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QUALITY MANAGEMENT IN CONSTRUCTION PROCESSES – CASE STUDY

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Purpose: The purpose of this article is to analyze the possibilities for improving construction processes, aiming to identify problems and analyze them using simple quality management tools and methods.
Design/methodology/approach: The article examines the need for quality improvement in various construction processes through a literature review and interviews with participants in construction processes. Then, a process for searching improvements in processes is proposed, considering simple quality management methods (flowchart, Ishikawa diagram, FMEA analysis, 5WHY).
Findings: The results showed that construction processes are not perfect and contain aspects that require improvement. The proposed sequence of quality management methods provides an opportunity for a quick and easy analysis of the construction process, identifying the causes of errors during project implementation, which in turn allows for proposing solutions.
Practical implications: Construction companies can use the simple methods proposed in the article to streamline their operations, enabling them to build more efficiently, safely, and easily.
Originality/value: Many construction companies often do not consider process improvements and do not seek solutions that can yield significant effects without large efforts.
Keywords: Construction, quality management, construction processes.
Category of the paper: Case Study.

1. Introduction

Construction has accompanied humankind for thousands of years, originating with the earliest forms of shelter. Today, it constitutes one of the key sectors of the Polish economy, alongside industry and trade and repair services (Perzyna, 2025). Over the centuries, building technologies have significantly evolved, enabling the construction of larger, more durable, and safer structures. Although the use of prefabricated reinforced concrete and steel components has become increasingly common, traditional cast-in-place reinforced concrete and masonry techniques still dominate the industry. Steel and timber frame systems are also utilized, but typically for smaller-scale projects.

The construction process is characterized by a high degree of variability in terms of structure types, functions, materials used, and environmental conditions. Each project has its own budget, schedule, and implementation context. This diversity, combined with the fact that most work is performed on-site, contributes to the complexity of construction processes and increases the risk of errors (Kowalski, 2013).

Even though many construction technologies have been in use for decades or even centuries they still have limitations. While construction today is executed faster and under safer conditions than in the past, numerous aspects of the process still require improvement to reduce costs, enhance quality, and minimize environmental impact.

A significant issue in modern construction is the tendency to submit bids with minimal financial buffers, which encourages cost-cutting measures and accelerated schedules (Syahrizal, 2019). As a result, efforts to optimize processes are often deprioritized in favor of ensuring timely and profitable project completion. This short-sighted approach may overlook the fact that certain issues can be addressed at low cost, ultimately improving the financial performance of construction companies.

To be effective in construction environments, quality management methods must be simple, affordable, and quick to implement. While advanced analytical and statistical tools exist, not all construction managers are able to learn and apply them efficiently. Therefore, it is necessary to adopt practical methods that can be implemented across various projects without the involvement of specialists and with the help of commonly available software. This is particularly important for small and medium-sized construction enterprises, which often face constraints in human and financial resources.

For project managers and site engineers, such methods can support the improvement of overall project execution, profitability, scheduling, and worker safety. Periodic process evaluations conducted by different individuals can help identify new areas for enhancement, gradually bringing operations closer to optimal performance in line with the Kaizen philosophy (Vieira et al., 2022).

This article presents fundamental quality management methods in the context of their applicability to the improvement of construction processes. The analysis of selected tools formed the basis for proposing a methodology for identifying and eliminating problems within construction workflows. The proposed methodology was validated through a case study involving reinforced concrete works—one of the most widely used technologies in structural construction.

2. Quality management in construction

The concept of quality was first introduced in ancient Greece. Plato described it as a measurable and assessable attribute (Mackenzie, 1985), while Aristotle considered quality to be what makes a thing what it is (Bulska, 2018). Although many thinkers have addressed the notion of quality, it was only later that the concept of quality management emerged, focusing on how to achieve and maintain excellence in products, processes, or services.

In recent decades, several influential quality management philosophies have been developed, including KAIZEN (Vieira et al., 2022), Six Sigma (Linde, 2020), and TQM – Total Quality Management (Alawag et al., 2023). While they differ in principles, structure, and implementation tools, their shared goal is the continuous improvement of quality.

Quality management encompasses not only broad frameworks but also practical tools and methods for process improvement. These methods are applicable across various sectors – from manufacturing to services, both private and public – including healthcare (Ręba, 2021), education (Nasim, 2019), and industry (Azouza, 2023). However, in construction, the use of quality management tools is far less common due to the unique challenges of project-based work.

Modern civil engineers face increasing pressure to reduce both costs and completion times. Project management in construction must be comprehensive, covering everything from design and construction to quality control and real-time decision-making. This must all be achieved within the "iron triangle" of budget, time, and quality (Pollack, 2018).

