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Evaluating Maintenance Priority of Structural and Architectural Elements in School Facilities Using AHP Methodology

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ABSTRACT

This paper examines the urgent problem of declining school infrastructure in Iraq, attributed to constrained maintenance funding and the lack of systematic prioritization procedures. It especially seeks to identify and prioritize the most essential maintenance work in educational facilities *via* the Analytic Hierarchy Process (AHP). The research sample comprised 30 individuals with substantial expertise in school building management, and five comprehensive interviews were conducted to integrate expert viewpoints and validate the chosen criteria. The Analytic Hierarchy Process (AHP) was utilized to conduct pairwise comparisons of structural and architectural components through a structured questionnaire. The consistency ratio (CR = 0.00) validated the dependability of the assessments. The results indicated that structural components (88%) were substantially more important than architectural components (11%). Among the structural components, foundations had the highest priority weight (0.36), followed by ceilings (0.20) and roofs (0.16). Elements such as ceiling paint were assigned the lowest priority (0.01). These findings establish a quantitative framework for prioritizing maintenance decisions and efficiently allocating scarce resources. By concentrating on elements that directly affect structural integrity, decision-makers can improve safety, extend building longevity, and optimize budget allocation. The study emphasizes the regional significance of emphasizing foundations in Iraqi schools, in contrast to findings from other areas. The study enhances the field by illustrating the applicability of AHP in a tangible school setting and providing a reproducible framework for analogous contexts. Future research may investigate the integration of AHP with digital tools, such as BIM, and broaden its focus to encompass private schools or various geographic regions.

Keywords: School buildings, Maintenance, Priority, Analytical hierarchy process, Decision making.

INTRODUCTION

Maintenance is essential for educational institutions to fulfill their intended functions. The upkeep of school facilities is essential for guaranteeing the optimal functioning of all building systems and components. This fosters an educational atmosphere that enhances academic success. The expense of maintenance constitutes a significant portion of a building's life cycle cost and serves as a metric for evaluating maintenance performance (Khodeir, 2015). Because of inadequate finance, poor planning, and the absence of data-informed decision-making procedures, school buildings in Iraq suffer structural damage, outdated infrastructure, and inadequate upkeep. Particularly in areas already under administrative and financial constraints, these problems hinder the provision of safe and efficient learning environments (Alraie & Breesam, 2018). Previous research has examined many facets of school maintenance across numerous contexts; however, there has been less focus on Iraqi school infrastructure. Most contemporary methodologies lack a framework specifically designed for the socio-economic and institutional contexts of Iraq. Consequently, there is an urgent requirement for a systematic and transparent approach to prioritize maintenance activities, especially for facilities that have experienced prolonged neglect. This discrepancy emphasizes the necessity of a strategically devised plan suitable for the local context. This study addresses the research gap by emphasizing maintenance objectives in Iraqi school buildings and offering a systematic framework for decision-makers. The Analytic Hierarchy Process (AHP) was selected as the primary method to achieve the research objectives. The Analytical Hierarchy Process is a robust multi-criteria decision-making process that enables decision-makers to systematically evaluate competing requirements through pairwise comparisons and expert evaluations. This study clearly connects the Analytic Hierarchy Process (AHP) to Iraq's pressing maintenance challenges, offering practical solutions for the effective distribution of limited resources. The results demonstrate that foundations, ceilings, and roofs should be prioritized due to their impact on structural integrity and occupant safety. The study additionally examines specific challenges in Iraq, such as declining school infrastructure, inadequate funding, and limited access to modern maintenance equipment. This research leverages AHP to propose a replicable system for prioritizing school maintenance that is evidence-based, transparent, and adaptable, thereby supporting local stakeholders in making informed decisions to strengthen educational infrastructure.

