

ANALYSIS OF THE EFFECT OF CONCRETE QUALITY IN HOUSE CONSTRUCTION: A DECISION-MAKING MODEL BASED ON ENVIRONMENTALLY FRIENDLY CRITERIA

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Abstract

This study analyzes the influence of concrete quality on house construction using a Decision Tree. Good concrete quality and proper maintenance are key factors for building sturdiness and longevity, especially in areas with varying environmental conditions. The study was conducted on 20 houses in three regions of Aceh, with samples selected purposively based on concrete quality documentation (K-225, K-300, K-350) and maintenance records. Data were collected through observation, project documentation, and interviews with contractors and builders. The analysis included descriptive, inferential (correlation and multiple regression), and the application of a Decision Tree to identify the concrete parameters most influential on building quality. The results indicate that concrete quality is the most critical factor, followed by maintenance quality and environmental conditions. Houses with high-quality concrete (K-300/K-350) and a minimum curing period of 14 days have optimal sturdiness, minimal cracking, and a longer service life. The Decision Tree produced a consistent pattern with 82.5% accuracy, while qualitative data reinforces these findings by emphasizing the importance of maintenance protocols and the quality of implementation in the field. This research provides practical implications in the form of minimum quality recommendations, standard maintenance protocols, and enhanced quality control. The results contribute to the development of a data-driven decision-making framework for selecting efficient, safe, and sustainable concrete specifications.

Keywords: concrete quality, house construction, Decision Tree, concrete maintenance, Aceh.

INTRODUCTION

The introduction includes background on issues or problems, urgency and rationalization of service activities. The activity objectives and problem-solving plans are presented in this section. Relevant literature reviews and analysis of specific situations for service are included in this section. The citation and citation model used in the article is APA Style. (Times New Roman, 12, normal). Housing is a fundamental human need that not only serves as shelter but also plays a crucial role in physical, psychological, and social well-being. Within Maslow's hierarchy of needs, housing constitutes the foundation of physiological and safety needs, enabling individuals to pursue higher-level needs (McCray & Day, 1977; Fullilove, 2010). Adequate housing cannot be assessed solely based on the presence of a physical structure; it must also consider affordability, sufficient living space, and a supportive environment that enhances community quality of life (Bratt, 2002). Moreover, housing conditions directly affect health by providing a safe and clean environment and by reducing stress levels (Fullilove, 2010). Deficiencies in location, community services, or social dimensions may hinder the fulfillment of higher-level needs even when housing is physically available (Hale et al., 2019). In the Indonesian context, housing demand has intensified due to rapid population growth and urbanization. To address this challenge, the government has introduced initiatives such as the One Million Houses Program and public housing credit schemes. However, housing development practices continue to face various obstacles, including project delays caused by weak planning and supervision (Proboyo, 2004; Dolo et al., 2012), rising construction costs due to land price speculation (Mangkoesebroto, 1992), and legal issues related to housing marketing and sales (Yetti & Yalid, 2022). In addition, technical aspects of building construction are often neglected, despite the fact that construction quality is a critical determinant of housing

adequacy, particularly in urban areas (Meng et al., 2006). One of the most influential technical elements affecting construction quality is concrete quality. Concrete quality plays a vital role as it is directly related to the strength, durability, and safety of building structures (Brian Alfandi et al., 2021; Resatoglu & Jkhsi, 2022). Therefore, analyzing the influence of concrete quality is essential to ensure that housing is safe, comfortable, and durable. Decision-model-based approaches can be applied to determine optimal concrete quality, thereby minimizing the risk of structural failure while improving construction cost efficiency. Concrete is the dominant construction material in modern housing development, replacing traditional materials such as wood and bricks in many structural elements. As a composite material consisting of cement, coarse aggregate, fine aggregate, and water, concrete possesses characteristics that allow flexible shaping, high compressive strength, and resistance to various environmental conditions. These properties make concrete the primary choice in contemporary residential construction.

