price of the contractors and the estimated cost by the owner.

(v) A long time delay in the contract signing after the referral by the owner.

(vi) The lack of specialists in the bidding analysis committees.

(vii) Lack of clarity of the approval controls to trade-off between the companies and lack of precise criteria for the referral and, therefore, giving the referral to the lowest price offer.

Table 7 represents the relative importance and rank of the causes in project contract management process group. Figures 9 and 10 show the fishbone diagram and Pareto chart of the project contract management process group, respectively.

Fifthly, in project executing and monitoring management process group, several causes were identified as follows:

(i) The general conditions of the civil engineering not applying to all the fields.

Table 7: Main causes weights, relative importance, and rank for project contract management process group.

Code		Weights of Secondary Causes	RI%	Rank
Main Causes	Secondary Causes			
S4	S41	79.30	15.30	2nd
	S42	75.93	14.65	4th
	S43	82.90	15.99	1st
	S44	73.72	14.23	5th
	S45	62.20	12	7th
	S46	67.20	12.97	6th
	S47	76.97	14.85	3rd
∑		518.22	100	

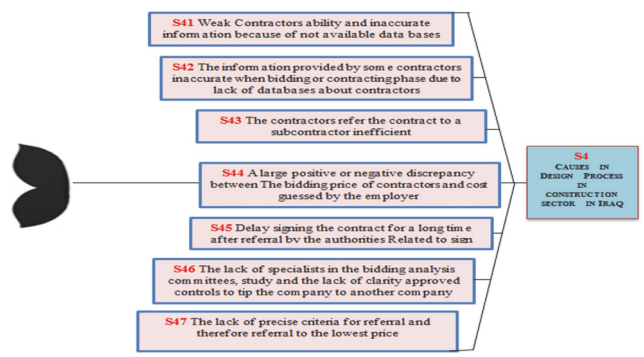

Figure 9: Fishbone diagram for project contract management process group.

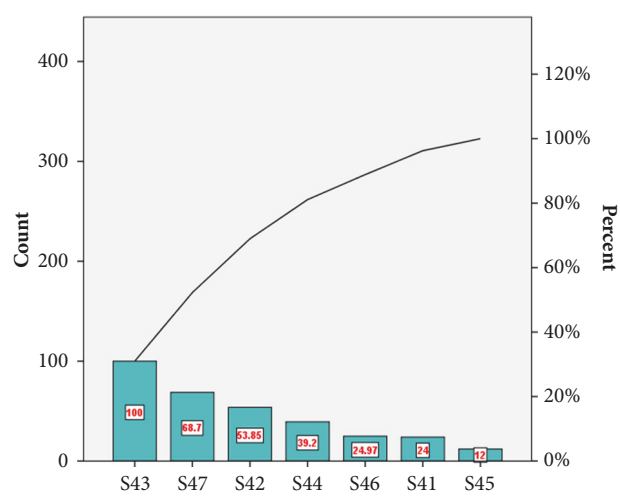

Figure 10: Fishbone diagram for project contract management process group.

(ii) Inefficient engineers and supervisors working in the construction projects.

(iii) Inefficient contracting companies having the project referral.

(iv) Adoption of the general contracting method continuously in spite of the evidence that problems are caused

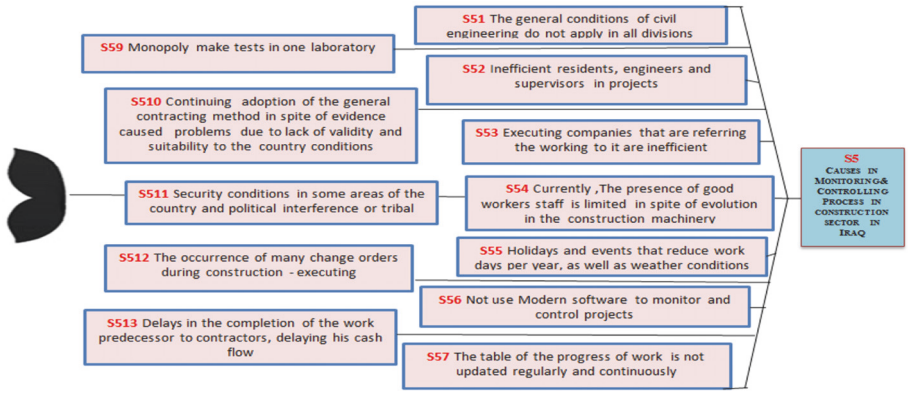

Figure 11: Fishbone diagram for project executing and monitoring management process group.

by the lack of validity and suitability circumstances of the country.