LITERATURE REVIEW

Previous Research on School Building Maintenance

There has been an increase in the amount of published research on implementing priority maintenance plans for buildings over the last few years (Raed et al., 2016). This is proved by the increasing number of books, research articles, and conference papers tackling this issue. It is clear that researchers and practitioners have realized that for facilities to remain functional and durable, there is a need to find efficient solutions for maintenance. Literature review findings indicate a rising interest among scholars and practitioners in priority maintenance plans for educational buildings indicated by its continual growth trend. For this reason, more research should be carried out to unravel complexities involved in sustainable and cost-effective maintenance of education infrastructure. Although the quantity of literature on building maintenance is expanding, empirical investigations into Iraq's public school facilities are scarce. Noting that the majority of research has been conducted in stable or developed countries, such as China, Malaysia, and other European countries, the Iraqi context, which is grappling with security and economic challenges, lacks comparable practical studies. Research has primarily concentrated on the upkeep of commercial structures, residential complexes, and hospitals, neglecting governmental schools, which are among the most neglected and deteriorating facilities. Despite the fact that numerous studies employed pre-existing or global standards, their applicability in various nations, including Iraq, was undermined by their failure to consider their suitability for local contexts. No research has explicitly examined the influence of wars, funding delays, or infrastructure failures on maintenance priorities, all of which present substantial obstacles for Iraqi schools. For example, Besiktepe, Ozbek and Atadero (2020) thoroughly analyzed economical ways of maintaining learning institutions. The evaluation covers preventive, predictive, as well as condition-based methods, among others. The authors stressed the significance of deliberately maintaining and sustaining educational infrastructure. The main conclusions of the research underline the importance of being pro-active in relation to maintenance strategies for educational buildings for saving costs, better building performance and higher tenant satisfaction. Chan et al. (2023) carried out a case study in China wherein they employed the Analytical Hierarchy Process (AHP) to determine the order of importance for school building maintenance needs. Their study pointed out that decisions on maintenance should be based on factors, such as the state of structure, safety concerns, financial limitations, among others. The basic conclusion from this research is that AHP is a very efficient technique when it comes to arranging school building maintenance needs according to their relative importance. Analytic Hierarchy Process (AHP) provides systematic decision-making towards maintenance where numerous criteria are taken into account by various stakeholders, as mentioned in (Waris et al., 2019). Without a clear-cut preservation method and with poor maintenance measures, alongside the oldness of the buildings, building parts such as windows, doors, roofing materials, electric cables… etc., are damaged. In public housing, maintenance preferences have been examined by Nor'Aini et al. (2012). They found that user safety and health together with the preservation of the building's habitability and operating conditions were responsible for causing maintenance actions. For users, maintaining installation problems, sanitary problems and pipe leaks are of topmost priority.

Identifying Criteria through Literature Review for Building Maintenance

A literature review was undertaken to identify the key factors influencing the decision-making process for school building repair. The literature emphasizes the significance of explicit standards and pre-requisites to provide efficient maintenance processes and prosperous school facility management. Multiple studies have highlighted the significance of identifying criteria for enhancing the overall quality and functionality of educational infrastructure. The literature evaluation focused on research that analyzed the criteria and factors influencing building maintenance processes and decision-making methodologies. The established criteria were employed in the formulation of the questionnaire disseminated to a sample of engineers, specialists, and school administrators. This methodology sought to gather and examine data to discern the elements affecting maintenance procedures and associated decision-making. Table 1 provides a concise overview of the criteria and pertinent research discovered in the literature.

Table 1. A review of the criteria for building maintenance.

Num.	Criteria	Source
1	Risk	(Alani, Tattersall, and de Brito, 2002), (Desbalo, Woldesenbet, and Yehualaw, 2024)
2	Cost	(Balubaid & Alamoudi, 2015),(Kashkool, 2024)
3	Quality	(Machado et al., 2022)
4	Safety	(Machado et al., 2022)
5	Importance	(Alani et al., 2002)
6	- Construction materials - Building services - Age and condition of the building - Structure type - Property utilization - Failure to perform maintenance promptly	(Kadhim & Altaie, 2023), (Besiktepe, Ozbek & Atadero, 2020)
7	- Updated health and safety protocols - Financial limitations	(Kadhim & Altaie, 2023),(Besiktepe, Ozbek & Atadero, 2020)

