Contents lists available at: http://qu.edu.iq

Al-Qadisiyah Journal for Engineering Sciences

Journal homepage: https://qjes.qu.edu.iq

Research Paper

Evaluating alternative construction materials used in the floors of major halls in Iraq

Zaid Ali K. Alzaidi [1], ***Salam Maythem Al-Obaidi*** [1], ***Hasan Hadi Kraidi*** [1]
Jaafar Salman Abdulsada [2], ***and Bin Xi*** [3]

[1] *Roads and Transportation Engineering Department, College of Engineering, University of Al-Qadisiyah, Al-Diwaniyah, Iraq.*
[2] *Department of Civil and Environmental, College of Engineering, University of Al-Qadisiyah, Al-Diwaniyah, Iraq.*
[3] *Department of Civil and Environmental Engineering, College of Engineering, Politecnico di Milano, Milano, Italy.*

ARTICLE INFO

Article history:
Received 16 September 2024
Received in revised form 22 November 2024
Accepted 05 September 2025

keyword:
Construction materials
Construction companies
Major halls
Iraq
TOPSIS
Value engineering

ABSTRACT

The labor market has been constantly changing in recent decades, so choosing the type of construction materials in general and floor finishing materials in particular is of great importance for construction projects. This research helps to determine how to choose the flooring materials used in major halls in Iraq and how to employ TOPSIS, Technique for Order Preference by Similarity to an Ideal Solution technical foundation in evaluating them. The study involves determining the criteria used to find the optimal alternative, as well as determining the quality index of those alternatives through the value engineering methodology in order to choose the best from this aspect. Therefore, arriving at appropriate alternatives for the purpose of construction works that can be implemented in the region, For the purpose of achiev-ing the goal of the research, the data was collected from the literature that dealt with the topics of the system's preference by similarity to the ideal solution and value engineering, Finally from field visits and personal interviews with specialists from company managers and department and project managers. Descriptive, analytical, and statistical approaches were adopted for the study, and the results of data anal-ysis showed for sample members that carpet is the most relatively important alternative that can be cho-sen for the purpose of constructing floors for large halls, based on the standards studied. Also, the sound insulation standard is followed by the ease of maintenance standard, and then safety is more important than the rest of the standards in evaluating alternatives to flooring materials.

1. Introduction

Most large-scale projects, such as sports halls, meeting rooms, and exhibition halls, are characterized by the fact that their floor finishes have sustainable properties and possess standards that make them long-lasting and high-performance in order to meet the requirements of a sustainable green environment [1]. As a result of the rapid development in building technologies and the availability of construction materials needed for various types of floor finishes, the investigation and analysis of alternatives to building materials for flooring is extremely important and required in the construction sector [2, 3]. In this study, the selection of the studied materials (porcelain tiles, carpets, and granite tiles) had several reasons, including the availability of these materials in the local market in abundance and in various types and origins, as well as the fact that the prices of these materials are appropriately compared to other flooring materials such as parquet wood and marble tiles, which have very high prices, in addition to the ease of working and installing these materials in floors and others. When identifying and evaluating alternatives to special building materials for the finishing works of hall floors, all environmental, technical, economic, and quality criteria must be taken into account primarily to achieve safety for the user as well as to ensure the longevity of the chosen building material [4]. It has become clear that the use of alternatives to traditional flooring materials has a harmful effect on both the safety and health of users as well as on the surrounding environment, so the evaluation of suitable materials for flooring of large halls must be analyzed for the purpose of choosing the optimal alternative [5]. The goal of this study is to group common finishing materials in the construction market in Iraq that can be used for finishing work in large-space halls on the basis of a number of standards and characteristics, including safety, sound insulation, maintainability, health, aesthetics, quality, and cost. Major halls represent closed halls with a large space and whose heights are more than 6 meters, such as major meeting rooms, music halls, theaters, and other halls in which the standards studied in this paper must be taken into account. The process of producing and organizing building materials for finishing floors in infrastructure projects, such as marble, carpets, granite tiles, and porcelain tiles, requires a lot of resources, so it is likely that they contain materials that pose a threat to the environment and the health of users. Therefore, it is necessary to choose building materials that can be produced and organized without risks to health and the environment [6, 7]. The safety criteria are one of the most important factors that must be taken into consideration and analyzed when evaluating floor finishing materials. It must be taken into account that the finishing materials are largely safe to reduce risks [8]. The aesthetic criterion is also considered one of the criteria relied upon in evaluating and selecting flooring alternatives for finishing large halls [9]. These halls are usually used to hold many events, so it is necessary that these materials be of quality and aesthetics that meet the design requirements and tastes of customers and users.

