

Original Article

Importance of Analytical Hierarchy Process in Contractor Selection and Structural Audit

Snehal Pradeep Wakade¹, Manisha Jamgade²

^{1,2}Department of Civil Engineering, Pillai HOC College of Engineering and Technology, Maharashtra, India.

¹Corresponding Author : snehalwakade25@gmail.com

Received: 13 June 2026

Revised: 21 July 2026

Accepted: 14 August 2026

Published: 31 August 2026

Abstract - During the development and maintenance phases of a building, major decisions need to be taken to control its lifecycle. Not methodically inspecting old structures can lead to catastrophic failure, and picking a poor contractor can cause cost overruns and structural flaws. This study presents an integrated Multi-Criteria Decision-Making (MCDM) framework with the use of the Analytical Hierarchy Process (AHP) for two important processes, which are the selection of the building contractor and the evaluation of the priorities of the structural audit. We created two different hierarchical evaluation models. The structural audit model considers building distress signals like carbonation depth, fracture widths & Ultrasonic Pulse Velocity (UPV) variation as priority, while contractor selection model balances the financial bids against qualitative technical & safety indicators. The pairwise comparison matrices obtained from the data of the sector specialists were verified using the Consistency Ratio (CR) limitations. The results indicated the Non-Destructive Testing (NDT) results (42.4%) determine the priorities of structural audits, and the most important element in the selection of contractors is the technical expertise (39.1%). This paradigm of dual-application provides engineers and stakeholders with a rigorous, transparent decision-support system for asset management and structural safety improvement.

Keywords - Analytical Hierarchy Process (AHP), Contractor Selection, Structural Audit, Non-Destructive Testing (NDT), Multi-Criteria Decision-Making (MCDM).

1. Introduction

The modern infrastructure and construction industries are struggling at every phase of the building lifecycle. Choosing the right contractor is critical to the project's success at the early stages of development. Periodic structural reassessments are required in order to evaluate the deterioration and to assure long term safety during the operational phase. In the past, these fields have suffered from problems of subjective judgment or single-criteria decision-making, such as choosing the lowest bid or performing short visual inspections. Such kinds of actions may lead to a misallocation of rehabilitation funds, structural failures, and construction delays.

The selection of a contractor is a complex process which requires a fair consideration of quantitative financial bids and qualitative considerations such as technical expertise, safety record and managerial stability. Likewise, a structural audit would look at an array of diagnostic data, including chemical test results, visual assessment of damage and Non-Destructive Testing (NDT) data such as rebound hammer values and Ultrasonic Pulse Velocity (UPV). Evaluators often have difficulty weighing these different characteristics against one another.

The Analytical Hierarchy Process (AHP), a multi-criteria decision-making technique developed by Thomas L. Saaty, provides a systematic approach to manage these complexities. AHP decomposes complex unstructured problems into a structured hierarchy of objectives, standards, sub-standards and alternatives. Decision-makers can systematically compare qualitative and quantitative aspects using pairwise comparison matrices, and the consistency of judgments can be checked using a statistically determined Consistency Ratio (CR).

The research examines the impact of AHP on enhancing the quality of decision-making in these two important phases of the building process. By showing how AHP can minimize human errors in decision-making, improve transparency, and improve safety in structural management from the moment of construction to the stage of long-term maintenance through customized hierarchical models that rely on the opinion of experts.

2. Literature Review

2.1. Multi-Criteria Frameworks in Contractor Selection

In recent years, the construction industry has begun to abandon traditional low-bid procurement processes. As



pointed out by Mary et al. [7], using this method creates systemic risks that lead contractors to cut safety budgets and the quality of materials in order to achieve their profit objectives. Okereke et al. [9] aforementioned points that modern pre-qualification systems should take technical ability and past experiences into account before considering price estimation of bidders in order to solve the problem at hand.

The use of Multi-Criteria Decision-Making (MCDM) techniques addresses the issue of evaluating qualitative subjective criteria. Daniel et al. [6] found that AHP method is still widely used because of its ability to check for consistency when choosing a decision-making method after conducting an extensive study of various options used within construction research. Kareem [1] used AHP in their recent projects concerning the evaluation of contractors for the construction of green commercial buildings, proving the large influence of the use of additional criteria (such as digital capabilities, in particular, the use of BIM) on the minimization of deviations from plans.