RESEARCH METHODOLOGY

The study's methodology is to provide standards for the maintenance of school buildings in Iraq. In order to accomplish the study's goal, the researchers separated it into three separate phases. In order to accomplish this, we performed an extensive examination of the current academic literature pertaining to the topic. Before creating the survey, the researchers conducted multiple interviews with school building maintenance experts to determine the relevance of the criteria specified through a literature review in their decision-making process. The conversations regularly generated input indicating that danger, safety, security, and cost were the primary factors to be considered when making decisions regarding school building upkeep. Furthermore, we highlighted the significance of reviewing present circumstances, following legal obligations, guaranteeing adherence to the law, and taking sustainability into account when assessing cost and financing alternatives in certain scenarios. Taking these variables into consideration, we developed an internet-based survey to confirm the criteria outlined in previous studies, evaluate their significance, and determine any supplementary criteria required for making decisions regarding school building upkeep. The paper offers guidance to decision-makers in Iraq on how to establish clear criteria for maintaining school buildings. The essay underscores the significance of creating precise standards to guarantee efficient maintenance operations and underlines crucial aspects that must be taken into account during the definition process. The study centers on the identification of the most effective maintenance practices for school buildings. The study aims to determine the most pertinent criteria and indicators for ensuring the maintenance and repair of school facilities, which is crucial for delivering high-quality services. In the third stage, we employed the Analytical Hierarchy Process (AHP) technique to ascertain the relative significance of the specified criteria. Figure 1 illustrates the flowchart of the research methodology depicting the three distinct phases of the research methodology for the maintenance of school buildings in Iraq, including the tools used and objectives of each phase:

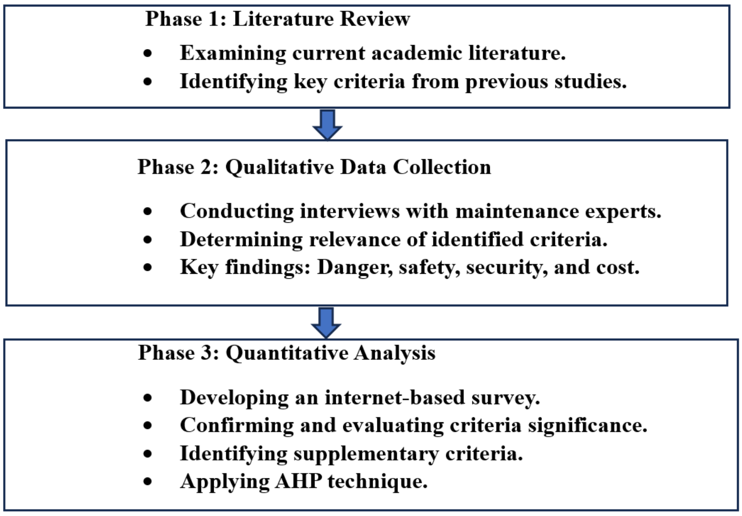

Figure 1. Flowchart of the methodology of the study

DATA COLLECTION

The study utilized expert interviews, thus collecting qualitative data and an AHP-based structured electronic survey to gather quantitative information.

Five experts from school building maintenance fields participated in semi-structured interviews for this study, because they had various professional backgrounds in civil engineering, architecture and project management. The researchers created open-ended questions ahead of time, yet kept the survey open for participants to share their opinions freely. The researchers analyzed the gathered data through thematic analysis, so that they could identify prevailing themes and repeated patterns. The gathered information from interviews helped develop and verify the fundamental set of criteria which would later be included in the survey.

An electronic questionnaire was developed which employed the pairwise comparison model (Saaty scale: 1-9) that derives from AHP methodology. The questionnaire employed the AHP method to gauge the maintenance priority of building components. A total of 9 building elements were assessed through Saaty's 1-9 pairwise comparison framework. The participants were asked questions like:

The foundation requires more attention in maintenance endeavors compared to roof preservation needs.

The prioritization lies between repairing walls or doing maintenance on ceilings.

Does maintaining beams take priority over doors during maintenance activities?

The importance of ceiling paint stands lower compared to the importance of columns.

The questionnaire was distributed through email using Google Forms before the participants answered the questions during a one-week time frame. Survey participants needed between 15 minutes and 20 minutes to finish the questionnaire on average. A preliminary trial involving three impartial individuals assessed the readability and functionality of the survey questions before the official survey deployment. The participants received minor design updates after sharing their feedback.

The research utilized purposive sampling methods to obtain participants who worked in school building maintenance. The analysis involved 35 qualified experts with civil engineering expertise at 40%, while architectural engineers made up 30% and project managers together with government officials responsible for maintenance constituted the remaining 30%. Experts were chosen through purposive sampling, because the intent was to assemble representatives from the maintenance sector with specialized perspectives.

