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RESEARCH ARTICLE

Root-cause analysis of building inspection firm-based problems encountered in Turkish building audit practices

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Abstract

The safety, durability, and sustainability of buildings in Türkiye depend heavily on an effective building audit system. However, shortcomings in the enforcement of Law No. 4708 undermine structural safety and increase risks to life and property. This study takes a systematic, evidence-based approach to identify major problems in building inspection firms, analyze their root causes, and propose practical solutions. Using expert interviews, Root Cause Analysis (Ishikawa diagrams), and Pareto analysis, the research identifies key issues such as insufficient qualified personnel, cost-driven processes, and policy gaps. The novelty of this study lies in its focused examination of building inspection firms as a distinct stakeholder group and its application of structured problem-solving tools to building audit practices in Türkiye, enabling both a rigorous diagnosis of problems. The association of RCA and Pareto analysis enables targeted, evidence-based strategies to improve inspection quality and prevent the recurrence of deficiencies. Recommendations include strengthening transparency and independence in inspections, raising quality standards, improving training for inspectors, and revising fee structures. The findings offer actionable strategies for Türkiye and transferable insights for countries facing similar regulatory challenges, contributing to both theory and practice in construction quality assurance.

1. Introduction

In a country like Türkiye, located on an active seismic belt, ensuring earthquake-resistant buildings and preserving their structural integrity is of critical importance. Post-earthquake investigations reveal that destruction is often caused not by the earthquakes themselves but by design flaws and inadequate inspection practices by building inspection companies [1]. The main issue in sustaining a safe and resilient building stock is the construction of buildings without proper oversight and in violation of standards. The devastating effects of earthquakes largely stem from stakeholders' (architects, engineers, workers, etc.) failure to comply with established rules [2]. Thus, minimizing earthquake impacts requires strict regulatory adherence by all parties. In this context, an effective building audit process is essential. Major cities such as Istanbul are implementing urban transformation projects to replace substandard housing, prevent unplanned sprawl, and strengthen building resilience. However, much of Türkiye's housing stock was built without compliance with zoning and building

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regulations. Despite legal reforms, poor urban planning and low construction quality persist, heightening disaster risks [3]. Addressing these challenges requires strategically planned interventions.

The building audit system, launched in 2001 to ensure earthquake-resistant construction, faces significant implementation issues. As of now, the Ministry of Environment, Urbanization, and Climate Change has inspected 1,066,987 buildings, with inspections ongoing for another 480,000 [4]. Progress remains slow, and inspection capacity is insufficient, with 2,580 companies, 452 laboratories, 15,885 licensed inspectors, 21,665 assistants, and 1,264 laboratory engineers engaged [4]. Despite 154,682 audits of inspection firms, resulting in 85.5 million TRY in fines for misconduct and 3,165 temporary project bans, and 2,379 audits of 485 laboratories leading to 11.5 million TRY in fines [5], irregularities persist. Cases of incomplete documentation for high-risk buildings undermine the system's credibility. The current state of affairs indicates that many actors involved in the inspection process, such as building inspection companies, laboratories, and technical personnel, are not adequately fulfilling their responsibilities.

Effective building inspection in Türkiye is essential not only for ensuring structural safety and quality control but also for safeguarding public financial interests and providing legal protection for property owners and users by generating verifiable documentation for use in potential disputes. However, it appears that Law No. 4708 on Building Inspection is not being effectively enforced by inspection companies due to several practical and material limitations, such as insufficient inspection capacity, lack of financial and human resources, issues related to organizational independence, gaps in training and expertise, and avoidance of legal and financial responsibilities. As a result, the building inspection process fails to deliver its intended outcomes, contributing to the construction of substandard housing and endangering overall building safety.

Based on this theoretical background, the present study aims to address the research question of "What are the underlying causes of problems stemming from building inspection companies in Türkiye's building audit practices?" The study seeks to identify these root causes and develop practical recommendations.

Accordingly, following the introduction, Section 2 presents the building audit systems and practices in Türkiye, as well as in countries with well-established systems focusing on their legal frameworks and key stakeholders, and make a comparative analysis of building audit systems. It then highlights existing studies on building audit practices in Türkiye. Section 3 outlines the research methodology, which includes identifying issues related to building inspection companies through a literature review, analyzing root causes using Ishikawa (Fishbone) diagrams, and applying Pareto analysis to determine which causes have the greatest impact on the identified problems. Section 4 is dedicated to presenting and discussing the findings derived from the collected data. Finally, Section 5 highlights the theoretical and practical implications of the study, outlines its limitations, and offers recommendations for future research.

This study makes several important contributions to the literature on building inspection systems and construction quality assurance, particularly in the context of Türkiye:

- By concentrating specifically on building inspection firms, the study provides a micro-level analysis of systemic problems that are often overlooked in broader evaluations of the construction audit process by employing a structured problem-solving framework that combines Root Cause Analysis (Ishikawa diagrams) and Pareto analysis.
- By combining academic problem-solving tools with empirical data from expert interviews, the research offers Practical solutions, recommendations and strategies to address current deficiencies that are both theoretically grounded and practically implementable.
- While focused on Türkiye, the findings offer relevant strategies and frameworks that can be

adapted by other countries facing similar regulatory and operational challenges in construction oversight.

2. Overview of Building Audit System and Practices

The following sections are organized into four sub-sections, respectively focusing on: the building audit process in Türkiye, building audit systems in countries with well-established frameworks, a comparative analysis between Türkiye and these international systems, and a review of existing studies on the building audit process in Türkiye.

2.1. Building audit process in Türkiye: Legal infrastructure and actors

Building audit is a regulatory process carried out independently from the relevant authorities and contractors, aiming to ensure safe, healthy, and economic construction by supervising structures during their design and construction phases. This process ensures that buildings comply with zoning plans, technical, and health standards, as well as relevant norms and regulations. The primary objective is to guarantee that buildings are constructed correctly and with high quality, in accordance with current building regulations. According to Law No. 4708, titled "Law on Building Inspection", building inspection includes verifying whether structures are built in compliance with the zoning plan and applicable technical, and health rules. In Türkiye, along with the Law No. 4708 on Building Inspection, the legal and regulatory framework governing building audit practices is shaped by a set of legislations and regulations including: Law No. 3194 on Zoning, Law No. 6306 on the Transformation of Areas Under Disaster Risk, Law No. 5272 on Municipalities, Regulation on the Implementation Principles of Building Inspection, Regulation on Buildings in Disaster-Prone Areas, Architectural Design Principles, Regulation on Planned Areas Zoning, Türkiye Building Earthquake Code, Regulation on Thermal Insulation in Buildings, Regulation on Energy Performance in Buildings, Elevator Regulation, Fire Protection Regulation.

The building inspection process in Türkiye can be summarized as follows [2, 6, 7, 8]: The building audit process in Türkiye begins when the building owner submits the project to the municipality for approval. Once approved, construction details are entered into the National Building Audit System, after which the Ministry issues a "Building Information Form" and assigns an inspection firm through the system. A supervision contract is signed between the building owner and the assigned firm, outlining the scope of services. Certified inspectors (architects, engineers, and technical staff approved by the Ministry) are appointed to oversee compliance. Project documents, including technical drawings and the inspection agreement, are submitted to the municipality's zoning department; a construction permit is issued if all regulations are met. After the permit, construction begins, accompanied by regular inspections to verify project compliance, material quality, structural calculations, and workmanship. Material tests are conducted by Ministry-authorized laboratories, with results reported to the owner. Upon completion, the inspection firm conducts a final review and issues a "Completion Report." Firms are legally liable for five years for damages resulting from noncompliance. A temporary occupancy permit is then granted by the municipality. Post-occupancy, building owners and local authorities remain responsible for maintenance and periodic safety checks to ensure continued structural integrity.

The responsibilities of each of the main actor involved in the building audit process in Türkiye are summarized below:

- Building Inspection Firm: Authorized by the Ministry under Law No. 4708 and Regulation No. 26778, these public or private bodies inspect buildings during design, construction, and usage to ensure compliance with safety, durability, and quality standards. Duties include verifying and approving project documents, ensuring work follows permits, conducting material compliance tests via authorized labs, monitoring occupational safety, reporting violations, and confirming project completion.

- Public Authorities: Municipalities and governorships issue building permits and occupancy certificates, authorize inspection firms, oversee inspection processes, and enact regulations based on outcomes.
- Building Owners: Individuals or institutions commissioning construction must cooperate with inspection firms, provide required documentation, and implement corrective measures.
- Contractors and Site Supervisors: Contractors build in compliance with approved plans and regulations, while site supervisors ensure adherence on-site, maintain the inspection log, and follow inspector instructions. Both share liability for construction defects.
- Project Designers: Architects, engineers, and related professionals prepare feasibility studies, technical designs, and reports in line with regulations, submitting them to inspection firms for review.