The standard construction project lifecycle includes five stages: initiation, planning, execution, monitoring, and closure. However, this model should be extended to include a sixth stage: improvement. Rather than limiting quality management to post-completion reviews, it should be integrated throughout project execution, when real-time feedback is most valuable.

The quality of design, planning, and construction directly affects a structure's durability, safety, and long-term usability. Studies on the causes of building failures show that:

- about 40% result from design errors not caught in the design phase,
- 25-30% stem from construction execution errors,
- 15% are due to poor material quality,
- 9% are caused by operational misuse,
- the remaining are mostly due to incorrect material application (Kowalski, 2013).

Each of the aforementioned groups of errors and problems is influenced by numerous factors, and their cumulative effect determines the final quality of a construction project. One effective way to prevent such errors and their underlying causes is the implementation of quality management methods.

Quality management tools can generally be divided into two main categories: “traditional” and “new.” The first group often referred to as the “Seven Basic Tools” or the “Old Seven” includes:

- Process Flowchart – a graphical representation of the process flow (Anjard, 1998).
- Ishikawa (Fishbone) Diagram – a tool for visualizing cause-and-effect relationships (Botezatu et al., 2019).
- Pareto Chart – a bar chart identifying the most significant factors in a process (Alkiayat, 2021).
- Histogram – a visual representation of data frequency distribution across intervals (Li, 2019).
- Scatter Diagram – a plot showing correlation between two variables (Gogtay, 2017).
- Check Sheet – a structured form for collecting data about a specific process.
- Control Chart – a chart used to monitor process performance and detect variation within tolerance limits.

The “new” tools of quality management primarily rely on verbal and conceptual relationships, making them particularly useful in areas such as brainstorming, design, and opinion gathering. These tools include:

- Relations Diagram – illustrates interrelationships among multiple factors.
- Affinity Diagram – groups data or ideas into categories for clearer analysis.
- Arrow Diagram – displays the sequence and duration of project activities.
- Decision Tree – helps determine the most favorable solution for a given problem.
- Matrix Diagram – visualizes relationships between multiple variables or groups.
- Process Decision Program Chart (PDPC) – maps out steps in a decision-making process and possible outcomes (Tsironis, 2018).

In addition to these, two other notable methods are frequently used in quality management:

- 5WHY– a simple yet powerful technique involving repeatedly asking “Why?” (typically five times) to identify the root cause of a problem (Siwiec, Pacana, 2021).
- Failure Mode and Effects Analysis (FMEA) – a method that identifies potential failure modes within a process, their causes, and consequences. Each failure mode is assigned a numerical score based on predefined criteria (severity, occurrence, detection), and these values are multiplied to calculate a Risk Priority Number (RPN). The issue with the highest RPN is prioritized for corrective action, as it poses the greatest risk to the process (Koprivica et al., 2024).

3. Proposal of an original methodology for Quality Management in construction processes

Assuming that the proposed methodology should be simple and quick to implement—given the often limited human resources in construction companies—a four-stage process has been developed for introducing quality management into construction processes.

Stage 1: Identification and graphical representation of the process using a flowchart.

Stage 2: Problem identification and classification using the Ishikawa diagram.

Stage 3: Root cause and solution analysis using the FMEA method.

Stage 4: In-depth analysis of key issues using the 5WHY method along with proposed corrective actions.

The implementation of this quality management methodology should begin with a thorough understanding of the process: its sequence, complexity, interdependencies, working environment, the number of personnel involved and their responsibilities, tools used, and so on. For an engineer supervising a construction process, this step should be relatively straightforward. An essential task at this stage is to transform the acquired knowledge into a flowchart that reflects the sequence of activities, relationships between stages, and control points.

This process mapping provides the basis for the identification and classification of issues. At the second stage, the Ishikawa diagram (also known as the fishbone diagram) may be applied. This tool can be used not only to identify and categorize problems but also to trace and classify their root causes. In construction, such classification might include categories such as: personnel, tools and equipment, working conditions, construction materials, and management/design teams.

The issues identified in Stage 2 are then subjected to FMEA analysis in Stage 3, which helps determine their causes and possible solutions. For each identified problem, both the cause and the resulting effect should be evaluated using the following criteria:

- Severity of the effect (1 – negligible, 10 – extremely severe).
- Probability of occurrence (1 – unlikely, 10 – very likely).
- Detection difficulty (1 – easy to detect, 10 – very hard to detect).

The product of these three values results in a Risk Priority Number (RPN). FMEA analysis also helps highlight the most critical issues, which should then be further analyzed using the 5WHY method (Stage 4). This final stage involves repeatedly asking the question “why?” in order to trace problems back to their root cause. The answers obtained can usually be grouped into categories such as financial, managerial, social awareness, nature of the work, etc.