Within residential structures, concrete plays a vital role in foundations, columns, beams, and walls. Reinforced concrete foundations safely transfer vertical and lateral loads from the superstructure to the soil; concrete columns act as vertical load-bearing elements that transmit loads to the foundation; and concrete beams function as horizontal members that support and distribute loads from floors and roofs. Concrete walls may serve both as load-bearing elements and spatial partitions. Concrete quality directly influences the strength, durability, and service life of buildings. Adequate compressive strength ensures that structures can withstand dead loads, live loads, and environmental loads such as wind or earthquakes. Resistance to moisture, temperature variations, and chemical attacks determines long-term durability. An optimal service life is achieved when concrete quality is appropriately matched to its structural function and environmental conditions.

Variations in concrete quality in construction practice are influenced by the quality of constituent materials, mix proportions, water–cement ratio, moisture content, casting processes, and curing methods. Concrete strength classes range from K-175 for non-structural applications to K-400 or higher for specialized structures. Excessive water–cement ratios reduce concrete strength and increase permeability. Inadequate curing can reduce compressive strength by up to 50% of its maximum potential, while environmental temperature and humidity also affect strength development and durability. Variability in these factors leads to inconsistent concrete quality, which in turn affects the safety and overall quality of building structures. This condition underscores the importance of implementing decision models to analyze and determine optimal concrete quality based on residential structural requirements, thereby minimizing the risk of damage and repair costs.

The use of low-quality concrete in housing construction constitutes a serious issue that compromises building safety and durability. This phenomenon is particularly prevalent in small- and medium-scale housing projects, where concrete quality control is often neglected in favor of cost and time efficiency. Substandard concrete in critical structural elements such as foundations, columns, and beams can result in cracking, excessive deformation, reduced load-bearing capacity, and even total structural failure. Cases of cracking in residential buildings that are only a few years old indicate serious problems related to concrete quality. Such cracks not only affect aesthetics but also serve as early indicators of broader structural failures, including uneven floors, wall damage, and disruptions to building utility systems.

The primary contributing factors include inadequate technical supervision and the absence of routine concrete testing. Many housing projects do not involve professional supervisory consultants and rely solely on visual inspection, leading to the neglect of technical aspects such as slump tests, compressive strength tests, and mix composition evaluations. Errors in concrete mix design or material selection—such as the use of aggregates or cement that do not meet standards—can also result in concrete with characteristics that deviate from specifications. External factors such as weather conditions and site environment further influence concrete quality. Casting under extreme weather conditions, the use of contaminated water or unclean sites, and material contamination can significantly degrade concrete performance. The complexity of these internal and external factors highlights the need for a systematic, decision-model-based approach to support decision-making in material selection, mix design, and quality control, thereby minimizing the risk of structural failure.

Decision-making in residential construction, particularly regarding concrete selection and specification, remains largely subjective and is often based on practical experience, customary practices, or purely economic considerations. Such approaches risk producing suboptimal decisions that negatively affect building quality, safety, and durability. The factors influencing concrete quality—ranging from mix composition and construction methods to quality supervision—are complex and therefore require systematic, data-driven approaches (Brian Alfandi et al., 2021; Setiyorini & Wahono, 2015). Decision models such as decision trees, the Analytical Hierarchy Process (AHP), fuzzy decision-making, and Multi-Criteria Decision Analysis (MCDA) provide structured frameworks for evaluating alternatives and selecting optimal solutions based on predefined criteria (Chaube et al., 2024).

The implementation of data-driven models in residential construction offers several benefits, including reduced risk of specification errors, improved resource efficiency, and enhanced building safety through systematic risk evaluation and quality monitoring (Seo & Yoon, 2025). By defining key parameters and standard thresholds, decision-support systems also enable early detection of deviations in concrete quality, allowing corrective actions to be taken before serious structural impacts occur. A review of the literature indicates that while numerous studies have examined concrete quality and decision models in construction, few have integrated these two aspects specifically for residential housing development. Most existing studies focus on large-scale infrastructure such as bridges, high-rise buildings, or commercial projects, leaving the unique characteristics and requirements of residential housing underexplored within model-based decision-making contexts.

