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Diagnosing and Identifying Standards Affecting on the Ready-Mix Concrete Production Plants Performance: An Analytical Study

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Keywords:
Read-Mix Concrete Plant; Root Cause Techniques; Pareto Diagram; Performance; Why Technique.

Highlights:

- *Standards of evaluating the performance of ready- mix concrete production plants.*
- *Using root cause analysis techniques to deviate ready-mix concrete production plants to its required performance.*
- *Pareto analysis is a technique used in project management methodologies (PMM) to identify the few critical factors responsible for most problems in a plant.*

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Abstract: Due to the rapid growth of the construction industry in Iraq, this study aims to identify and diagnose the reasons behind the poor performance of ready-mixed concrete production plants in Baghdad. This aim was achieved by analyzing the standards affecting the plants' performance and identifying the cause of the deviation from their required performance using the root cause analysis technique through innovative tools and techniques, such as Pareto charts and the why technique. The study analyzed 35 reasons, divided into seven main groups: work breakdown structure, skills, shared values, systems, Administrative Styles, strategy, and staff. The results showed 23 out of 35 reasons with significant importance on the plants' performance. The Pareto analysis revealed that nine causes out of 35 reasons were responsible for 80% of the poor plants' performance. These included the lack of work breakdown structure in enhancing the functional performance of work teams and maximizing the utilization of their skills, as well as the insufficient number of work teams, two root causes of the work breakdown structure group. Another root cause from the skills group was the necessary skills lack among most work teams and the training programs and workshops absence for work teams. The study also found that the plant management's lack of focus on competition, excellence, and innovation was a root cause of the strategy group. In addition, the advanced techniques used for producing high-quality concrete mixes and the absence of a fair and accurate incentive and reward system were the root causes of the systems group. Furthermore, the management's failure to adopt control methods in all field and administrative work stages was a root cause of the management systems group, and the work teams' failure to adopt the knowledge-sharing approach was a root cause of the work teams' group. Using the "why" technique, it was found that the root cause was the absence of an objective, fair, and accurate incentive system in ready-mixed concrete production plants.

تشخيص وتحديد المعايير المؤثرة في أداء مصانع إنتاج الخرسانة الجاهزة: دراسة تحليلية

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الخلاصة

نظرا للنمو السريع لصناعة البناء في العراق، تهدف هذه الدراسة الى تحديد وتشخيص أسباب الأداء الضعيف في معامل انتاج الخرسانة الجاهزة في القطاع الخاص في بغداد، من خلال تحليل المعايير المؤثرة على أداء المصانع وتحديد مسببات انحراف أدائها عن الأداء المطلوب باستخدام تقنية المسبب الجذري، لتحديد السبب الجذري والقضاء عليه أو تقليله لمنع تكرار المشكلة وباستخدام أدوات وتقنيات مبتكرة، مثل مخططات باريتو، وتقنية لماذا. حللت الدراسة ٣٥ سببًا، مقسمة إلى سبع مجموعات رئيسية (هيكل توزيع العمل، المهارات، القيم المشتركة، الأنظمة، الأساليب الإدارية، الإستراتيجية، والموظفين)، وأظهرت النتائج وجود ٢٣ سببًا من أصل ٣٥ ذات أهمية كبيرة على أداء المعامل. كشف تحليل باريتو أن تسعة أسباب من أصل ٣٥ سببًا كانت مسؤولة عن ٨٠٪ من الأداء الضعيف للمعامل. وشملت هذه عدم مساهمة هيكل تقسيم العمل في تعزيز الأداء الوظيفي لفرق العمل وتعظيم الاستفادة من مهاراتهم، فضلا عن عدم كفاية عدد فرق العمل، والتي كانت سببين رئيسيين من مجموعة هيكل تقسيم العمل. وإن الافتقار إلى المهارات اللازمة بين معظم فرق العمل وغياب البرامج التدريبية وورش العمل لفرق العمل هو سبب جذري آخر من مجموعة المهارات. وجدت الدراسة أيضًا أن افتقار إدارة المصنع للتركيز على المنافسة والتميز والابتكار كان سببًا جذريًا لمجموعة الإستراتيجيات. فضلاً عن ذلك، كان عدم استخدام التقنيات المتقدمة لإنتاج الخلطات الخرسانية عالية الجودة وغياب نظام الحوافز والمكافآت العادل والدقيق من الأسباب الجذرية لمجموعة الأنظمة. علاوة على ذلك، كان فشل الإدارة في اعتماد أساليب الرقابة في جميع مراحل العمل الميداني والإداري سببًا جذريًا لمجموعة أنظمة الإدارة، وكان فشل فرق العمل في تبني نهج تبادل المعرفة أحد الأسباب الجذرية لمجموعة فرق العمل. باستخدام تقنية "لماذا"، تبين أن السبب الجذري هو عدم وجود نظام حوافز موضوعي وعادل ودقيق في معامل إنتاج الخرسانة الجاهزة.

الكلمات الدالة: تقنية المسبب الجذري، خرسانة جاهزة، مخطط باريتو البياني، الاداء، الرسم البياني لباريتو.

1.INTRODUCTION

Ready-mix concrete production Plants in the private sector are vital in producing ready-mixed concrete; they provide a practical and efficient solution for on-site concrete production and are an essential building material in construction projects worldwide. The demand for RMC has been steadily increasing due to the ongoing infrastructure development projects in the city, contributing significantly to the construction industry [1]. However, these plants encounter several obstacles and issues threatening their productivity and profitability, especially in Baghdad, Iraq. These issues manifest as deviations from the desired performance levels, including weakness in the adopted administrative styles, shortage of skilled labor, and the absence of clear plans and vision, delaying and increasing costs, directly impacting the construction projects' quality and the completion timeline [2]. However, ensuring optimal performance in private concrete production plants remains a challenge. Therefore, it is essential to investigate the underlying causes of poor performance and implement effective solutions to improve the overall productivity of these plants. The present scientific study contributes to presenting one of the administrative innovation methods, which includes the Pareto technique and the Why technique, considered modern administrative techniques. Based on the systematic research and review conducted across different digital databases, four studies evaluated the performance of ready-mix concrete production plants in multiple Arab countries. Table 1 includes the most important previous similar studies obtained through tracking and searching in Database Springer and ScienceDirect on evaluating the ready-mixed concrete plant's performance and summarizes the study's description and most significant results.

