



Paper Type: Original Article

Identifying and Ranking Factors Affecting the Quality of Construction Projects Using the Fuzzy Delphi and Fuzzy ANP Approaches (Case Study of Construction Projects in Tonekabon City)

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Citation:

Received: 19 July 2024
Revised: 21 October 2024
Accepted: 25 January 2025

Zare, H. (2025). Identifying and ranking factors affecting the quality of construction projects using the Fuzzy Delphi and Fuzzy ANP approaches (A case study of construction projects in Tonekabon city). *International Journal of Research on Civil Engineering with Artificial Intelligence*, 2(1), 32-37.

Abstract

This research aims to identify and rank the factors influencing the quality of construction projects. The present study is based on a mixed-methods research design; a combination of qualitative and quantitative methods was used. From the perspective of purpose, it is applied research because the results of the present study are used to improve the quality of construction projects. In terms of data collection method, the present study is a descriptive survey research, and in terms of data analysis method, it was classified as quantitative research. The statistical population of the present study comprised all experts and activists in the field of construction in Tonekabon city, from which 10 individuals were selected using convenience sampling. Data analysis was performed using the Fuzzy Delphi method and Fuzzy AHP. The results of the Fuzzy Delphi analysis showed that 10 criteria including the employer's justification in terms of project quality, the employer's justification in terms of project time, the project manager's activity, the quality of project planning, the constructability of the designs, and supervision of the project's workshop activities, selecting and monitoring contractors, communication and cooperation between implementation agents, proper financial management, and selecting the best contractor are the most influential factors in improving the quality of construction projects in Tonekabon county. The ranking and importance of each criterion were determined using the Fuzzy AHP method. The results showed that the employer's justification in terms of project time, with a weight of (0.122), was in first place, the project manager's activity and the ability to build designs, with a weight of (0.108), in second place, and the quality of project planning, with a weight of (0.108), in third place. Communication and cooperation between implementation factors were ranked fourth with a weight of (0.100), sound financial management with a weight of (0.099) in fifth place, supervision of project workshop activities with a weight of (0.095) in sixth place, selection and supervision of contractors with a weight of (0.095) in seventh place, justification of the employer in terms of project quality with a weight of (0.0818) in eighth place, and selection of the best contractor with a weight of (0.809).

Keywords: Project quality, Multi-criteria decision making, Construction.

1 | Introduction

In today's world, given the many developments in construction projects, especially in the field of construction, along with the use of new and up-to-date technologies, tight global competition, and attention to service quality, the need for a more robust system is felt to be able to deliver the product or service provided in a

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doi: <https://doi.org/10.48314/ijrceai.v2i1.34>



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short time, at the lowest cost, and with high quality. Therefore, it can be claimed that Total Quality Management (TQM) plays an important role and its application in construction projects is absolutely essential [1].

The main goal of TQM is to lower total costs and increase the quality and speed of product and service delivery. Leadership, customer satisfaction, Employee participation, continuous improvement of the investor participation process, and performance measures are among the primary concepts of TQM in construction projects [2].

TQM, which is the same as comprehensive quality management, is an intelligent, calm, and continuous practice that has a powerful impact on achieving the organization's goals and ultimately brings satisfaction to the employer as the beneficiary, increased efficiency, and increased competitiveness in project investment [3].

Quality management can encompass all parts and sub-parts of a project. In this approach, top management organizes the strategy and operations to meet the client's needs and fosters close cooperation among the project team [4]. TQM is a management approach that originated in the 1950s but has gained popularity since the 1980s.

TQM is a method by which management and employees are involved in the continuous improvement of the production of goods and services in a project. The quality movement began in almost all countries with quality improvement projects in manufacturing areas. Over time, it was used in service sectors such as banking and insurance, and even in non-profit organizations, including educational and health institutions, as well as development and infrastructure projects [5].