The study heavily depended on expert judgment, so, the researchers focused on eliminating bias and maintaining uniform responses. Each criterion received a rating through the pairwise comparison system which minimized arbitrary or subjective assessments. Each participant received a Consistency Ratio (CR) calculated through the mathematical procedures from the AHP model. Among all gathered responses the average CR amounted to 0.06 which demonstrates strong consistency among the participants. The Consistency Ratio (CR) was automatically computed through the AHP model during survey response evaluation sessions. The reliability of the results required a threshold CR value of less than 0.1 for this assessment to be valid. The overall participant judgment consistency measured by CR average reached 0.06, which showed strong agreement among the participant responses. A couple of responses demonstrated values that barely exceeded the pre-defined threshold limit.

The analysis followed protective procedures through which results exhibiting CR values greater than 0.1 were eliminated to sustain data authenticity. A matrix consistency ratio below 0.1 led to inclusion in weight calculation for the final criteria. The evaluation method protected the reliability of research outcomes while upholding both validity and sample dimensions.

The displayed images in Figure 2 show real photographs of Iraqi school facilities with apparent deterioration in their architectural and structural components. The images functioned as extra material to illustrate the actual maintenance problems rather than belonging to quantitative data collection procedures. The data illustrates real-field requirements for maintenance interventions within the educational sector and backs up the study's assessment results.

Figure 2. Images of school buildings in Iraq

The Analytical Hierarchy Process (AHP)

Thomas L. Saaty developed the Analytical Hierarchy Process (AHP) which is a strategy of decision making (Saaty, 1980). By factoring in the decision maker's subjective evaluation, this method assigns numerical values to each of the available alternatives. The approach emphasizes the significance of the decision-maker's intuitive perceptions and the need for consistency when comparing alternatives in the decision-making process. It is proposed that the main advantage of this method is its ability to systematically organize both tangible and intangible aspects, providing a structured and straightforward answer to decision-making challenges.

The AHP-based strategy has gained popularity, primarily because of its straightforward and systematic implementation phases (Balubaid & Alamoudi, 2015). The Analytical Hierarchy Process entails the following steps:

Hierarchical Structure

Establishing a hierarchical structure is a fundamental aspect of AHP (Saaty, 1980). Creating a hierarchy is regarded as a crucial component of the Analytical Hierarchy Process (AHP), and there is no specific method dedicated to this task. Establishing a hierarchy is a process that follows a top-down approach and encompasses several levels. The elements inside each level are carefully regulated to ensure that they have the same size and importance. The elements at the same level must be associated with other corresponding factors of the structure. The process of constructing the AHP hierarchy normally commences with the overarching goal and subsequently breaks down into sub-ordinate decision elements. The number of hierarchical tiers in an Analytical Hierarchy Process (AHP) model is contingent upon the intricacy of the problem and the degree of quantification for each component. However, a typical AHP model comprises four layers. The hierarchy begins with Level 1, which represents the objectives or goals. Level 2 represents the main criteria associated with these objectives, while Level 3 represents the sub-criteria. Finally, Level 4 of the hierarchy contains the available options or choices. In summary, the criteria, sub-criteria, and alternative options are grouped together in order to achieve the highest level of excellence or target. A typical AHP hierarchy structure is shown in Figure 3.