2.RESEARCH PURPOSE

This study aims to use the root cause analysis technique to identify the underlying causes of the poor performance of plants. The study's objectives can be summarized as follows:

1. Identify the performance evaluation standards for ready-mix concrete production plants.
2. Analyze the effect of these standards by calculating or identifying each standard's weight Value (WV) and relative importance index (RII) to focus on the important standards for improving performance.
3. Identify and diagnose the important standards to focus on and provide solutions to help ready-mix concrete plants in Baghdad enhance their productivity, performance, and profitability by applying the root cause analysis technique.
4. Providing an actual perspective for plant managers who face problems in improving the performance of their plants in an attempt to overcome obstacles and reduce the problem.
5. Allowing researchers to do more research and connect it with the current study's findings.

Table 1 Summary of Similar Previous Studies on the Evaluation of Ready-Mix Concrete Production Plant.

No	Study Title	Authors	Year	Country	Tools and Techniques	Statical Methods	Construct--Ion Model
1	An Evaluation of Ready-Mixed Concrete Plants Operating at Khartoum State, Sudan	Yahia and Elshaikh [3]	2018	Sudan	Interviews and observation	Questionnaire analysis	None
	Research Objective: - This research had three primary objectives (1) to identify and survey RMC plants in Khartoum State, Sudan; (2) to evaluate the surveyed plants to determine their compliance with some selected attributes; and (3) to classify the plants according to the Saudi Manual for RMC facilities establishment. **Research Description:** - This study described the findings of a survey and audit conducted to identify, evaluate, and categorize RMC plants operating in Khartoum State, Sudan. The findings revealed 19 RMC plants in Khartoum State, the earliest of which was founded in 1998. Sixteen plants were examined thoroughly regarding plant arrangement, laboratory and internal quality control system, and the final output quality.						
2	Statistical Model for Predicting and Improving Ready Mixed Concrete Batch Plants'performance a Ratio Under Different Influences	Aziz [4]	2018	Egypt	Historical data	SPSS	Simplified Prediction Models
	Research Objective: - This study's main objective was to evaluate and improve concrete batch plants' performance ratio by analyzing big data sets from multiple concrete batch plants and identifying the most influential components. **Research Description:-** This study has seven main parts: (1) Introduction, (2) Literature Review, (3) Methodology of Data Source, Field Measurement, (4) Collecting Data and Analyzing its Effect on Concrete Batch Plants' Performance Ratio, (5) Developing General and Simplified Models between concrete batch plant performance ratio as a dependent variable with all effective variables as independent variables, (6) Applying a real Case Study to test the proposed model's accuracy, and (7) Determining the Conclusion and Recommendation.						
3	A Simulation-Based Model for Evaluating the Performance of Ready-Mixed Concrete (RMC) Production Processes.	Nellickal et al.[5]	2015	India	Field visits and Field analysis	None	discrete-event simulation (DES) mode Simulation model
	Research Objective:- This research aims to explain RMC production processes and develop a simulation-based model to evaluate RMC production scenarios and calculate the environmental factors of the understudied RMC production process. The study analyzed the RMC truck and batching plant energy, carbon, and utilization. Processes included daily concrete production, truck number, journey distance, and speed. **Research Description: -**This study used a discrete-event simulation model to investigate the RMC production scenarios and assess equipment (batching plant and truck) utilization, energy use, and carbon emissions. The operation of the RMC production processes was reviewed in great depth. Finally, this study offered some suggestions for enhancing the performance of the RMC sector.						
4	An Engineering Approach to Allocate and Evaluate Performance Influencing Factors for Ready Mixed Concrete Batch Plant under Different Effects	Aziz [6]	2018	Egypt	Historical data	SPSS	
	Research Objective: The main objective of this study was to analyze a clear understanding of measuring any concrete batch plant performance ratio by analyzing collected data from more real concrete batch plants and determining the most effective factors that greatly affect concrete batch plants' performance ratio. Predicting the actual future performance ratio and production rates for any concrete batch plant according to groups of effective factors was the essential sector suggested in this study using smart modeling analysis. **Research Description:** This study comprised seven main parts: (1) Introduction, (2) Literature Review, (3) Methodology of Data Source, Field Measurement, (4) Collecting Data and Analyzing its Effect on Concrete Batch Plants' Performance Ratio, (5) Developing General and Simplified Models between concrete batch plant performance ratio as a dependent variable with all effective variables as independent variables, (6) Applying a real Case Study to test the proposed model's accuracy, and (7) Determining Conclusion and Recommendation.						

2.1.Justifications for Choosing the Research Sample

There are several reasons why ready-mix concrete plants in Iraq might be selected as a community and sample for the research; some of these reasons include:

1. The Construction Industry Growth: The construction industry in Iraq has been growing rapidly in recent years, with numerous construction projects being undertaken across the country. This growth increased construction materials demand, including ready-mix concrete, making construction companies and ready-mix concrete plants a relevant sample for research in project management.
2. Projects complexity: Construction projects in Iraq are often complex and require effective project management strategies to ensure success.
3. Studying the performance of construction companies and ready-mix concrete

production plants can provide valuable insights into the challenges project managers face in Iraq and the strategies used to overcome them.

4. Need for Improved Efficiency: The construction industry in Iraq is highly competitive, and companies are pressured to complete projects on time and within budget.