Previous research generally addresses concrete quality from material science or structural engineering perspectives without considering the managerial and decision-making aspects that are critical in construction practice. Conversely, studies on decision models tend to be generic and do not specifically address the optimization of concrete quality in residential construction. This gap results in a lack of practical guidance for construction practitioners in determining optimal concrete specifications and management strategies. The urgency of this research is further underscored by the continued growth of housing development in Indonesia, accompanied by an increasing number of structural failures caused by low-quality concrete. Therefore, this study aims to map the influence of concrete quality on the final quality of residential buildings through a systematic approach and to develop a practical decision-making framework. Accordingly, this research is expected to fill this gap by developing a decision-making model specifically for residential housing construction that integrates concrete quality with other factors such as cost, time, risk, and user requirements. The resulting model is anticipated to serve as a practical tool for developers, contractors, consultants, and other stakeholders in making more informed decisions regarding concrete specification and management, thereby improving the overall quality and safety of residential buildings.

METHOD

This study adopts a quantitative approach employing a descriptive–analytical method to examine the influence of concrete quality on residential housing construction. The research design is an explanatory case study aimed at identifying and measuring the causal relationship between concrete strength grade and overall building quality. The primary analysis utilizes a Decision Tree model as a decision-support tool, as it is capable of handling multiple criteria simultaneously while producing results that are interpretable and transparent (Maças et al., 2024). To enrich the findings, qualitative elements are also incorporated through in-depth interviews with construction practitioners. The research population comprises small- to medium-scale residential housing projects. A total of 20 houses were purposively selected based on the availability of concrete quality documentation (K-225, K-300, and K-350) and records of concrete curing processes. The independent variables include concrete strength grade, mix composition (cement, sand, aggregates, and water), and the quality of concrete curing. The dependent variable is housing construction quality, measured in terms of structural integrity, the extent of cracking or damage, and the estimated service life of the building. Control variables include weather conditions, casting methods, and workforce experience.

Data were collected using a triangulation approach: (1) direct observation of the physical condition of the buildings, (2) project documentation such as material reports, concrete quality certificates, and construction logs, and (3) interviews with contractors, craftsmen, and homeowners to obtain qualitative insights. The analysis was conducted in several stages, beginning with descriptive analysis to map the distribution of concrete quality and building conditions, followed by inferential analysis to assess relationships among variables. Subsequently, the Decision Tree model was applied to classify the effects of concrete quality parameters on building performance (Firek et al., 2015; Alghamdi, 2022). Model validation was performed using cross-validation, a confusion matrix, and performance metrics including accuracy, precision, recall, and F1-score (Lane et al., 2018; Ruuska et al., 2018). The research workflow consists of data collection, data cleaning and transformation, development of the Decision Tree model using training and testing data partitions (Qian et al., 2022), interpretation of results to identify patterns in the influence of concrete quality—such as material factors affecting compressive strength (Song et al., 2021)—and evaluation of model performance to ensure predictive accuracy (Elhishi et al., 2023). The study concludes with the formulation of practical recommendations regarding the selection of optimal concrete strength grades for residential construction. Through this approach, the study is expected to provide a systematic understanding of the impact of concrete quality on housing construction performance while offering a data-driven basis for decision-making.

RESULTS

This study involved 20 residential housing units distributed across three different regions in Aceh Province, characterized by diverse geographical conditions. Table 4.1 presents the distribution of the research samples based on location, building type, and the concrete quality used.