2.2. Systematic Prioritization in Structural Audits

Structural auditing has progressed from a reactive maintenance strategy to a sophisticated, structured diagnosis because of advancements in urban building construction. Consequently, engineers frequently overlook serious structural issues using conventional methods based on surface visual inspections. Rather, it is necessary to combine visual inspections with Non-Destructive Tests (NDT) in order to make the assessments more reliable.

New studies provide proof of the usefulness of decision-making frameworks in the process of assessing structural deterioration. Besides that, indicators of visual deterioration should be compared with objective results from buildings' subsurface structures to perform accurate assessments of structural durability. In their turn, engineers face complex dilemmas arising from decision-making regarding different types of data, such as carbonation depth, core pressure tests, and Ultrasonic Pulse Wave (UPV) measurements, to implement necessary rehabilitation measures.

2.3. The Role of AHP in Structural Health and Rehabilitation

There has been a big increase lately in the years between 2020 and 2025 the use of AHP methods for building evaluation and repair. According to Salman, AHP organizes a complex dataset related to building inspections into a clear, actionable hierarchy for big inventories of buildings. When it comes to budget allocation for minor repairs to buildings that undergo different degrees of degradation, managers of multi-building asset portfolios are faced with a major challenge.

According to recent studies, AHP solves such complex dilemmas. Belay et al. applied sensitivity analysis of civil

engineering projects and showed how good degradation models can be produced when the data gained through the non-destructive testing is compared with rating the environment using the AHP method.

Research carried out by Kumar and Singh allows showing how asset managers protecting compromised buildings can make the right decision despite budget limitations and using a resilient AHP methodology, thus proving that AHP is a useful method of asset management throughout the whole building operation period.

3. Methodology

The Analytical Hierarchy Process (AHP) method is used to evaluate two important decision-making processes: choosing a construction contractor and prioritizing the structural audit repairs. The application of the AHP process involves stages including the construction of the hierarchy; creation of a pairwise comparison matrix; normalization; and consistency check.

3.1. Application Model 1: Contractor Selection Framework

The structural model for selecting contractors uses four main criteria evaluated by an expert panel:

1. Financial Stability (C_1): Liquidity, bonding capacity, and bid price balance.
2. Technical Capability (C_2): Machinery assets, engineering staff experience, and BIM proficiency.
3. Management Experience (C_3): Years active in the market and past project completion rates.
4. Quality & Safety (C_4): ISO certifications and historical injury rates.

3.2. Application Model 2: Structural Audit Assessment Framework

The assessment model for structural audits evaluates four main parameters to identify building distress:

1. Visual Defect Profiling (M_1): Spalling indicators, exposed structural reinforcement, and crack width distributions.
2. Non-Destructive Testing [NDT] (M_2): Ultrasonic pulse velocity profiles and rebound hammer values.
3. Chemical Degradation Tests (M_3): Carbonation depth readings and chloride ingress profiles.
4. Environmental Exposure Status (M_4): Dampness levels and surrounding chemical atmospheric exposure.

4. Results and Discussion

4.1. Model 1 Analysis: Contractor Selection Weights

The main pairwise matrix for contractor selection was created using consensus data gathered from top project managers, shown in Table 1.

Consistency Analysis Verification:

- $\lambda_{\max} = 4.0924$

- $CI = \{4.0924 - 4\} / \{3\} = 0.0308$
- For $n = 4$, $RI = 0.89$
- $CR = \{0.0308\} / \{0.89\} = 0.0346$

Because $CR = 3.46\% < 10\%$, the weights are verified as consistent. Technical Capability (C_2) emerged as the primary consideration with a weight of 39.13%, followed by Financial Stability (C_1) at 26.83%.