Focusing on key problems is particularly relevant in the context of limited financial, temporal and material resources. The study should conclude with a summary of the most significant issues along with proposed corrective actions. Implementing these improvements may lead to enhanced quality, greater efficiency, and improved working conditions. Repeating this type of analysis periodically is recommended to foster continuous improvement and move the process closer to optimal performance.

4. Case study

The proposed methodology was verified using a case study involving reinforced concrete works supervised by the author of this paper, who was employed as a construction engineer by the general contractor. Direct involvement in the process allowed for a detailed understanding of the workflow and identification of significant issues, which enabled a thorough examination and the identification of weak points in the analyzed process.

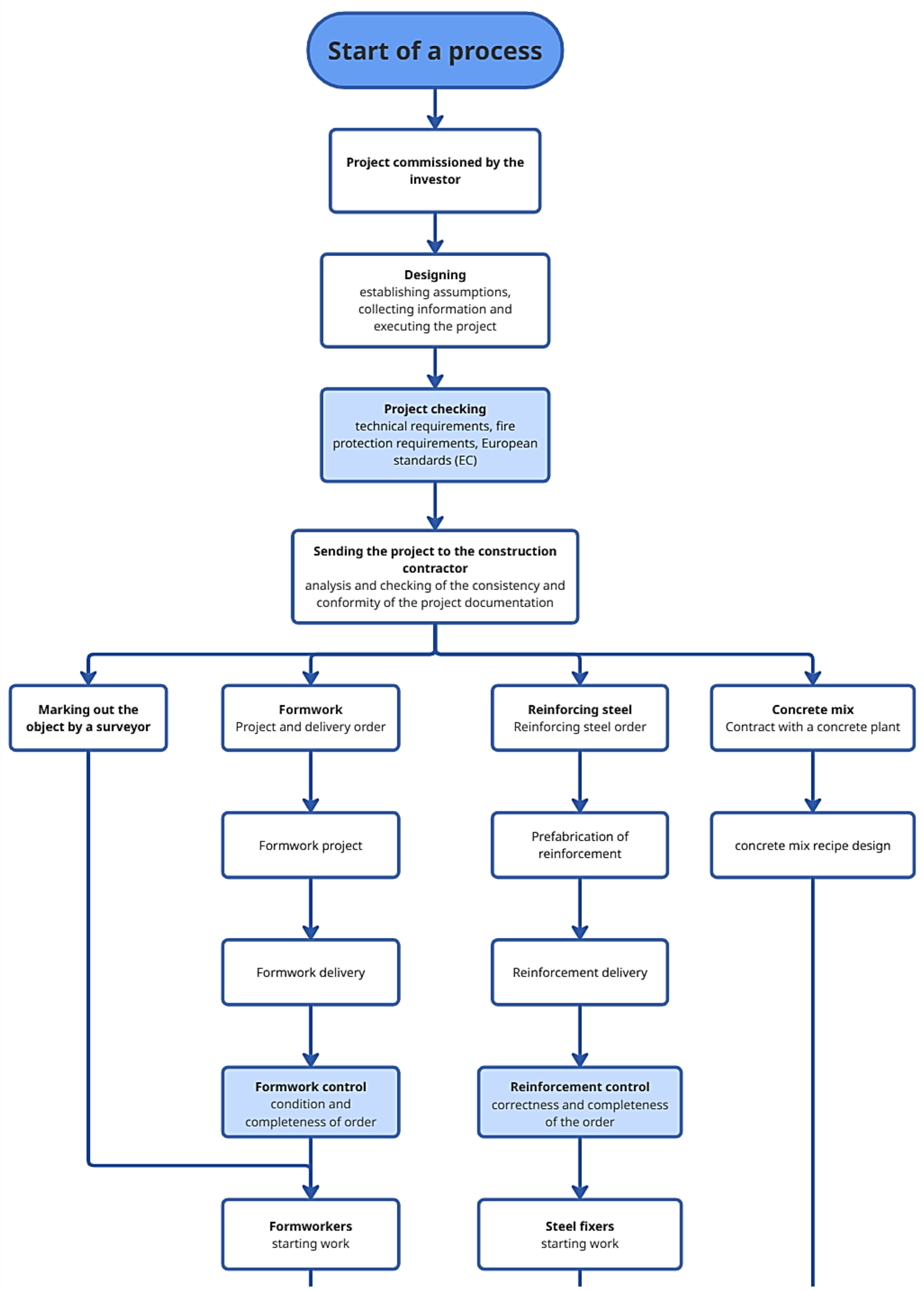
The subject of the study was a residential investment comprising five above-ground floors and two underground floors. The reinforced concrete works included, among others, diaphragm walls, columns, beams, slabs, external and internal walls. The methodology was applied to analyze a specific process — the construction of a reinforced concrete column or wall. The advantage of this approach is the focus on a detailed, narrowly defined area of operation rather than the entire activities of the construction company.