Table 1. Demographic Characteristics of the Research Samples

No.	Location	Number of Samples	Building Type	Concrete Grade	Age (years)
1	North Aceh (Coastal Area)	8	1-story (5), 2-story (3)	K-300 (5), K-350 (3)	3–12
2	Lhokseumawe City (Urban Area)	7	1-story (4), 2-story (2), Shophouse (1)	K-225 (3), K-300 (3), K-350 (1)	2–15
3	Bireuen (Inland Area)	5	1-story (3), 2-story (1), Shophouse (1)	K-225 (4), K-350 (1)	5–10
Total	3 Regions	20	1-story (12), 2-story (6), Shophouse (2)	K-225 (7), K-300 (8), K-350 (5)	2–15

The distribution of concrete grades across the Aceh region exhibits variations influenced by local geographical conditions and environmental characteristics. Figure 4.1 shows that residential buildings in North Aceh, particularly in coastal areas, tend to use higher concrete grades (K-300 and K-350) to anticipate aggressive environmental conditions resulting from salt exposure and coastal winds. In Lhokseumawe City, a wider range of concrete grades is observed, reflecting adjustments to construction needs and budget constraints. Meanwhile, in Bireuen, an inland area, the majority of houses use K-225 concrete, primarily due to economic considerations and relatively stable environmental conditions. In addition to concrete grade, differences are also evident in curing practices. The curing process varies from standard curing for 7 days to intensive curing for up to 28 days, implemented through regular water spraying or the use of membrane curing methods. To further clarify these variations, Table 4.2 presents detailed information on concrete mix compositions and curing characteristics for each concrete grade used in the study.

Table 2. Concrete Mix Composition and Curing Characteristics

Concrete Grade	Mix Ratio (Cement:Sand:Aggregate)	w/c Ratio	Curing Duration (days)	Actual Compressive Strength (MPa)	Number of Samples
K-225	1 : 2.5 : 3.5	0.65 ± 0.05	7–14	18.7 ± 2.1	7
K-300	1 : 2 : 3	0.55 ± 0.04	14–21	25.3 ± 1.8	8
K-350	1 : 1.8 : 2.7	0.50 ± 0.03	21–28	29.6 ± 2.3	5

Variations in mix composition were identified in three housing samples that exhibited significant deviations from standard specifications, particularly in terms of higher water–cement ratios. Figure 4.2 illustrates the distribution of curing quality, showing that 60% of the houses (12 samples) applied wet curing for 7–14 days, 25% (5 samples) implemented curing for 21–28 days, and 15% (3 samples) applied minimal curing for less than 7 days.



Figure 1. Distribution of Concrete Curing Quality in Residential Buildings

The evaluation of environmental conditions during the curing period revealed distinct challenges across the study areas. Houses in North Aceh experienced high humidity levels (75–85%) and exposure to salt carried by coastal winds, which can accelerate corrosion processes. Different conditions were observed in Lhokseumawe City, where the urban heat island phenomenon resulted in relatively wide daily temperature fluctuations (24–35 °C). In contrast, houses in Bireuen benefited from a relatively stable inland climate, characterized by controlled humidity levels (60–75%) and more consistent temperatures, thereby enabling more optimal curing processes. The relationship between curing quality and the physical condition of buildings is clearly illustrated in Figure 4.3. Houses that received proper curing exhibited minimal cracking (less than 0.1 mm) while maintaining overall structural integrity.