2.2. Building audit process in countries with well-established systems

Each country's building audit system has unique features shaped by factors such as culture, history, geography, politics, and influences like EU regulations [9]. To gain insight into how Türkiye's building audit practices align with or diverge from countries with well-established systems, a comparison of systems should be provided. Türkiye's building audit system has a strong emphasis on seismic safety due to the country's high earthquake risk. While the legal framework provides clear responsibilities, challenges remain in oversight, transparency, and consistency, especially regarding quality control and post-construction inspections. When compared to countries with mature building audit systems (such as France, Germany, the UK, the USA, and Japan), Türkiye's approach shows areas for improvement. In the EU, which is highly developed in this field, the Consortium of European Building Control was established under the leadership of England to enhance inspection systems. Broadly, two main building inspection approaches exist in Europe: the insurance-based model adopted in France and the strict regulatory control model implemented in Germany. Most EU member states employ either one of these systems or a hybrid of the two [1].

Germany has a highly structured inspection system, with accredited independent inspectors engaged from design to completion. Germany, federal authorities set a model of building regulations and enforcement rules that is adapted by regional authorities [10, 11]. The system emphasizes technical compliance, energy efficiency, and fire safety, with inspections integrated into local authorities. Audit engineers in local administrations hold long-term responsibility for buildings (up to 30 years) [1, 9]. Strict controls on certain building types require inspections during construction and official approval before occupancy [12, 13]. By contrast, Türkiye relies mainly on private inspection firms under centralized oversight, creating enforcement gaps. France applies a code-based model where independent technical controllers assess compliance, closely tied to insurance mechanisms under the Administrative Mechanisms for Building Insurance (MARC). Insurance includes a ten-year compulsory policy for structural safety and a two-year optional policy for elements subject to wear [1, 9]. Construction can begin once a permit is issued, with no mandatory inspections during or after works; permits remain valid for three years, and completion certificates may be issued within two years after delivery [12, 13]. Türkiye lacks such integration between audits and insurance-backed accountability. In France, applicants often opt for private building control schemes with site inspections, incentivized by reduced premiums for the compulsory ten-year insurance. By contrast, in Germany, site inspections are conducted by surveyors appointed by local authorities, ensuring direct public oversight [10, 11]. In the UK, inspections and certificates are embedded within the building permit process, unlike in Germany where inspections may occur separately. Building control is conducted by local authorities or private approved inspectors under the Building Regulations 2010 [9, 12]. The enforcement of building regulations related to quality requirements is delegated to private entities. Public authorities define the overall criteria, while private actors are responsible for specifying and implementing the details [10, 11]. Following the Grenfell Tower tragedy, reforms have focused on fire safety, oversight of high-rise buildings, and the creation of a national regulator—measures not yet adopted in Türkiye. Japan is noted for advanced seismic audits and strict enforcement of codes by public and private agencies. Post-occupancy checks and technologies such as seismic sensors provide a level of monitoring beyond Türkiye's largely paper-based inspections. The US has a decentralized system, with procedures varying by state and municipality. Many jurisdictions adopt the International Building Code (IBC), with multi-stage and third-party inspections common. Digital tools, including mobile inspection apps and permit systems, are widely used internationally, whereas Türkiye is only beginning to adopt such practices [9]. A key feature is the central role of licensed Professional Engineers (PEs), who prepare and approve projects, providing trust and accountability [1].

From that point, it can be assumed that Türkiye's building audit system benefits from a clear legal mandate and focus on earthquake resilience, but compared to countries with well-established systems, it shows gaps in areas such as technological integration, fire safety audits, post-construction and lifecycle inspections, inspector independence and accountability and integration with insurance and risk-based systems.

2.3. Comparative analysis of building audit systems: Türkiye vs. global counterparts

Below a deepened comparative analysis of Türkiye's building audit system when benchmarked against international best practices is presented:

- Legal and Administrative Structures: Türkiye's building audit system operates under a centralized model where private inspection firms are appointed via the Ministry's digital assignment system. While this provides consistency in legal mandate, it can lead to bureaucratic inefficiencies and potential enforcement gaps. In contrast, countries like Germany implement a federal model in which building codes are established at the national level but adapted and enforced regionally, often through public authorities or independently accredited engineers. France, on the other hand, follows a code-based approach with technical controllers closely tied to mandatory insurance mechanisms. The UK and USA exhibit hybrid systems where both public authorities and approved private inspectors share responsibilities under national building codes. Japan maintains a highly centralized system with strict enforcement mechanisms executed by both public and private agencies. These variations illustrate that Türkiye's system, while legally well-defined, lacks the multi-level enforcement and regional flexibility that characterize more mature systems.
- Inspector Independence and Accountability: In Türkiye, although inspectors are formally approved by the Ministry, their firm-based employment and project assignments raise concerns about true operational independence. Additionally, the five-year liability period imposed on inspection firms is relatively short compared to Germany, where inspectors may bear responsibility for up to 30 years, and France, where a mandatory 10-year insurance policy covers structural safety. The USA relies on licensed Professional Engineers (PEs) who are individually accountable, providing an added layer of trust and autonomy. These models indicate that Türkiye's current structure does not sufficiently safeguard against potential conflicts of interest, nor does it ensure long-term accountability for building safety.
- Integration with Insurance and Risk-Based Approaches: Türkiye's inspection system is largely disconnected from any insurance-based risk management framework. In contrast, France employs a well-developed insurance model under the MARC system, where building inspections are inherently linked to insurance policies. This integration ensures financial accountability and incentivizes rigorous oversight. UK, Germany and Japan also embed risk assessments into the inspection process, particularly for high-risk

building types. These examples suggest that Türkiye could enhance the reliability and effectiveness of its inspection system by incorporating insurance-based or risk-sensitive oversight mechanisms.

• Technological Integration and Innovation: While the recent regulatory amendment mandates the use of BIM for large-scale public projects starting in 2027, current inspection practices remain largely manual, and document based. In contrast, countries like Japan and the USA have adopted advanced digital tools including mobile inspection apps, drone-based site monitoring, seismic sensors, and AI-powered compliance systems. Germany and the UK have institutionalized the use of BIM and digital permitting systems to streamline workflows and improve transparency. The lack of such innovations in Türkiye not only reduces the efficiency of inspections but also limits the real-time monitoring and quality control capabilities needed for modern construction oversight.

• Post-Construction Monitoring and Lifecycle Safety: Türkiye's inspection system does not systematically cover post-occupancy monitoring or lifecycle building audits. Once a temporary occupancy permit is granted, long-term safety largely depends on local authorities and building owners, often without structured oversight. By contrast, Germany assigns long-term oversight responsibilities to local audit engineers, and Japan employs seismic sensors and other technologies to ensure continuous monitoring of building performance. France's insurance model allows for post-construction claims, albeit without regular inspections. Following the Grenfell disaster, the UK has also moved toward implementing stricter post-occupancy audits for high-risk buildings. These international examples reveal that Türkiye's current post-construction practices leave a major oversight gap in terms of lifecycle safety and structural performance.

• Public Awareness and Stakeholder Engagement: Another significant difference lies in the level of public involvement and awareness. In Türkiye, the public often lacks sufficient understanding of the importance and function of building audits, which diminishes external pressure on firms and authorities to ensure quality. In contrast, Germany and France foster public involvement through transparent planning and regulatory processes. In the UK, public scrutiny and political mobilization after high-profile incidents have led to substantive policy changes. Public education campaigns, professional visibility, and citizen reporting systems are commonly used in countries with mature systems to improve transparency and stakeholder accountability. Raising public awareness and civic engagement in Türkiye would not only strengthen the social legitimacy of the audit system but also create additional pressure for reform and compliance.