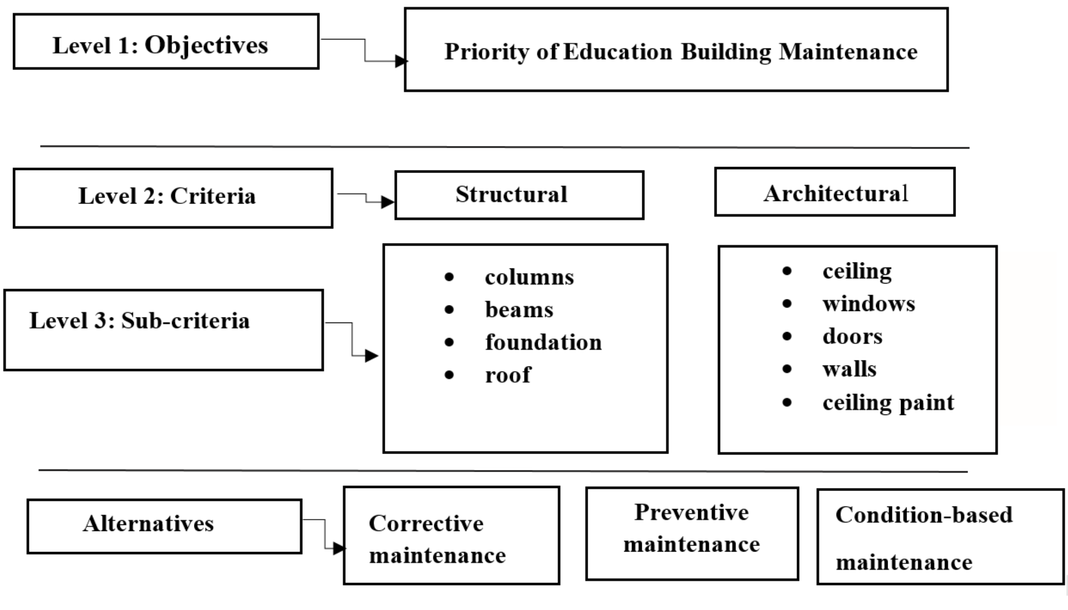

Figure 3. Analytical hierarchy process model

Pairwise Comparison

After the building of the hierarchy, the subsequent phase involves determining the relative significance of the primary criteria and sub-criteria by comparing them in pairs. This stage is crucial and is regarded as the backbone of AHP. Throughout this process, the constituents in every set within the hierarchy are juxtaposed with their corresponding members in the group. The items' relative importance is measured using a nine-point scale, as depicted in Table 2. The magnitude of this scale varies from 1 to 9 (Waris et al., 2019), where each value signifies the magnitude of preference or significance. We use even numbers (2, 4, 6, 8) as intermediary values to express a degree of preference or significance between neighboring odd numbers. When the preference or priority lies between the provided possibilities, these intermediary values allow decision-makers to make more nuanced judgments. In order to determine the importance of each criterion, the decision-makers' evaluations in the paired comparisons are utilized to create a pairwise comparison matrix (A). Since there are n criteria for comparison, Matrix A is a square matrix of size n x n The matrix is developed by placing the comparative criteria in the rows and columns.

These assessments are aggregated by taking the geometric mean of the pairwise comparison matrices involving the decisions. The geometric mean makes sure that the weights or priority values support the multiplicative structure of the judgment and have the same relative relation as from the pairwise comparison. To develop a uniform pairwise comparison matrix (A), the geometric mean method applies directly to evaluation judgments.

The matrix A from the analytical hierarchy process (AHP) supports structuring criteria and is applied to calculations and decisions derived from the selected criteria.

$$A=\begin{bmatrix} a11 & \ldots & a12 \ldots & a1n \\ a21 & \ldots & a22 \ldots & a2n \\ an1 \ldots & & an2 \ldots & a3n \end{bmatrix} \ldots\ldots\ldots\ldots(1)$$

Let A be the comparison matrix with elements a _{ij} and n the dimension of the matrix.

Table 2. The basic scale of pairwise comparison

Importance level	Definition
1	Both elements hold equal significance.
3	One element holds greater significance than the other elements.
5	One element holds greater significance compared to the other others.
7	One of the elements is undeniably more significant than the other ones.
9	One element is of paramount importance in comparison to the others.
2,4,6,8	The values of the two considerations are in close proximity.

Checking the Consistency Ratio

AHP for performing pairwise comparisons includes the consistency check to ensure the reliability of the results. Flaws may be observed in the form of inconsistencies in the sense that the results of one pair comparison may contradict those of another pair comparison. Checking is carried out in order to detect any inconsistency and this is conducted by using the consistency index (CI) and the consistency ratio. CI is established by applying the principal eigenvalue of the matrix that compares each pair of elements.

1. Create a matrix with two axes to compare each element to every other in the criterion or sub-criteria.
2. To get the consistency index CI, we check the rank or size of the matrix against its largest eigenvalue. A formula that is commonly used is (Unver and Ergenc, 2021). The confidence interval (CI) can be estimated by the following equation.