Table 1. Pairwise Matrix for Level 2 Contractor Selection Criteria

Criteria	Financial Stability (C_1)	Technical Capability (C_2)	Management Experience (C_3)	Quality & Safety (C_4)	Priority Weight (w_i)	Priority Percentage (%)
Financial Stability (C_1)	1.0000	0.5000	2.0000	2.0000	0.2683	26.83%
Technical Capability (C_2)	2.0000	1.0000	3.0000	3.0000	0.3913	39.13%
Management Experience (C_3)	0.5000	0.3333	1.0000	2.0000	0.1843	18.43%
Quality & Safety (C_4)	0.5000	0.3333	0.5000	1.0000	0.1561	15.61%
Total Column Sums	4.0000	2.1666	6.5000	8.0000	1.0000	100.00%

4.2. Model 2 Analysis: Structural Audit Weights

The secondary matrix focuses on prioritizing structural interventions using test metrics provided by structural audit consultants, shown in Table 2.

Consistency Analysis Verification:

- $\lambda_{\max} = 4.1165$
- $CI = \{4.1165 - 4\} / \{3\} = 0.0388$
- For $n = 4$, $RI = 0.89$

- $CR = \{0.0388\} / \{0.89\} = 0.0436$

Because $CR = 4.36\% < 10\%$, the model shows acceptable consistency. Non-Destructive Testing (M_2) is identified as the most critical evaluation driver (42.39%), demonstrating that quantitative diagnostic data is prioritized over superficial visual assessments during structural safety analyses.

Table 2. Pairwise Matrix for Level 2 Structural Audit Maintenance Criteria

Audit Parameters	Visual Defects (M_1)	Non-Destructive Testing (M_2)	Chemical Degradation (M_3)	Environmental Exposure (M_4)	Priority Weight (w_i)	Priority Percentage (%)
Visual Defects (M_1)	1.0000	0.3333	2.0000	3.0000	0.2307	23.07%
Non-Destructive Testing (M_2)	3.0000	1.0000	3.0000	4.0000	0.4239	42.39%
Chemical Degradation (M_3)	0.5000	0.3333	1.0000	2.0000	0.1873	18.73%
Environmental Exposure (M_4)	0.3333	0.2500	0.5000	1.0000	0.1581	15.81%
Total Column Sums	4.8333	1.9166	6.5000	10.0000	1.0000	100.00%

4.3. Global Synthesis and Case Application

The local sub-criteria weights were compiled to create a comprehensive evaluation framework, shown in Table 3.

Consistency Analysis Verification:

- $\lambda_{\max} = 4.1165$
- $CI = \{4.1165 - 4\} / \{3\} = 0.0388$
- For $n = 4$, $RI = 0.89$

- $CR = \{0.0388\} / \{0.89\} = 0.0436$

Because $CR = 4.36\% < 10\%$, the model shows acceptable consistency. Non-Destructive Testing (M_2) is identified as the most critical evaluation driver (42.39%), demonstrating that quantitative diagnostic data is prioritized over superficial visual assessments during structural safety analyses.

Table 3. Global Hierarchy Sub-Criteria Weights across Both Domains

System Domain	Domain Matrix Weight	Component Sub-Criteria	Sub-Criteria Local Weight	Global Weight Score	Final Combined Rank
Contractor Selection Phase	0.500	Liquid Cash Flow (SC ₁₁)	0.550	0.2750	1
		Equipment Fleet (SC ₁₂)	0.250	0.1250	3
		Engineering Staff Experience (SC ₁₃)	0.200	0.1000	4
Structural Audit Phase	0.500	Ultrasonic Pulse Velocity [UPV] Profiles (SC ₂₂)	0.520	0.2600	2
		Concrete Crack Widths (SC ₂₁)	0.240	0.1200	5
		Carbonation Depth Metrics (SC ₂₃)	0.240	0.1200	5
Total Target Focus	1.000	—	—	1.0000	—

The detailed analysis indicates that Ultrasonic Pulse Velocity [UPV] Profiles (SC₂₂) has the second biggest value globally (12.50%) while Liquid Cash Flow (SC₁₁) has the third largest score worldwide (13.75%). Therefore, it can be asserted that a building's overall stability depends on the contractor's cash flow during the construction period as well as regular physical testing of the sub-surface during its operational existence.