2.4. Existing studies on building audit practices in Türkiye

When reviewing studies on building audit practices in Türkiye, it is observed that although there are works examining the development of the building audit system and the challenges encountered in its operation [14-17], these studies generally focus on a broad, system-level perspective. In contrast, a number of researchers have conducted more localized studies. For example, [3, 6, 18-27] conducted surveys in specific provinces -namely İstanbul, Sivas, Ankara, Afyonkarahisar, Adana, the Southeastern Anatolia Region, Muğla, Bolu, Van, Kırşehir, and Osmaniye- identifying the challenges in building audit practices. [28] examined the quality management perspectives of building inspection firms in Adana. [29] conducted fieldwork through interviews with building inspection firms in Konya, aiming to evaluate the quality of inspections and identify related problems. [30] investigated the relationships between building owners and inspection firms using data from 28 provinces, applying factor analysis to determine the ethical issues present in building audit practices. [31] analyzed public building audit practices in Karabük based on the perspectives of technical staff from the Provincial Special Administration. [32] evaluated the general nature of complaints regarding building inspection based on reports submitted to the Bursa Provincial

Directorate of Environment and Urbanization. [33] assessed the reasons behind the closure of building inspection firms in Şanlıurfa through survey data. [34] proposed a certification-based and performance-oriented integrated evaluation and inspection model, aiming to improve concrete structural components used in load-bearing systems. [35] applied multi-criteria decision-making methods such as AHP, ELECTRE, and SAW to the selection of building inspection firms in Isparta. [36] identified selection criteria for building inspection firms for a mass housing project in Sakarya and used a hybrid AHP-TOPSIS approach to determine the most appropriate inspection firm. [37] assessed the quality of ready-mixed concrete used in structures subject to building inspection in Isparta following the implementation of an electronic concrete monitoring system. [38] evaluated the occupational health and safety responsibilities of building inspection firms in Çorum by calculating the Elmeri safety index for construction sites under different supervision levels. [39] categorized the issues within Law No. 4708 on Building Inspection, while [40] identified the legal and regulatory challenges faced by building inspection firms in Düzce. [1] identified problems in Türkiye's building audit practices using a focus group method and then applied the fuzzy AHP technique to determine the significance levels of these issues. [2] examined the contractual liabilities of building inspection firms toward building owners for damage caused by earthquakes. [7] proposed a model for integrating the building audit system into BIM processes. [41] categorized the building inspection process into seven stages under Law No. 4708 and discussed how Industry 4.0 technologies could address specific issues in each stage. [42] conducted face-to-face interviews with employees from four different building inspection firms operating in Antalya and Burdur after the February 6, 2023 Kahramanmaraş earthquakes, to reveal both the strengths and the deficiencies of the current building audit system in Türkiye. [8] highlight deficiencies in Turkey's building inspection system, showing that stakeholder performance and insufficient legal sanctions undermine its effectiveness, and based on insights from the Yalova case, recommend strengthening penalties, improving stakeholder competence, standardizing procedures, enhancing communication, and adopting innovative technologies.

The review of existing studies on building audit practices in Türkiye reveals that the majority focus on evaluating the effectiveness of the building audit system from the perspective of various stakeholders involved in the process. These studies generally aim to identify problems within inspection procedures shaped by Law No. 4708 on Building Inspection. Most of the research relies on data collected through questionnaires using 1–5 Likert scales and presents participants' evaluations of the system's effectiveness in the form of percentage distribution charts, typically within province-based field studies. Studies employing multi-criteria decision-making techniques such as AHP, TOPSIS, and Fuzzy AHP primarily aim to assist in the selection of inspection firms or to rank the importance of problems identified in the building inspection process.

In contrast, the originality of the present study lies in its focused approach: it specifically examines building inspection firms as a single stakeholder group within the broader inspection process and goes beyond merely identifying problems by aiming to understand the root causes of these problems, an aspect largely overlooked in prior research. Identifying root causes in building inspection is a crucial indicator for assessing and ensuring the quality of inspection processes. Understanding the root causes of recurring problems allows for the identification of weak points in the system, highlights areas for improvement, and helps prevent the recurrence of similar issues. To enable a detailed and systematic analysis of these root causes, the study employs Ishikawa (Fishbone) Diagrams and Pareto Analysis, two established quality management tools. The use of these methods is a key methodological feature that distinguishes this study from others in literature. Effectively addressing any problem first requires accurately identifying the factors that cause it. Doing so enables the development of targeted strategies and actions for each factor, thereby preventing the issue or minimizing its impact. In this regard, the findings of this study are significant, as they not only identify critical weaknesses in current building audit practices but also provide a basis for proactive improvements that can enhance the overall effectiveness of the system.

3. Research Methodology

Within the scope of this study, first, a literature review was conducted to identify problems associated with building inspection firms. Then, Root Cause Analysis (RCA) was performed using Ishikawa (Fishbone) Diagrams. Subsequently, Pareto Analysis was used to determine which identified root causes had a greater impact on specific problems. Fig. 1 summarizes the stages carried out in line with the objective of the study and the methods used at each stage.

3.1. Literature review

Identifying the fundamental problems related to building inspection, developing solution proposals for these issues, and improving the processes are of great importance. Therefore, a comprehensive literature review was conducted to identify the problems encountered in Turkish building audit practices. As part of the literature review, keywords such as "building inspection/audit in Türkiye", "building inspection/audit problems", "building inspection/audit system", "building inspection firms" and "Building Inspection Law" were used with a time span of 2010 and 2024. As a result of examining 28 relevant studies, a total of 45 distinct problems encountered in Türkiye's building audit system. According to the literature review findings, 20 of these 45 problems (44%) were found to originate from building inspection firms. Therefore, the scope of the study was narrowed to focus specifically on problems related to building inspection firms. The frequency of each identified problem as observed in the literature is presented in Table 1, while all 45 problems determined across all stakeholders are provided in Appendix A. According to Table 1, the three most frequently observed problems in the literature regarding building inspection firms in Türkiye are: "Lack of knowledge, training, and experience among technical personnel", "Insufficient quality control due to understaffing", "Inadequate compensation for personnel" and "Prioritization of cost over inspection quality."

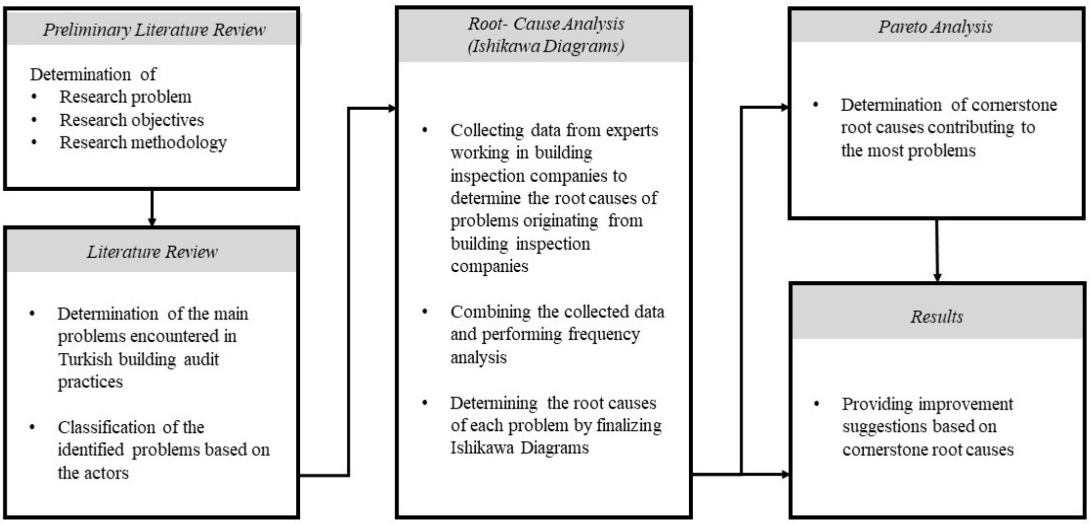

Fig. 1. Research methodology

Table 1. Building inspection firm-based problems in Türkiye

	References																												
Problems	[1]	[3]	[15]	[16]	[17]	[19]	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[6]	[28]	[29]	[30]	[31]	[32]	[33]	[34]	[36]	[38]	[39]	[40]	[7]	[42]	Frequency
P1: Excessive workload of inspection firms and hiring based on diplomas		✓					✓	✓					✓							✓	✓				✓	✓	✓	✓	10
P2: Insufficient wages given to personnel	✓	✓	✓			✓	✓			✓	✓	✓	✓	✓	✓				✓		✓	✓				✓	✓		16
P3: Inadequate review of projects by building inspection firms	✓	✓							✓			✓	✓	✓	✓		✓	✓		✓	✓	✓						✓	13
P4: Lack of applications to motivate employees						✓	✓																			✓			3
P5: Incomplete quality control due to insufficient personnel	✓	✓	✓		✓		✓	✓	✓			✓	✓	✓			✓		✓	✓	✓	✓		✓			✓		17
P6: Emphasis on cost rather than the quality of inspection		✓	✓		✓		✓	✓	✓	✓	✓					✓		✓		✓	✓	✓		✓		✓		✓	16
P7: Incorrect sampling of concrete specimens		✓		✓								✓	✓	✓	✓			✓			✓	✓	✓						10
P8: Unethical influence on test results		✓											✓		✓			✓											4
P9: Lack of quality control on construction materials		✓		✓						✓				✓		✓		✓		✓		✓							8
P10: Personnel working only for signature purposes		✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓						✓		✓		✓	✓	✓		15
P11: The inspector and the responsible officer being different people				✓				✓							✓		✓	✓		✓	✓	✓							8
P12: Lack of continuous inspection on-site	✓	✓			✓					✓	✓	✓	✓				✓	✓		✓	✓	✓		✓					13
P13: Quality control performed only on concrete and steel	✓		✓									✓			✓												✓		5
P14: Insufficient concepts of work discipline and ethics	✓	✓					✓		✓				✓		✓		✓		✓		✓	✓		✓					11
P15: Inspectors failing to find qualified solutions to problems encountered at the workplace			✓		✓		✓	✓											✓		✓								6

Table 1. Cont'd

P16: Building inspection firms providing services below the minimum service fee		✓	✓		✓	✓	✓	✓									✓					✓							8
P17: Missing signatures of parties in the building inspection service contract	✓			✓																						✓			3
P18: Distance between the building inspection firm's location and the site they are responsible for											✓		✓					✓					✓		✓				5
P19: Considering building inspection practice as a formality			✓	✓	✓		✓	✓					✓				✓	✓			✓								9
P20: Lack of knowledge, education, and technical personnel's experience		✓	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	22

3.2. Root Cause Analysis (RCA)

After identifying the problems originating from building inspection firms in Turkish building audit practices, Root Cause Analysis (RCA) was performed based on interviews with experts experienced in building inspection.