(v) Holidays and events that reduce the work days per year as well as the weather conditions.

(vi) The monitor and control projects done without using modern software.

(vii) The table of the progress of work not regularly and continuously updated.

(viii) Large number of regular and frequent field visits for propaganda or advertising purposes.

(ix) A lot of changing orders.

(x) Delays in the completion of the work predecessor to the contractors (cash flow delay).

Also, the author agrees with these opinions because of the realistic and logical answers. In addition, the safety conditions in some areas of the country and political or tribal interference had an important effect on the Iraqi construction sector. The problems of executing process group can be explained in Table 8. Figure 11 shows the fishbone diagram for executing process group. Figure 12 shows the Pareto chart for the rank of the failure causes in executing process group.

Sixthly, in project close management process group, the last part of the project life cycle is the delivery process (the closure of the project). During this process, there were several problems as follows:

(i) Problems in the calculations and measurement.

(ii) Penalties.

(iii) Leniency with the executing company if there is a defect in the executed projects with no reaction taken regarding the defect diagnosing.

(iv) Creating the interview committees in slow way.

Table 9 represents the relative importance and rank of the causes in project close management process group. Figures 13 and 14 show the fishbone diagram and Pareto chart for the project close management process group, respectively.

(C) Five-Why Technique. The root cause analysis (RCA) is an identifying process of the causal factors by using a structured

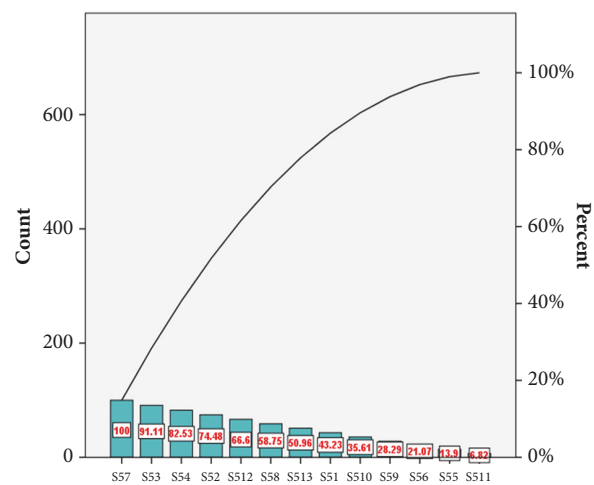

Figure 12: Pareto chart for project executing and monitoring management process group.

Table 8: Main causes weights, relative importance, and rank for project executing and monitoring management process group.

Code		Weights of Secondary Causes	RI%	Rank
Main Causes	Secondary Causes			
S5	S51	70.46	7.62	8th
	S52	72.79	7.88	4th
	S53	79.30	8.58	2nd
	S54	74.41	8.05	3rd
	S55	65.46	7.08	12th
	S56	66.27	7.17	11th
	S57	82.09	8.88	1st
	S58	71.97	7.79	6th
	S59	66.74	7.22	10th
	S510	67.67	7.32	9th
	S511	63.02	6.82	13th
	S512	72.55	7.85	5th
	S513	71.39	7.73	7th
∑		924.12	100	

Table 9: Main causes weights, relative importance, and rank for project close management process group.