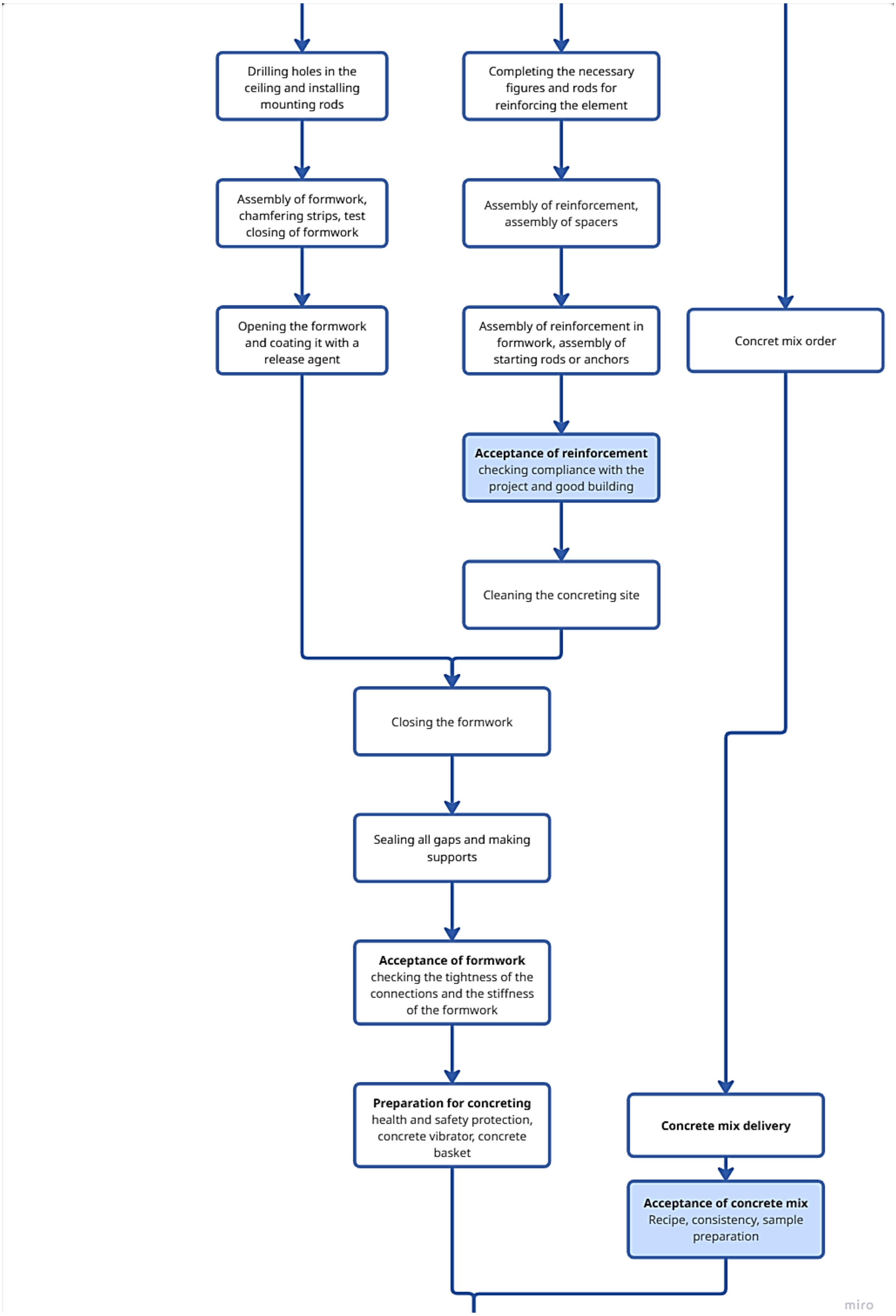
Stage 1. Identification and graphical presentation of the process using a flowchart

The process of constructing a reinforced concrete column begins with the design of the structural element by a designer with appropriate building qualifications. The design assumptions depend on factors such as the building's intended use, the investment's location, and the operational conditions. Key parameters affecting the quality of the structure include: the appropriately selected dimensions of the element, the correct amount of reinforcement, and the concrete class.

At the preparation stage, consultations with branch designers responsible for sanitary, electrical, and fire installations are also crucial to avoid potential design collisions. The next step in the process is ordering the reinforcement steel and concrete mix with parameters in line with the project requirements.

Correctly executed stages of design and planning form the foundation for the efficient and proper execution of the reinforced concrete element. The detailed process flowchart for constructing a reinforced concrete column is presented in Figure 1.