RCA is a problem-solving method frequently used in literature and industry practices to identify the primary causes of errors or problems, especially related to quality and efficiency [43]. In science and engineering, problems are addressed either through reactive management, which involves quickly responding by treating the effects after the problem occurs, or through proactive management, which involves preventing problems from occurring in the first place. RCA is used in proactive management to determine the fundamental causes of a problem rather than its effects, enabling preventive measures to be taken to avoid the problem [44]. Although RCA is one of the main tools frequently used in total quality management applications to improve quality and reliability [45, 46], its scope of application is continuously being developed by researchers and practitioners [43]. RCA usually starts with a problem statement and investigates which threats may have caused this problem to arise. The same technique can also be used to identify opportunities by starting with a statement of benefit and exploring which opportunities may have led to that benefit [47]. One of the commonly used tools in RCA to visualize, categorize, and determine the root causes of a problem is the cause-and-effect diagram, also known as the (Fish)ikawa or fishbone diagram [48]. The Ishikawa (Fishbone) Diagram is defined as a very useful problem-solving approach that reveals all the factors causing a specific problem and helps identify and improve the factors that have the greatest impact on the outcome, providing an easy-to-use visual representation of cause-and-effect relationships [48-50].

The fishbone method is commonly adapted with different versions such as 4M, 6M, and 8P. These types focus on the analysis of a specific problem, each examining different factors to help deeply understand the issues. The 4M version, generally used to understand problems encountered in manufacturing processes, represents four basic factors (man, machine, material, method). The 6M version, especially used in production and industrial processes, adds two more factors (measurement, Mother Nature) to the 4M by also considering environmental factors. The 8P version is commonly used for analyzing problems. Compared to 4M and 6M, 8P is more comprehensive because it considers not only internal factors such as production or workforce but also external factors like marketing, performance, place, and promotion. Therefore, compared to 4M and 6M, due to its multidimensional nature and the advantage of offering a versatile approach to problem-solving, this study analyzed the root causes of problems originating from building inspection firms under the 8P framework. The 8P factors are explained below from the perspective of building audit practices:

1. People: Human resource-related issues within the building inspection firm affecting the inspection process (e.g., education level, experience, motivation, professional ethics violations, sense of responsibility, workforce shortages, etc.)
2. Price: The pricing of inspection services, determination of costs, budgeting, and the financial sustainability of these services during the building inspection process.
3. Process: Refers to the sequence of steps to be performed within the scope of building inspection. These processes include all steps from creating inspection plans to performing and reporting inspections.
4. Product (Service): Refers to the building inspection service itself, including the scope, quality, and variety of services offered.
5. Physical Location / Place: The locations where building inspection practices are provided and the locations of the inspected buildings are evaluated under this heading.
6. Policies: Refers to the policies and regulations guiding the building audit system.
7. Procedures: Concerns how each step in the building inspection process is performed, which

methods will be used (work instructions, etc.), and which operational standards will be applied.

8. Promotion: Includes the promotion of building inspection services and activities to raise awareness.

3.2.1. Data collection

To identify the root causes leading to problems originating from building inspection firms in the Turkish construction industry, interviews were first conducted with experts working in the field of building inspection within the scope of the 8P framework. Since the validity of the study is critically important for obtaining more accurate and reliable results, experts with at least 5 years of experience in the construction industry and building audit practices were preferred. In the study conducted by [44], it was stated that to obtain more precise and accurate analysis results through expert opinion, at least 9 experts should be consulted. In this context, data was collected from 10 experts with face-to-face interviews. Demographic information of the experts is presented in Table 2.

According to Table 2, it is seen that all of the experts have at least five years of professional experience in building inspection. The experts' long-standing professional experience shows that they have in-depth knowledge and application skills related to the research area.

While the number of experts inevitably limits the statistical generalizability of the findings, data saturation was considered during the interviews. After the fourth interview, no substantially root causes emerged, and the last six interviews confirmed the consistency of the earlier findings, suggesting that saturation was reached.

To ensure transparency in the analytical process, the interview data were transcribed and were then clustered into sub-categories based on semantic similarity and subsequently mapped onto the eight main dimensions of the 8P framework. Overlapping or synonymous codes (e.g., "lack of inspector knowledge" and "insufficient competence of auditors") were merged after discussion to avoid redundancy, and category boundaries were clarified through iterative comparison. Coding was independently checked by researchers, and disagreements were resolved through discussion until full consensus was reached, ensuring reliability in classification.

Table 2. Demographic information of experts

Number	Profession	Industry Experience	Experience in Building Audit	Title	Area of Expertise
Expert-1	Civil Engineer	21 Years	9 Years	Inspector	Superstructure Projects
Expert-2	Civil Engineer	11 Years	10 Years	Inspector	Superstructure Projects
Expert-3	Civil Engineer	9 Years	5 Years	Inspector	Superstructure Projects
Expert-4	Civil Engineer	30 Years	8 Years	Project and Design Inspector	Superstructure Projects
Expert-5	Civil Engineer	15 Years	15 Years	Inspector	Superstructure Projects
Expert-6	Civil Engineer	10 Years	8 Years	Project and Design Inspector	Superstructure Projects
Expert-7	Civil Engineer	24 Years	11 Years	Project and Design Inspector	Superstructure Projects
Expert-8	Civil Engineer	19 Years	11 Years	Project and Design Inspector	Superstructure Projects
Expert-9	Civil Engineer	6 Years	5 Years	Inspector	Superstructure Projects
Expert-10	Civil Engineer	8 Years	6 Years	Inspector	Superstructure Projects

This systematic coding scheme not only strengthened consistency but also provided a clear bridge between qualitative insights and the quantitative frequency analysis used in the Pareto analysis stage.

3.2.2. Data analysis

As a result of the interviews conducted with the experts, all root causes indicated by the experts for each problem were examined using frequency analysis, and expressions with similar meanings were simplified and consolidated. During this consolidation process, the total repetition count for each group was also calculated and recorded. Additionally, unique expressions that were mentioned only once and did not resemble any other root cause were simplified and directly added to the fishbone diagram. The study was carried out carefully to ensure that no root cause was overlooked, and the obtained results were presented within a clear systematic framework. Consequently, the root causes were grouped under 8Ps and arranged in fishbone diagrams in descending order based on their frequency of occurrence. In this ranking, the most frequently repeated root cause was placed first, while the other root causes were listed in descending order according to their repetition counts. This method enhanced the comprehensibility of the root causes and ensured the accuracy and transparency of the analysis process.

The fishbone method generally helps analyzing the root causes of a problem by collecting data through brainstorming. However, within the scope of this study, the data obtained from experts were consolidated and analyzed using frequency analysis, similar to some application examples found in the literature [51]. The consolidation of data and examination through frequency analysis offers different advantages compared to brainstorming. While brainstorming primarily collects ideas based on participants' opinions, frequency analysis provides decision-makers with more concrete and definitive results by quantitatively showing which root causes are mentioned more frequently. In the frequency analysis method, the frequency of each problem's root cause is determined, providing a clearer picture of which issues should be prioritized. In the brainstorming process, as the group size increases, the likelihood of participants influencing each other's ideas also rises. Frequency analysis allows data to be analyzed independently of such influences. Although frequency analysis has a more limited potential for creativity and depth compared to brainstorming, its use is favored because it provides an objective and systematic approach to problem-solving based on concrete numerical data obtained.

To explain how the Ishikawa diagrams are used in the RCA, the fishbone diagram of P1 (presented in Table 1) is given as an example in Fig. 2.

