Journal of Architectural Sciences and Applications
JASA 2024, 9 (2), 908-927
Research article
e-ISSN: 2548-0170
https://dergipark.org.tr/en/pub/mbud

Determination of the Importance Level of Basic Criteria in Building Construction with AHP and FAHP Methods

Serkan YILDIZ [1], Sinan GÜNEŞ [2*]

ORCID 1: 0000-0002-6020-1993
ORCID 2: 0000-0001-7753-8333
[1, 2] Ankara University, Faculty of Applied Sciences, Department of Real Estate and Development, 06590 Ankara, Türkiye.
**** e-mail**: sinan.gunes@ankara.edu.tr*

Abstract

The primary expectations from buildings include safety, cost-effectiveness, aesthetics, durability, functionality, and sustainability. Addressing these complex criteria and potential trade-offs requires determining their relative importance to guide construction practices. This study evaluates these criteria using the Analytic Hierarchy Process (AHP) and Fuzzy Analytic Hierarchy Process (FAHP). Interviews with seven engineering experts helped define the criteria. Subsequently, 22 architects and engineers performed pairwise comparisons, producing individual matrices. These matrices were aggregated into a single matrix via geometric averaging, with consistency verified. Safety emerged as the highest priority, followed by durability, while the remaining criteria were balanced. FAHP enhanced robustness by integrating fuzzy logic to handle subjective judgments. The findings offer practical insights for designers, contractors, and industry professionals, aiding in informed decision-making and prioritization of building criteria.

Keywords: *Building construction, safety, durability, AHP, FAHP.*

Yapı İnşasında Temel Kriterlerin Önem Seviyesinin AHP ve BAHP Yöntemleri ile Belirlenmesi

Öz

Binalardan öncelikli beklentiler güvenlik, maliyet etkinliği, estetik, dayanıklılık, işlevsellik ve sürdürülebilirliği kapsamaktadır. Bu kriterlerin karmaşıklığı ve potansiyel ödünleşimleri göz önüne alındığında, göreceli önemlerinin belirlenmesi, inşaat uygulamalarını optimize edilmiş sonuçlara doğru yönlendirebilir. Bu çalışma, bina yapımında bu temel kriterlerin önemini Analitik Hiyerarşi Süreci (AHP) ve Bulanık Analitik Hiyerarşi Süreci (FAHP) yöntemleriyle değerlendirmeyi amaçlamaktadır. İlk olarak, her bir kriteri tanımlamak için yedi mühendislik uzmanı ile derinlemesine görüşmeler yapılmıştır. Daha sonra, 22 mimar ve mühendis kriterleri değerlendirmek için ikili karşılaştırmalar yapmış ve sonuçta bireysel karşılaştırma matrisleri elde edilmiştir. Bu matrisler geometrik ortalama yoluyla tek bir matriste toplanmış ve tutarlılık teyit edilmiştir. Analizler, güvenliğin en yüksek öncelik olduğunu, bunu dayanıklılığın izlediğini, diğer kriterlerin ise nispeten dengeli bir öneme sahip olduğunu ortaya koymuştur. FAHP yöntemi, öznel yargıları hesaba katmak için bulanık mantık kullanarak değerlendirmeye sağlamlık katmıştır. Bulgular, tasarımcılar, endüstri profesyonelleri ve yükleniciler için değerli bilgiler sağlayarak bina kriterlerinin önceliklendirilmesinde bilinçli karar vermeyi desteklemektedir.

Anahtar kelimeler: *Yapı inşası, emniyet, dayanıklılık, AHP, BAHP.*

Citation: Yıldız, S. & Güneş, S. (2024). Determination of the importance level of basic criteria in building construction with AHP and FAHP methods. *Journal of Architectural Sciences and Applications*, 9 (2), 908-927.
DOI: https://doi.org/10.30785/mbud.1451408

Received: *March 12, 2024 –* ***Accepted:*** *November 20, 2024*

1. Introduction

Building is the activity initiated by early humans to meet the need for shelter. The first shelters were built to meet the need for a controlled environment to mitigate climate impacts. Shelter construction enabled humans to adapt to different climatic conditions and paved the way for humans to become a global species. Building activities have evolved and exhibited different trends. The principles that determined this development and trend were the materials' durability, the growth in building heights and widths, the degree of control over the internal environment and the energy that can be used for the construction process (Designingbuildings, 2023). The initial substances utilized were perishable materials, including leaves, branches, and animal skins. Subsequently, there was a shift towards more enduring natural elements like clay, stone, and wood. Eventually, synthetic materials, such as bricks, concrete, metals, and plastics, became prevalent. The advancement of robust materials and an enhanced understanding of their behavior have enabled the construction of taller buildings with larger footprints. This progress has been instrumental in refining the control of the indoor environment, with a heightened focus on precise regulation of factors such as air temperature, light intensity, sound levels, humidity, odors, air velocity, and other elements that impact human comfort. Finally, while the first shelters were built entirely based on human muscle power, the energy of powerful and technological machines began to be utilized (Chang & Swenson, 2023). While the first function of building construction, which has developed and changed in close relation and interaction with human civilization, has been to provide shelter and security, over time, this function has started to include reflecting the cultural and social values of different periods, adopting and developing technological developments (Designingbuildings, 2023). In contemporary times, construction endeavors involving diverse stakeholders have emerged as a significant facet of industrial culture. This phenomenon serves as a reflection of the intricate and multifaceted nature of the industry, representing a measure of proficiency in harnessing natural forces to create a diverse spectrum of built environments that cater to the varied needs of society (Chang & Swenson, 2023). All this transformation has caused users' expectations of the constructed buildings to grow in content.

Increasing prosperity and education level have led to the diversification and elaboration of conscious consumption criteria. There needs to be more than one point of view to meet increasing expectations. Besides the criteria such as safety, durability, aesthetics, economy and functionality that affect building construction, sustainability criteria should be considered. However, it is naturally not possible to maximize the expectations in all these criteria. For example, it may be necessary to sacrifice functionality for greater aesthetics or to compromise durability in order to build more economical structures. For an optimum solution, determining the relative importance levels of these criteria is necessary and such a study will guide the sector stakeholders. In this study, the importance levels of the mentioned criteria were determined by AHP and BAHP analyses, and safety and durability were ranked as the first two. In contrast, the other criteria were given approximately equal importance.

2. Basic Expectations of Users from Buildings

Article 5 of the Zoning Law No. 3194 defines a building as follows: "A building is a structure that can be used on its own, is covered and can be entered by people, and is used by people to live, work, have fun, rest or worship, and for the protection of animals and goods" (Zoning Law, 1985). While the definition requires a building to be inherently safe, limited resources require it to be economical and human nature requires it to be aesthetic. Adding durability, functionality, and sustainability, become increasingly indispensable every day, is possible to these three basic expectations.

2.1. Safety

Naturally, the first thing expected from a structure is to be safe. Safety refers to the ability of a structure to resist loads and stresses with a sufficient margin of safety. Errors related to structural design create a severe risk of loss of life and property. In this respect, particular care should be taken during the structural design phase to ensure that structural components can provide safe service under the loads to which they will be subjected. The structures' capacity generally refers to its mechanical resistance to its weight, user loads, furniture and effects such as snow, wind and earthquake loads. The damage or collapse of the structure due to the insufficiency of this resistance is not only a consequence related to the structure. Many negative consequences, such as loss of life, injuries, loss of property, disruption of services and psychological damages, occur. Large-scale damages caused by floods, hurricanes, fires, explosions, and especially earthquakes can even shake the economy of countries (Mittal, 2023). For example, the February 6, 2023 Pazarcık and Elbistan earthquakes in our country caused hundreds of thousands of houses to be unusable. They caused a cost exceeding 100 billion dollars (Presidency of Strategy and Budget, 2023).

Another issue considered in safety is the usefulness of the structure according to its structural purpose. For example, the floor on which a high-precision mechanical equipment is placed should not vibrate in such a way as to disturb the precise settings of the equipment. Similarly, floors should not oscillate in such a way as to create a sense of insecurity when people move around on them.

Understanding the structural capacity of the structure to withstand environmental influences throughout its projected working life is a crucial aspect of safety. Factors that threaten safety, such as exposure of a timber structure to termite attacks due to lack of precautions; damage to concrete and reinforcement due to a lack of good waterproofing; settlement and collapse of foundations over time, should be thoroughly understood and addressed (Housing for Health, 2024).