   Thus, the formula is $(\lambda_{max} - n) / (n - 1)$ … (2)

   λ_{max} is the symbol used to denote the largest eigenvalue of the matrix and n is the order or size of the matrix.
3. Calculate the random index (RI): The random index (RI) is a reference value that is determined by the matrix's order and size. It represents the level of consistency that can be expected. Tables or lookup values are available to calculate the RI based on matrix size.
4. Determine the consistency ratio (CR) by dividing the CI value by the RI value. RI values are shown in Table 3. The formula for calculating CR is (Balubaid & Alamoudi, 2015):

CR = CI/RI ……. (3)

CR measures the consistency of pairwise comparisons. A CR value of less than 0.1 (or 10%) is generally accepted as demonstrating a fair level of consistency. Calculating the consistency ratio allows to determine the level of inconsistency in pairwise comparisons. If the CR exceeds the allowed threshold, it indicates that discrepancies exist, and modifications may be required in pairwise comparisons to improve consistency. Decision-makers need to review problematic pairwise comparisons that resulted in inconsistency; then to readjust their evaluation decisions to achieve better coherence. This iterative process involves:

- Decision-makers should use consistency improvement techniques to review the most inconsistent pairwise entries.
- Experts should clarify their assessments together to reach consensus during evaluations with multiple participants.
- The CR-consistency check should be repeated after modifications have been made to reach a level of ≤ 0.1 for CR.

The elimination of contradictions through consistency checks during this step makes sure that the AHP model becomes both reliable and valid.

Table 3. Values of random Index

Matrix size (n)	1	2	3	4	5	6	7	8	9
Random Index (RI)	0	0	0.58	0.9	1.12	1.26	1.36	1.41	1.45

RESULTS AND DISCUSSION

Weighting of Building Criteria

Weights are assigned based on the assessment of criteria, elements, and components. The data was gathered by a questionnaire in which respondents provided a comparison value. The calculations were made with the AHP method and were finished in Excel. The answers from the respondents will be added together to figure out how much weight each part of the questionnaire should have. To calculate the mean weight of each component, Table 4 shows construction professionals' pairwise comparisons of structural and architectural components. The scale operates from 1 to 9 with higher numbers indicating that structural elements have more significance compared to architectural features. The assessment team consisted of a civil engineer together with an architect and a site engineer and a project manager. All evaluators scored 35 points which resulted in an average comparative weight of 8.75. A consensus exists among experts that structural components should be prioritized above all other components because of their high average score. The comparison weights serve as inputs in AHP calculation methods that establish building element priority rankings.

The pairwise comparison matrix of structural and architectural components uses AHP (Analytical Hierarchy Process) methodology, as shown in Table 5. Each value shows how critical one criterion is relative to another criterion. The rating between structural components and architectural components showed an 8:1 ratio, thus the matrix cell contains the value '8'. The value '0.125' is used as an inverse relationship to state that architectural components are less important than structural components. Each component maintains equal importance to itself according to the values found on the diagonal. The final row contains a column summary calculation that serves in the normalization process to determine relative criteria weights. The adopted matrix structure provides crucial information which allows the determination of the final component weights within the decision-making framework.

Table 4. Component pairwise comparisons

Respondent	Structural *vs.* Architectural Importance
Civil Engineer	9
Architect Engineer	8
Site Engineer	9
Project Manager	9
Total	35
Average	8.75

Table 5. Comparing the structural and architectural components' importance: A pairwise matrix

Criteria	Structural Components	Architectural Components
Structural Components	1	8
Architectural Components	0.125	1
Total	1.125	9

Table 6. Priority scale for building criteria

No.	Criteria	Weight of the criteria	Weight of the criteria (%)
1.	Structural Components	0.888	88%
2.	Architectural Components	0.111	11%

Weighting of the Questionnaire's Components

Weights are allocated according to an assessment of criteria, elements, and components. The data was gathered through the administration of a questionnaire, in which participants offered a comparative value. The computations were performed using the Analytical Hierarchy Process (AHP) and subsequently processed in Excel. The weighting of the questionnaire's components will be determined by aggregating the respondents' responses and computing the mean weight for each component. A summary of the findings is presented in Tables 7, 8 and 9.