3.3. Pareto analysis

Pareto analysis is a technique used in quality management processes that evaluates the causes of poor quality in proportion to their impact on process performance. The core principle is based on the idea that "80% of the problems are caused by 20% of the causes." Also known as the 80-20 rule, this method emphasizes that certain factors have a significantly greater impact compared to others [52]. In this context, Pareto analysis was applied to the identified problems related to building inspection firms to understand which root causes have the greatest influence. In doing so, the "vital few" causes that most significantly affect the problems were identified. The goal here is to achieve the highest impact with limited resources and to make process improvements more efficient.

During the Pareto analysis, the root causes identified in the fishbone diagrams of 20 different problems, classified according to the 8P method, were systematically coded. To ensure comparability, similar or synonymous causes were merged under a single expression, while overlapping causes were assigned to the most relevant P category to avoid double counting. The frequency with which each root cause appeared across different problems was then determined, based on the rationale that causes recurring more frequently reflect systemic weaknesses with a higher likelihood of affecting inspection outcomes.

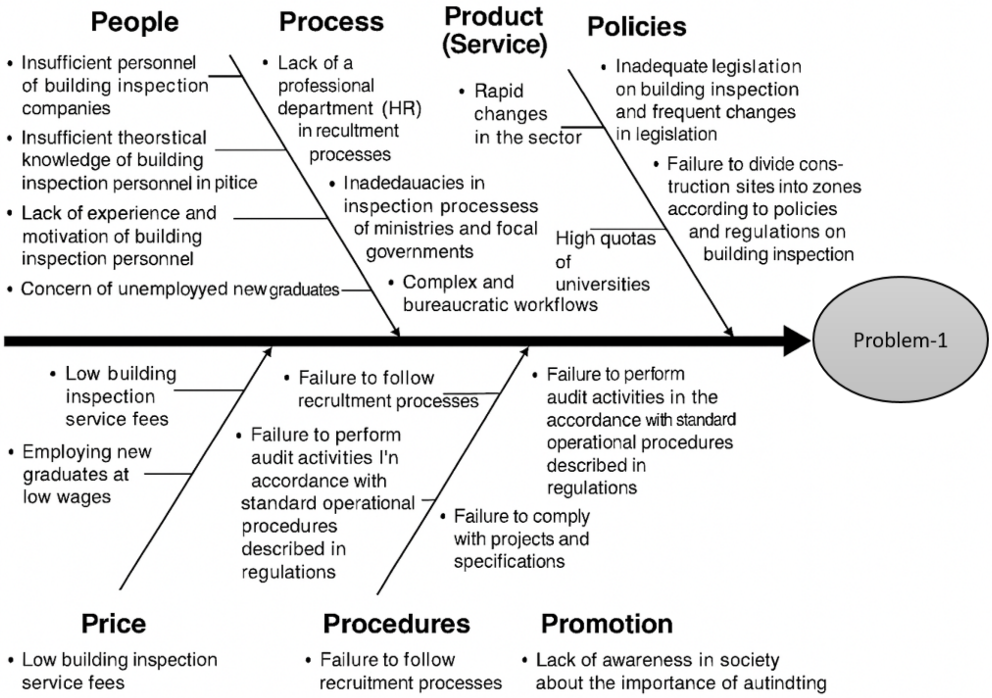

Fig. 2. Ishikawa diagram for P1

This process facilitated the transition from qualitative coding (RCA) to quantitative ranking (Pareto analysis). Specifically, the grouped causes were ranked in descending order according to their frequency, and the percentage and cumulative percentage of each within the total were calculated. In the resulting Pareto chart, the root causes are displayed on the horizontal axis, their frequencies on the vertical axis, and the cumulative percentage is represented as a line. In this way, the analysis not only identifies the most common underlying factors but also highlights those that account for the majority of the problems, thus enabling prioritization of the most critical issues for targeted improvement.

4. Results and Discussions

Below, the findings of RCA and Pareto analysis are presented, respectively.

4.1. Findings of RCA

- P1-Excessive workload of inspection firms and hiring based on diplomas: The root causes stem mainly from staff shortages, lack of experience, and difficulties in the recruitment process. Most firms tend to hire newly graduated engineers at low wages, and their lack of experience negatively affects the effectiveness of inspection processes. This situation leads to incomplete site inspections and deviations in project implementation.
- P2-Insufficient wages given to personnel: Key root causes include an oversupply of graduates increasing job competition, which in turn drives wages down. New graduates tend to accept lower salaries, and employers aim to minimize costs. Additionally, the failure to enforce minimum wage policies set by professional chambers exacerbates the issue of unfair wage practices in the sector. Low service fees also contribute to hiring newly graduated engineers at low wages instead of qualified and experienced personnel. Moreover, concerns over unemployment due to the shrinking market and excess number of graduates make it easier for employers to hire at lower wages.
- P3-Inadequate review of projects by building inspection firms: Root causes include insufficient

time and resources allocated to project review. Firms often address projects superficially, focusing on fieldwork instead of detailed office-based evaluations. Due to a lack of extra compensation, staff do not take ownership of their tasks. Additionally, project review is often seen as separate from building inspection services, and shortcomings are blamed on inspectors who do not share responsibility and on inadequately informed personnel. Other contributing factors include lengthy bureaucratic procedures in municipalities, delays in reporting project revisions, and contractors' lack of attention to project evaluation. Staff shortages and workload also result in quick and superficial project reviews.

- P4-Lack of applications to motivate employees: A major root cause is the absence of additional payment for work outside regular hours. Employees generally rely solely on their base salary and are not supported by incentive systems such as bonuses. The lack of performance monitoring, absence of HR departments, and budget constraints due to low service fees lead to a lack of motivation mechanisms. Additionally, the insufficient emphasis on building inspection as a public service and the lack of adequate support and regulation in the sector reinforce the absence of incentives.
- P5-Incomplete quality control due to insufficient personnel: Main root causes include low service fees, staff shortages, excessive bureaucracy, inability to serve remote sites, and lack of incentives. These factors prevent adequate staffing, increase workload, and reduce quality. Poorly managed recruitment processes and ineffective use of staff further compound the issue. Firms aim to maximize profit with minimal staffing, which results in ineffective inspections. Excessive bureaucracy distracts inspectors from their core duties and reduces inspection quality. Another major factor is low staff motivation. The absence of material or moral incentives reduces efficiency and contributes to inspection deficiencies. Undefined job roles and inconsistent pricing policies also impact quality control. A limited number of staff and excessive workloads hinder efficient inspection processes. Lastly, insufficient knowledge of construction laws and regulations among personnel leads to incomplete inspections.
- P6-Emphasis on cost rather than the quality of inspection: One of the primary root causes is the low service fees. Building inspection firms offering services at reduced rates leads to minimal staffing and rushed inspections, ultimately reducing the quality of inspections. Another significant factor is the profit-driven approach of firms, which often results in hiring low-cost personnel. The lack of investment in staff development causes firms to focus solely on fulfilling basic legal requirements, leading to superficial inspections and neglect of necessary steps to improve quality. Additionally, inspections of remote construction sites are often limited due to high transportation costs and time constraints, preventing inspections from being sufficiently comprehensive and accurate.
- P7-Incorrect sampling of concrete specimens: Root causes include a lack of qualified personnel, insufficient training, a rushed approach, low pricing policies, gaps in inspection practices, transportation challenges, and adverse weather conditions. These factors hinder the correct execution of concrete sampling procedures, leading to compromised construction quality.
- P8-Unethical influence on test results: The unethical manipulation of test results stems from insufficient oversight, lack of training, disregard for ethical responsibilities, cost pressures, negligence at construction sites and laboratories, and inadequate inspection in remote regions.
- P9-Lack of quality control on construction materials: Key root causes include gaps in inspection processes, inadequate staffing and training, economic concerns, transportation difficulties, use of non-standard materials, and weak inspection infrastructure.
- P10-Personnel working only for signature purposes: The root causes include low wages aimed at reducing costs, part-time employment, violations of professional ethics, inadequate legal regulations, systemic loopholes, and insufficient oversight.
- P11-The inspector and the responsible officer being different people: The core reasons involve

excessive workload and cost-saving efforts, inexperience among newly graduates, low wages and job insecurity, uncertainty and lack of responsibility in inspection processes, systemic weaknesses, lack of inspections, as well as geographical distance and difficulties in inspecting rural areas.