* *Corresponding Author.*
E-mail address: Zaid.alzaidi@qu.edu.iq ; Tel: (+964) 782-392 6175 (Zaid Alzaidi) and bin.xi@polimi.it ; Tel: (+39) 345-879 2466 (Bin Xi)

https://doi.org/10.30772/qjes.2024.153625.1388

Nomenclature

$TOPSIS$	Technique for order preference by similarity to ideal solution	N_{ij}	Normalization solution matrix for the criteria
V_i	Value engineering	P_i	The relative proximity to the ideal solution
M	Matrix	n	Sample size of respondents
A_F	Flooring alternatives	Z	The level of confidence
R_{ij}	Relative importance of each criterion	P	The variation degree between the items of the target samples
e_j	Criterion's entropy value, which ranges from 0.0 to 1.0	ε	The maximum estimated error, which can be 8 or 9%
m	Number of alternatives	Q	Quality
W_j	The criterion's weight	C	Cost

One of the important criteria that is taken into consideration is the cost, which is required in the analysis and evaluation of construction materials based on value engineering, as it is not necessary to choose the materials with the lowest cost, but rather the rest of the criteria studied must be taken into consideration [10, 11]. As for sound insulation criteria, it is a methodology that aims to obtain suitable insulation for a region to limit or decrease disturbing sounds resulting from different sources of sounds, as well as to reduce severe noise in large-space halls that use audio recordings or for other commercial purposes that require sound isolation [12, 13]. Growing interest in building materials and finishes that are environmentally friendly, highly efficient, highly safe, and easy to maintain while maintaining an attractive appearance makes this study essential for creating contemporary infrastructure and making sure the major halls are operated in a correct and comfortable way [14]. The study's primary problem is how to select finishing materials for large-space hall floors based on a variety of criteria, such as safety, ease of upkeep, health, sound insulation, aesthetic appearance, etc. This allows decision-makers to select the optimal materials (the suitable substitute) for hall floor construction. The building sector is continuously looking for substitutes for the conventional materials that are utilized to create hall enormous flooring [15, 16]. This study seeks to find optimal, more sustainable, and effective solutions when creating finishing materials for floors, based on a set of criteria that are analyzed in order to enable them to meet the requirements of contemporary design and architecture. This analysis of the literature attempts to assess several substitutes for main hall floor building materials in terms of their effectiveness, environmental effect, and viability from an economic standpoint. Researchers have thoroughly examined sustainable building materials to limit environmental impacts in order to assess alternatives to the construction materials utilized in the flooring of main halls. [10, 17, 18]. Research has concentrated on examining the characteristics and uses of a variety of materials, including terrazzo, linoleum, ceramic, marble, and vinyl composite tiles; polymer concrete; cement stabilized rammed earth; bamboo fiber geopolymer; and waste steel slag. For the floors of large halls in particular in Iraq, analyzing, identifying, and evaluating alternatives to the materials used in them is extremely important to meet environmental, health and design criteria [19, 20]. Hilal et al.[21] identified and analyzed the priorities of the criteria for selecting wooden floors using hierarchical analysis to determine and analyze the priority of each criterion, and they reached results stating that safety and health properties, durability properties, walking safety, freedom from harmful substances, and scratch resistance are the most important criteria that affect the selection of wooden floors Zaki and others[22] proposed a comprehensive evaluation system for flooring materials based on the functional requirements of projects. It relied on studying 26 criteria according to the needs of customers and users. The hierarchical analysis methodology was studied and used for multi-criteria decision-making, as well as the use of life cycle costing technology. The life cycle cost was calculated for each alternative of the finishing floor. The study reached the conclusion that imported HDF material is the ideal solution that achieves the highest value. Adriana and others [23, 24] conducted a study in which they emphasized the importance of analyzing, evaluating, and selecting alternatives to safer building materials for floors and other structures based on a set of criteria such as risk factors, health, economic efficiency, and others for the purpose of reducing or reducing risk factors and promoting the preservation of a sustainable green environment. The lack of regular maintenance of construction buildings and the rapid, noticeable disappearance of these buildings as a result of many factors, including climate change and weather conditions, leads to a rapid deterioration in the condition of the construction materials used. Therefore, performing maintenance operations in a timely manner is an important matter as it is one of the main criteria for evaluating and selecting the optimal materials. So, evaluating the performance of construction materials and prioritizing maintenance procedures leads to extending the service life of materials, and contributes to achieving a sustainable green environment [25]. This comprehensive approach aligns with the goal of advancing science and practice in selecting construction materials that are both environmentally friendly and safe for occupants [26]. The environmental impact of building materials is a significant factor to consider, especially in the context of reducing greenhouse gas emissions related to construction activities, as shown in a research paper on material-related emissions in the building sector [27]. Al Orabi and Khaled's study [28] suggested a procedure to automatically calculate the VE process of choosing materials for building flooring. The framework pointed to the chosen preferred criteria materials that were used for floor finishings, which have been measured according to specified standard tests, the proposed framework was correlated to two questioners and consultants. Onochie and others [29] evaluated the factors that influence the preference of the various finishes for floors in the Industry Building in the Abia state based on the usage, quality of aesthetics, durability, and toughness of the materials, and cost-effectiveness to dampness among various materials. The study revealed that selecting floor finishes depends on the functionality of specific variables particularly, the usage of the building is the main factor.