Table 7. Building elements

No.	Building Element
1	Foundation
2	Roof
3	Walls
4	Ceiling
5	Columns
6	Beams
7	Doors
8	Windows
9	Ceiling paint

Table 8. Pairwise comparison scores for different building elements

Comparison	Total Respondents	Average Score
Foundation *vs.* Roof	28	7.0
Foundation *vs.* Walls	23	5.8
Foundation *vs.* Ceiling	30	7.5
Foundation *vs.* Columns	26	6.5
Foundation *vs.* Beams	30	7.5
Foundation *vs.* Doors	30	7.5
Foundation vs. Windows	26	6.5
Foundation *vs.* Ceiling Paint	32	8
Roof *vs.* Walls	26	6.5
Roof *vs.* Ceiling	26	6.5
Roof *vs.* Columns	25	6.3
Roof *vs.* Beams	27	6.8
Roof *vs.* Doors	23	5.8
Roof vs. Windows	25	6.3
Roof *vs.* Ceiling Paint	23	5.8

Walls *vs.* Ceiling	28	7
Walls *vs.* Columns	30	7.5
Walls *vs.* Beams	28	7.0
Walls *vs.* Doors	21	5.3
Walls *vs.* Windows	17	4.3
Walls *vs.* Ceiling Paint	19	4.8
Ceiling *vs.* Columns	24	6
Ceiling *vs.* Beams	27	6.8
Ceiling *vs.* Doors	22	5.5
Ceiling *vs.* Windows	25	6.3
Ceiling *vs.* Ceiling Paint	24	6
Columns *vs.* Beams	30	7.5
Columns *vs.* Doors	19	4.8
Columns *vs.* Windows	17	4.3
Columns *vs.* Ceiling Paint	31	7.8
Beams *vs.* Doors	28	7.0
Beams *vs.* Windows	20	5.0
Beams *vs.* Ceiling Paint	16	4.0
Doors *vs.* Windows	18	4.5
Doors *vs.* Ceiling Paint	24	6.0
Windows *vs.* Ceiling Paint	22	5.5

Using Excel's Analytical Hierarchy Process (AHP) to analyze the survey findings, Table 8 presents the results of pairwise comparisons between various building elements, as evaluated by the participants in the questionnaire. The number of respondents per comparison ranged from 16 to 32. These comparisons were conducted using the Analytical Hierarchy Process (AHP), which relies on a scale of 1 to 9 to express the degree of preference of one element over another. The average score of each comparison reflects the relative importance of one element compared to another from the perspective of construction professionals.

For instance, the comparison between the "foundation" and the "ceiling paint" yielded the highest average score (8.0), indicating that respondents considered the foundation to be far more critical than the ceiling paint. This is consistent with engineering logic, as the foundation plays a central role in the structural stability and safety of a building. On the other hand, the "ceiling paint" element received the lowest overall priority value (0.01), underscoring its limited relevance when prioritizing maintenance tasks.

Moreover, the foundation scored high in almost all comparisons with other elements, such as 7.5 against beams, ceiling, and doors, which led to its highest overall weight (0.36) in the AHP analysis. This weighting confirms that the foundation is regarded as the most crucial component in terms of maintenance priority, justifying the need to allocate resources accordingly. To complement the findings of Table 8, Table 9 shows the average rank and standard deviation for each element. Elements with high average ranks and low standard deviations, such as B and D, are regarded as extremely significant, and their importance is widely agreed upon. Elements with high average rankings, but high standard deviations, such as A, C, and E, necessitate further discussion and compromise to guarantee that all stakeholders' needs are addressed.