Research into project management in the industry can help companies identify ways to improve efficiency and reduce costs giving them a competitive advantage. Moreover, based on the study's objectives, this step includes selecting seven private-sector plants to produce ready-mixed concrete in Baghdad using the intentional sampling method. The chosen sample included Al-Shumoukh columns, Al-Bawaaba, Taj- Alsaahil, Naqaa Al-Saad, Riah-Almawasim, Nakhil- Alkhali, and Shams-Alaska. After careful investigation and examination, it was found that these plants closely matched the research environment as they met all the necessary conditions for obtaining accurate data and information regarding organization, planning, and control of ready-mix concrete production. The study was conducted between January 1, 2023, and April 1, 2023, during which data collection and analysis occurred in the selected plants.

3.RESEARCH METHODOLOGY

The research methodology included two main parts:

1. The theoretical part includes a literature review of pertinent literature and research published in the digital databases ScienceDirect, Springer, Google Scholar, Iraqi Scientific Journal, and ResearchGate.
2. The practical part of this study involves interviews and field visits to samples of concrete production plants. These visits were conducted to gather real-time data and insights regarding the plants' operations and performance. Following the field visits, the collected data were subjected to the following:
   a. Diagnosing the root causes of performance obstacles in ready-mix concrete production plants.
   b. Sata analysis using statistical and mathematical methods.
   c. Applying the Root Cause Analysis technique.

3.1.Data Collection

A survey research approach was adopted to identify the seven groups of basic standards adopted in this study to evaluate the performance of ready-mixed concrete production plants in Baghdad and identify and analyze the root causes of the deviation of the performance from the required levels. This approach was used due to its advantage in the rapid approach in data collection. Moreover, it is considered one of the statistical methods employed in project management, as it comprehensively and accurately covers all aspects of data and information surveying. Employed the brainstorming method by reviewing references, textbooks, dissertations, conference proceedings, publications, and manuscripts on the Internet [7- 9] published in local and international journals inside and outside the State of Iraq dealing with the subject of research (construction performance) and selecting fifteen experts based on their experience and qualifications. As illustrated in Table 2, the questionnaire was prepared based on seven groups conducting interviews and personal contacts with academics and stakeholders to complete the main and secondary standards.

Table 2 Personal Qualification of Arbitrators.

No	Functional Grade	Experience Years	Specialization	Workplace
1	Assistance professor	33	Construction Project Management	University Of Baghdad
2	Assistance professor	32	Construction Project Management	University Of Baghdad
3	Assistance professor	32	Educational Psychology	University Of Baghdad
4	Assistance professor	31	Educational Psychology	University Of Baghdad
5	Assistant Professor	20	Construction	Al-Nahrain University
6	Assistant Professor	24	Construction Project Management	University Of Anbar
7	Assistance	29	Construction Project Management	University Of Baghdad
8	Assistance	24	Construction	University Of Baghdad
9	Assistance	22	Construction Project Management	Al-Nahrain University
10	lecturer	20	Construction Project Management	Al-Nahrain University
11	Chief Eng. Senior	30	Civil Engineering	Housing Directorate
12	Assistant Chief Eng	15	Civil Engineering	Housing Directorate
13	Project Manager	20	Civil Engineering	Private Sector Companies.
14	Project Manager	17	Construction Project Management	Private Sector Companies.
15	Assistant Professor	31	Business Administration	University Of Baghdad

Moreover, the first form of the questionnaire covered only some of the study's main goals until it was edited more than five times to reach the final form. Afterward, seventy-five questionnaires were distributed to specialized engineers and executive managers working in the Iraqi Ministry of Construction, Housing, and Municipalities, specifically within the Department of Buildings and Engineers, and academic experts at the College of Engineering in Baghdad and Al-Nahrain Universities. These professionals specialize in the field of projects and business management. Additionally, construction site engineers with experience in construction sites work in the government and private sectors, working in different construction fields to cover the questionnaire items. The questionnaires employed a fivepoint Likert scale for data collection. The major and minor performance evaluation standards of ready-mix production concrete Plants in Baghdad are listed in Table 3. The responses adopted in the analysis were (50) forms because some forms received contained marginal answers and were incomplete. Accordingly, the number of questionnaires received was greater than (25), achieving a confidence level equal to (99.7%). These models (50) were considered the basis for the statistical analysis.

3.2.Results Analysis

Finding a strategy for statistically assessing the responses was the next step after distributing and collecting the questionnaire forms. The following computations and data analysis were performed using the following statistical techniques and procedures:

1. The Weight Value (WV) calculation for each of the five answer classes. This Weight Value (WV) corresponds to the middle of each class on the five-class decimal scale, as shown in Table 4.
2. The Arithmetic Mean or Weighted Average calculation using Eq. (1) [12]:

$$\mathrm{A.M} = \sum(\text{number of Frequencies} * \text{WV for each class}) / \text{Total numbers of the answers} \quad \textbf{(1)}$$

3. Relative Importance Index Technique (RII) calculation, the relative importance Index of identifying and rating the standards influencing the performance of ready-mix concrete production plants is calculated using the following expression [11,13].

$$\mathrm{RII} = \Sigma W / A * N \quad (0 \leq \mathrm{RII} \leq 1) \quad \textbf{(2)}$$

Where W is the column's attached score, which typically ranges from (1 to 5), where "1" denotes "not important" and "5" denotes "very important," and N is the total number of respondents, i.e., 50 in this study, and A is the highest score (5 on a 5-point Likert scale).
The important level is shown in Table 5 [14, 15].