After World War II, industrial and service managers in various countries were forced to close their production and service units due to a lack of information, insufficient attention to quality, and failure to properly utilize components in the operational process. At a time when Western countries were suffering from unemployment and economic recession, Japanese companies took a major step towards increasing production and creativity, and gaining more market share, by applying the ideas of quality theorists such as Deming, Juran, Feigenbaum, and Ishikawa [6].

In addition, Japanese manufacturing and service institutions, by paying proper attention to organizational culture, using industrial, commercial, and service systems, and paying proper attention to factors such as behavior management, creating appropriate motivation, and providing a comprehensive flow of information among various organizational levels, strive to solve unit problems and meet the changing demands of users of the product have been met by continuously improving quality and reducing operating costs, and along with that, reducing the return on investment period has been made the most important goal of their organization [7].

In fact, TQM is a management philosophy that believes that the two things, common needs and company goals, are inseparable [8].

It is used in business, industry, and services to ensure maximum efficiency and effectiveness and to reinforce business leadership by applying governance to processes and systems. It also leads to increased efficiency and error prevention and assures the organization that all its goals are aimed at meeting employers' needs [9].

Construction projects constitute a large part of a country's basic infrastructure, which has led to their attracting special attention, so that they can achieve the highest quality at the least cost and in the least time. Undoubtedly, quality, time, and cost are three key factors in construction projects that are realized with strong management. In recent years, governments have paid greater attention to providing high-quality public services. To gain public trust and increase social capital, governments tend to provide services that satisfy the public and increase citizens' participation in social activities.

Based on an exploratory study of the dimensions of TQM in the public sector, experts in quality management have compiled and published numerous articles. In addition, various opinions have been expressed regarding the problems and bottlenecks in the way of quality management in the public projects sector, which, due to

different perspectives, make it difficult to define the monopoly operator and allocate budgets for establishing quality management in government projects. Therefore, in addition to defining and explaining the subject, this research addresses the proper and principled implementation of TQM and presents a set of measures implemented by the Urmia Municipality's Infrastructure and Urban Transportation Affairs Department.

2| Project Definition

In different languages and across different organizations in each country, there are lexical, semantic, and legal differences in the terms 'plan,' 'plan,' or 'project.' Therefore, they lack a clear, obvious framework and are sometimes used interchangeably. The goals and objectives set by the government at the long-term or strategic planning level are called programs, which have a series of qualitative objectives, such as the chemical industry development program and the national road network development program. Achieving these goals and ideals is possible over a long-term period, generally between ten and twenty-five years.

After determining the plans at the long-term planning level, each plan at the medium-term or tactical planning level, with the consultation of the first-level management or the country's executive system, is separated into a set of executive plans or programs, which are the same cross-sectional or executive decisions that must be implemented and achieved within the next five to ten years.

Each plan at the short-term or executive planning level, by the headquarters units or the middle management levels of the country's executive system, can be divided into a set of tasks and operations called a project. A project consists of a series of activities that are carried out to achieve specific goals.

Projects include a set of activities that must be completed within specified dates, costs, and quality; the success of each project depends on achieving all three factors of time, cost, and quality, and any deviation from any of the three factors mentioned above is considered a failure. It can lead to project failure and economic problems. The PRINCE standard provides two definitions of projects: the first emphasizes project objectives, and the second emphasizes project characteristics. In terms of objectives, this standard defines a project as a management environment created to deliver one or more business products in accordance with a specific business situation. And elsewhere, given the project's characteristics, it is considered a temporary organization that must deliver a unique, predetermined result within a predetermined time and with specific resources. The PMBOK standard defines a project as a temporary endeavor undertaken to produce a specific product, service, or result. According to the ICB standard, a project is a performance constrained by time and cost to achieve defined deliverables of significant scope, all of which take into account the constraints of time, cost (resources), and temporality, along with the production of a specific and unique product.

3| Project Management Application

Rapid progress and changes in industry and commerce have rendered classical methods outdated and unable to meet today's needs. In this process, several new management methods have been invented that can constantly update themselves. One of these methods is the Participatory Management and Employee Engagement (PMEI) method.