Start of a process
Project commissioned by the investor
Designing
establishing assumptions, collecting information and executing the project
Project checking
technical requirements, fire protection requirements, European standards (EC)
Sending the project to the construction contractor
analysis and checking of the consistency and conformity of the project documentation
Marking out the object by a surveyor
Formwork
Project and delivery order
Reinforcing steel
Reinforcing steel order
Concrete mix
Contract with a concrete plant
Formwork project
Prefabrication of reinforcement
concrete mix recipe design
Formwork delivery
Reinforcement delivery
Formwork control
condition and completeness of order
Reinforcement control
correctness and completeness of the order
Formworkers
starting work
Steel fixers
starting work



Drilling holes in the ceiling and installing mounting rods
Completing the necessary figures and rods for reinforcing the element
Assembly of formwork, chamfering strips, test closing of formwork
Assembly of reinforcement, assembly of spacers
Opening the formwork and coating it with a release agent
Assembly of reinforcement in formwork, assembly of starting rods or anchors
Concret mix order
Acceptance of reinforcement checking compliance with the project and good building
Cleaning the concreting site
Closing the formwork
Sealing all gaps and making supports
Acceptance of formwork checking the tightness of the connections and the stiffness of the formwork
Preparation for concreting health and safety protection, concrete vibrator, concrete basket
Concrete mix delivery
Acceptance of concrete mix Recipe, consistency, sample preparation
miro

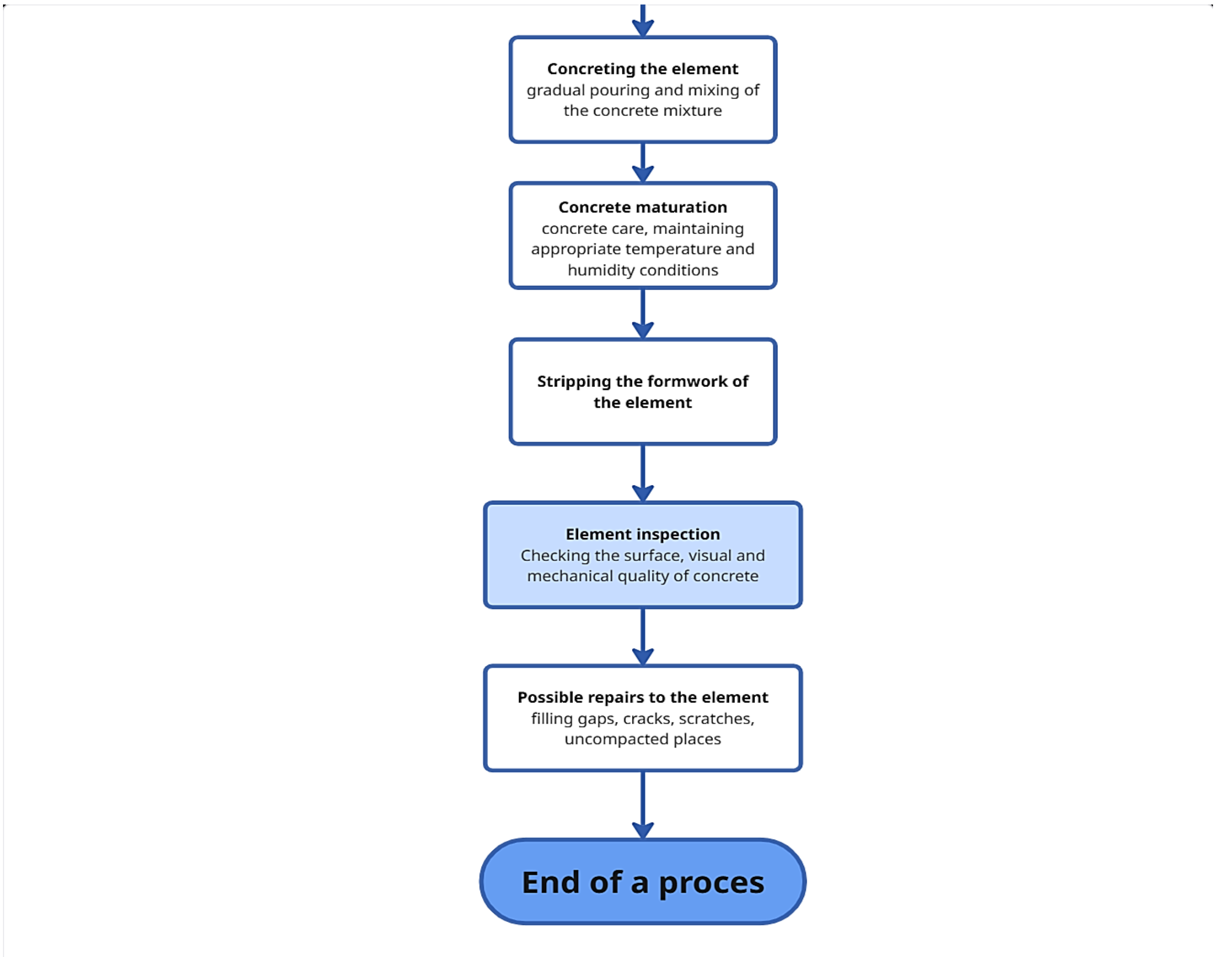


Figure 1. Flowchart of the reinforced concrete works process.