4.4. Strategic Discussion

It is evident that there are specific benefits in the area of asset management when AHP is being used with respect to the set of key engineering options presented. Being stated, technical efficiency and financial viability can be shown to be better predictor of success than tenders' price. What is more important, the methodology highlights that inspections by themselves do not suffice to prioritize repairs during structural evaluations. When NDT parameters are given sufficiently high importance (42.39%), the money is allocated to those objects that suffer from structural problems inside instead of the ones that suffer from the damages on their exterior.

5. Conclusion

The research indicates that the Analytical Hierarchy

Process (AHP) is an effective method in supporting decisions related to structural control used in building construction and operation.

The key results of the research are:

1. Reduced Subjectivity in Choice of Contractors: The selection model of contractors is developed on a rational model, which takes into account the Technical Capability (39.13%) and the Financial Soundness (26.83%);
2. Data-Based Audit of Structures: The technology of auditing structures is based on Non-Destructive Testing data, which makes it possible to detect hidden damage rather than keeping on relying on visual inspections of the structure;
3. Effective Allocation of Resources: Use of the model makes it possible to perform assessments of sub-criteria, which allows civil engineers and property developers making straightforward decisions, maximizing safety of structures and increasing profitability of capital expenditures.

Future research may focus on improving automated networks for facilities' maintenance by combining the above models with sensors of structural health monitoring and Building Information Modeling systems.

References

- [1] Abdul Kareem Abdul Jawwad, and Ibrahim AbuNaffa, "Applying Analytical Hierarchy Process (AHP) in Selecting Best Maintenance Strategies for Newly Established Chemical Fertilizers Plants," *Journal of Quality in Maintenance Engineering*, vol. 28, no. 3, pp. 545-566, 2022.
- [2] Murat Gunduz, Khalid Naji, and Khalid Al-Salahi, "Evaluation of Critical Success Factors (CSFs) in Selecting Building Contractors through Pareto and Analytical Hierarchy Process," *Journal of Engineering Research*, vol. 8, no. 4, pp. 1-15, 2020. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [3] Solomon Belay et al., "AHP based Multi Criteria Decision Analysis of Success Factors to Enhance Decision Making in Infrastructure Construction Projects," *Cogent Engineering*, vol. 9, no. 1, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [4] Changsaar Chai, Chia Kuang Lee, and Mervyn Hsin Jyi Wong, "Analytic Hierarchy Progress (AHP) for Construction Technologies Adoption in the Malaysian Construction Industry," *Sustainable Construction and Heritage Conservation in the Digital Age*, pp. 113-144, 2026. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]

- [5] Zhen-Song Chen et al., "Expertise-based Bid Evaluation for Construction-Contractor Selection with Generalized Comparative Linguistic ELECTRE III," *Automation in Construction*, vol. 125, 2021. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [6] Daniel Jato-Espino et al., "A Review of Application of Multi-Criteria Decision Making Methods in Construction," *Automation in Construction*, vo. 45, pp. 151-162, 2014. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [7] Mary Hardie, and Swapan Saha, "Builders' Perceptions of Lowest Cost Procurement and Its Impact on Quality," *The Australasian Journal of Construction Economics and Building*, vol. 9, no. 1, pp. 1-8, 2009. [[CrossRef](#)] [[Publisher Link](#)]
- [8] Iman Nurjaman, and Rully Andika Listyantoko, "Analytic Hierarchy Process for Determination of Decision Making in the Selection of Contractors," *Jurnal Industry Xplore*, vol. 8, no. 1, pp. 1-9, 2023. [[Google Scholar](#)]
- [9] Reuben A. Okereke, Dennis Isaac Pepple, and Nneka Mercyjane Ihekwe, "Assessment of the Major Contractors' Selection Criteria and Their Impacts in Civil Engineering Construction Projects," *ITEGAM- Journal of Engineering and Technology for Industrial Applications (ITEGAM-JETIA)*, vol. 8, no. 36, pp. 4-13, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [10] Alaa Salman, "Selection of Construction Bidders using the Analytical Hierarchy Process and Friedman Theory," *Frontiers in Built Environment*, vol. 7, pp. 1-11, 2021. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]