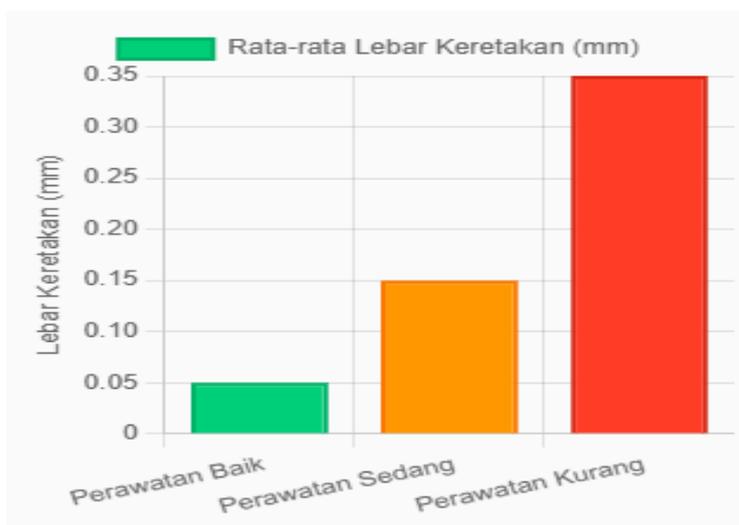


Figure 2. Relationship between Curing Practices and Crack Width

Subsequently, non-destructive testing using the Schmidt Hammer and Ultrasonic Pulse Velocity (UPV) methods was conducted to quantitatively assess variations in structural integrity. The test results are summarized in Table 4.3 based on concrete grade and building condition.

Table 3. Building Quality Test Results

Concrete Grade	Rebound Hammer	UPV (km/s)	Crack Severity	Building Condition Score*	Estimated Service Life (years)
K-225	32–38 (35.2 ± 2.1)	3.8–4.2 (4.0 ± 0.15)	Minor–Moderate	6.2 ± 1.3	25–35
K-300	38–42 (39.8 ± 1.7)	4.1–4.5 (4.3 ± 0.12)	Minor	7.8 ± 0.9	40–55
K-350	42–45 (43.6 ± 1.2)	4.4–4.8 (4.6 ± 0.11)	Minimal	8.7 ± 0.6	50–70

*Building condition score: scale of 1–10 (1 = very poor, 10 = excellent).

The cracking levels observed in the studied houses varied, ranging from hairline cracks to structural cracking. Cracks were most frequently found at beam–column joints and in structural elements subjected to high bending loads. Table 4.4 details the relationship between concrete grade and the physical condition of the buildings, including the percentage of houses with minimal cracking (crack width ≤ 0.2 mm), the average crack width, and the relative structural capacity compared to the design strength. The results indicate that houses constructed with higher concrete grades tend to exhibit fewer cracks and smaller crack widths. For example, in the K-350 grade, all houses (100%) showed minimal cracking, with an average crack width of 0.05 ± 0.02 mm and a structural capacity of 103.2 ± 4.1% of the design strength. In contrast, for the K-225 grade, only 14.3% of the houses exhibited minimal cracking, with an average crack width of 0.28 ± 0.15 mm and a structural capacity of 82.3 ± 8.5% of the design strength. These findings confirm that concrete quality plays a significant role in determining the integrity and robustness of residential buildings.

Table 4. Correlation between Concrete Grade and Building Physical Condition

Parameter	K-225	K-300	K-350
Percentage of houses with minimal cracking	14.3%	62.5%	100%
Average crack width (mm)	0.28 ± 0.15	0.12 ± 0.08	0.05 ± 0.02
Structural capacity (% of design)	82.3 ± 8.5	94.7 ± 5.2	103.2 ± 4.1

The findings reveal a strong correlation between concrete grade and the physical condition of buildings. Figure 4.5 presents a scatter plot with a positive linear trendline ($R^2 = 0.789$), indicating that houses constructed with higher concrete grades and subjected to proper curing practices tend to exhibit optimal physical conditions. This condition is reflected in minimal cracking (≤ 0.2 mm) and improved structural robustness. These results are consistent with Table 4.4, which shows that houses built with K-350 concrete exhibit an average crack width of 0.05 ± 0.02 mm and a structural capacity of 103.2 ± 4.1% of the design strength. In contrast, houses constructed with K-225 concrete display larger crack widths (0.28 ± 0.15 mm) and lower structural capacity (82.3 ± 8.5% of the design strength). Taken together, the scatter plot and the table reinforce the conclusion that concrete quality and curing practices are dominant factors in determining building integrity.