Errors in design and detailing are among the most critical factors that may cause a structure to be so unsafe that it may collapse completely. However, this is not the only reason and dozens of other reasons can be mentioned. Some of these include poor geological conditions, poor quality materials, defects in construction methodology, poor craft, poor quality control, non-compliance with standards, inadequate maintenance, thoughtless structural additions or alterations, changes in types of use, overloading, keeping in use beyond the planned service life, exposure to all kinds of additional/new loads not taken into account in the design, accidents, negligence during design and construction, unethical behaviors such as corruption, ignorance, incompetence, lack of supervision, lack of interest, regulatory deficiencies, system and procedure deficiencies, inadequacy and indifference in the implementation of laws (Mittal, 2023). It is of utmost importance that users who expect their buildings to serve safely are aware of these issues, the number of which can be increased much more.

2.2. Economy

The second thing expected of a building from an engineering point of view is that it should be economical. Everyone wants to incur the least cost to have a structure that is equally satisfactory in all other respects. The term "economy" pertains to the financial and material resources allocated for the constructing and maintaining buildings and related structures. This encompasses expenses associated with labor, materials, and additional resources essential for the successful completion of a Project (Mamauag, 2023). The main problem with economics is that although human needs and wants are unlimited, their resources are limited. Owners have a limited budget available to them and in reality this limit sets the limits of design (Robinson & Symonds, 2015). So much so that even structural design, although directly related to the safety of life and property, is related to economics and it is essential to use an adequate but not excessive safety factor in the design. For example, regulations on earthquake-resistant building design stipulate that structures should not be damaged in small earthquakes, their structural elements should not be damaged in moderate earthquakes, and they should be severely damaged in large earthquakes. However, they should not collapse and cause loss of life and property. Otherwise, it would mean designing structures that are not economical.

Similar to structural design, architectural design is intricately tied to economic considerations. The geometric attributes of a building, encompassing aspects such as size, shape, layout, and height, exert a notable influence on capital expenses. Projects marked by intricate designs and challenging geometries incur higher costs than simpler, often repetitive projects that benefit from economies of scale and reduced unit costs. The level of complexity significantly impacts costs, especially in instances where projects involve unconventional, untried, and untested design features, making planning, construction, and management more challenging (Robinson & Symonds, 2015).

The materials and equipment to be used in the building also significantly affect the cost. Contractors try to get the best quality products at the lowest cost. Similarly, customers, whether they are in high or low-income groups, try to obtain the most economical structure that meets their needs according to their budgets. This fact does not change the fact that when the general economic conditions are good, more ostentatious and expensive designs are tried to be acquired, and when the economic situation is poor, more practical and functional designs are tried to be acquired (Mamauag, 2023).

Economy in building design is not just about the initial construction or acquisition cost, but also about the long-term utilization cost. This includes maintenance and repair costs that accrue over time, as well as energy costs for functions such as heating, cooling, lighting and ventilation. In some cases, the savings from utilization costs can offset the high initial construction cost, making the building more advantageous for the users. Ultimately, designing a building with economic factors in mind is crucial to creating buildings that are not only aesthetically pleasing and functional but also financially viable and sustainable in the long term. The goal is to create buildings that are economically viable and cost-effective, without compromising on quality, functionality, and sustainability. Every building should be economically viable and cost-effective without overdoing it in terms of permanence, beauty and fulfillment of function, as well as other necessary qualities that the users seeks.

2.3. Functionality

Functionality encompasses movement areas, ventilation needs, lighting, relationships between spaces, technical requirements, movement and communication in a building and requires consideration of all human needs, psychological, social and cultural (Majeed, Oleiwi & Yaseen, 2019).

It covers many aspects, such as how the spaces are organized, how people move around the area, how accessible the space is and whether it contains the necessary services. For example, a window that is too high and therefore difficult to open and close; a socket that is too far away from the mirror when you connect your electric shaver; a kitchen that is too narrow to accommodate a dining table; a layout where all rooms open onto the living room is inherently non-functional. Each of these is a design mistake that leads to a decrease in quality of life and comfort. In this respect, functionality is an indispensable requirement for the success of architectural design. A functional building is a building with the practical components necessary for its successful and efficient operation. It includes layout, design, and features that guarantee that the infrastructure fulfills its task as effectively as possible (Vrcconstruction, 2023).

An intelligently designed space maximizes efficiency and usability. Whether it is a commercial office, residential complex or retail space, the design must be fit for the intended purpose and ensure that it best serves its occupants.

Several pivotal principles underpinning functionality in architecture and design include program, flexibility, accessibility, energy efficiency, and safety and security (Archisoup, 2023). The program entails the information and documentation distinctly outlining the function and intended use of the building upon which the design will be based. This encompasses details such as the anticipated number of occupants, the nature of activities to be conducted within the space, and the requisite equipment and resources. Flexibility denotes the building's capacity to undergo easy modifications or reconfigurations to adapt to evolving needs or requirements. Accessibility pertains to the building's ability to be easily reached and enjoyed by individuals of diverse ages and abilities, incorporating features like ramps, elevators, and wide doors to accommodate those with disabilities. It is also part of the functionality that the building includes elements that help reduce energy costs, such as insulation, energy-efficient windows and equipment. The fact that the building includes safety and security measures for its users, such as fire prevention systems, security cameras, emergency exits, etc., is also one of the principles of functionality.

As a result, almost intuitive functionality includes aspects that benefit the user, and the utility component is a prerequisite that must be met in all human production. The consistency between functionality and form indicates satisfaction and confidence in the validity of the production. In this respect, it is possible to define architecture as the science of building structures that meet people’s material, spiritual, mental, individual and collective needs, including the conditions of utility, beauty and economy (Majeed et al., 2019).

2.4. Aesthetics

It is impossible to say that any building whose aesthetic features are not pleasing, which does not arouse a sense of beauty in its users and the surrounding residents, meets expectations and is satisfactory. Aesthetics emphasizes the artistic dimension of architectural quality and points out that buildings should be beautiful and attractive (Architects' Council of Europe, 2019). The allure of a building is the cumulative result of various factors, including its shape, size, texture, color, balance, unity, movement, emphasis, contrast, symmetry, proportion, space, alignment, pattern, decoration, cultural considerations, and contextual relevance (Designingbuildings, 2020). Buildings that are aesthetically pleasing and attractive possess the capacity to inspire individuals, instill a positive sense of identity, pride in their activities, and a connection to their living environment. More importantly, such structures have the potential to motivate people to strive for personal and communal achievements, thereby inspiring a sense of motivation and inspiration (McIntyre, 2006).

Like painting and sculpture, architecture can be regarded as a visual art to which aesthetic philosophy can be applied. However, applying aesthetics to buildings and architecture is intricate due to physical constraints such as program, budget, structural system, standards, climate, and weather. This complexity implies that building design is influenced by both form and function, in addition to aesthetics (Designingbuildings, 2020). Amidst these considerations, it is essential to acknowledge that beauty and attractiveness are subjective concepts. Santiana notes, "The sense of beauty is not just a perception but an understanding of the value of the discovery of an aesthetic signifier." Alberte defines architectural beauty as "the harmony of everything and a certain harmony between all the elements of the building in such a way that no part can be added, removed, or changed without damaging the design." Cliff Bill sees it as an impressive photograph of all kinds of relationships between lines, colors and volumes (Mohsen, 2000). Based on these definitions, it will be understood that when it comes to aesthetics, the exterior designs of buildings can be considered, and the aesthetics of each production can be mentioned. Just as a bad exterior design is not aesthetic, plasters that are not on their plumb, cornices that do not come together with the ceiling from every point, ceramics whose joints do not match each other even if they are of high quality and expensive, paint productions where brush strokes are visible, doors and windows that are not fully closed, installation columns that are not fully vertical and parallel to each other, wallpapers whose joints are visible, floor coverings laid at different levels, and similar productions that are often the result of poor craft are not aesthetic, even if they do not prevent use.

2.5. Durability

Another crucial aspect expected from a building is its durability. Durability, by definition, denotes the capability to resist damage, deterioration, and degradation over a specified period (Nireki, 1996). Mora has characterized durability as an indicator of the degree to which a material maintains its original specifications over time. A material, component, or system can be deemed durable when its helpful service life aligns considerably with the time needed for the ecosystem to assimilate the associated impacts on the building (Mora, 2007).