Table 1. Flooring alternatives in large halls and their criteria.

Criteria	Flooring alternatives		
	Porcelain tiles (A1)	Carpet (A2)	Granite tiles (A3)
Safety (C1)	A1C1	A2C1	A3C1
Ease of maintenance (C2)	A1C2	A2C2	A3C2
Health (C3)	A1C3	A2C3	A3C3
Aesthetic (C4)	A1C4	A2C4	A3C4
Sound insulation (C5)	A1C5	A2C5	A3C5

Al Orabi and others [30] developed a methodology using BIM, Building Information Modeling, and engineering value concepts while considering a proper rating system. For choosing materials for building finishing flooring. Modern and advanced engineering programs such as Building Information Modeling (BIM) were used taking into account the impacts from social, economic, and environmental. That a particular choice might have on the project sustainability, in addition, it takes into account the engineering value components of the choices in terms of function, quality, and cost-effectiveness. Koulinas G.K. et. al, [31] suggested safety and evaluating alternatives in the construction industry for selecting priorities for workplace risks to enhance the health and safety of workers, and the issues of well-being that have been implemented inside the concept of sustainability, particularly belonging to the social part of sustainability, the fuzzy extension of the TOPSIS, Technique has for the Order of Preference by Similarity to Ideal Solution has been used for this purpose. Managers can evaluate alternatives and make informed orders about how to spend a limited cost to optimize safety, and health at work by using this integrated multi-criteria approach. El-Alfy [32] offered a strategy for enhancing the sustainability of buildings. The suggested approach uses the Value Engineering program's job plan as a tool for researching and evaluating sustainability requirements. It also makes use of a database with the most recent data on building systems and materials. Table 1 shows the following categories of flooring alternatives that have been used in many construction projects in Iraq, along with the criteria that are studied and analyzed for the purpose of selecting the appropriate alternative for each project [28, 33–36]. There are not many studies concerned with analyzing alternatives to construction materials for building floor finishes in general and hall floors for their various uses and evaluating those using statistical methods, and there are no adequate previous studies covering this topic. This makes information about this issue or topic very limited, so the researchers conduct further research and investigation using descriptive, analytical, statistical, and expert evaluation methods to bridge this gap between topics.