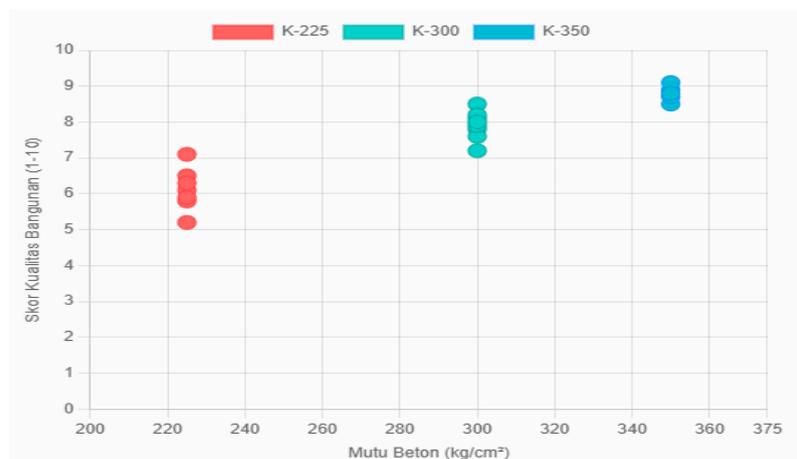


Figure 3. Correlation between Concrete Grade and Building Condition ($R^2 = 0.789$)

The results of the information gain calculations for the parameters used in the development of the Decision Tree model indicate varying levels of influence. As shown in Figure 4.6, the Concrete Grade parameter has the highest information gain value (0.742) and is therefore selected as the root node in the decision tree structure. This finding indicates that concrete grade is the most dominant factor in determining the predicted building condition.

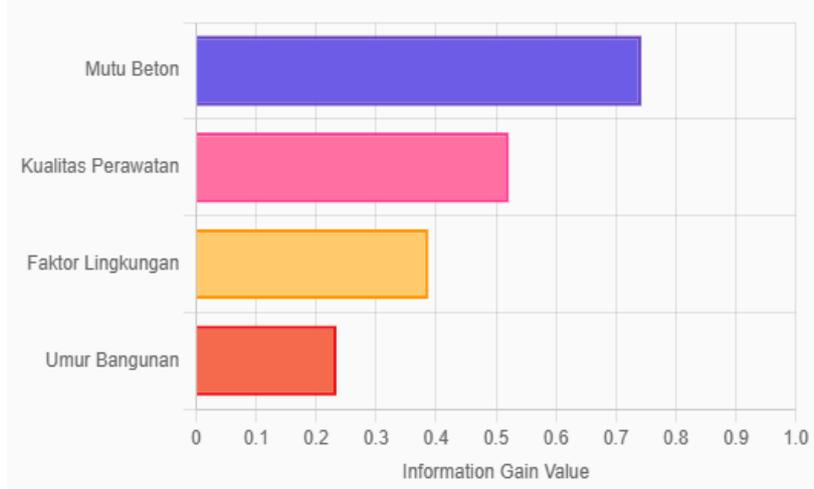


Figure 4. Information Gain in the Decision Tree Model

Table 5 shows that the parameter ranked next after concrete grade is Curing Quality, with an information gain value of 0.521. This parameter is classified as having a high level of importance and yields a prediction accuracy of 78.5%. Subsequently, Environmental Factors exhibit an information gain of 0.387, corresponding to a moderate level of importance and a prediction accuracy of 72.0%. Building Age ranks last, with the lowest information gain value of 0.234, classified as low importance and associated with a prediction accuracy of 65.5%.