The way materials and buildings deteriorate over time depends on their physical structure, how they are manufactured and the environmental conditions to which they are exposed (NAHB, 2002). Several factors contribute to determining the durability of a material, encompassing molecular structure, resilience against moisture and water, resistance to corrosive substances, protection against pests and insects, resilience to mold and rot, fire resistance, adaptability to movement, ability to withstand atmospheric pollution, resistance to heat and cold, moisture absorption capacity, surface profiles, orientation, texture, and color (Designingbuildings, 2021). The type and frequency of durability problems and overall performance issues can be related to design, materials, construction method, maintenance or a combination of these factors (NAHB, 2002). Buildings are subjected to wear and tear from users, and the constant effects of environmental conditions such as snow, rain, frost, sun and heat. These effects cause deterioration and decrease in the durability of the materials and the structure, often leading to deterioration of the aesthetic appearance. The effects of climate change should be taken into account when selecting materials. As an illustration, materials like concrete, brick, and stone may exhibit greater durability than in specific climates wood or plaster. Similarly, materials like stainless steel or fiberglass may demonstrate increased resistance to corrosion (Archisoup, 2023). The outer cover of the building, including the roof covering, has a protective function. It acts as a barrier to prevent rain, and snow and moisture from seeping into the building. It also provides protection against fire, strong sunlight and frost, while saving heating and cooling energy by preventing heat from entering and leaving the building (Turton, 2012).

In some cases, wrong design or wrong construction method may prevent the material from showing the expected performance by losing its durability. Even if the right material is used for insulation, it is known that design and workmanship errors cause damage to structural elements caused by water or moisture. The greater the durability of buildings, the less time and resources are required to maintain them. Nevertheless, even the most durable materials need to be maintained over time. Lack of maintenance or poor designs that make maintenance difficult negatively affect durability.

The fact that building elements are not durable for various reasons does not only lead to negative consequences such as increased maintenance and repair costs, deterioration of aesthetics, and decreased user comfort. At the same time, it may also cause the structural system elements to lose their bearing capacity, thus jeopardizing building safety. All these problems should be considered together during the design phase and balanced solutions should be produced to increase durability even if the initial cost is high. This includes designing spaces that are easy to clean and maintain, and incorporating materials and systems that are easy to repair or replace (Archisoup, 2023). Choosing the best materials is often the most costly but often results in using the highest quality and most durable materials. Nowadays, the increasing number and duration of extreme weather events due to climate change require putting more emphasis on the durability of buildings (Designingbuildings, 2021).

2.6. Sustainability

The most familiar definition of sustainability is to support the fulfillment of the needs of future generations while meeting the needs of the present (WCED, 1987). Sustainability involves improving the quality of life, thus enabling people to live in a healthy environment with better conditions (Ortiz, Castells & Sonnemann, 2009). Sustainable development encompasses numerous economic, social, and environmental factors that benefit human development and improve the quality of human life (Stead & Stead, 2014). The construction sector is a vital element of any economy, but it has significant negative impacts on the environment. The sector consumes large amounts of natural resources, mainly raw materials and energy, to create the built environment where human life occurs. It, therefore, has a much more significant impact on society, the environment and the economy than any other industrial sector, making it one of the leading sectors on which sustainability is focused (Xia, Rosly, Wu, Bridge & Pienaar, 2016; Aghimien, Aigbavboa & Thwala, 2019). Hence, there is an increasing consensus among organizations dedicated to environmental performance goals that implementing suitable strategies and initiatives is imperative to enhance the sustainability of construction activities (Barrett, Sexton & Green, 1999; Abidin, 2010).

Considering the substantial influence of the construction sector, adopting a sustainable construction approach holds substantial promise for making a meaningful contribution to sustainable development. Sustainable construction ensures that all activities, from the planning phase to completion and eventual demolition, are conducted sustainability. This approach considers construction activities' economic, social, and environmental impacts (Ismail, Halog & Smith, 2017). It has been noted that sustainable construction plays a vital role in protecting the local environment through the use of resources, assets and water and that the industry contributes significantly to improving the quality of human life (Oke, Aigbavboa & Semenya, 2017; Shurrab, Hussain & Khan, 2019). Sustainable construction aims to improve indoor air quality while reducing energy, water and material use and waste generation, both during the construction process and throughout the operational life of buildings (Archisoup, 2023; Ismail et al., 2017; Shurrab et al., 2019). The concept of sustainability within the construction industry has evolved, shifting from a primary focus on addressing challenges related to insufficient resources, particularly energy, to encompass technical considerations. These technical aspects include materials, building components, construction technologies, and designs commonly known as “eco-building”, “green building” and “sustainable building” (Balasubramanian & Shukla, 2017). A sustainable project is one that is designed, constructed, renovated, operated, or repurposed in an ecologically and resource-efficient manner (Ortiz, Pasqualino & Castells, 2010). This entails achieving specific objectives such as resource and energy efficiency, reduction of CO2 and greenhouse gas emissions, pollution prevention, noise reduction, improvement of indoor air quality, and environmental compatibility. An exemplary sustainable construction project is characterized by its cost-effectiveness, long-lasting quality with minimal maintenance requirements, and the ability to return entirely to the earth upon abandonment (Bainbridge, 2004). Advocates argue that sustainable buildings can significantly decrease energy consumption by 24% to 50%, lower CO_2 emissions by 30%, and reduce water usage by 40% (LEED, 2000).

Sustainable buildings are expected to uphold robust and consistent levels of local economic growth and employment to achieve economic sustainability. Simultaneously, they aim to ensure the adequate protection of the environment and the judicious utilization of natural resources, aligning with principles of environmental sustainability. Moreover, these structures aspire to contribute to social progress that acknowledges the needs of all stakeholders, promoting social sustainability (Akadiri, Chinyio & Olomolaiye, 2012).

Safety, economy, functionality, aesthetics, durability, and sustainability criteria are the main factors prioritized in building construction. However, their interactions with each other and determining their order of importance are critical for effective building construction management. This study aims to reveal the relative importance of these criteria by focusing on their conceptual content.

3. Material and Method

In AHP and FAHP methods, the relative importance of the criteria is determined through pairwise comparisons. Each criterion should be explained to the respondents shortly and concisely for pairwise comparisons. For this reason, it was decided to conduct the study using a mixed research method. The mixed research method, which meets the criteria of scientific rigor, combines the strengths of quantitative and qualitative approaches while compensating for the weaknesses of both approaches (Khaldi, 2017). The first part is the qualitative research part, in which the participants are asked to explain what the essential criteria expected from a building mean to them. This part, conducted with a fewer participants, tried to determine how the participants handled the essential criteria and the similarities and differences of their views with the literature. Thus, making short and correct definitions of each criterion was possible. The second part is the Analytic Hierarchy Process (AHP) and Fuzzy Analytic Hierarchy Process (FAHP) analysis study conducted to determine the weights of the main criteria. AHP is a hierarchical and pairwise comparison matrix-based multi-criteria decision analysis technique that helps to solve the multi-criteria decision problem (Belay, Goedert, Woldesenbet & Rokooei, 2022). AHP tools help construction practitioners make quick decisions (Razi, Ramli, Ali & Ramadhansyah, 2020). In this section, the importance level of each criterion was obtained from the matrix obtained as a result of the pairwise comparisons of the participants and the results were compared. In the study, the importance level of the criteria was also determined by the FAHP method, and the results were compared. Fuzzy logic cannot measure the level of consistency in a decisionmaker's judgments. On the other hand, AHP cannot capture the subjectivity of human judgments as verbal assessments are converted into crisp values (Ishizaka, 2014). FAHP, as a method that combines the advantages of Fuzzy logic and AHP, is used widely in construction sector in multi-criteria decision-making problems (Iqbal, Ma, Ahmad, Ullah & Ahmed, 2021; Mathiyazhagan, Gnanavelbabu & Lokesh Prabhuraj, 2019).

3.1. Qualitative Analysis

This part of the study was carried out to provide brief and accurate definitions of the criteria. Therefore, conducting the study with 7 participants, consisting of engineers from different branches, was deemed sufficient. The participants were asked to state what they understood by the essential criteria a building should meet: Safety, Functionality, Aesthetics, Economy, Sustainability and Durability.

As a result of the interviews with the participants, the basic criteria for building construction were evaluated as follows:

The participants defined safety as the need for a building to ensure the safety of people's lives and property. In this context, they associated the concept of safety with the ability to resist risky situations such as earthquakes and fires. Safety's purpose is summarized as ensuring that users are in a safe environment in the face of such emergencies.

The economy was a concept where participants generally focused on the initial investment cost. However, it was stated that the operating cost should also be considered when evaluating affordability. Economy was defined as the ability to produce at low cost without sacrificing quality, as well as the ability to construct the building economically and for the contractor to make a profit. In this context, the economy has a perspective that aims to optimize both the initial costs in the construction process and the costs in the structure's operation process by the set standards and to make a profit.

The participants generally defined functionality as the ability of a building to fulfill its expected tasks. In this context, functionality includes a structure's capacity to meet the expected needs and effectively fulfill predetermined functions. This perspective understands functionality as the ability not only to meet basic needs, but also to fulfill these functions efficiently and user-friendly.