2. Method and methodology

The alternatives that are frequently used in the grand hall floors with their various functions and the criteria for those alternatives were selected and sorted using prior studies, field visits, and the realities of the labor market. The study employed both qualitative and quantitative measures, and the required procedures were established to work with these alternatives [37]. The TOPSIS method was employed to compare the options according to the chosen criteria

[38, 39]. The weighted evaluation of floor alternatives is also conducted based on value engineering (based on the quality and cost of the studied alternatives by setting selection criteria for the alternatives that have been arranged using statistical methods as well (so that each criterion is weighted with a maximum of five points and a minimum of one point). The study model's flowchart is displayed in Fig. 1.

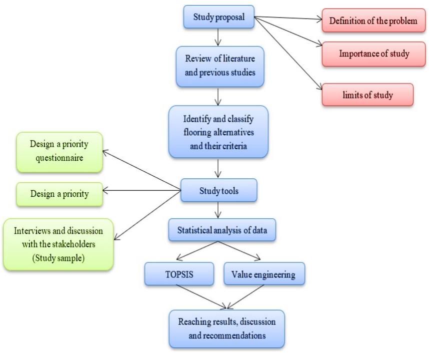

Figure 1. General plan of the study.

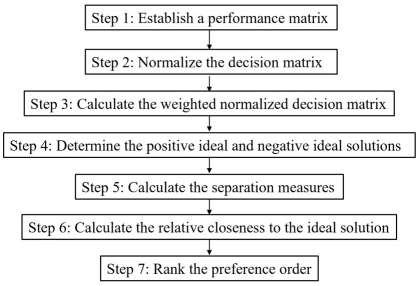

Figure 2. Flow chart of the TOPSIS procedure.

-TOPSIS method (Technique for order preference by similarity to an ideal solution):

The alternative should be the closest to the positive ideal solution and the farthest from the negative ideal solution, according to the fundamental tenet of the TOPSIS technique, Fig. 2 [40–43]. The study aimed to identify and evaluate three alternatives for flooring materials used in large halls with different functions in Iraq. In order to make computations easier, the criteria (applied measures) were marked as C1, C2, Cn, and the first alternative was designated A_1, the second as A_2, and the third as A_3. According to survey results [44, 45], Table 2 shows the outcomes of the evaluation of each option for alternatives based on criteria (applied measures) on a 1 to 10 scale [46].

Table 2. The matrix of responses to criteria assessment [42].

A3	A2	A	B3	B2	B	C3	C2	C	D
10	09	08	07	06	05	04	03	02	01

Where A3- is the symbol with the highest score of 10 for the criteria, and so on in descending order for the rest of the symbols. The solution matrix (mij) = m × n will take the following form Eq. 1 if assuming that the problem of a multi-criteria with (m) alternatives and (n) criteria has a solution [47]:

$$[M] = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_3 \end{matrix} \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ \vdots & \vdots & \vdots \\ C_{m1} & C_{m2} & C_{m3} \end{bmatrix} \tag{1}$$

Utilizing the TOPSIS approach, the flooring alternatives are evaluated based on the investigated criteria. The process consists of the following stages [48, 49]:

1. Following a summary of the questionnaire responses in line with Table 2, the format of the questionnaire is presented in Appendix A. The significance of the criterion is determined as follows, Eq. 2:

$$R_{ij} = \frac{C_{ij}}{\sum_{i=1}^{m} C_{ij}} \tag{2}$$

Where R_{ij} is the relative importance of each criterion. Next, each criterion's entropy value is determined utilizing the following equation, Eq. 3:

$$e_j = \frac{-1}{\ln m} \sum_{i=1}^{m} K_{ij} \ln R_{ij} \tag{3}$$

Where e_j is each criterion's entropy value, which ranges from 0.0 to 1.0. m is the total number of alternatives. Then, using the following equation, the weights $w1$, $w2$, ... wn for the assessed criterion are determined, Eq. 4:

$$Wc_j = \frac{1 - e_j}{\sum_{i=1}^{n} (1 - e_j)} \tag{4}$$

2. Using the equation below, the normalization solution matrix for the criteria (evaluation characteristics of flooring materials selection) is calculated. Where N_{ij} is a criterion matrix-normalization solution. Next, the following equation is used to get the weighted matrix of normalizing criteria solution, Eq. 5:

$$N_{ij} = \frac{C_{ij}}{\sqrt{\sum_{i=1}^{m} C_{ij}^2}} \tag{5}$$

Where N_{ij} is a criterion matrix-normalization solution;
$i = 1, 2, 3 \ldots m$
$j = 1, 2, 3 \ldots n$
Next, the following equation is used to get the weighted matrix of normalizing criteria solution, Eq. 6:

$$M_{ij} = wc_j \times N_{ij} \tag{6}$$

Where (w_j) is the criterion's weight, and the following equation indicates that the total of the criteria's weights is 1, Eq. 7:

$$\sum_{i=1}^{n} wc_j = 1 \tag{7}$$

3. Ideal solutions, both positive and negative, are identified, Eq. 8 and Eq. 9 respectively.

$$Is^+ = maxM_{ij}, j = 1, 2, \ldots, n \tag{8}$$

$$Is^- = minM_{ij}, j = 1, 2, \ldots, n \tag{9}$$

4. The alternative's distance as compared to the positive ideal solution, Eq. 10:

$$= (M_{ij} - m^+ j)^2 \tag{10}$$

5. The alternative's distance as compared to the negative ideal solution is identified, Eq. 11:

$$= (M_{ij} - m^- j)^2 \tag{11}$$

6. The distance of Euclidean (n) is utilized to find the distance scale (Si^+). The following equation,Eq. 12 determines the absolute distance for each alternative of a positive ideal solution [50, 51]:

$$Si^+ = \sqrt{\sum_{i=1}^{n} (M_{ij} - m^+ j)^2} \tag{12}$$

7. The distance of Euclidean (n) is used to measure the distance scale (Si^-). The following equation, Eq. 13 determines the distance for each alternative of a positive ideal solution:

$$Si^- = \sqrt{\sum_{i=1}^{n} (M_{ij} - m^- j)^2} \tag{13}$$

8. Next, the following equation, Eq. 14 is used to determine the relative proximity (P_i) to the ideal solution:

$$P_i = \frac{Si^-}{Si^- + Si^+} \tag{14}$$

-Value engineering methodology:

Value engineering is known as a systematic procedure to process the project's value and correlate them to the goals and standards of the owner and stakeholders, and then create alternative suggestions [52] that can handle those suggestions and accomplish the purpose and aims at the minimum costs without affecting the project's qualities and basic functions. Value engineering is an effective systematic method for solving problems and making the appropriate decision, and the secret of its success lies in identifying unnecessary costs and improving quality and performance together, as improvements in quality and performance are the result of suggestions and recommendations from the work team or stakeholders who participate in the process of selecting alternatives and criteria for those alternatives. The alternatives in this study are selected using value engineering by comparing them in terms of the cost that is known from the labor market and the quality that is measured by evaluating different criteria such as safety, health, ease of maintenance, sound insulation, etc.) on a scale from 1 to 5 to find the specific weight of each criterion and then divide the weight of each criterion by the total weight of the standards to find the percentage of importance of each of the studied criteria. The other step is to evaluate the alternatives for each criterion and multiply the weight of the evaluated alternative by the importance of each corresponding criterion, the qualitative weights of all alternatives are collected on the basis of all criteria and find a quality indicator that depends on that evaluation and the cost that has been studied and found in the field from the labor market in Iraq. Using value engineering, the process of weighted evaluation and selection between alternatives (flooring materials) is carried out by setting selection criteria for those alternatives that have been arranged using statistical methods [53, 54] Through weight evaluation of alternatives for flooring materials on the basis of value engineering by finding a value index as in the following equation [55, 56], Eq. 15:

$$V_i = Q/C \tag{15}$$

Where Q - The quality of the studied flooring materials (which are evaluated using statistical methods by evaluating them by a sample of respondents from one to five); C - The cost of the studied flooring materials according to the labor market.