Source: author's own elaboration.

Stage 2. Identification and classification of problems using the Ishikawa Diagram

The Ishikawa diagram was used to classify the problems related to the analyzed process of reinforced concrete works (Figure 2).

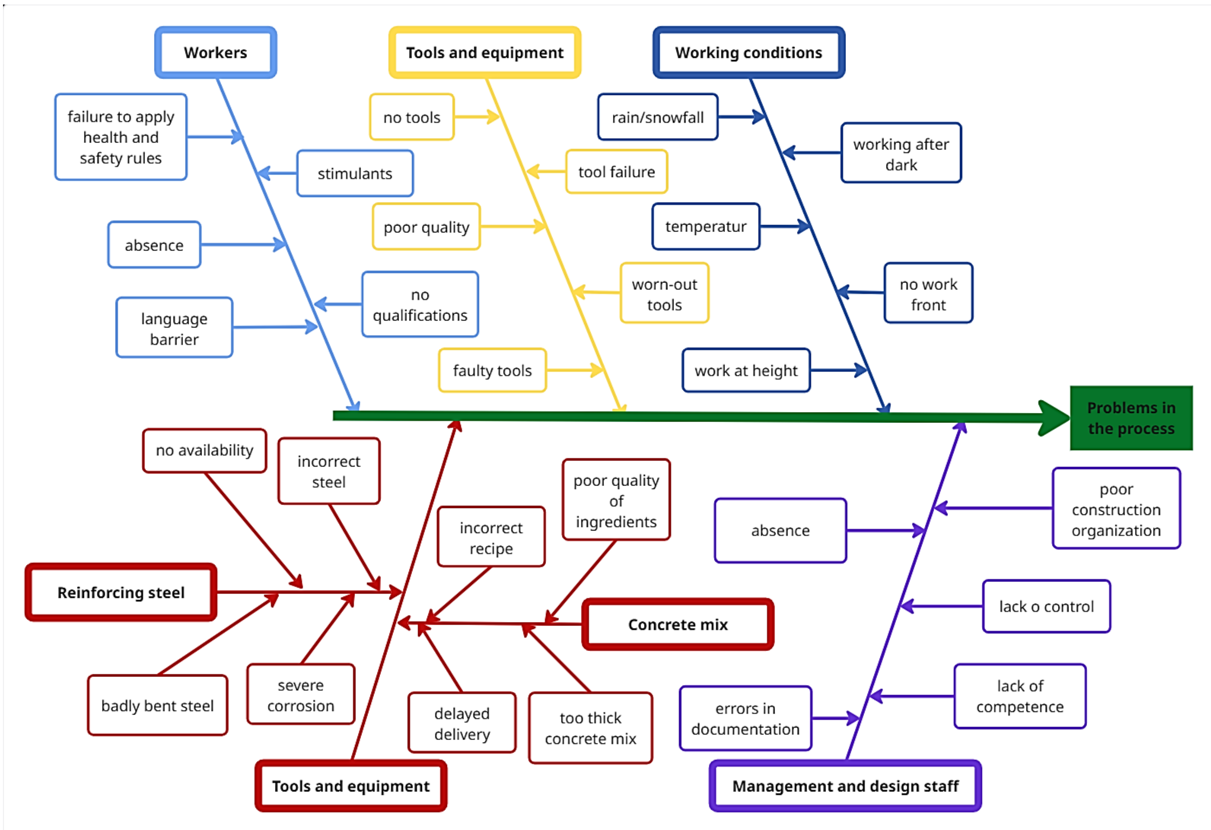


Figure 2. Ishikawa Diagram for the Reinforced Concrete Works Process.

Source: author's own elaboration.

The diagram briefly presents the issues within the analyzed process. Below, selected problems are described.

Workers:

- stimulants – alcohol problems among construction workers are common;
- failure to apply health and safety ruler – this stems from ignorance of the law, lack of awareness about the consequences of actions, or shortcuts in procedures;
- absence – companies often handle multiple construction sites at once, leading to a fluctuating number of workers on different days. additionally, construction firms increasingly face worker shortages in various positions;
- no qualifications – the current labor market issues cause a shortage of skilled workers;
- language barrier – construction sites often employ workers from various nationalities, including Belarus, Ukraine, Georgia, Turkey, and Kazakhstan.