Code		Weights of Secondary Causes	RI%	Rank
Main Causes	Secondary Causes			
S6	S61	62.90	23.45	4th
	S62	64.76	24.14	3rd
	S63	72.55	27.05	1st
	S64	68.02	25.36	2nd
∑		268.23	100	

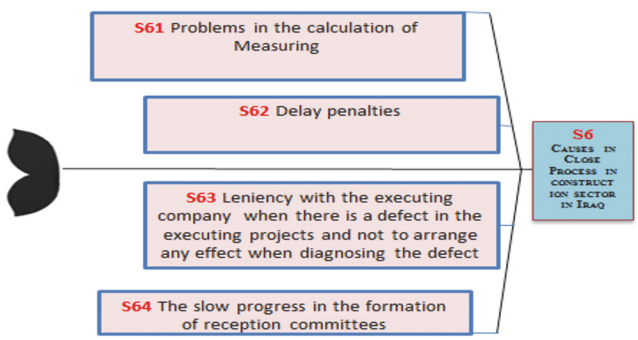

Figure 13: Fishbone diagram for project close management process group.

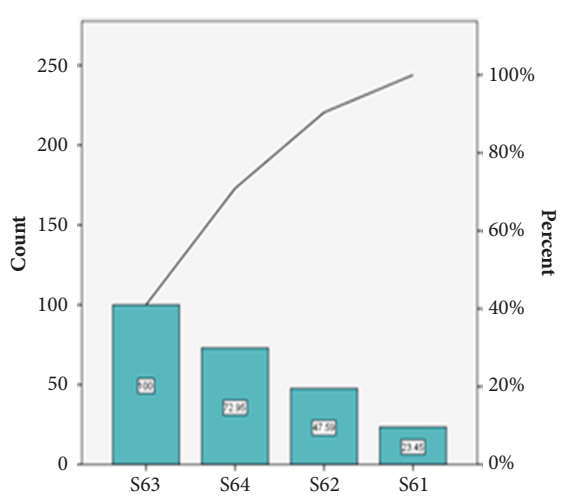

Figure 14: Pareto chart for project close management process group.

approach with designed techniques to provide focus on identifying and resolving the problems. The tools that assist the groups or individuals in identifying the root causes of problems are known as root cause analysis tools. The RCA is a step-by-step method that leads to finding the faults or root causes. The RCA traces the cause and effect trail from the failure end and then back to the root cause [8].

The root cause analysis techniques are a good choice to be adopted to diagnose the root causes of cost deviation in highway projects. Many root cause analysis tools have emerged from the literature as generic standards for identifying root causes such as fishbone diagram, Pareto diagram, and the 5-Why analysis [9].

The root cause analysis (RCA) is one of the many brainstorming methodologies of asking "why". It is one of the many brainstorming methodologies asking "why" five times repeatedly to help in identifying the root cause of the problem. If the problem is repeatedly questioned, each time an alternative solution comes out which is linked to the root cause. However, asking "why" may continue till getting an agreeable solution. "Five" is an arbitrary figure. The assumption is, after asking "why" five times, one is most likely to arrive at the root cause [8].

Five-why analysis technique can be used individually or as a part of the fishbone diagram. The fishbone diagram contributed to the exploration of all the potential or real causes that led to the construction projects failure in Iraqi construction sector. All the input variables are once put in the fishbone, and then the 5-why technique can be used to drill down to the root causes.

The author used the 5-why analysis technique because of its contribution to the identification of the root cause of the problem and determination of the relationship between the different root causes of the problem. Also, this technique is one of the simplest tools and is easy to complete without statistical analysis.

In this study, the author used the 5-why analysis technique for identifying the root causes of the problems in Iraqi construction sector, and the problems resolving can be briefed as follows:

(1) Write down the specific problem, formalize the problem, and then describe it completely. The absence of project management methodology is the root cause.

(2) Ask why this problem (failure in construction projects) happens and then write down the answer below the problem. Table 6 shows the reasons that led to the failure of construction projects. The most important of these causes is the lack of strategy for the management of construction projects in Iraq.

(3) If the answer is just provided, do not identify the root cause of the problem that you wrote down in Step 1. Ask "why" again and write down the answer, as shown in Figure 15.