4. Assessing the outcomes attained.

The last step was to compare the results of (AM) to the Class Interval. From the example, it can be concluded that the outcome was within the range of 60 to 80, i.e., Very Important. Furthermore, the results of (RII) can be compared over the relative importance index interval. As a result, the example shows that the result lay inside the range (0.8–1), or Important High Level, as shown in Table 6. Table 6 lists the number of frequencies, the Arithmetic Mean (AM), the impact degree, the relative importance index (RII), and the important level arranged in descending order based on their level of importance. After gathering the opinions of the research sample, all the standards mentioned came of degree arithmetic mean (Very Important) except standards (S11, S21, and S44) (Adequate a sufficient number of work teams available in the ready-mix concrete production plants implemented the work and the plans set. The work teams in the ready-mix concrete production plants had the necessary skills to carry out the work and implement the plans according to the required specifications. The management of ready-mix concrete production plants uses cutting-edge techniques for producing high-quality concrete mixtures simplifying the workflows and increasing speed completion), which are important. as Also, standards (S35, S52, S53, and S74) may significantly affect the performance of ready-mix concrete plants in Baghdad. Regarding the important Relative Index, it was found that 23 standards were rated as having a high level of importance on the performance of ready-mix Concrete. Additionally, 11 standards were rated high to medium importance in the performance of ready-mix concrete. One standard (S52) was rated as having a medium level of importance that may affect the performance of ready-mixed concrete in Baghdad. Furthermore, one standard was rated as having a medium level of importance. The researcher proposes that the important answers are those that got an arithmetic mean (AM) of more than seventy (AM ≥70) and an important relative index of more than (RII≥ 0.8) through the general determinations of the performance evaluation criteria, to increase the reliability of the answers. Ignoring the answers showed an average frequency of "non-important, rarely Important, and important," and the arithmetic mean (AM) value of less than seventy (AM ≤ 70), and relative important the general selections of the performance evaluation standards recorded less than 0.8 [16]. The number of frequencies, Arithmetic mean, and the Relative Importance Index for secondary standards (A.M≥ 70 and RII ≥ 0.8) are listed in Table 7.

Table 3 Major and Minor Standards of Performance Evaluation of Ready-Mix Production Concrete Plants in Baghdad.

Performance Evaluation Standards Groups	Symbols	Main Causes	Symbols
Work Breakdown Structure	S1	• An adequate number of work teams are available in ready-mix concrete production plants to implement the work and plans.	S11
		• The work breakdown structure contributes an important role in enhancing work teams' job performance and maximizing the use of their skills.	S12
		• The work breakdown structure supports the strategic plan of ready-mix concrete production plants.	S13
		• Adapting the work breakdown structure periodically to stay up with advances and changes.	S14
		• The powers and responsibilities in the work breakdown structure are clear and known to the work teams, and they are flexible in terms of relationships and administrative levels to coordinate work between the different departments.	S15
Skills	S2	• Work teams in ready-mix concrete production plants have the skills to carry out the work and implement the plans according to the required specifications.	S21
		• Training programs and workshops are available for work teams to aid them in advancing their careers, enhancing their performance, and building their skills.	S22
		• Concrete production plant management contributes to the work teams' knowledge and professional development.	S23
		• Ready-mix concrete production plants are concerned with competition, excellence, creativity, integrity, and community service.	S24
		• Work teams acquire technical and administrative skills that meet total quality management requirements.	S25
Shared Values	S3	• Ready-mix Concrete production management strengthens the connections of communication, conversation, and social interactions among the workforce.	S31
		• The shared values embraced by ready-mix concrete production plant management reinforce the principles of integrity within work teams.	S32
		• Ready-mix Concrete production plant management supports the principles of equity, fairness, and transparency among work teams.	S33
		• Ready-mix concrete production plant management encourages team spirit and promotes equality, tolerance, and respect among work teams.	S34
		• A work environment in concrete production plants is characterized by interdependence and cohesion among senior management, work teams, and beneficiaries.	S35
Systems	S4	• The ready-mix concrete production plant administration provides a work procedures manual (in either paper or electronic format) to deal with the beneficiary party (customers).	S41
		• A system of incentives and rewards exists in ready-mix concrete production plants that is fair, accurate, and objective.	S42
		• Ready-mixed concrete production plants have efficient management information systems, communication networks, and a unified accounting system to complete on-time completion of tasks.	S43
		• The management of ready-mix concrete production plants uses cutting-edge techniques for producing high-quality concrete mixtures simplifying workflows and increasing speed completion.	S44
		• A Global Positioning System (GPS) is available in concrete production plants to track the work teams at the implementation sites.	S45
Administrative Styles	S5	• The administrative patterns employed in ready-mix concrete production plants contribute to crisis management, problem resolution, and improving work performance.	S51
		• The upper management of concrete production plants follows an intellectual ideology characterized by stability, solidity, and a steadfast perspective.	S52
		• Ready-mix concrete production plants are used in modern administrative systems.	S53
		• The ready-mix concrete production plant management adopts control methods at all field and administrative work stages.	S54
		• Ready-mix concrete production plants' management employs a (reward and punishment) approach toward the work teams based on their adherence to the factory's policies and internal regulations.	S55
Strategy	S6	• Concrete production plants have a clear strategy (vision and mission) about what they aspire to become in the future.	S61
		• Ready-mix concrete production plants' management formulates their strategy after scrutinizing the strengths and weaknesses within their internal environment and evaluating the opportunities and challenges their external environment presents.	S62
		• Modify the strategy and objectives of the concrete production plant effectively in response to emerging environmental change.	S63
		• Ready-mix concrete production plant management has indicators to gauge the level of progress toward accomplishing its strategic plan.	S64
		• The presence of operational sub-plans in concrete production plants serves the strategic plan attainment.	S65
Staff	S7	• The work teams adopt a knowledge-sharing approach whereby experienced professionals exchange ideas and discuss results with new teams. This fusion of experience and youthful energy culminates in a high-quality performance.	S71
		• The work teams design activities and events that support the vision of their plant and contribute to achieving its goals in line with the lab's vision and shared values.	S72
		• The work teams understand the group's work mechanisms and methods of discussing ideas freely to provide constructive recommendations and focus on important issues to reach methods that serve the work.	S73
		• Each worker's job description in the ready-mix concrete production plant is aligned with the administrative and field tasks assigned to them.	S74
		• The senior management of concrete production plants grants sufficient space for work teams to participate in proposing developmental ideas and solving problems to achieve optimal performance.	S75

Table 4 Weight Value of Descriptive Frequencies [10, 11].

Descriptive Frequency	Class Interval	Weight Value (WV)
Non-Important	0 <AM≤ 20	10
Rarely Important	20< AM≤ 40	30
Important	40 <-AM≤ 60	50
Very Important	60<AM≤ 80	70
Excellent Important	80< AM≤ 100	90

Table 5 Important Level of Descriptive Frequencies.