Table 9. Average ranking and standard deviation

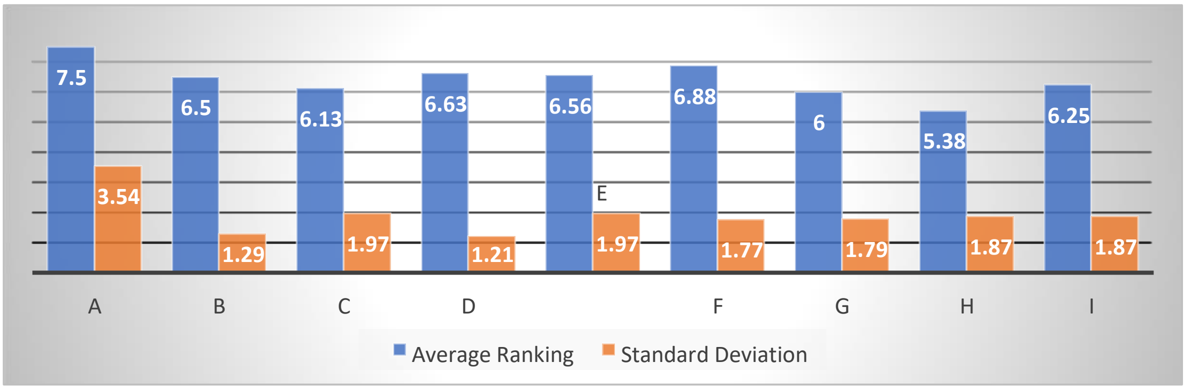

Table 10 shows the priority scale for building elements in school buildings, as well as the value of the analysis of results.

Table 10. Prioritization scale for sub-criteria in school building maintenance

No.	Component	Importance
1	Foundation	0.36
2	Ceiling	0.20
3	Roof	0.16
4	Walls	0.10
5	Beams	0.07
6	Columns	0.04
7	Windows	0.03
8	Doors	0.02
9	Ceiling Paint	0.01
10	Total	1.000

AHP Results

The AHP analysis revealed that the importance of structural components for maintenance prioritization was found to be much higher (88%) compared to that of architectural components (11%). The foundation was given the highest priority (0.36) among the various building parts, followed by the roof (0.28) and walls (0.15). The consistency ratio was 0.00, signifying a very high level of consistency in the judgments provided by the respondents. These findings indicate that it is advisable to prioritize maintenance efforts and allocate resources to important structural components that have a significant impact on the overall stability and safety of school buildings. The significant emphasis focused on foundations is in accordance with their pivotal function in providing support to the entire construction. Roofs and walls are considered to be of significant importance due to their crucial role in safeguarding the building inside from environmental elements. This aligns with previous findings. Alani, Tattersall & de Brito (2002) conducted a study entitled "Prioritizing Building Maintenance Projects: A Fuzzy Approach," which stressed the relevance of structural aspects in building maintenance. However, our study found a greater rate, which could be due to Iraqi-specific factors. Our results are different. Foundations were given the highest priority in our study (0.36). This finding is consistent with Waheed, Saeed & Ullah (2015) study, "Ranking of Maintenance Factors Affecting Building Performance in Developing Countries," which stressed the importance of foundations in developing-country buildings. However, Ashworth & Perera (2015) in their book "Cost

Studies of Buildings" placed the roof as the most important element, indicating potential variances related to climatic and regional conditions.

CONCLUSIONS

This research utilized the Analytical Hierarchy Process (AHP) to create an evidence-based systematic method that determines priority order of educational facility maintenance work. The research used experts alongside pairwise tests to determine which main structural elements, require immediate improvement. The study outcomes conclusively demonstrated that structural elements especially foundations, ceilings and roofs, occupy a vital position, since they serve to protect the safety along with stability of educational institutions. Trustworthy results demonstrated AHP's effectiveness as a decision guidance tool for distribution of Iraqi schools' limited maintenance resources. The research findings demonstrate a reliable basis for maintenance planning, since expert responses exhibit strong consistency (average CR = 0.06). The research clarifies that maintenance decision adjustments are essential, because they must align with present circumstances while factoring in budget issues, ecological aspects and legal obligations. The output is a flexible operation framework which enables policymakers and engineers to create clear maintenance plans that boost safety performance and operational duration of educational buildings. Further research should integrate AHP with modern technologies, especially fuzzy logic, BIM and machine learning, to enhance maintenance planning when faced with uncertainty conditions. The present investigation provides foundational understanding for data-driven public infrastructure maintenance approaches notably in schools that lack proper funding.

Recommendations for Future Research Topics

The integration of AHP and the expansion of the research area to other domains will greatly improve future studies on school building maintenance.

1. Implementing AHP technique: Educational institutions and entities accountable for school building maintenance should utilize the Analytical Hierarchy Process (AHP) approach to enhance the efficiency of maintenance prioritization.
2. Training staff: Training programs for engineers and technicians should be coordinated in charge of maintenance to acquaint them with the utilization of the Analytical Hierarchy Process (AHP) model for assessing and ranking maintenance tasks.
3. Evaluating the potential of AHP in its integration with modern technologies that may include BIM and predictive analysis.
4. Conducting comparative research with other countries to share best practices in school building maintenance and use lessons learned.

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