Two participants defined durability as the ability not to deteriorate physically and to serve for a long time, while others emphasized resistance to natural disasters. In this context, a similar understanding of durability and safety is observed. The participants understood durability as both the ability of a building to remain physically intact and its ability to resist natural disasters.

One participant defined aesthetics as having a visually pleasing and balanced appearance and being designed in harmony with the environment in a way people like. In this context, the concept of aesthetics includes a visually attractive design and environmental harmony. On the one hand, aesthetics is associated with the materials' shape, size and appearance. On the other hand, architectural style, color selection and exterior appearance are emphasized.

Participants generally focused on not harming the environment, being environmentally sensitive and protecting natural resources. In this context, the concept of sustainability emphasizes energy efficiency, recycling and building longevity requirements. Sustainability has a perspective that focuses on minimizing environmental impacts, using resources effectively and fulfilling environmental responsibilities for future generations.

3.2. Analytic Hierarchy Process (AHP)

AHP is a decision-making and estimation method used when a decision hierarchy can be defined. It gives the percentage distribution of decision points regarding the factors affecting the decision. The method aims to enable people to make better decisions by allowing them to recognize their decision-making mechanisms instead of forcing them to use a method on how they should decide (Albayrak, 2004). AHP is a frequently used method for analyzing complex decision problems due to its simplicity, flexibility, ease of use and straightforward interpretation (Yılmaz, 2005).

Solving a decision-making problem using the Analytical Hierarchy Process (AHP) involves several key steps. The decision-making problem is initially defined by identifying decision points and factors, emphasizing the importance of a precise and detailed factor description for consistent pairwise comparisons. Subsequently, a comparison matrix is created, capturing the relationships between factors. Percentage importance distributions are assigned to factors, and the consistency of comparisons is measured. The calculations extend to determining percentage importance distributions at decision points and analyzing the distribution of results. Careful adherence to a predefined importance scale is maintained throughout this process, as outlined in Table 1, to ensure accuracy and reliability in the decision-making model. Overall, AHP provides a systematic approach, aiding in informed and comprehensive decision-making. After creating the pairwise comparison matrices, the percentage importance distributions of each factor are determined. According to the AHP method, the eigenvector corresponding to the largest eigenvalue in the comparison matrix determines the importance distributions. AHP requires consistency in thought and judgment, but preference consistency may be violated. At this stage, it is necessary to calculate the consistency ratio for each generated comparison matrix to measure whether the decision maker acts consistently when comparing factors (Dağdeviren, Diyar & Mustafa, 2004). The consistency ratio (CR) obtained from the product of the pairwise comparisons matrix and the importance distribution vector should be less than 0.10. The other two stages of the AHP, which were not used in this study since no decision-making problem was solved within the scope of the study, are the stages of finding the percentage importance distributions at m decision points and the distribution of results at the decision points, for each factor.

Table 1. Importance scale (Saaty, 1980)

Imp.	Definition	Description
1	Equally important	Both options contribute equally to the goal.
3	Moderately more important	Experience and judgment slightly favor one over the other.
5	Strongly more important	Experience and judgment strongly favor one over the other.
7	Very strongly more important	Experience and judgment very strongly favor one over the other.
9	Extremely more important	Evidence that favors one over the other has the highest possible validity.
2,4,6,8	Intermediate values	Values between two consecutive judgments used when consensus is needed.

3.2.1. Determination of criteria weights

The study's criteria for evaluating a building are safety, economy, functionality, durability, aesthetics and sustainability. Therefore, the factors that will determine the decision are clear (Figure 1).

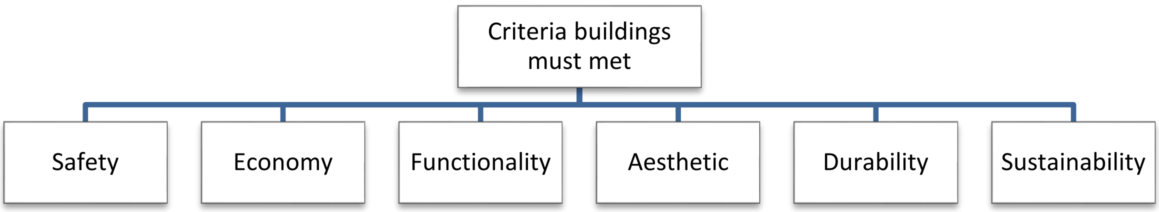

Figure 1. AHP model factor structure (Created by authors)

As seen in the qualitative analysis part of the study, some criteria, particularly safety and durability, were understood differently. In order to enable healthy pairwise comparisons, the questionnaires included the definitions given in Table 2 and various examples of what the respondents should understand from the criteria.

Table 2. Criteria and their definition (Created by authors)

Criteria	Definition
Safety	The structure should not collapse under the loads it bears during its lifetime and should not make excessive deformation; for example, it should not be damaged in mild and moderate earthquakes and should not cause loss of life in severe earthquakes.
Economy	Construction of the building should be done in the most cost-effective way, not spending too much to make it more secure than necessary or for unnecessary productions that can be considered luxurious.
Functionality	The building is suitable for use; room sizes are determined appropriately, kitchen countertops are at the appropriate height, sufficient sockets, etc.
Durability	The building and building elements can fulfill their functions without deteriorating for extended periods; the roof does not leak in a few years, the exterior paint does not fade, and the door and window joinery do not deteriorate.
Aesthetic	The applications in the building are beautiful, correct and properly made; such as the exterior of the building is beautifully designed, the plasters are in alignment, the joints in the ceramics are consistent with each other, the floor coverings are at the same level.

Sustainability	To construct the building in a way that is environmentally sensitive throughout its life cycle minimizes damage to nature, and uses energy, water, materials and land efficiently.

AHP is widely acknowledged as a subjective approach that does not require a statistically significant sample size to produce reliable results (Zhang & Zou, 2007; Hyun, Cho, Koo, Hong & Moon, 2008; Lam, Lam & Wang, 2008; Pan, 2008; Dalal, Mohapatra & Chandra Mitra, 2010; Zou & Li, 2010; Li & Zou, 2011; Pan, Dainty & Gibb, 2012; Akadiri, Olomolaiye & Chinyio, 2013; Baby, 2013; Chou, Pham & Wang, 2013; Kamaruzzaman, Lou, Wong, Wood & Che-Ani, 2018; Darko, Chan, Ameyaw, Owusu, Pärn & Edwards, 2019). One advantage of AHP over other multi-criteria decision-making (MCDM) methods is that it does not require a large sample size to generate sound and statistically robust results (Dias & Ioannou, 1996; Doloi, 2008). For example, Lam & Zhao (1998) note that reliable results can be obtained even with a small sample in AHP studies, and in some cases, a single expert's judgment may be sufficient to represent broader perspectives (Golden, Wasil & Harker, 1989; Abudayyeh, Zidan, Yehia & Randolph, 2007; Tavares, Tavares & Parry-Jones, 2008). This flexibility is one of the primary reasons AHP is popular in construction management research.

There is no strict minimum sample size requirement in AHP, as evidenced by studies that have employed sample sizes ranging from 4 to 9 participants (Zhang & Zou, 2007; Hyun et al., 2008; Lam et al., 2008; Pan, 2008; Dalal et al., 2010; Zou & Li, 2010; Li & Zou, 2011; Pan et al., 2012; Akadiri et al., 2013; Chou et al., 2013). Only a few studies have involved more than 30 participants (Ali & Al Nsairat, 2009; El-Sayegh, 2009). AHP's ability to produce meaningful decision models with small sample sizes makes it a preferred method in MCDM applications.

Moreover, AHP is known for achieving a high level of consistency, which helps to reduce bias and ensure that subjective judgments are validated through consistency analysis (Saaty, 1980; Saaty & Vargas, 1991). Literature shows that this ability to align subjective judgments from experts with potentially varying perceptions, experiences, and understandings is a significant reason why AHP is often selected for construction-related decision-making (Cheung, Suen, Ng & Leung, 2004; Abudayyeh et al., 2007; Hsu, Wu & Li, 2008). In this study, consistency analysis was applied in AHP to ensure the validity and coherence of the experts' judgments. In this study, AHP analysis was conducted with 22 participants. The demographic data of these participants are presented in Table 3. 15 are male, and 7 are female. 40% of the participants are under 30 and 27% are between the ages of 30-39. Since the AHP analysis requires expert opinion, all participants were selected from people with a university education or above. While 20 participants were university graduates, 2 participants had a master's degree. More than half of the participants are architects and civil engineers, while the rest are electrical, mechanical, computer and material engineers. 50% of the participants have 5 years or less experience, while 23% have 20 years or more of work experience.