RII	Important Level	
0.8 ≤ RII ≤ 1	High	H
0.6 ≤ RII < 0.8	High -Medium	H-M
0.4 ≤ RII < 0.6	Medium	M
0.2 ≤ RII < 0.4	Medium – Low	M-L
0 ≤ RII < 0.2	Low	L

Table 6 The Number of Frequencies, Arithmetic Mean, and Relative Importance Index for Standards.

Standards	Degree of Important 1	2	3	4	5	A.M	The Impact Degree	RII	Important Level
	Observed Frequency 10	30	50	70	90				
S21	0	0	4	7	39	84	Excellent Important	0.94	H
S11	0	0	7	10	33	80	Excellent Important	0.9	H
S44	0	1	3	15	31	80	Excellent Important	0.9	H
S42	0	1	5	14	30	79	Very Important	0.89	H
S12	0	0	6	20	24	77	Very Important	0.88	H
S22	0	1	5	17	27	78	Very Important	0.88	H
S54	0	0	9	15	26	77	Very Important	0.87	H
S71	0	4	4	16	26	76	Very Important	0.86	H
S24	0	0	11	16	23	75	Very Important	0.85	H
S43	0	1	8	18	23	75	Very Important	0.85	H
S61	0	3	4	20	23	75	Very Important	0.85	H
S14	0	0	10	20	20	74	Very Important	0.84	H
S25	0	2	7	21	20	74	Very Important	0.84	H
S15	1	2	7	18	22	73	Very Important	0.83	H
S62	0	0	11	21	18	73	Very Important	0.83	H
S63	0	1	11	17	21	73	Very Important	0.83	H
S64	1	0	12	14	23	73	Very Important	0.83	H
S31	1	2	8	20	19	72	Very Important	0.82	H
S32	1	4	7	16	22	72	Very Important	0.82	H
S75	1	2	6	23	18	72	Very Important	0.82	H
S45	1	3	9	18	19	70	Very Important	0.8	H
S55	0	2	14	16	18	70	Very Important	0.8	H
S72	0	4	10	19	17	70	Very Important	0.8	H
S33	0	4	10	22	14	68	Very Important	0.78	H-M
S34	1	2	13	19	15	68	Very Important	0.78	H-M
S73	0	3	9	27	11	68	Very Important	0.78	H-M
S13	2	5	10	15	18	67	Very Important	0.77	H-M
S65	0	2	12	27	9	67	Very Important	0.77	H-M
S41	3	3	12	15	17	66	Very Important	0.76	H-M
S51	0	0	18	23	9	66	Very Important	0.76	H-M
S23	0	5	10	28	7	65	Very Important	0.75	H-M
S35	3	7	14	16	10	59	Important	0.7	H-M
S74	6	13	10	8	13	54	Important	0.64	H-M
S53	2	14	19	11	4	50	Important	0.6	H-M
S52	9	12	10	16	3	47	Important	0.57	M

Table 7 Number of Frequencies and Arithmetic Mean and the Relative Importance Index for Secondary Standards that have (A.M≥ 70& RII ≥ 0.8).

Standards	Degree of Important 1	2	3	4	5	A.M	RII	Rank
	Observed Frequency 10	30	50	70	90			
S11	0	0	7	10	33	80	0.9	2nd
S12	0	0	6	20	24	77	0.87	6th
S14	0	0	10	20	20	74	0.84	12th
S15	1	2	7	18	22	73	0.83	14th
S21	0	0	4	7	39	84	0.94	1st
S22	0	1	5	17	27	78	0.88	5th
S24	0	0	11	16	23	75	0.8	19th
S25	0	2	7	21	20	74	0.84	13th
S31	1	2	8	20	19	72	0.82	18th
S32	1	4	7	16	22	72	0.85	11th
S42	0	1	5	14	30	79	0.89	4th
S43	0	1	8	18	23	75	0.85	9th
S44	0	1	3	15	31	80	0.9	3rd
S45	1	3	9	18	19	70	0.8	22th
S54	0	0	9	15	26	77	0.87	7th
S55	0	2	14	16	18	70	0.8	23th
S61	0	3	4	20	23	75	0.85	10th
S62	0	0	11	21	18	73	0.83	15th
S63	0	1	11	17	21	73	0.83	17th
S64	1	0	12	14	23	73	0.83	16th
S71	0	4	4	16	26	76	0.86	8th
S72	0	4	10	19	17	70	0.8	21th
S75	1	2	6	23	18	72	0.82	20th

3.3.Root Cause Analysis Technique

The Root Cause Analysis is a valuable tool for analyzing and identifying the factors affecting the performance of concrete production plants regarding their numerous problems and issues [17]. This Technique enables users to understand the causes and influencing factors of problems and focus on resolving them effectively and permanently [18]. Moreover, The Root Cause Analysis reduces the costs associated with problem-solving and improving plant performance while concurrently improving quality, productivity, and internal processes. Therefore, it can be asserted that the Root Cause Analysis plays a crucial role in improving and identifying the primary causes of problems and factors that influence the efficiency of concrete production plants [19]. There are many tools for creative thought. The researcher concentrated on two of these: Pareto diagrams and the Whys technique due to its infrequent utilization within the Iraqi construction sector; specifically, it is one of the seldom employed tools in project management.

3.3.1.Pareto Diagram

The Pareto analysis is a technique used in project management methodologies (PMM) to identify the few critical factors responsible for most problems in a plant. In PMM, Pareto analysis can identify the most significant risks, problems, or changes affecting plant progress or results [20]. Analyzing the frequency and impact of these factors, plant managers can prioritize their efforts and resources to address the most important issues first [21]. The following steps are usually followed to perform the Pareto analysis in PMM:

1. Determine the problem or issue that must be addressed in the plant (poor performance in the ready-mixed concrete plants in Baghdad).
2. Collect data on the frequency and impact of each factor contributing to the problem.
3. Group the factors into categories, i.e., seven major categories: S1, S2, S3, S4, S5, S6, S7, and determine their relative importance, then create a Pareto chart, which displays the factors in descending order of importance and arithmetic Mean, along with the cumulative effect of each factor.
4. Focus on the few key factors responsible for most of the problem and prioritize actions to address them.