Table 5. Information Gain and Prediction Accuracy of the Decision Tree Model

Parameter	Information Gain	Level of Importance	Prediction Accuracy (%)
Concrete Grade	0.742	Very High	85.0
Curing Quality	0.521	High	78.5
Environmental Factors	0.387	Moderate	72.0
Building Age	0.234	Low	65.5

Thus, both the graphical results and Table 4.5 consistently indicate that the higher the information gain value of a parameter, the greater its role within the decision structure of the model, which is directly proportional to the resulting prediction accuracy. This pattern is reflected in the structure of the constructed Decision Tree, which consists of the following decision levels:

1. Level 1 (Root Node): Concrete Grade (K-225, K-300, K-350)
2. Level 2: Curing Quality (Good \geq 21 days, Moderate 14–20 days, Poor < 14 days)
3. Level 3: Environmental Factors (North Aceh Coastal Area, Lhokseumawe Urban Area, Bireuen Inland Area)

Furthermore, Table 4.6 presents the Decision Tree classification results, illustrating the model’s performance across various parameter combinations. For instance, houses constructed with K-350 concrete and subjected to good curing practices are classified as having very good building quality with a confidence level of 100%. In contrast, houses built with K-225 concrete, receiving poor curing, and located in the coastal area of North Aceh are classified as having poor building quality with a confidence level of 83.3%.

Table 6. Decision Tree Classification Results

Decision Branch	Number of Samples	Building Quality	Confidence (%)
K-350 → Good Curing	5	Very Good	100.0
K-300 → Good Curing	5	Good	87.5
K-300 → Moderate Curing	3	Good–Moderate	75.0
K-225 → Good Curing → Lhokseumawe/Bireuen	2	Moderate	80.0
K-225 → Poor Curing → North Aceh	3	Poor	83.3

This classification pattern confirms a consistent hierarchy of influence, in which concrete grade remains the most dominant factor. As shown in Table 4.6, the model achieves an overall accuracy of 82.5%, reinforcing the interpretation that investment in higher concrete quality yields significant returns in terms of long-term durability, particularly when accompanied by adequate curing practices. To validate these findings, Pearson correlation analysis was conducted (Table 4.7). The results indicate that Concrete Grade ($r = 0.834$; $p < 0.001$) and Curing Quality ($r = 0.721$; $p < 0.001$) exhibit very strong and statistically significant positive correlations with building quality. In contrast, Environmental Factors show a negative correlation with building quality ($r = -0.456$; $p < 0.05$), suggesting that certain environmental conditions may accelerate structural degradation. Building Age demonstrates only a weak negative correlation ($r = -0.234$) and is not statistically significant.

Table 7. Correlation Matrix among Variables

Variable	Concrete Grade	Curing Quality	Environmental Factors	Building Age	Building Quality
Concrete Grade	1.000	0.654**	-0.321*	0.187	0.834**
Curing Quality	0.654**	1.000	-0.298*	0.145	0.721**
Environmental Factors	-0.321*	-0.298*	1.000	-0.098	-0.456*
Building Age	0.187	0.145	-0.098	1.000	-0.234
Building Quality	0.834**	0.721**	-0.456*	-0.234	1.000

Multiple regression analysis produced the following predictive model: Building Quality = 2.341 + 0.521 (Concrete Grade) + 0.387 (Curing Quality) - 0.234 (Environmental Factors)

Table 8. Results of Multiple Regression Analysis

Parameter	Beta Coefficient	Standard Error	t-value	p-value	Contribution (%)
Concrete Grade	0.521	0.089	5.854	< 0.001	45.7
Curing Quality	0.387	0.095	4.074	0.002	32.1
Environmental Factors	-0.234	0.078	-3.000	0.009	22.2

$R^2 = 0.762$; Adjusted $R^2 = 0.718$; F-statistic = 17.12 ($p < 0.001$)

The results of the multiple regression analysis (Table 8) indicate that the model explains 76.2% of the variance in building quality (Adjusted $R^2 = 0.718$). Concrete Grade contributes the largest proportion (45.7%), followed by Curing Quality (32.1%), while Environmental Factors exert a negative influence (22.2%). Significance testing ($p < 0.05$) confirms that all three variables have statistically significant effects, suggesting that concrete quality and curing practices can be regarded as the primary determinants of long-term building performance. These quantitative findings are reinforced by interviews with contractors and construction workers. They highlighted budget constraints, low awareness of proper curing practices, and technical challenges such as inappropriate water–cement ratios, inadequate mixing equipment, and inconsistent curing procedures. These insights align with the Decision Tree results, which emphasize the critical role of curing quality. Notably, even experienced contractors stated that using high-quality concrete without adequate curing is essentially “a waste of resources.” The integration of both quantitative and qualitative approaches confirms a clear hierarchy of influence: (1) concrete grade, (2) curing quality, and (3) environmental conditions. The combination of concrete grades \geq K-300 with curing durations of at least 14 days was found to be optimal, providing a practical recommendation for minimum quality standards, curing protocols, and strengthened quality control mechanisms.