Table 3. Demographic data of the participants (Created by authors)

Variable	N	%
Gender		
Male	15	68,2
Female	7	31,8
Age Group		
20-30	9	40,9
30-39	6	27,3
40-49	4	18,2
50-59	2	9,1
> 60	1	4,5
Educational Status		
University	20	90,9
Master's Degree - PhD	2	9,1
Work Experience Duration		

≤ 5	11	50,0
6-10	4	18,2
11-15	2	9,1
16-20	0	0,0
> 20	5	22,7
Profession		
Civil Engineer	8	36,4
Electrical Engineer	5	22,7
Architect	4	18,2
Computer Engineer	2	9,1
Mechanical Engineer	2	9,1
Materials Engineer	1	4,5
Total	22	100,0

Each participant determined the importance of the criteria with pairwise comparisons by the values in Table 1. In this way, 22 comparison matrices were obtained for 22 participants. These matrices were transformed into a single matrix by taking the geometric average of the responses. The consistency of this matrix was checked and weights were obtained for each criterion. The matrix obtained by the participants making pairwise comparisons between the factors regarding the basic expectations from a building is presented in Table 4. This matrix's Consistency Ratio (CR) was found to be 0.039, below the limit value of 0.1.

Table 4. Pairwise comparison matrix (Created by authors)

Factor	SAF.	ECN.	FUN.	DUR.	AES.	SUS.	Eigen Value
SAF.	1,00	6,00	3,12	1,61	4,19	2,58	0,364
ECN.	0,17	1,00	1,18	0,43	1,72	0,78	0,098
FUN.	0,32	0,57	1,00	0,67	2,27	0,74	0,112
DUR.	0,62	2,30	1,49	1,00	4,87	2,25	0,236
AES.	0,24	0,58	0,44	0,21	1,00	1,43	0,078
SUS.	0,39	1,27	1,35	0,44	0,70	1,00	0,112
			CR =	0,039			

The eigenvector values in the matrix's last column indicate the factors' importance level. According to the analysis, in terms of basic expectations from a building, the importance of safety is 36%, economy 10%, functionality 11%, durability 24%, aesthetics 8% and sustainability 11%. It is expected that safety will be given high importance. On the other hand, although a precise definition is given for durability, it is thought that some participants perceived it as safety, which may have affected its reaching the second highest importance. The fact that the other four criteria reached similar importance weights is essential in that one cannot be sacrificed for the sake of the other.

3.3. Fuzzy Analytic Hierarchy Process (FAHP)

FAHP also determined criteria importance levels. FAHP is a multi-criteria decision-making method developed by Thomas L. Saaty in 1971 (Saaty, 1980). This method consists of previously known discrete concepts and techniques such as hierarchical structuring of complexity, pairwise comparison, eigenvector in deriving weights and measurement of consistency. Saaty combined these concepts and techniques with some innovations to create more powerful process than the sum of its parts.

FAHP is a method that integrates fuzzy logic and the analytic hierarchy process and aims to solve complex decision-making problems. Fuzzy logic is a mathematical approach used to handle uncertainty and uncertain information. Although there is no clear superiority of Fuzzy AHP over AHP in terms of solution quality, there has been a significant increase in the use of Fuzzy AHP in the academic literature in the last 20 years, as stated by Chan, Sun & Chung (2019), indicating a growing trend in the field. Within the scope of this study, the workflow for the application of the FAHP method is as follows:

Criteria identification, Fuzzy pairwise comparison matrix generation, Fuzzy weight calculation, and Analysis of results and comments.

The decision hierarchy for FAHP analysis is as given in Figure 1. Pairwise comparison matrices were created, and comparisons were made between the criteria. To check whether these comparisons meet the consistency condition, the criteria were tested with the condition of falling below the 0.10 ratio predetermined in the AHP method. Then, relative weights (eigenvector values) were calculated from the pairwise comparison matrices.

The pairwise comparison matrices created according to the determined criteria were scaled according to the degree of importance using fuzzy numbers (Table 5). In this context, a different approach from the AHP methodology was adopted, which was the fuzzy AHP method. The matrices are expressed as a 3-dimensional fuzzy matrix for each dimension. This means that a matrix value, which is usually 2x2 in the AHP process, is transformed into a (1, 2, 3) x (1, 2, 3) scale in the Fuzzy AHP (FAHP). Triangular Fuzzy Numbers are preferred due to the ease of calculation for decision-makers. Triangular fuzzy numbers are represented as A=(a,b,c). The parameters here indicate the lower limit, peak (mode) value and upper limit value, respectively. Also, b has a membership degree of 1 (Chang, Wu & Lin, 2009). This method allows for a more detailed examination of the relationships between specific criteria, as fuzzified matrices have been used to handle uncertainty more effectively.

Table 5. Importance levels used in comparison (Created by authors)

Fuzzy Number	Explanation	Scale of Fuzzy Number	Reversal of Fuzzy Number
1	Equally important	(1, 1, 1)	(1, 1, 1)
2	Weak advantage	(1, 2, 3)	(1/3, 1/2, 1/1)
3	Not bad	(2, 3, 4)	(1/4, 1/3, 1/2)
4	Preferable	(3, 4, 5)	(1/5, 1/4, 1/3)
5	Good	(4, 5, 6)	(1/6, 1/5, 1/4)
6	Pretty good	(5, 6, 7)	(1/7, 1/6, 1/5)
7	Very good	(6, 7, 8)	(1/8, 1/7, 1/6)
8	Absolute	(7, 8, 9)	(1/9, 1/8, 1/7)
9	Perfect	(9, 9, 9)	(1/9, 1/9, 1/9)

The binary decision matrices created according to the criteria were compared and weighted according to their importance. According to the results obtained, the most effective criterion in building construction is safety, while the least effective factor is aesthetics. As seen in Table 6, the results of the Fuzzy AHP method and the AHP method are quite close to each other as expected.

Table 6. Fuzzy AHP weighting results (Created by authors)

Criteria	Fuzzy AHP Weights	AHP Weights
Safety	0,383	0,363
Economy	0,102	0,100
Functionality	0,106	0,112
Durability	0,227	0,235
Aesthetic	0,071	0,078
Sustainability	0,111	0,113

In addition to using traditional AHP, FAHP was applied to handle the inherent uncertainty and subjectivity in expert judgments. FAHP enables the incorporation of linguistic variables into the pairwise comparisons, allowing for a more nuanced reflection of participants' perceptions where precise numeric judgments might be challenging. By transforming participants' judgments into fuzzy values, FAHP provided a more robust framework to capture the subtle differences in importance assigned to each criterion. This approach not only helped obtain more reliable weights but also improved the consistency of the aggregated matrix by reducing the potential inconsistencies in subjective evaluations.

4. Results and Discussion

Structures are subjected to loads during their lifetime. The loads have the potential to cause the structure to deteriorate, wear down, sustain various types of damage, or collapse entirely or partially, all of which inevitably result in losses. These losses are realized as economic loss, loss of cultural value, injury, and death (Madsen, Krenk & Lind, 2006). Global research has demonstrated that design and manufacturing flaws during the building process are the primary reasons for structural damage and collapse (Terwel & Jansen, 2015). In this respect, the most basic expectation from a structure is to safely carry the loads acting on it and ensure the safety of the life and property of its users. However, it is a fact that all structures and materials deteriorate and disappear over time. Therefore, a building loses its bearing capacity over time, and it is essential to design it to have the intended lifetime (Sundquist, 2010). In this respect, safety also includes being resistant to the environmental effects that the building is exposed to during its lifetime. Again, the usefulness of the structural system of the building according to the structural purpose, such as the floors not vibrating while walking, is also considered within safety. In the AHP analysis conducted within the scope of the study, the safety factor emerged as by far the most essential criterion, with 36%. However, the results of the qualitative research revealed that the respondents considered the concept of safety intertwined with the concepts of strength and durability. Notably, most participants did not refer to natural disasters, especially earthquakes. The difference between the original meanings of the concepts and the meanings attributed by the participants has several consequences. It is both a legal and a conscientious responsibility to fulfill all legal obligations and standards related to uncompromisingly building safety regardless of everything. However, a good understanding of the safety criteria, especially by users and owners, will naturally lead to the realization of a control mechanism. For example, a user who understands the structural system safety relationship at a certain level will avoid operations that damage the structural system, such as column cutting, beam breaking to pass installation elements, and curtain wall drilling, and will prevent such attempts. Thanks to the advances in structural systems and designs and high-strength materials, building weights have significantly decreased and slenderness has increased. This situation causes lateral loads such as earthquakes and wind to dominate the structural design, while vertical loads due to gravity can be carried more easily (Shakir, Jasim & Weli 2021). It is thought that users who are aware of this situation will question the issues related to the safety of the building more and take timely and adequate measures against durability problems that weaken the structural capacity.