3. Results

The study's target sample includes customers (clients), stakeholders (investors), contractors, consultants, and personnel with more than ten years of experience as investors in the public industrial, and private sectors. Equation 16, which has been used in many studies, is used to find the target sample that represents statistical value [57, 58].

$$n = \frac{z^2 \times \rho \times (1-\rho)}{\varepsilon^2} \approx 106 \tag{16}$$

Where:
n: The size of the sample.
Z: Shows the level of confidence, for instance, 2.575, 1.96, and 1.645 represent the levels of confidence at 99%, 95%, and 90%, respectively.
ρ: The variation degree between the items of the target samples.
ε: The maximum estimated error, which can be 8 or 9%.
$n \approx 106$ questionnaires were recorded. Thirteen questionnaires were excluded because they were not filled out correctly, as a result of which the whole number of participants in the questionnaires after completion carried out in the process amounted to 93 forms. Table 3 details the study's sample distribution (characteristics of response and demography).
The sample size was selected using statistical methods by 106 respondents, to whom the questionnaire forms were distributed, which is an acceptable number for the study as well as meets the quantitative classification of the required standards and alternatives, 93 of which were received accepted and 13 were neglected for incomplete or incorrect and this is contained in all applicable questionnaires, the selection of the target group, which included contractors, consulting engineers, implementing engineers and stakeholders (investors) involved in the implementation of construction projects significantly affect the quantitative evaluation process and qualitative for the purpose of choosing the studied alternatives because of having sufficient experience and keeping pace with the reality of the labor market and the continuous development in it. The results of the questionnaire conducted by respondents (engineers, project managers, and contractors) involved in infrastructure projects in Iraq were analyzed according to Table 4.

Table 3. Flooring alternatives in large halls and their criteria.

Characteristics of demography		Characteristics percentage%	Frequency	Percentage %	Cumulative percentage%
	Work Nature	Consultants	34	37	37
		Contractors	27	29	66
		Investors	13	14	80
		Others	19	20	100
	Edu. Level	BSc degree	44	47	47
		MSc degree	32	35	82
		Ph.D.	17	18	100
	Years of Experience	5–10 years	31	33	33
		11–15 years	29	31	64
		16–25 years	19	21	85
		More than 25	14	15	100

Table 4. Matrix of decisions for criteria.

Alternatives flooring materials	Safety (C1)	Ease of maintenance (C2)	Health (C3)	Aesthetic (C4)	Sound insulation (C5)
A_1	07.2	06.3	07.4	07.8	06.8
A_2	08.4	08.1	06.8	06.7	08.5
A_3	07.3	07.5	06.2	08.0	06.5
$\sum C_{ij}$	22.9	21.9	20.4	22.5	21.8

Using Eq. 2, Eq. 3 and 4, the significance of the criteria is determined according to Tables 5, 6, 7 and 8.

Table 5. Evaluations on the significance of the criteria (stage 1) $R_{ij} = \frac{C_{ij}}{\sum_{i=1}^{m} C_{ij}}$.

Alternatives flooring materials	Safety (C1)	Ease of maintenance (C2)	Health (C3)	Aesthetic (C4)	Sound insulation (C5)
A_1	0.314	0.288	0.363	0.347	0.312
A_2	0.367	0.369	0.333	0.298	0.389
A_3	0.319	0.342	0.304	0.356	0.299

Table 6. Evaluations on the significance of the criteria (stage 2) $R_{ij} \ln R_{ij}$.

Alternatives flooring materials	Safety (C1)	Ease of maintenance (C2)	Health h(C3)	Aesthetic (C4)	Sound insulation (C5)
A_1	-0.364	-0.359	-0.368	-0.367	-0.363
A_2	-0.368	-0.368	-0.366	-0.361	-0.367
A_3	-0.364	-0.367	-0.362	-0.368	-0.361

A normalization solutions matrix was computed for the parameter (criteria for evaluating alternatives to flooring materials) utilizing data collected at the TOPSIS method's application phases and equations Eqs. 5, 6, 7, 8, 9 and 10, as in Tables 9 and 10.