- P12-Lack of continuous inspection on-site: The root causes include insufficient personnel, excessive workload, low wages, lack of coordination and undefined responsibilities, lack of participation in on-site inspections, external influences, system-level deficiencies, and a tolerance for low quality.
- P13-Quality control performed only on concrete and steel: The root causes of this issue include the exclusion of finishing works and mechanical inspections from the scope due to a lack of architectural and other technical expertise. There is also a general lack of awareness regarding the importance of inspecting materials, mechanical systems, and finishing works beyond just concrete and reinforcement. Another key issue is that building inspection firms often do not employ specialists for finishing works and instead conduct these inspections merely on paper.
- P14-Insufficient concepts of work discipline and ethics: Root causes include insufficient teaching and implementation of ethical standards, lack of coordination and discipline during inspection processes, inadequate penalties, low motivation, procedural and digital transformation shortcomings. Inspection firms typically limit themselves to preparing progress and payment files and neglect additional responsibilities such as occupancy permits and documentation. This leads to deficiencies in inspection procedures and weakens work discipline. Moreover, municipalities and relevant authorities do not provide adequate guidance on ethical practices, which fosters widespread unethical behavior in the sector. The infrequency of inspections and lack of penalties further aggravate the problem.
- P15-Inspectors failing to find qualified solutions to problems encountered at the workplace: The inability of inspectors to solve problems encountered on site stems from coordination deficiencies, lack of training and experience, excessive workload, legal ambiguities, low service fees, shortage of qualified staff, and lack of institutional support.
- P16-Building inspection firms providing services below the minimum service fee: Although building inspection fees are determined based on the Domestic Producer Price Index, these prices do not reflect real market conditions and inflation throughout the year. Additionally, contracts are based on unit prices set by the ministry and are only updated annually in January. During inflationary periods, these updates are insufficient and negatively impact the financial stability of firms. This prevents firms from meeting minimum operating standards and reduces service quality. Another critical root cause is the excessive price competition in the sector, which forces firms to offer services at lower prices, consequently decreasing the overall quality of services.
- P17-Missing signatures of parties in the building inspection service contract: The root causes most frequently associated with missing signatures include procedural differences between municipalities, lack of digital infrastructure, oversight or negligence, varying interpretations of legislation by local authorities, unnecessary bureaucratic procedures, and legal uncertainties.
- P18-Distance between the building inspection firm’s location and the site they are responsible for: Root causes include fixed service fees, lack of regional planning and distribution policies, shortage of coordination and technical staff, and traffic congestion. Service fees are fixed and do not account for additional travel costs, making frequent visits to distant sites financially unviable. The lack of regional distribution policies and distance-based planning contributes to infrequent inspections in remote areas. Coordination and staff shortages further hinder inspection activities. In large cities, traffic exacerbates the time and psychological burden of travel, reducing the effectiveness and frequency of inspections. Additionally, since fees are based on the project’s estimated construction cost, firms suffer time and financial losses when

dealing with small and remote sites, leading to decreased service frequency and quality.

- P19-Considering building inspection service as a formality: The perception of building inspection as a formality is mainly due to low service fees, lack of motivation, superficial inspections, insufficient penalties, conflicts of interest between contractors and inspection firms, lack of training, shortage of technical personnel, and lack of awareness about the inspection process.
- P20-Lack of knowledge, education, and technical personnel's experience: Core root causes include an oversupply of graduates, shortage of qualified workforce, insufficient post-graduation training opportunities, inability to keep up with technological innovations, lack of professional development, certification, and mentoring systems. Increased university quotas lead to a high number of graduates, which does not correlate with the availability of qualified personnel. Despite the large number of graduates, finding experienced professionals is difficult, and newly graduated engineers and architects often lack the required skills and knowledge before entering the workforce. The high cost of certification and training programs, along with the lack of mentorship, hinders staff development. Furthermore, poor technological integration and limited access to education in smaller cities exacerbate the qualified labor shortage.

The analysis of building inspection firm-related problems in Türkiye reveals several recurring root causes. Staff shortages, low wages, and the hiring of inexperienced personnel emerge as consistent factors, leading to incomplete inspections, superficial project reviews, and low overall quality. Financial constraints, including low service fees and cost-driven practices, exacerbate these issues by limiting investment in staff development, motivation mechanisms, and comprehensive inspections. Organizational deficiencies, such as excessive workload, unclear responsibilities, inadequate coordination, and weak oversight, further undermine effective inspection processes. Other frequent challenges include insufficient technical expertise, lack of training, inadequate application of ethical standards, and logistical barriers such as distance to construction sites. Together, these factors contribute to a systemic reduction in inspection quality, a perception of inspections as formalities, and persistent risks to building safety and compliance.

4.2. Findings of Pareto analysis

Findings of Pareto analysis is given in Fig. 3. According to the results of the Pareto analysis presented in Fig. 3, the root causes with the greatest impact on the identified problems are as follows:

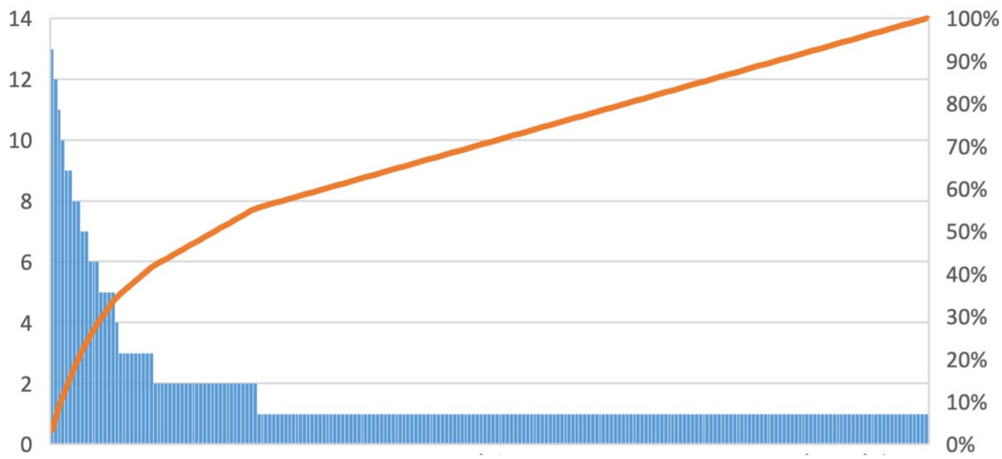

Fig. 3. Pareto analysis diagram

1) The insufficiency of ministry inspections and punitive measures, 2) employment of building inspection personnel at low wages, 3) lack of public awareness regarding the importance of inspections, 4) low service fees for building inspection, 5) reduced frequency and quality of inspections at remote sites, 6) insufficient staffing in building inspection firms, 7) heavy workload of inspection personnel, and 8) lack of professional knowledge and field experience among technical staff.

4.3. Conceptual system map

While this study primarily focused on identifying recurrent causes, it emphasizes diagnosis rather than full modeling of causal pathways. However, a conceptual system map was developed using causal mapping techniques to illustrate how the most frequent root causes interact to shape recurring problems within Türkiye's building audit system.

Causal mapping is widely recognized as the most frequently employed cognitive mapping technique for mapping a set of relationships forming the complex system [53, 54]. As the term suggests, a causal map depicts a network of cause-and-effect relationships, interactions and interrelations among constructs within a system, showing how one concept influences others. By tracing these chains of reasoning, it provides insights into an individual's thought processes [53]. However, it can also be viewed as a teaching tool for understanding system complexity, since it does not capture changes over time. Therefore, the constructed causal maps serve as a reference framework and form the foundation for further refinement and the development of a simulation model using system dynamics techniques [54]. Steps adopted to create the causal map are explained below:

- Step 1- Identification of Key Components: Constructing a causal map begins with identifying the system's key components. In this study, it involves a total of eight root causes with the greatest impact on the problems, as determined by Pareto analysis (C1-C8). These components were presented in Table 3.
- Step 2 - Identification of Relationships: The next step is to define how these components influence one another, through causal links, feedback loops, or interdependencies. Based of RCA and Pareto analysis's results, the causal relations were presented in Table 3.
- Step 3- Categorization of Components: In the next step, the components were grouped into categories; namely regulatory structure, market forces, and human resource constraints. This categorization helps organize the components so that their relationships are displayed more clearly and without visual cluster. The layer categorization can be found in Table 3.
- Step 4 - Illustrating the Conceptual casual Map: In this step, components are placed as nodes, nodes relate to arrows representing relationships. In casual maps, the elements are linked together by arrows that indicate a causal relationship as a direct influence. A causal link between two variables implies direction of change between the cause-and-effect pairs [54].

The conceptual casual map showing the relations between key root causes encountered in Turkish building audit practices is presented in Fig. 4.

5. Conclusions and Recommendations

In order to prevent any problem or minimize its impact, it is essential first to accurately identify the root causes of that problem. This enables the development of effective actions and strategies targeted at each specific cause. Accordingly, within the scope of this study-which aims to identify the root causes of problems arising from building inspection firms in the Turkish construction industry, Root Cause Analysis (RCA) was conducted using Ishikawa (Fishbone) diagrams, followed by a Pareto analysis.