The second most important criterion was durability, which was 23%. In its simplest form, durability refers to the ability to withstand damage, decay and deterioration over time (Nireki, 1996). More broadly, it can be defined as the ability of a building or a component of a building to fulfill its functions at the required levels for a certain period in a service environment without unforeseen costs for maintenance or repair, either under the influence of environmental influences or as a result of the self-aging process (Lacasse, Ge, Hegel, Jutras, Laouadi, Sturgeon & Wells, 2018). Although durability is a concept that includes all the materials that make up the detail and protective structure together with the carrier materials, the participants in the qualitative research directly considered durability as safety. Even though the definitions of safety and durability were given in the AHP analysis, it is considered that this idea may also affect pairwise comparisons. In any case, durability covers all building components. Over the years, the performance of the structural system elements also deteriorates. However, the structure should be designed to perform and maintain its structural integrity for a specific expected design life (Blok, Herwijnen, Kozlowski & Wolinski, 2003). Therefore, the structural system elements must exhibit the expected durability for the structure to continue to function without damage. On the other hand, the details or protective components of a building, such as roof or floor covering, exterior paint, and rain gutters, should also be durable. If such materials are not durable, they negatively affect the criteria of function, aesthetics, economy and sustainability. Considering the effects on other criteria, it is a natural consequence that durability has gained high importance.

Although the criteria of economy, functionality, aesthetics and sustainability gained around 10% importance in the AHP analysis, the participants in the qualitative research defined these criteria superficially. For example, while only the initial investment cost was emphasized for the economy, the fact that the operating period costs were not mentioned is a deficiency. However, a building also causes great costs to its users during the period of use. Researchers argue that life cycle cost analysis should be used early in the project to evaluate the economic impact and cost of different design alternatives and to support decision-making (Alshamrani, 2022; Rad, Jalaei, Golpour, Varzande & Guest, 2021). It should be recognized that the most crucial step in achieving economy is the additional acquisition and use cost of each additional m^2. The room/space requirements of houses to be built, purchased or rented should be decided by considering current and future family needs. It should be kept in mind that passive architectural design strategies that are functionally efficient, allow plenty of sunlight in cold climates, prevent direct heat gain in hot and humid climates, provide natural ventilation and optimize abundant daylight reduce the cost of use in buildings (Zaki, Nawawi & Ahmad, 2010).

Functionality is generally defined as being able to meet the need. However, functionality is a concept beyond this. Architecture organizes and structures space by making it comprehensible, understandable and interpretable (Lawson, 2007), as exterior and interior spaces, and the materials and objects within them, can facilitate - or hinder - our activities by the way they imply and represent specific messages (Bels & Branco, 2017). In this context, recognizing that functionality encompasses a wide range of issues, from impractical placement of spaces to rooms that are too small or too large to fit furniture, to misplaced or inadequate sockets, to kitchen countertops that are too low or too high, can lead to more thoughtful design and production.

Assessing an environment typically entails judging its likability or dislikability, which can be a conscious or unconscious process. The cognitive procedure underlying this judgment primarily involves perceiving the visual characteristics of the environment and subsequently conducting an emotional evaluation. In essence, individuals use cognitive and emotional analysis when evaluating an environment, forming opinions about their preferences or aversions based on the perceived visual elements (Kaplan & Kaplan, 1982; Nasar, 2000). From this point of view, it is natural to describe aesthetics as pleasing to the eye and beautiful. However, aesthetics also means that specifications and standards make the productions for the construction sector. Regarding standards, the core of the issue is achieving and maintaining high-quality craft (Louw, 2003). Improving construction craft improves aesthetics, safety, durability and functionality (Gunasinghe, De Silva & De Silva, 2017). In this respect, first of all, it is necessary to look for the production's compliance with the rules of science and art and pay attention to issues such as color, shape, pattern, and texture.

The fact that sustainability is slightly ahead of functionality, economy and aesthetics criteria in AHP analysis shows that such an awareness has been created in the society. This is likely due to the increased awareness of the environmental problems experienced by our country. Although Türkiye has a rapidly increasing energy need and a lack of primary energy resources, energy intensity, which indicates inefficient use of, is very high (Yıldız, Kıvrak & Arslan, 2017). Again, although Türkiye is expected to become a water-poor country shortly, pollution and wastage of water resources continue at full speed (Yıldız, Kıvrak & Arslan, 2018). Many other environmental and economic and social sustainability issues are indirectly related to sustainability in the construction sector, which is extremely important for our country.

If the results are generally evaluated, understanding and explaining what it is expected from the buildings in which we spend most of our days and the built environment, which shapes almost all of our lives, will create a balance and control mechanism for the wide stakeholder mass of the construction sector. Buildings will be shaped according to expectations, directly or indirectly increasing our standard of living and comfort. Safety and durability were emphasized in the AHP and FAHP analyses, while other criteria have been given approximately equal importance. While this is an expected result, it is clear that users need to be taught practical ways and methods how to question whether expectations are met. This is demonstrated by the fact that in the February 2023 earthquake, many newly built houses were not destroyed, but were heavily damaged and had to be demolished later. The fact that the importance levels of the other criteria are close to each other indicates that one of these criteria cannot be sacrificed for the other. For example, the fact that these criteria are as prominent as the economy shows that owners, designers and contractors should not compromise on some things for economic reasons. Since the sustainability criterion is as important as economics, the contractor should not easily give up energy efficiency measures based on the initial construction cost. It is also wise to bear certain costs for a more functional design and aesthetic production.

The research will likely be instructive for a wide range of construction sector stakeholders, from owners to contractors, designers to construction site workers, and authorities to customers. This study is limited to defining the six essential criteria expected from a structure and determining their weights. Determining sub-criteria for each criterion, the importance of these sub-criteria, and concrete indicators for each will ensure that a complete model is obtained. Although the study was conducted with university graduate architects and engineers who are industry stakeholders, similar studies can be conducted for different groups such as contractors, consumers, and public authorities.

Acknowledgements and Information Note

The article complies with national and international research and publication ethics. Ethics Committee approval was obtained with the decision numbered 04/17 taken at the meeting of Ankara University Ethics Committee dated 05/07/2024.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

References

Abidin, N. Z. (2010). Investigating the awareness and application of sustainable construction concept by Malaysian developers. *Habitat International*, *34*(4), 421-426.

Abudayyeh, O., Zidan, S. J., Yehia, S. & Randolph, D. (2007). Hybrid prequalification-based, innovative contracting model using AHP. *Journal of Management in Engineering*, *23*(2), 88–96.

Aghimien, D. O., Aigbavboa, C. O. & Thwala, W. D. (2019). Microscoping the challenges of sustainable construction in developing countries. *Journal of Engineering, Design and Technology*, *17*(6), 1110-1128.

Akadiri, P. O., Chinyio, E. A. & Olomolaiye, P. O. (2012). Design of a sustainable building: A conceptual framework for implementing sustainability in the building sector. *Buildings*, *2*(2), 126-152.

Akadiri, P. O., Olomolaiye, P. O. & Chinyio, E. A. (2013). Multi-criteria evaluation model for the selection of sustainable materials for building projects. *Automation in Construction*, *30*, 113–125.

Albayrak, Y. E. (2004). Performance-based multi-objective decision making in the service sector: Analytical hierarchy process application in banking performance evaluation (Doctoral thesis). Institute of Science and Technology, Istanbul University, Istanbul. Council of Higher Education Thesis Center. Access Address (15.02.2024):https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=DQrmOiz7e_8fMrkDRZW9hQ&no=Ibughl4seY0xK0Gatxr3OA

Ali, H. H. & Al Nsairat, S. F. (2009). Developing a green building assessment tool for developing countries–case of Jordan. *Building and Environment, 44*(5), 1053–1064.

Alshamrani, O. S. (2022). Integrated LCA-LCC assessment model of offsite, onsite, and conventional construction systems. *Journal of Asian Architecture and Building Engineering*, *21*(5), 2058-2080.

Archisoup. (2023). The principles of architecture: The 10 essential rules of architectural design. Access Address (10.02.2024):https://www.archisoup.com/architecture-design-principles

Architects' Council of Europe. (2019). Achieving quality in the built environment. Access Address (10.02.2024):https://www.ace-cae.eu/fileadmin/New_Upload/5._Policies/

Baby, S. (2013). AHP modeling for multicriteria decision-making and to optimise strategies for protecting coastal landscape resources. *International Journal of Innovation, Management and Technology*, *4*(2), 218.