The participatory management approach is a combination of techniques and skills that prepares employees at all levels for review, creating opportunities for active participation in key management processes that relate to and impact work-related issues. Employee Involvement (EI) is a process by which employees at all levels actively participate in key management processes related to their work.

These groups are often called quality circles and have very interconnected responsibilities, meaning they must participate in almost all operational aspects, such as goal setting, the first step in project management, planning, organization (division of tasks), and decision-making. The overall goal of PEEI, or quality circles, is to create a management method that encourages all employees at a complex, at all levels, to cooperate and coordinate to achieve their common goals.

The necessity of applying comprehensive quality management in construction projects. Some managers' understanding of the approach to reducing project implementation costs is that using TQM in construction projects inherently entails high direct and indirect costs, and, accordingly, without observing the macro-project implementation, they mistakenly conclude that using it will increase costs.

The answer to this line of thinking is that, due to numerous requirements, we are forced to use TQM. In fact, failure to use a comprehensive quality management system will result in the employer's role in projects and the expansion of the employer's organization being left behind. In the first case, there is a failure in project implementation, resulting in the waste of all allocated resources.

In this case, the entire allocated credit is destroyed for limited savings. In the second case, due to the lack of use of a comprehensive quality management system, the relevant employer organization must be formed, which is costly and, in addition, is not suitable for the country's major plans for the growth and expansion of the private sector. TQM is a management philosophy that considers the company's common needs and goals inseparable. It is used in trade, industry, and services, ensuring maximum efficiency and effectiveness.

It strengthens business leadership by applying governance to processes and systems, increasing efficiency and preventing errors, and ensuring that all goals are aligned with the employer's needs. The TQM System provides a solution and framework for project improvement with two approaches. The first dimension is the time dimension, which develops a path based on the sequence of activities required for the project. The path generally has five initial stages in the project management framework: 1) planning, 2) execution, 3) monitoring, 4) control, and 5) the final stage of the project. The order and sequence of these paths in this method is useful for starting, but for the principled use of a TQM system on the path to project management knowledge, the second approach is more complete and practical. The second approach, by using a project management system, divides project management areas into 10 knowledge areas: project integrity management, project scope management, project time management, cost management, project quality management, It divides project human resource management, project communication management, project risk management, procurement management, and stakeholder management into 47 processes and applies the knowledge and techniques of this section based on the requirements and needs of the project.

Some of the mentioned necessities in using a comprehensive quality management system include improving the quality of the project management system and therefore preventing the horizontal expansion of the employer's organizations, the need for coordination between authorities, and distributed responsibilities among the factors involved in the project and the organization, and in larger dimensions, the three principals involved in project implementation. The necessity to resolve and eliminate delays caused by organizational problems in project implementation.

The complexity of projects and the employers' lack of familiarity with the subject matter of all projects within that organization. The necessity of risk management of defined projects in connection with making changes. The necessity of applying a structured approach.

To coordinate a set of projects to achieve strategic goals, there is a need to use project management technical knowledge in prioritizing projects, The existence of technical knowledge related to the implementation of numerous projects, the existence of specialized management knowledge in construction projects related to the supervision and control of projects, the necessity of applying scientific and technical principles and foundations to improve technology and achieve more desirable quality, the necessity of strengthening the capabilities of companies, research institutions, and the scientific use of the private sector in the preparation and implementation of projects, The need to optimally utilize existing resources and capacities and create the basis for creating new required capacities. The need to create a suitable basis and strengthen it to foster the emergence of initiatives and creativity, especially to attract new domestic and foreign resources. The need to increase the quality and reduce the cost and time of project implementation. The need to document the method of collecting, extracting, creating, and disseminating project knowledge.