According to the results of the analysis, the root cause with the greatest impact on the problems identified regarding inspection firms is the inadequacy of ministry inspections and punitive measures.

Table 3. Layered categorization of root causes and key causal loops

Layered Categorization	Root Cause	Causal, Feedback Loops, Or Interdependencies
Regulatory Structure	C1 Insufficient ministry inspections and punitive measures	Weak regulatory oversight → Superficial compliance → Reduced inspection quality → Ethical lapses → Superficial inspections
	C3 Limited public awareness of the importance of inspections	Low public awareness → Low demand for thorough inspections → Reduced pressure on firms to improve quality → Superficial inspections
Market Forces	C4 Low service fees for building inspection	Low service fees → Cost-cutting by firms → Low wages & Staff shortages → Reduced inspection quality → Superficial inspections
	C5 Reduced frequency and quality of inspections at remote sites	Reduced frequency and quality of inspections at remote sites (Less frequent inspections) → Missed errors → Increased systemic risk → Compromised overall construction quality
Human Resource Constraints	C2 Employment of building inspection personnel at low wages	Low wages → Hiring inexperienced staff → Low motivation → Reduced inspection quality → Ethical lapses → Superficial inspections
	C6 Inadequate staffing within building inspection firms	Staff shortages → Excessive workload → Errors / rework → Superficial inspections Feedback: Staff shortages ↔ Excessive workload ↔ Reduced inspection quality
	C7 Excessive workload of inspection personnel	Excessive workload → Rushed inspections → Errors → Reduced quality → Further workload (rework) → Superficial inspections
	C8 Insufficient professional knowledge and field experience among technical staff	Hiring inexperienced staff & insufficient technical knowledge → Errors / rework → Need for supervision → Reduced efficiency and inspection quality → Superficial inspections

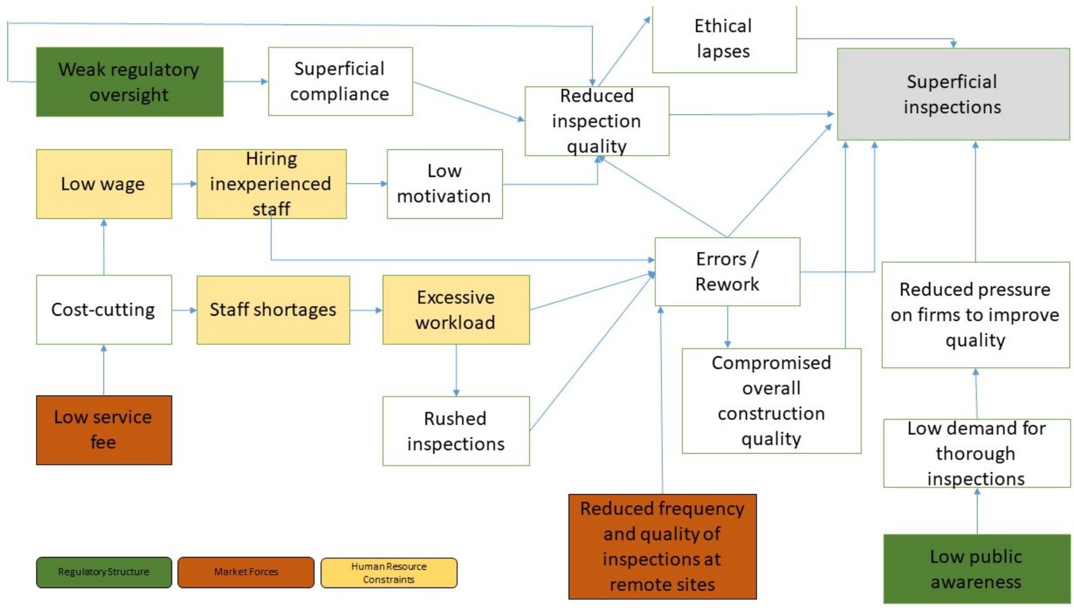

Fig. 4. Conceptual casual map

Although building inspection firms are responsible for monitoring construction processes, inspections carried out by the Ministry are often insufficient. The low frequency of inspections and lack of deterrent penalties result in firms failing to fulfill their responsibilities effectively. In fact, 81.25% of technical staff in municipalities stated that the fines imposed do not improve the quality of inspection firms [6]. Additionally, the majority of building inspection firms reported that they have not received any administrative sanctions [26], indicating that either penalties are not being enforced, or they are ineffective. To enhance the effectiveness of the inspection processes, strategies below can be adopted:

- Strengthen ministry oversight and enforcement: The number of Ministry personnel should be increased, and independent inspectors should be involved to ensure unbiased supervision. The scope and frequency of inspections should be broadened to cover all critical stages of construction. To operationalize this, the Ministry should issue a directive to standardize inspection protocols across municipalities and initiate quarterly audits of inspection firms, beginning with high-risk seismic zones. This targeted approach will help focus limited resources where they are most needed and improve consistency across regions Practices such as the building insurance system in France could be integrated into the Turkish inspection system to ensure third-party oversight [1]. Moreover, stricter sanctions should be introduced for violations of the law, and existing penalties should result in serious consequences, not only financial but also operational, such as the suspension of construction activities. As seen in the case of the UK, regulations should be made more detailed and strictly enforced to improve the functioning of the system [6, 34]. However, implementing these measures would demand substantial investment in staffing, training, and enforcement capacity. Tangible improvements in the inspection system would also require capital to upgrade infrastructure, equipment, and digital tools [55]. Ministries may need restructuring to manage increased oversight, and stricter inspections and penalties could face resistance from those benefiting from the current leniency.
- Increase public awareness and sector accountability: The effectiveness of building inspection processes depends not only on experts but also on the importance and awareness society places on these processes. However, there is a significant lack of public awareness regarding the role and importance of building inspections. The public's insufficient understanding of these processes can lead to ineffective inspections and the overlooking of safety risks. Therefore, public awareness about building inspections must be increased. Ministries and relevant institutions should organize informative campaigns to educate citizens about building safety and the importance of inspections. Municipalities, non-governmental organizations (NGOs), and the media should collaborate to implement targeted outreach programs, including social media campaigns and community workshops, particularly in regions with higher construction activity. Moreover, by increasing the visibility of professionals in the construction industry, the public can gain a better understanding of inspection processes. From an institutional standpoint, the proposed actions are highly feasible, as they can be implemented through existing public communication infrastructure. On the political front, the initiative is expected to encounter minimal resistance, given its non-controversial nature and broad public support.
- Improve financial sustainability of inspection firms: Low service fees negatively impact the financial sustainability of inspection firms and reduce the overall quality of services. This situation leads to shortcomings in staff recruitment, training, investment in technology, and the provision of necessary equipment; it also limits salaries, making it difficult to retain qualified personnel within the sector [26]. The current rate of "1.43% of the construction cost" set for inspection fees is insufficient and often results in inspections being treated as a mere formality, leading only to signature-based approvals. Adjusting fees according to project size will, in the long term, enhance both quality and safety in the sector [17].

Therefore, increasing service fees is essential to ensure quality and safety in the building inspection sector. In this direction, the Ministry should establish a sustainable, tiered fee structure aligned with project size and complexity, accompanied by transparent financial monitoring mechanisms. At this point, it is important to note that, for the proposed actions to be implemented, the Ministry requires financial monitoring systems and sufficient institutional capacity to enforce new fee regulations [55]. Another challenge can be the potential opposition from developers and industry stakeholders who are sensitive to cost increases.

- Utilize digital and remote inspection technologies: According to the Pareto analysis, one of the influential root causes among all identified problems is the decrease in the frequency and quality of inspections in remote locations. Inspections conducted at construction sites located far from the inspection firms pose logistical and financial challenges, leading to reduced inspection frequency and diminished quality. Despite the increased workload associated with distance, the fixed service fees prevent firms from conducting frequent and effective inspections [21]. This situation jeopardizes building safety. To address this issue, inspection planning must be revised, service fees for remote sites should be increased, and additional incentives should be provided to inspection firms. Furthermore, the use of digital and remote inspection technologies can enhance both frequency and quality of inspections. Remote inspection systems including drones, sensors, artificial intelligence (AI), and Internet of Things (IoT) technologies linked with Building Information Modeling (BIM) can enable real-time and effective monitoring of construction sites. These technologies allow for the supervision of building processes without requiring inspectors to always be physically present at the site. The deployment of remote inspection technologies requires adequate IT infrastructure, skilled personnel, and significant initial investments in equipment, software, and training. However, existing studies indicate that remote inspection technologies yield considerable cost–benefit advantages [56, 57] and can support value-for-money decisions, making their adoption feasible for construction engineering organizations [58].