Bainbridge, D. A. (2004). Sustainable building as appropriate technology. In J. Kennedy (Ed.), *Building without borders: Sustainable construction for the global village* (s. 55–84). Gabriola Island, Canada: New Society Publishers.

Balasubramanian, S. & Shukla, V. (2017). Green supply chain management: An empirical investigation on the construction sector. *Supply Chain Management: An International Journal*, *22*(1), 58-81.

Barrett, P. S., Sexton, M. G. & Green, L. (1999). Integrated delivery systems for sustainable construction. *Building Research & Information*, *27*(6), 397-404.

Belay, S., Goedert, J., Woldesenbet, A. & Rokooei, S. (2022). AHP based multi criteria decision analysis of success factors to enhance decision making in infrastructure construction projects. *Cogent Engineering*, *9*(1), 2043996.

Bels, M. & Branco, P. (2017). Law and architecture: Courthouse architecture, searching for a new balance between representation and functionality. In Gephart W, Leko J (Ed.), *Law and the arts. elective affinities and relationships of tension* (s. 177-206). Frankfurt am Main: Vittorio Klostermann, 177206.

Blok, R., Herwijnen, F. V., Kozlowski, A. & Wolinski, S. (2003). Service life and life cycle of building structures. In *Proc., COST C12 Seminar on Improvement of Building's Structural Quality by New Technologies.* Brussels, Belgium: European Commission.

Chan, H. K., Sun, X. & Chung, S. H. (2019). When should fuzzy analytic hierarchy process be used instead of analytic hierarchy process? *Decision Support Systems*, *125*, 113114.

Chang, C. W., Wu, C. R. & Lin, H. L. (2009). Applying fuzzy hierarchy multiple attributes to construct an expert decision-making process. *Expert Systems with Applications*, *36*(4), 7363-7368.

Chang, P., & Swenson, A. (2023). Construction. Access Address (01.11.2023):https://www.britannica.com/technology/construction

Cheung, S. O., Suen, H. C. H., Ng, S. T. & Leung, M. Y. (2004). Convergent views of neutrals and users about alternative dispute resolution. *Journal of Management in Engineering*, *20*(3), 88–96.

Chou, J. S., Pham, A. D. & Wang, H. (2013). Bidding strategy to support decision-making by integrating fuzzy AHP and regression-based simulation. *Automation in Construction, 35,* 517–527.

Dağdeviren, M., Diyar, A., & Mustafa, K. (2004). Analytic hierarchy process and its application in job evaluation process. Gazi University Journal of Engineering and Architecture Faculty, *19*(2). Access Address (15.02.2024):https://dergipark.org.tr/en/pub/gazimmfd/issue/6660/88912

Dalal, J., Mohapatra, P. K. & Chandra Mitra, G. (2010). Prioritization of rural roads: AHP in group decision. *Engineering, Construction and Architectural Management*, *17*(2), 135–158.

Darko, A., Chan, A. P. C., Ameyaw, E. E., Owusu, E. K., Pärn, E. & Edwards, D. J. (2019). Review of application of analytic hierarchy process (AHP) in construction. *International Journal of Construction Management*, *19*(5), 436–452.

Designingbuildings. (2020). Aesthetics and architecture. Access Address (10.02.2024):https://www.designingbuildings.co.uk/wiki/Aesthetics_and_architecture

Designingbuildings. (2021). Durability. Access Address (11.02.2024):https://www.designingbuildings.co.uk/wiki/Durability

Designingbuildings. (2023). The history of buildings. Access Address (10.02.2024):https://www.designingbuildings.co.uk/wiki/The_history_of_buildings

Dias, A. & Ioannou, P. G. (1996). Company and project evaluation model for privately promoted infrastructure projects. *Journal of Construction Engineering and Management*, *122*(1), 71–82.

Doloi, H. (2008). Application of AHP in improving construction productivity from a management perspective. *Construction Management and Economics*, *26*(8), 841–854.

El-Sayegh, S. M. (2009). Multi-criteria decision support model for selecting the appropriate construction management at risk firm. *Construction Management and Economics*, *27*(4), 385–398.

Golden, B. L., Wasil, E. A., & Harker, P. T. (1989). The analytic hierarchy process. *Applications and Studies, Berlin, Heidelberg*, 2(1), 1-273.

Gunasinghe, M., De Silva, S., & De Silva, S. (2017). A categorization of factors influencing workmanship through a comprehensive analysis of secondary information. In *8th International Conference on Structural Engineering and Construction Management.* University of Peradeniya, Sri Lanka. Retrieved February 25, 2024, from https://www.researchgate.net/publication/352670205

Housing For Health. (2024). Structural safety. Access Address (10.02.2024):https://www.housingforhealth.com/housing-guide/structural-safety

Hsu, P. F., Wu, C. R. & Li, Z. R. (2008). Optimizing resource-based allocation for senior citizen housing to ensure a competitive advantage using the analytic hierarchy process. *Building and Environment*, *43*(1), 90–97.

Hyun, C., Cho, K., Koo, K., Hong, T. & Moon, H. (2008). Effect of delivery methods on design performance in multifamily housing projects. *Journal of Construction Engineering and Management*, *134*(7), 468–482.

Ismail, F. Z., Halog, A. & Smith, C. (2017). How sustainable is disaster resilience? An overview of sustainable construction approach in post-disaster housing reconstruction. *International Journal of Disaster Resilience in the Built Environment*, *8*(5), 555-572.

Ishizaka, A. (2014). Comparison of fuzzy logic, AHP, FAHP and hybrid fuzzy AHP for new supplier selection and its performance analysis. *International Journal of Integrated Supply Management*, *9*(1-2), 1-22.

Iqbal, M., Ma, J., Ahmad, N., Ullah, Z. & Ahmed, R. I. (2021). Uptake and adoption of sustainable energy technologies: Prioritizing strategies to overcome barriers in the construction industry by using an integrated AHP-TOPSIS approach. *Advanced Sustainable Systems*, *5*(7), 2100026.

Kamaruzzaman, S. N., Lou, E. C. W., Wong, P. F., Wood, R. & Che-Ani, A. I. (2018). Developing weighting system for refurbishment building assessment scheme in Malaysia through analytic hierarchy process (AHP) approach. *Energy Policy*, *112*, 280-290.

Kaplan, S. & Kaplan, R. (1982). *Cognition and environment: functioning in an uncertain world.* New York: Praeger. Chapter 4.

Khaldi, K. (2017). Quantitative, qualitative or mixed research: Which research paradigm to use. *Journal of Educational and Social Research*, *7*(2), 15-24.

Lacasse, M. A., Ge, H., Hegel, M., Jutras, R., Laouadi, A., Sturgeon, G. & Wells, J. (2018). *Guideline on design for durability of building envelopes.* National Research Council (NRC) of Canada: Ottawa, ON, Canada. Access Address (15.02.2024):https://doi.org/10.4224/23003983

Lam, K. C., Lam, M. C. K. & Wang, D. (2008). MBNQA-oriented self-assessment quality management system for contractors: Fuzzy AHP approach. *Construction Management and Economics*, *26*(5), 447–461.

Lam, K. & Zhao, X. (1998). An application of quality function deployment to improve the quality of teaching. *International Journal of Quality & Reliability Management*, *15*(4), 389–413.

Lawson, B. (2007). *Language of space.* Great Britain: Architectural Press.

Leadership in energy and environmental design (LEED) rating system. (2000). Green building rating system. US. Green Building Council. Access Address (12.02.2024): http://www.civil.uwaterloo.ca/beg/ArchTech/LEED%20rating%20V2_0.pdf

Li, J., & Zou, P. X. W. (2011). Fuzzy AHP-based risk assessment methodology for PPP projects. *Journal of Construction Engineering and Management*, *137*(12), 1205–1209.

Louw, H. (2003). Aesthetics, ethics and workmanship: The need for a cultural dimension to construction history. Huerta S., (Ed.) Proceedings of the First International Congress on Construction History (s. 1335-1344). Madrid, İspanya. Access Address (15.02.2024): http://www.sedhc.es/biblioteca/actas/CIHC1_127_Louw%20H.pdf

Madsen, H. O., Krenk, S. & Lind, N. C. (2006). *Methods of structural safety.* Courier Corporation. New Jersey: Dover Publications.

Majeed, N. N., Oleiwi, M. S., & Yaseen, R. A. (2019). *The architectural variables (shape, function, and durability) and their impact in the architectural design to guarantee the design efficiency: Vol.528. IOP Conference Series: Materials Science and Engineering,* (s. 022054). IOP Publishing. doi:https://doi.org/10.1088/1757-899X/518/2/022054. Access Address (10.02.2024): https://iopscience.iop.org/article/10.1088/1757-899X/518/2/022054/meta.