Overall, Pareto analysis is a powerful tool that can help plant managers identify the most critical issues in their plants and allocate their resources more effectively to address them. The data provided in Table 6 are shown in a modified Pareto chart, as shown in Fig.1. From Fig.1, it can be concluded that 20% of the dimensions represented by "A work teams have the necessary skills (S21)", "An adequate number of work teams are available (S11)", "The management uses cutting-edge techniques for producing high-quality concrete mixtures" (S44), "A system of incentives and rewards exist that is fair, accurate" (S42), "Training programs and workshops are Available for work teams" (S22), "The work breakdown structure contributes an important role in enhancing work teams' job performance and maximizing the use of their skills" (S12), "The management adopts control methods at all stages of field and administrative work" (S54), "The work teams adopt a knowledge-sharing approach" (S71), and "The focus on competition, excellence, and innovation" (S24). Therefore, targeting focusing on these nine standards, representing 20% of the total, will improve 80% of the plant's performance. Fig.2 describes the Pareto diagram for standards that significantly improve the performance of ready–mix concrete production plants.

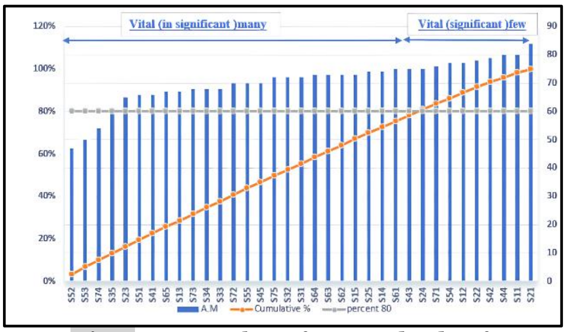

Fig.1 Pareto Chart for Standards of Performance Evaluation of Ready-Mix Concrete Production Plants in Baghdad.

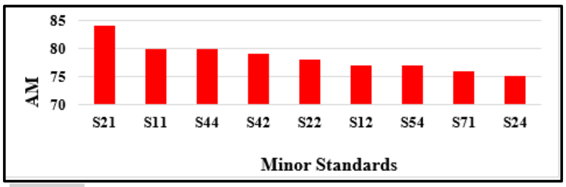

Fig. 2 Pareto Chart for Standards that Have a Significant Impact.

3.3.2.Whys Technique

The "Whys" technique is a problem-solving methodology used in project management to identify the root cause of a particular issue or problem [22]. The Why technique was used because it identifies the root cause of a problem and determines the relationship between different root causes of a problem [23]. Also, this technique is one of the most straightforward tools and is easy to complete without statistical analysis [24]. In this study, the researcher used the Whys technique to identify the root causes of poor performance problems in ready-mix concrete production plants in Baghdad. The identification was made after examining the extent of application of the standards in each plant according to Likert's tri-scale, i.e., applied, partially applied, not applied, and relying on the review list in Table

3, and because the data and information related to the plant's performance were specific to each plant, making collecting and analyzing this information difficult. The brainstorming principle was adopted in the research to obtain relevant descriptive data. Seven workers were selected from each plant based on their experience and qualifications, and interviews and communications were conducted with the most knowledgeable and aware plant managers, officials, and engineers about plant operations. Then the average responses for each factory were considered to ensure the accuracy of the results allowing for the proper compilation of the list and the collection of tangible data and results. The technique of "Why-Analysis" was applied, focusing on the common non-applied standards among most of the plants listed in Table 8 and analyzing them using the Why technique as follows:

1. Write down a specific problem, then formalize and describe it completely. (Not achieving the ideal degree of application for a ready-mixed concrete production plant) is the root.
2. Ask Why this problem (The ready-mix concrete production plants lack a clear strategy and vision about what they aspire to become). Write the reasons; the most important of these causes is ready-mix concrete production plants' management not formulating their strategy after scrutinizing the strengths and weaknesses within their internal environment and evaluating the opportunities and challenges their external environment presents.
3. If the answer just provided does not identify the root cause of the problem that wrote down in Step 1, ask Why again and write that answer down.
4. Loop back to Step 3 until the team agrees that the problem's root cause is identified. Again, this may take longer than the five reasons shown in Fig. 3. Finally, the root cause was identified after it was presented to experts specialized in the field of construction project management, who hold a Ph.D. with the scientific titles of professor and assistant professor and engineers working in ready-mix concrete production plants, who confirmed that the root cause is the absence of a fair, accurate, and objective system of incentives and reward.

Table 8 Non-Common Standards between the Plants.

Standards Symbols	Description	Number of common plants
S14	Adapting the work breakdown structure periodically to stay up with advances and changes.	4
S15	The powers and responsibilities in the work breakdown structure are clear and known to the work teams, and they are flexible in terms of relationships and administrative levels to coordinate work between the different departments.	4
S23	Concrete production plant management contributes to the work teams' knowledge and professional development.	4
S24	Ready-mix concrete production plants are concerned with competition, excellence, creativity, integrity, and community service.	4
S42	A system of incentives and rewards exists in ready-mix concrete production plants that is fair, accurate, and objective.	4
S43	Ready-mixed concrete production plants have efficient management information systems, communication networks, and a unified accounting system to complete tasks on time.	4
S54	The ready-mix concrete production plant management adopts control methods at all field and administrative work stages.	4
S41	The ready-mix concrete production plants administration provides a work procedures manual (in either paper or electronic format) to deal with the beneficiary party (customers).	5
S61	Concrete production plants have a clear strategy (vision and mission) about their aspirations.	5
S62	Ready-mix concrete production plants' management formulates their strategy after scrutinizing the strengths and weaknesses within their internal environment and evaluating the opportunities and challenges their external environment presents.	5
S22	Training programs and workshops are available for work teams to aid them in advancing their careers, enhancing their performance, and building their skills.	7
S31	Ready-mix Concrete production management strengthens the connections of communication, conversation, and social interactions among the workforce.	7
S45	A GPS is available in concrete production plants to track the work teams at the implementation sites.	7
S72	The work teams design activities and events that support the vision of their plant and contribute to achieving its goals in line with the lab's vision and shared values.	7