Tools and Equipment:

- no tools – sometimes basic tools are missing due to the company's limited resources or the need to allocate tools across multiple sites,
- tool failure – working on a construction site requires durable equipment, which is subject to heavy use and thus prone to failure,
- poor quality – resulting from cost-cutting measures by company owners,

- worn-out tools – due to being used to the limit for cost-saving purposes,
- faulty tools– intense use leads to equipment wear and tear, resulting in many items becoming non-functional.

Working Conditions:

- rain/snowfall – reinforced concrete work is mainly performed outdoors, and precipitation often halts work,
- working after dark – large concrete pours in periods when the sun sets early require work to continue after dusk,
- temperature – excessive heat in the summer and extreme cold in the winter cause problems in maintaining proper conditions for concrete setting,
- no of work front – poor construction management or delays from other contractors sometimes cause stoppages, delaying subsequent stages of work,
- work at height – big element demand working at heights. a lot of work has to be done above safe height.

Materials:

- reinforcing Steel:
  - no availability – an increasingly common issue due to a shortage of raw material deliveries to steel mills,
  - incorrect steel – incorrectly selected steel grade or errors in ordering,
  - badly bent steel – errors made in the factories that fabricate reinforcement,
  - severe corrosion – poor storage of steel over time can lead to corrosion, making it unusable,
- concrete:
  - incorrect mix – errors at the concrete plant in selecting components and proportions for the concrete mix,
  - poor quality ingredients – Low-grade raw materials, which are often cheaper,
  - too thick concrete mix – results in difficulties with proper vibration and extends the concreting time,
  - delayed delivery – can lead to excessive waiting time for the workers and premature setting of concrete in the truck mixer.

Management and Design Team:

- poor construction organization – incorrect time allocations for specific stages, lack of space on the site, and poor communication between subcontractors,
- absence – construction managers often oversee multiple projects simultaneously and cannot be present at all times,
- lack of control – a heavy workload or excessive trust in staff results in insufficient monitoring of some stages,

- errors in documentation – complex projects often contain mistakes that only emerge during construction,
- lack of competence – sometimes, young engineers are assigned tasks without sufficient experience, and no guidance is provided on how to complete the tasks.

Stage 3. Analysis of causes and solutions for problems using the FMEA method

The application of the FMEA method was conducted in relation to the problems previously identified and described in Stage 2, concerning the "Management and designing staff" category. A crucial part of this stage is the proposed solutions for the identified issues, which are presented in the last column of Table 1.

Table 1.
FMEA Analysis for the "Workers" Category

Category	Problem	Effect	Cause	S	P	D	RPN	Proposed Solutions
Management and designing staff	Poor construction organization	Delays, lack of efficiency, etc.	Lack of experience	4	3	4	48	- Experienced management - Verifying knowledge during hiring - Training for management team
	Absence	Employee neglect, lack of control	Managing multiple construction sites at the same times	4	3	4	48	- Fair compensation for working on a single construction site - Requirement for the presence of management on-site during worker shifts
	Lack of Control	Construction errors	Lack of time for management, insufficient stuff	6	3	5	90	- Establish stages requiring inspection approval - Hire a construction supervision inspector - Adjust staff size in accordance with the size of the project
	Errors in documentation	Lack of consistency between disciplines	Incompetent designer, making changes without verification	7	6	6	252	- Use experienced design office - Implement BIM technology - Verify the design by different specialists before the work begins
	Lack of competence	Execution and design errors	Lack of proper education, lack of worker in the labor market	7	5	3	105	- Verify knowledge before hiring - Do not leave young employees alone - Provide support for inexperienced employees

After conducting the analysis, the RPN values were obtained, indicating the significance of each cause of problems within the process. The highest results from all categories are as follows:

- Errors in documentation – 252.
- Failure to apply safety regulations – 196.
- Incorrect concrete mix recipe – 180.
- Worn-out tools – 160.
- No work front – 144.

Stage 4. Analysis of key problems using the 5WHY method along with proposed solutions

The FMEA analysis, through a quantitative (point-based) evaluation of identified problems, makes it possible to identify key and most critical issues requiring urgent preventive or corrective actions. A complementary method is the 5WHY approach, which allows for an in-depth and reflective analysis of the causes of observed phenomena, problems, and their origins. Repeatedly asking the question "Why?" forces all participants in the process to reflect on the root causes. Only by reaching the root causes can one ensure that similar problems are avoided in the future.

An example of using the 5WHY method in relation to a specific problem — errors in documentation — is presented in Table 2.