Mamauag, J. (2023). The role of the economy in shaping architectural design. Access address (10.01.2023):https://jonnelmamauag.medium.com/of-economy-and-design-in-architecture-part-1-an-introduction-8ad9a6bdff1c#:

Mathiyazhagan, K., Gnanavelbabu, A. & Lokesh Prabhuraj, B. (2019). A sustainable assessment model for material selection in construction industries perspective using hybrid MCDM approaches. *Journal of Advances in Management Research*, *16*(2), 234-259.

McIntyre, M. H. (2006). *A literature review of the social, economic and environmental impact of architecture and design.* Edinburgh, Scotland: Scottish Executive Social Research.

Mittal M. (2023). Structural safety?. Access address (10.06.2023): https://www.linkedin.com/pulse/structural-safety-manoj-mittal

Mohsen, M. A. (2000). *Aesthetic Values in the Plastic Arts.* Dar Al-Fikr Al-Arabi. 1st Edition. Cairo.

Mora, E. P. (2007). Life cycle, sustainability and the transcendent quality of building materials. *Building and environment*, *42*(3), 1329-1334. DOI: https://doi.org/10.1016/j.buildenv.2005.11.004. Access Address (11.02.2024): https://www.sciencedirect.com/science/article/pii/S0360132305004737

Nasar, J. L. (2000). The evaluative image of places. Walsh et al., (Ed.) *Person-environment psychology*. Psychology Press (May 2000), (s. 117-168) Access Address (20.02.2024): https://www.taylorfrancis.com/chapters/edit/10.4324/9781410605771-5/evaluative-image-places-jack-nasar

National Association of Home Builders (NAHB) Research Centre. (2002). Durability by Design: A Guide for Residential Builders and Designers. U.S. Department of Housing and Urban Development. Washington D.C. Access Address (11.02.2024): https://www.huduser.gov/portal/publications/durability_by_design.pdf

Nireki, T. (1996). Service life design. *Construction and Building Materials. 10*(5)403–406. DOI: https://doi.org/10.1016/0950-0618(95)00045-3. Access Address (11.02.2024): https://www.sciencedirect.com/science/article/pii/0950061895000453

Oke, A. E., Aigbavboa, C. O. & Semenya, K. (2017). Energy savings and sustainable construction: Examining the advantages of nanotechnology. *Energy Procedia*, *142*, 3839-3843.

Ortiz, O., Castells, F. & Sonnemann, G. (2009). Sustainability in the construction industry: A review of recent developments based on LCA. *Construction and Building Materials*, *23*(1), 28-39. Access Address (28.2.2024): https://www.sciencedirect.com/science/article/pii/S0950061807003005

Ortiz, O., Pasqualino, J. C. & Castells, F. (2010). Environmental performance of construction waste: Comparing three scenarios from a case study in Catalonia, Spain. *Waste Management*, *30*(4), 646-654. Access Address (13.02.2024): https://doi.org/10.1016/j.wasman.2009.11.013

Pan, N. F. (2008). Fuzzy AHP approach for selecting the suitable bridge construction method. *Automation in Construction*, *17*(8), 958–965.

Pan, W., Dainty, A. R. J. & Gibb, A. G. F. (2012). Establishing and weighting decision criteria for building system selection in housing construction. *Journal of Construction Engineering and Management*, *138*(11), 1239–1250.

Presidency of Strategy and Budget. (2023). Kahramanmaraş and Hatay earthquakes report 2023. Presidency of Strategy and Budget. Access address (05.01.2024): https://www.sbb.gov.tr/wp-content/uploads/2023/03/2023-Kahramanmaras-andHatay-Earthquakes-Report.pdf.

Rad, M. A. H., Jalaei, F., Golpour, A., Varzande, S. S. H. & Guest, G. (2021). BIM-based approach to conduct Life Cycle Cost Analysis of resilient buildings at the conceptual stage. *Automation in Construction*, *123*, 103480. Access Address (20.02.2024): https://doi.org/10.1016/j.autcon.2020.103480.

Razi, P. Z., Ramli, N. I., Ali, M. I. & Ramadhansyah, P. J. (2020). *Selection of method in construction industry by using analytical hierarchy process (AHP): Vol. 712. IOP Conference Series: Materials Science and Engineering* (s. 012015). IOP Publishing. doi:10.1088/1757-899X/712/1/012015

Robinson, H. & Symonds, B. (2015). Theories and principles of design Economics. Robinson, H. et al., (Ed.). *Design economics for the built environment: impact of sustainability on project evaluation* (March 2015), (s. 16-30). Access Address (10.02.2024): https://doi.org/10.1002/9781118944790.ch2.

Saaty, T. L. (1980). The analytic hierarchy process (AHP). *The Journal of the Operational Research Society*, *41*(11), 1073-1076.

Saaty, T. L. & Vargas, L. G. (1991). *The logic of priorities*. Pittsburgh, PA: RWS Publications.

Shakir, I., Jasim, M. A. & Weli, S. S. (2021). High Rise Buildings: Design, Analysis, and Safety: An Overview. *International Journal of Architectural Engineering Technology*, *8*, 1-13.

Shurrab, J., Hussain, M. & Khan, M. (2019). Green and sustainable practices in the construction industry: A confirmatory factor analysis approach. *Engineering, Construction and Architectural Management*, *26*(6), 1063-1086.

Stead, J. G. & Stead, W. E. (2014). *Sustainable strategic management*. New York: Routledge. Access Address (11.02.2024): https://www.taylorfrancis.com/books/mono/10.4324/9781315700533/sustainable-strategic-management-jean-garner-stead-edward-stead

Sundquist, H. (2010). Risks and Safety in Building Structures. Grimvall, G. et al., (Ed.). *Risks in Technological Systems. Springer Series in Reliability Engineering.* Springer (2010), (s. 47-68). ISBN 978-1-84882-640-3. London: Springer.

Tavares, R. M., Tavares, J. L. & Parry-Jones, S. L. (2008). The use of a mathematical multi-criteria decision-making model for selecting the fire origin room. *Building and Environment*, *43*(12), 2090–2100.

Terwel, K. C. & Jansen, S. J. (2015). Critical factors for structural safety in the design and construction phase. *Journal of Performance of Constructed Facilities*, *29*(3), 04014068.

Turton, P. (2012). How Climate Influenced Early Modernist Architecture and the International Style (IDBE). University of Cambridge.

Vrcconstruction. (2023). Functional & Aesthetic Infrastructure. Access Address (12.10.2023): https://medium.com/@vrcgroup9/functional-aesthetic-infrastructure-with-the-best-civil-construction-company-ed0a7f7aaad2

World Commission on Environment and Development (WCED). (1987). *Our Common Future;* World Commission on Environment and Development, Oxford University Press: Oxford, UK.

Xia, B., Rosly, N., Wu, P., Bridge, A. & Pienaar, J. (2016). Improving sustainability literacy of future quantity surveyors. *Smart and Sustainable Built Environment*, *5*(4), 325-339.

Yıldız, S., Kıvrak, S. & Arslan, G. (2017). Factors affecting environmental sustainability of urban renewal projects. *Civil Engineering and Environmental Systems*, *34*(3-4), 264-277.

Yıldız, S., Kıvrak, S. & Arslan, G. (2018). Built Environment Design and Sustainability Relationship in Urban Transformation. *Çağdaş Yerel Yönetimler Journal*, *27*(1), 53-75

Yılmaz, E. (2005). A land use planning model: The example of Cennetdere Valley. Ministry of Environment and Forestry Eastern Mediterranean Forestry Research Institute.

Zaki, W. R. M., Nawawi, A. H. & Ahmad, S. S. (2010). Economic assessment of Operational Energy reduction options in a house using Marginal Benefit and Marginal Cost: A case in Bangi, Malaysia. *Energy Conversion and Management*, *51*(3), 538-545.

Zhang, G. & Zou, P. X. W. (2007). Fuzzy analytical hierarchy process risk assessment approach for joint venture construction projects in China. *Journal of Construction Engineering and Management*, *133*(10), 771–779.

Zou, P. X. W. & Li, J. (2010). Risk identification and assessment in subway projects: Case study of Nanjing Subway Line 2. *Construction Management and Economics*, *28*(12), 1219–1238.

Zoning Law. (1985, March 5). Official Gazette (Number: 18749). Access Address (15.03.2024): https://mevzuat.gov.tr/mevzuat?MevzuatNo=3194&MevzuatTur=1&MevzuatTertip=5