Remote visual inspection using drones or robotic platforms enables inspectors to collect imagery data without physically accessing the site. The autonomous capabilities of drones help reduce inspection time and costs, while also decreasing the need for on-site personnel and enhancing worker safety. These technologies enhance the reliability and consistency of collected data while substantially reducing both inspection costs and duration. Furthermore, by minimizing downtime, they enable industries to maintain operations for longer periods, thereby generating higher revenue [59]. In current inspection practices, on-site quality data are collected using various tools and analyzed by comparing them against design criteria to determine compliance. BIM addresses many of the associated data management challenges by consolidating diverse quality data into a single, integrated digital model. It allows for the seamless integration of 3D point clouds with design specifications, supports automated defect detection through add-in software, and ensures that inspection data are accurate, traceable, and readily accessible. This approach reduces redundancy, minimizes human error, and significantly enhances the efficiency and reliability of quality control processes [60].

It is recommended that the Ministry pilot a digital inspection program in selected regions, focusing on high-risk and remote sites, and allocate funding for initial investments in IT infrastructure, training, and software development. Partnerships with technology providers and academic institutions can accelerate capacity building.

However, realizing these benefits in practice demands substantial institutional capacity. Inspection authorities and firms must invest in IT infrastructure, regulatory compliance systems, trained personnel, and maintenance protocols. Without such capacity, encompassing both financial monitoring systems and human resource development, new technologies may be underutilized or fail to integrate effectively into existing workflows. Thus, while the long-term value-for-money of these remote technologies is compelling, its realization in contexts like Türkiye hinges on strengthening institutional frameworks and capabilities to manage the financial, technical, and regulatory demands of implementation.

- Enhance personnel capacity and competency: Building inspection firms should recruit a sufficient number of qualified technical staff. However, many building inspection firms struggle to recruit enough personnel to handle increasing workloads. This problem becomes even more apparent when firms must oversee multiple large-scale projects simultaneously [17]. Recruitment in inspection firms typically begins before construction permits are obtained, creating additional financial burdens. Therefore, there is a need for flexible personnel management strategies. To solve this issue, the government should provide financial support for personnel recruitment, and inspection service fees should be increased to help firms cover these costs [3]. Additionally, part-time or project-based employment models could be implemented. A shared personnel network among firms could be established to meet temporary staffing needs. The widespread adoption of digital inspection tools would also improve workforce efficiency, allowing human resources to be used more effectively.

Most technical staff working in building inspection firms have between 1 to 3 years of experience, and many are recent graduates. This situation negatively affects the quality of inspections [26]. To solve this problem, technical personnel should receive continuous training, particularly in construction regulations, material science, and safety standards. In addition, experienced inspectors should be encouraged to work alongside new staff in the field to foster on-the-job learning. Similar to the professional qualification systems implemented in developed countries, government should develop and enforce a licensing system for building inspectors based on qualifications and experience, modeled after systems like Germany's, which require a minimum of 10 years of engineering experience and specific certifications [34]. Introducing such qualification-based systems would improve the competency of technical personnel and enhance the safety and effectiveness of inspection processes.

- Reduce workload and improve task allocation: Being required to oversee multiple projects simultaneously causes inspections to become superficial and increases the risk of overlooking errors in projects. The growing workload, rushed inspections, and time pressure all heighten the risk of mistakes and make it difficult to detect critical deficiencies [61]. To address these issues, inspection personnel should be assigned only to tasks relevant to their area of expertise, and their job descriptions should be clearly defined. The Ministry should allocate construction sites to firms based on the inspectors' capacity. Moreover, integrating digital software and systems such as BIM into the inspection processes could simplify workflows and accelerate data collection and reporting. This would enable inspectors to manage their workload more efficiently. According to the recent amendment to the "Zoning Regulation for Planned Areas", the use of BIM will become mandatory for large-scale public construction projects as of January 1, 2027 [62]. This regulatory development can also be expected to act as a major catalyst for BIM adoption in inspection process.

The findings of this study provide a valuable guide for improving the building inspection system in Türkiye. The research offers key strategies that can contribute to the construction of safer and more sustainable buildings by forming a foundation for future studies. By applying systematic problem-solving approaches supported by detailed analysis, this research not only adds valuable input to national discussions on construction oversight but also presents adaptable methods that can benefit other countries dealing with comparable regulatory issues. This study's focus on building inspection firm-level root causes complements global insights by providing a micro-level perspective, which can inform both national and comparative research. From that perspective, the study contributes to international literature by offering a more nuanced understanding and lessons that could be applied in other countries facing similar challenges in construction inspection and enforcement.

While this study offers insights into the root-cause of building inspection firm-based problems in Türkiye, it is essential to recognize its limitations. The limitations are three-fold. The first and the primary limitation of the study is its exclusive focus on the root causes of problems originating from building inspection firms. Second limitation is the lack of consideration for regional differences in the assignment of building inspection firms. In this context, upcoming research could expand by involving other stakeholders in the audit process, allowing for a more holistic evaluation of problems within the system. Additionally, incorporating a wider range of expert opinions could enable comparative analysis of practices across different regions or countries, leading to more specific and effective recommendations for improving the efficiency of the building inspection system. Lastly, Pareto analysis was applied as a heuristic decision-support tool to prioritize the most frequently recurring root causes identified through expert interviews in this study. The aim was not to make inferential claims about statistical variance, but rather to provide a structured framework for highlighting the causes with the highest recurrence frequency that are likely to have the greatest impact on the system. While this approach is effective for prioritization, it does not statistically validate the extent to which these causes account for variance in problem severity. Therefore, acknowledging this limitation future research could complement Pareto analysis with statistical techniques such as regression models or variance decomposition to further assess the relative influence of different causes. Additionally, future research could develop formal causal models, such as system dynamics or structural equation modeling, to quantitatively examine the interactions among the 8P constraints and their influence on recurring problems in building inspection. Such approaches would provide deeper explanatory insights, validate the relationships identified in this study, and support the development of more targeted interventions to improve inspection processes.

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Author Contributions

B. Temizel: Data curation, Validation, Formal analysis, Investigation, Writing – Original draft preparation. H. Aladağ: Conceptualization, Methodology, Writing – Reviewing and Editing, Visualization, Supervision, Project administration.

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Data Availability Statement

The data presented in this study are available on request from the corresponding author.

Ethics Committee Permission

The authors declared that all participants were fully informed consent for inclusion before they participated in the study, and the study meets national and international guidelines.

Conflict of Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Appendix A

Problems encountered in Turkish Building Audit Practices.

Building Inspection Firm-Based Problems	
1	Excessive workload of inspection firms and hiring based on diplomas
2	Insufficient wages given to personnel
3	Inadequate review of projects by building inspection firms
4	Lack of applications to motivate employees
5	Incomplete quality control due to insufficient personnel
6	Emphasis on cost rather than the quality of inspection
7	Incorrect sampling of concrete specimens
8	Unethical influence on test results
9	Lack of quality control on construction materials
10	Personnel working only for signature purposes
11	The inspector and the responsible officer being different people
12	Lack of continuous inspection on-site
13	Quality control performed only on concrete and steel
14	Insufficient concepts of work discipline and ethics
15	Inspectors failing to find qualified solutions to problems encountered at the workplace
16	Building inspection firms providing services below the minimum service fee
17	Missing signatures of parties in the building inspection service contract
18	Distance between the building inspection firm's location and the site they are responsible for
19	Considering building inspection practice as a formality
20	Lack of knowledge, education, and technical personnel's experience
Project Designer-Based Problems	
1	Lack of necessary coordination and interaction in project preparation
2	Errors and deficiencies in projects
3	Incompatible projects with each other
4	Study-based works not conducted in compliance with regulations
Relevant Public Institution-Based Problems	
1	Issuance of building permits despite inconsistencies between projects
2	Differences in practices of provincial and district administrations
3	Political pressure
4	Forgery in documents
5	Unequal and unfair treatment of inspection firms by authorities
6	Time loss due to bureaucratic procedures
7	Problems arising from public buildings being exempted from inspection
8	Problems caused by all procedures being managed solely by the ministry
9	Deficiencies in inspection permit documents
10	Missing project control forms
11	Problems arising from legislation related to the Building Inspection System
12	Frequent changes in building inspection legislation
Building Owner-Based Problems	
1	Building owner not appointing a building inspection firm
2	Delay in progress payment disbursements
3	Requests for applications outside the scope of the project
4	Methods of collecting building inspection service fees
Contractor and Site Supervisor-Based Problems	
1	Granting site supervisor authority to technicians
2	Site supervisor not being present on site
3	Lack of workforce meeting contractors' technical requirements
4	Failure to control occupational health and safety measures
5	Unreliable solutions related to disputes between administrators, contractors, and control personnel