The relationships identified in this study are consistent with material science theory, which emphasizes that the intrinsic strength of materials fundamentally determines structural durability (Papadakis et al., 1991). Concrete with high water–cement ratios (> 0.6) and low cement content ($< 280 \text{ kg/m}^3$) tends to be more brittle, porous, and crack-prone, thereby accelerating degradation processes (Chidiac et al., 2003). The very strong correlation observed ($r = 0.834$) further confirms that investment in concrete quality yields more consistent performance outcomes compared to other factors. However, the identification of a critical threshold at the K-300 grade suggests the presence of diminishing returns, whereby further increases in concrete strength do not result in proportionally equivalent performance improvements. This phenomenon can be explained through particle packing theory and the characteristics of the interfacial transition zone (ITZ), where the sand-to-aggregate ratio (S/A) and ITZ properties strongly influence mechanical behavior and durability (Lin, 2020; An et al., 2017). Percolation theory further explains that pore system connectivity undergoes significant changes at critical aggregate contents, causing the marginal benefits of increasing aggregate quality to decline beyond a certain threshold (Winslow et al., 1994; Forero et al., 2022).

The synergy between concrete quality and curing practices further reinforces the understanding of cement hydration processes. High-strength concrete (K-350) requires a minimum curing period of 21 days to achieve optimal performance, whereas curing durations of less than 14 days were shown to significantly reduce quality. This issue is particularly critical in Aceh, which is characterized by a humid climate interspersed with dry periods that accelerate moisture loss from freshly cast concrete. Geographical effects are also evident. For lower concrete grades (K-225), buildings located in the coastal areas of North Aceh exhibited degradation rates approximately 40% faster than those in the inland region of Bireuen, primarily due to chloride ion penetration and carbonation. In contrast, for higher concrete grades (K-350), reduced porosity minimized environmental impacts. These findings underscore the importance of adjusting concrete quality as an adaptive strategy for coastal environments. The Decision Tree model, with an accuracy of 82.5%, proved particularly valuable for interpretation due to its simplicity and transparency, making it accessible to practitioners. Nevertheless, several limitations remain, including the relatively small sample size, binary classification of building quality, and the exclusion of time-dependent degradation processes.

CONCLUSION

Based on the analysis of 20 residential buildings across three regions in Aceh, this study concludes that concrete grade is the most critical factor influencing residential building quality. Houses constructed using higher concrete grades (K-300 or K-350) combined with curing periods of at least 14 days exhibited superior structural integrity, minimal cracking, and longer service life. The Decision Tree analysis identified a clear hierarchy of influence—concrete grade \rightarrow curing quality \rightarrow environmental factors—which was further corroborated by qualitative evidence from interviews with contractors and construction workers. Inferential analysis revealed significant positive relationships between concrete grade, curing quality, and overall building performance, with concrete grade contributing the largest share (45.7%) to the variance in building quality. These findings emphasize the importance of investing in higher concrete quality and consistent curing protocols, particularly in regions exposed to aggressive environmental conditions such as coastal areas. From a practical perspective, this study recommends the use of a minimum concrete grade of K-300, the implementation of standardized curing procedures for at least 14 days, and the strengthening of quality control during mixing and curing processes. Furthermore, this research provides a data-driven decision-making framework for selecting concrete specifications that balance technical performance, economic feasibility, and long-term sustainability.

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