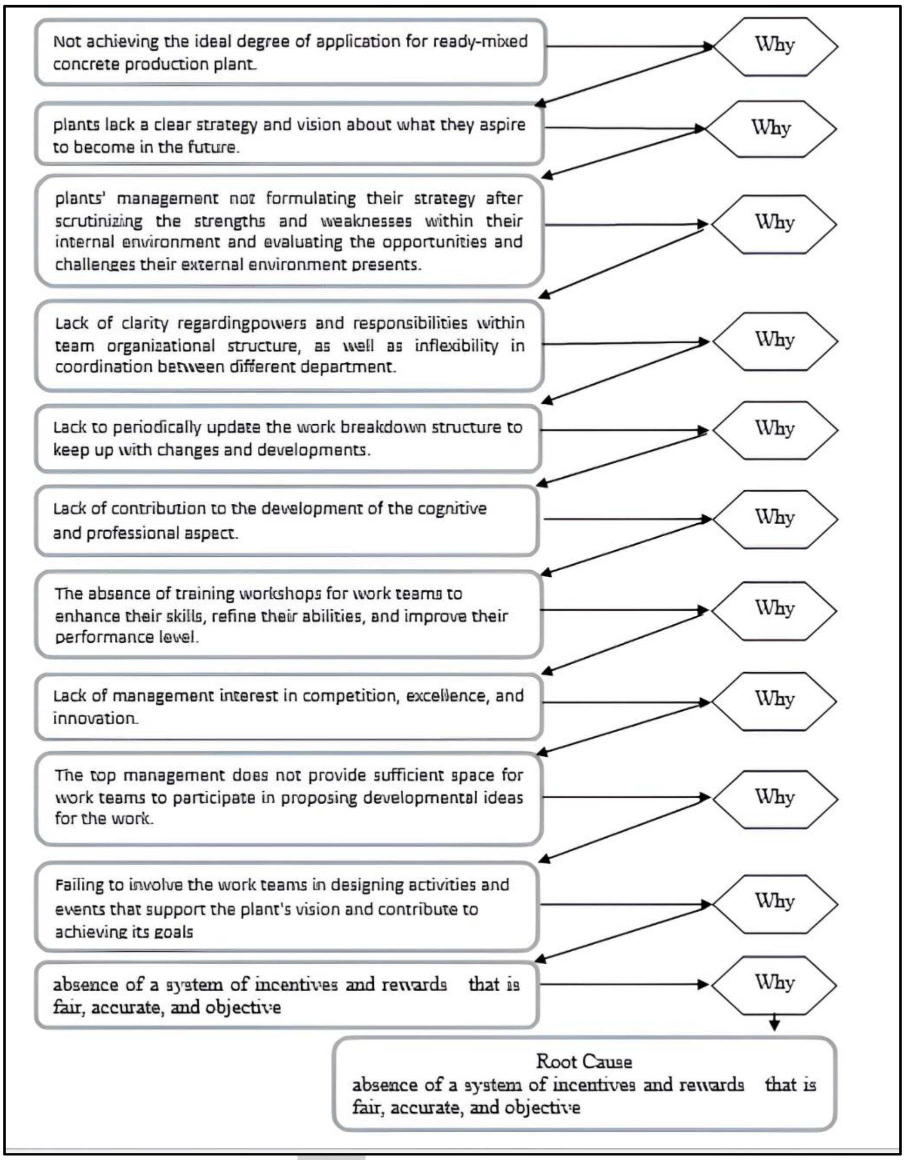

Fig.3 Final Why Analysis.

4.RESULTS

The results of the study can be summarized based on the results of the practical side of the study as follows:

1. Analyzing the arithmetic mean (AM) and the relative importance index (RII) of the causes affecting the performance of the ready-mix concrete production plants showed that 28 standards were assessed as "very important," including standards (S11, S21, and S44), which were rated as "excellent important," while four standards were assessed as "important." As for the relative importance (RII), 23 standards were assessed as "high," and one standard (S52) was assessed as "important."
2. Twenty-three standards shared relative weight and importance after considering the threshold of≥70.
3. The Pareto analysis showed that nine standards were identified as root causes of performance weakness in the ready-mix concrete production plants. The most important of these was the lack of a sufficient number of work teams with the necessary skills (S21, S11), the failure to use advanced technologies to produce high-quality concrete mixes (S44), and the absence of a fair and accurate system of incentives and rewards (S42).
4. A Why technique analysis showed that adopting the non-applied paragraphs that were common between the plants and filtering the root causes resulting from the Pareto analysis resulted in the absence of a fair, accurate, and objective system of incentives and rewards (S42) was the root cause.

5.CONCLUSION

The study summarized a set of conclusions based on the results of the practical side of the study as follows:

1. Through field observations and personal interviews, it was found that ready-mix concrete production plants in Baghdad (the research sample) do not realize the

importance of evaluation and lack a performance evaluation system.

2. In this study, the methodology was to identify the root cause approved to diagnose the causes of deviation of the performance of ready-mixed concrete production plants from the required performance levels.
3. Diagnosing the root causes of the plants' performance weakness is necessary to improve performance.
4. Many tools for root cause analysis have emerged from the literature, such as the Pareto diagram (PD) and the 5 Whys analysis.

6.RECOMMENDATIONS AND FUTURE STUDIES

Based on the study's findings, the researcher recommends and suggests the following:

1. Adopting the results of this assessment in the Iraqi construction sector, specifically in concrete production plants, to enhance productivity and quality.
2. Study the technological advancements' impact: Investigate the influence of emerging technologies, such as automation and artificial intelligence, on the performance of concrete production plants furthermore, how these advancements can enhance productivity, efficiency, and quality.
3. Study the supply chain impact on the ready-mix concrete production plants' performance. Analyze factors such as raw material sourcing, transportation logistics, and inventory management to identify areas for improvement and optimize overall operations.