Problems beyond implementing quality management in construction projects

Problems in establishing quality management can be divided into the following categories:

- I. Managers' lack of familiarity with the concept of TQM and its elements
- II. Financial issues and problems in construction projects
- III. Lack of a proper system for selecting designers and contractors in construction projects
- IV. Professionalism in construction projects and old design and implementation systems
- V. Lack of a healthy competitive environment
- VI. Dispute between the contracting and consulting agencies
- VII. Issues related to delays in construction projects, with a focus on project factors
- VIII. Laying the groundwork for implementing comprehensive quality management in construction projects

Since implementing TQM has many benefits, it is necessary to provide the necessary grounds for implementing this management system in construction projects. Considering the problems raised in implementing this system, the necessary grounds should be created, considering the following issues:

- I. Familiarity and awareness of managers in the construction field with quality control concepts, and with TQM concepts such as employee training and motivation, teamwork, communication, and quality standards such as ISO, through seminars, training courses, and booklets.
- II. Promoting a culture of continuous improvement in development matters among managers of various companies.
- III. Proper feasibility assessment of development projects with a focus on material issues and economic justification.
- IV. Establishing an appropriate system for selecting contractors and consultants in construction projects and requiring construction companies to meet quality standards for presenting construction projects.
- V. Creating a healthy competitive environment.

Factors affecting construction quality based on quality cost modeling

Construction quality is one of the main criteria for evaluating the performance of construction projects, and its impact on the project's exploitation period further underscores its special position. In addition, the desired quality of execution is an important factor in reducing the costs and execution time of construction projects. Studies have shown that quality management in construction projects can reduce additional costs associated with quality deficiencies.

Therefore, as a first step, it is necessary to identify the factors that affect construction quality. This study aims to identify and structure the factors that affect the quality of construction of buildings. In this study, a tool for collecting information and expert opinions was used to identify these factors and to structure the factors of the failure assessment prevention model.

The failure assessment prevention model is considered the basic model for costing quality in projects and indicates that, to achieve the desired quality and reduce the costs of failure and rework, it is necessary to bear the costs of prevention and assessment. A very important point in this model is finding the optimal point for quality costs. As a result of this research, the factors affecting construction quality in Iran were identified and structured.

4 | Conclusion

This study was conducted to identify effective factors for improving the quality of construction projects. The statistical population of the present study consists of all experts in the construction industry, from whom 10 people were selected and responded to the questionnaires. The data collection tool in the present study was a fuzzy Delphi questionnaire, the criteria for which were derived from a review of past sources. In this stage,

18 criteria were selected, including knowledge, human resources, meritocracy in human resources, Understanding and justifying the employer regarding safety quality and accidents, justifying the employer in terms of project quality, justifying the employer in terms of project time, having the constructability of designs, monitoring project workshop activities, determining realistic requirements, Management and management commitments, selection and supervision of contractors, communication and cooperation between implementation factors, proper financial management, selection of the best contractor, and clarity of the project scope were extracted. Using the Fuzzy Delphi method, 5 less important criteria were eliminated, and in the final questionnaire, 10 criteria were identified, which were ranked using the fuzzy Analytical Network Process (ANP) method.

In the Fuzzy ANP analysis, each of the 10 criteria identified in the previous stage was presented to 10 experts, who assigned a score to each. The results of ranking each of the identified factors showed that the order of importance of the criteria is: 1) the employer's justification in terms of project time, 2) the project manager's activity and the ability to build designs, 3) the quality of project planning, 4) communication and cooperation between implementation factors, 5) proper financial management, 6) supervision of project workshop activities, 7) selection and supervision of contractors, 8) the employer's justification in terms of project quality, 9) selection of the best contractor.

Given the importance and key role of construction projects as one of the major industries in our country, the need to improve their quality is particularly urgent. Therefore, quality management is an issue that requires greater attention in construction projects. What is more important than ever in construction projects is paying attention to the employer's expectations and ensuring user satisfaction. The benefits of the present study can help managers in government organizations improve the application of TQM components and guide future planning to achieve greater user satisfaction with the services provided by the government.

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