Table 2.
5WHY analysis for the problem "errors in documentation"

Problem	1. Why?	2. Why?	3. Why?	4. Why?	5. Why?
Errors in documentation	Inaccurate review of the project before construction began	Lack of time for project verification	No checking designer was hired	No requirement	A building with a simple structure
				Failure to hire a reviewing designer	Cost savings
					Desire to release the project as quickly as possible
			Checking designer signed the documents without actually checking	Laziness	Old age
					Desire to earn easy money
				Trust in the design office	Connections among designers
					Relying on the reputation of the design office
		Lack of time for project verification	Work overload	Working on multiple projects at the same time	Desire for high profit
					High expectations from the company management
				Sudden need to introduce corrections to old projects	Previously poorly executed project
					Introducing changes in already completed projects
			Small number of experienced designers	Not hiring new employees	Lack of experienced designers
					Cost savings
				Training newly hired employees	Lack of experience
					Low level of education

Cont. table 2.

	Introducing changes to the project	Poorly thought-out initial solutions	Failure to consider all aspects	Limited experience	Rarely used solutions
					Low level of education
				Demanding project	Rarely used solutions
					Specialized facility, e.g., hospital, military facility
			Highly demanding building	Complicated building structure	Architect's creativity
					Investor's request
				Required advanced installations	Specialized facility, e.g., hospital, military facility
					Modern building
		Changes to the design and assumptions in the project	Looking for alternative solutions	Seeking cost savings	Desire for higher profit by the contractor
					Desire to save money by the investor
				Looking for alternative solutions	Greater efficiency and better adaptation to the investment
					Unavailability of originally planned solutions
			Change in functionality and purpose	Change of concept by the investor	Desire for higher profit by the investor
					Desire for faster project completion
				Changes proposed by the contractor	Poorly designed building
					Difficult-to-execute design

Source: author's own elaboration.

After analyzing the problem of errors in documentation, 31 potential causes of this issue were identified. Most of these causes can be grouped based on a common feature:

- green represents the connection to finances. In construction, money plays a crucial role, leading to a conflict between the investor, who wants to spend as little as possible, and the contractor, who aims to maximize profits. Frequent cost-cutting measures in a project lead to changes in the structure, material solutions, and other building aspects. Additionally, using cheaper design firms often results in either a lack of experience or a minimal amount of time dedicated to the project, which can result in an underdeveloped design,
- blue is associated with education and experience. Lack of experience is a common problem that can lead to a range of difficulties, from minor issues to even construction disasters. Young, inexperienced workers need to be constantly monitored by more experienced individuals, which allows them to develop and improve their skills,
- orange is linked to the complexity of the project and situations where the likelihood of making errors is high due to the type of building and its characteristics. Specialized structures, such as sewage treatment plants, hospitals, or other buildings with non-standard solutions, are not built frequently. Consequently, design firms often have limited experience, significantly increasing the risk of problems.

After conducting an FMEA analysis for each category using the Ishikawa diagram, several critical issues were identified. Subsequently, the 5WHY method was employed to gain a deeper understanding of these problems and break them down into their root causes. The gathered information should be sufficient to identify solutions.

For the most serious issue, namely errors in documentation, the ideal solution would be the implementation of BIM technology in both design and construction processes. This technology involves creating 3D models that contain more easily accessible information. Specialized software enables checking for clashes between installations and the structure. Specific elements can be assigned details such as reinforcement cover thickness or mix composition, which significantly reduces the risk of errors during the construction phase.

5. Conclusion

This article proposes a quality management methodology that can be applied during various stages of design and construction processes. The suggested solution is quick and can be effectively handled by anyone performing tasks or supervising the respective process. The presented case study confirms that the sequence of applying quality management methods is efficient and allows for an in-depth analysis of the scope of work. The obtained information is sufficient to propose solutions to problems that can significantly impact efficiency, project costs, and workplace safety.

The versatility of the proposed methodology is demonstrated by its applicability to various construction processes. The proposed methodology could be subjected to further research in the form of case studies in other areas of construction. Additional analysis of the impact of its implementation on quality indicators such as execution time, costs, and the number of accidents would help confirm its actual influence on construction processes. If these studies were able to determine the savings generated by the changes, along with the implementation costs of the methodology, it would be possible to assess the financial viability of introducing these quality management methods.

The proposed solution is intended for small and medium-sized enterprises, where the number of personnel is limited and quality management specialists are rarely employed. As a result, quality management responsibilities often fall to civil engineers. The methodology could be implemented through its inclusion in training programs or by developing industry guidelines and best practices for management personnel. Collected data and outcomes from various construction sites and companies could be compiled into a shared knowledge base. The exchange of information and experiences would contribute to the overall development of the construction sector.

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