REFERENCES

[1] Obe RKD, de Brito J, Silva RV, Lye CQ. **Sustainable Construction Materials: Recycled Aggregates**. United Kingdom: Woodhead Publishing; 2019.

[2] Qaramohammed HN, Al-zwainy FMS. **Strategic Evaluation Plan and Improvement of Cement Plants (Iraqi Kurdistan Region-as a Case Study).** *Tikrit Journal of Engineering Sciences* 2021; **28**(2): 124-136.

[3] Mahmoud SYM, Elshiekh EAM. **An Evaluation of Ready-Mixed Concrete Plants Operating At Khartoum State.** *Red Sea University Journal of Basic and Applied Science* 2017; **2**(3): 86-103.

[4] Aziz RF. **Statistical Model for Predicting and Improving Ready Mixed Concrete Batch Plants' Performance Ratio under Different Influences**. *Alexandria Engineering Journal* 2018; **57**(3): 1797–1809.

[5] Nellickal AG, Rajendra AV, Palaniappan SA, Palaniappan S. A Simulation-Based Model for Evaluating the Performance of Ready-Mixed Concrete (RMC) Production Processes. *49th International Conference of the Architectural Science Association* 2015; Melbourne, Australia. The Architectural Science Association and The University of Melbourne: P. 658–667.

[6] Aziz RF. **An Engineering Approach to Allocate and Evaluate Performance Influencing Factors for Ready Mixed Concrete Batch Plant under Different Effects**. *Alexandria Engineering Journal* 2018; **57**(4): 3237-3247.

[7] Samour MII. *Mckinsey's Model for Organizational Diagnosis as an Approach for Develop the Institutional Performance. M.Sc. Thesis.* Al-Aqsa University; Gaza, Palestine: 2021.

[8] Madi K, Abu Nada A. proposed framework for the role of good governance in the relationship between the dimensions of the McKinsey model (McKinsey 7S) of organizational diagnosis and the activation of the values of integrity, transparency and organizational reputation (a field study on Palestinian municipalities). Gaza: Palestine; 2021: pp. 1-25.

[9] Alghalibi TM, Hoshan NN. **Use the McKinsey 7S Analysis Framework to Address the Strategy Implementation Issues Related to Human Resources (Applied research in the Directorate of Sewage in Basra)**. *Iraqi Academic Scientific Journals* 2018; **34**(37): 53–98.

[10] Al-Zwainy FMS, Mohammed IA, Raheem SH. **Investigation and Assessment Of the Project Management Methodology in the Iraqi Construction Sector**. *International Journal of Applied Engineering Research* 2016; **11**(4): 2494–2507.

[11] AL-Zwainy FM, Al-Marsomi MS, Mohammed S. Developing a Novel Approach for Evaluation Performance of the Engineering Departments Managers Using 360 Technique. In: 3rd International Engineering Conference on Developments in Civil & Computer Engineering Applications 2017 Feb 26-27; Erbil, Iraq. Polytechnic University: p. 179.

[12] Al-Zwainy FMS. **A State-of-the-Art Survey to Estimate Construction Costs in Highway and Bridge Projects: Analytical Diagnostic Study**. *International Journal of Civil Engineering and Technology* 2018; **9**(5): 795–821.

[13] Sambasivan M, Soon YW. **Causes and Effects of Delays in Malaysian Construction Industry**. *International Journal of Project Management* 2007; **25**(5): 517–526.

[14] Al-Marsomi MS, Al-Zwainy FM. **Assessing Obstacles in Construction Phases for Regional Development Programs RDPs**. *Asian Journal of Civil Engineering* 2023; **24**(8):3425–3436.

[15] Sirhan FM, Abdelrahman Sh K, Zaki RI K. **Statistical Evaluation of the Affective Factors on the Process of Preparing Time Schedules for Iraqi Construction Projects**. *Journal of Engineering and Sustainable Development* 2013; **17**(1): 33-61.

[16] Benjamin B, et al. **Evaluation of Student Learning: Accumulative and Formative**. (1st ed.), Cairo: Egypt; 1993.

[17] Abellana DP. **A Proposed Hybrid Root Cause Analysis Technique for Quality Management**. *International Journal of Quality & Reliability Management* 2021; **38**(3): 704–721.

[18] Ghauri P, Grønhaug K, Strange R. **Research Methods in Business Studies**. (1st ed.), United Kingdom: Cambridge University Press; 2020.

[19] Soldani J, Brogi A. **Anomaly Detection and Failure Root Cause Analysis in (Micro) Service-Based Cloud: Applications a Survey** *ACM Computing Surveys (CSUR)* 2022; **55**(3): 1–39.

[20] Anvari S, Mahian O, Solomon E, Wongwises S, Desideri U. **Multi-Objective Optimization of a Proposed Multi-Generation Cycle Based on Pareto Diagrams: Performance Improvement, Cost Reduction, and CO2 Emissions.** *Sustain Energy Technol Assessments* 2021; **45**: 101197.

[21] Grenzfurtner W, Rudberg M, Mayrhofer R, Loike K, Gronalt M. **Performance Measurement and Management Practices of On-Site Activities in Industrialized Housebuilding**. *Construction Management and Economics* 2022; **40**(4): 239–253.

[22] Serrat O. **The Five Whys Technique. in: Knowl Solute Tools, Methods, Approaches to Drive Organ Perform**. Springer: Singapore; 2017.

[23] Gangidi P. **A Systematic Approach To Root Cause Analysis Using 5why's Technique**. *International Journal of Lean Six Sigma* 2018; **10**(1): 295–310.

[24] Benjamin SJ, Marathamuthu MS, Murugaiah U. **The Use of 5-Whys Technique to Eliminateoee's Speed Loss in a Manufacturing Firm**. *Journal of Quality in Maintenance Engineering* 2015; **21** (4): 419–435.