(4) Loop back to step 3 until the team is in agreement and the problem's root cause is identified. Again this may take fewer or more times than five whys. Finally, the root cause is the absence of project management methodology.

7. Conclusion

In this study, root cause identification methodology was adopted to diagnose the causes of failure in the Iraqi construction project. There are different problems related to the construction projects and project management process groups in Iraqi construction industries. The root cause identification for the project problems is a key step to improve the project management methodology. The root cause is

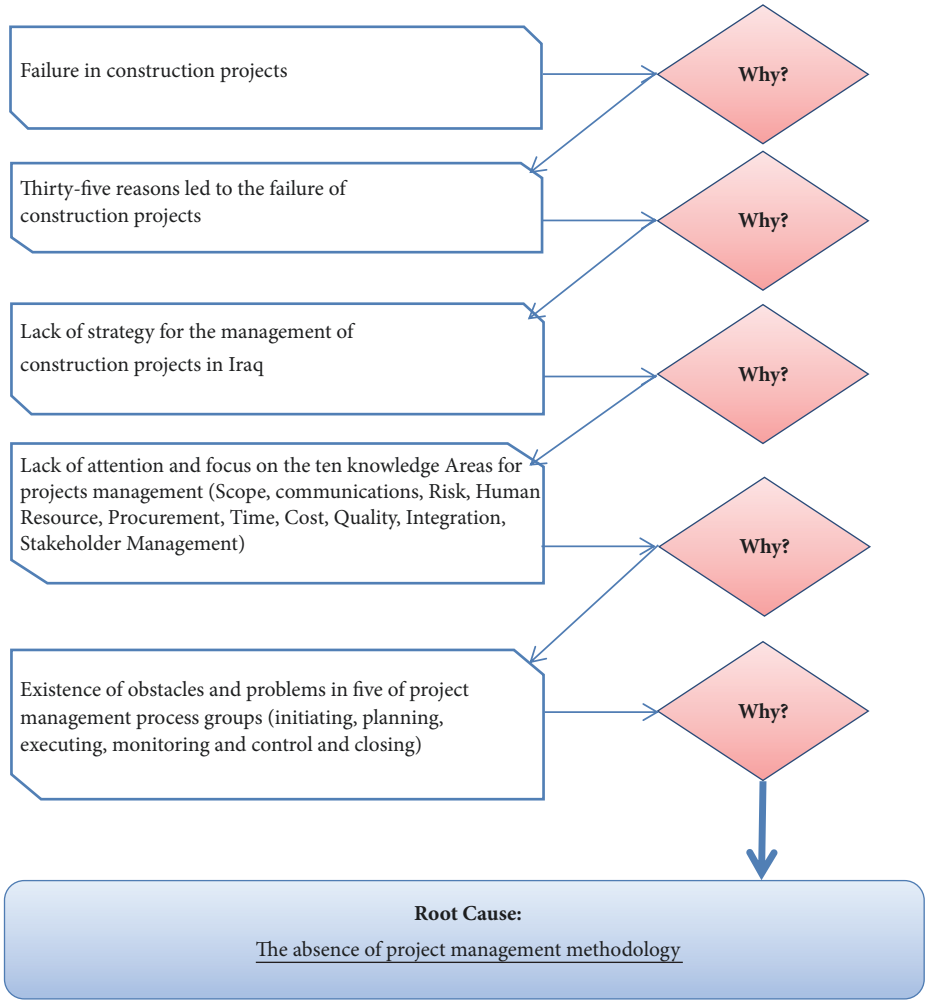

Figure 15: Five-why technique.

the absence of project management methodology. Many root cause analysis tools appeared from the literature as general standards to identify the root causes. They were the fishbone diagram (FD), Pareto diagram (PD), and the 5-why analysis. The results were generally identified and diagnosed thirty-five causes of the construction project failure; however, only twenty-three of the causes were the most important. The majority of causes (thirteen causes) were obtained by using executing and monitoring project management process group. Seven causes were obtained by using contract project management process group. In addition, fewer causes (only three causes) were obtained by using initiation project management process group.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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