Table 7. Evaluations on the significance of the criteria (stage 3)- $e_j = \frac{-1}{\ln m} \sum_{i=1}^{m} R_{ij} \ln R_{ij}$, $m = 3$ (number of alternatives).

Criteria	Safety (C1)	Ease of maintenance (C2)	Health (C3)	Aesthetic (C4)	Sound insulation (C5)
e_j	0.997	0.996	0.997	0.998	0,993
$1-e_j$	0.003	0.004	0.003	0.002	0.007
$\sum 1 - e_j = 0.019$					

Table 8. Evaluations on the significance of the criteria (stage 4)-$Wc_j = \frac{1-e_j}{\sum_{i=1}^{n}(1-e_j)}$.

Criteria	Safety (C1)	Ease of maintenance (C2)	Health (C3)	Aesthetic (C4)	Sound insulation (C5)
Wc_j	0.158	0.211	0.158	0.105	0.368

Table 9. The normalization matrix of criterion solutions (stage 1).

Alternatives flooring materials	Safety (C1)	Ease of maintenance (C2)	Health h(C3)	Aesthetic (C4)	Sound insulation (C5)
A_1	7.2	6.3	7.4	7.8	6.8
A_2	8.4	8.1	6.8	6.7	8.5
A_3	7.3	7.5	6.2	8.0	6.5
$\sum_{i=1}^{m} C_{ij}^2$	175.69	161.55	139.44	169.73	160.74
$\sqrt{\sum_{i=1}^{m} C_{ij}^2}$	013.25	012.71	011.81	013.03	012.68

Table 10. The normalization matrix of criterion solutions (stage 2) - $N_{ij} = \frac{C_{ij}}{\sqrt{\sum_{i=1}^{m} C_{ij}^2}}$.

Alternatives	Safety (C1)	Ease of maintenance (C2)	Health (C3)	Aesthetic (C4)	Sound insulation (C5)
A_1	0.543	0.496	0.627	0.599	0.536
A_2	0.634	0.637	0.576	0.514	0.670
A_3	0.551	0.590	0.525	0.614	0.513

A valued matrix of the normalization solutions is computed for the criteria as in Table 11 utilizing the acquired values (Wcj) (from Table 8) and (Nij) (from Table 10).

Table 11. The valued matrix of criteria-specific normalization solutions, $M_{ij} = w_{cj} \times N_{ij}$).

Alternatives	Safety (C1)	Ease of maintenance (C2)	Health (C3)	Aesthetic (C4)	Sound insulation (C5)
A_1	0.086	0.105	0.099	0.063	0.197
A_2	0.100	0.134	0.091	0.054	0.247
A_3	0.087	0.124	0.097	0.064	0.189

As a result, can determine the values of the ideal solutions, both positive and negative:
$Is^+ = 0.100, 0.134, 0099, 0.064, 0.247$
$Is^- = 0.086, 0.105, 0.091, 0.054, 0.189$
Next, the alternative's distance from both ideal solutions, the positive and negative, is shown in Tables 12, 13, 14, and 15.

Table 12. The alternative's distance from the positive ideal solutions (stage 1)-$(M_{ij} - Is^+ j)$.

Alternatives	Safety (C1)	Ease of maintenance (C2)	Health (C3)	Aesthetic (C4)	Sound insulation (C5)
A_1	-0.014	-0.029	0.000	-0.001	-0.050
A_2	0.000	0.000	-0.008	-0.010	0.000
A_3	-0.013	-0.010	-0.002	0.000	-0.058

Table 13. The alternative's distance from the positive ideal solutions (stage 2) - $(M_{ij} - Is^+ j)^2$.

Criteria	A_1	A_2	A_3
Safety (C1)	0.000190	0.000000	0.000160
Ease of maintenance (C2)	0.000800	0.000000	0.000100
Health (C3)	0.000000	0.000025	0.000320
Aesthetic (C4)	0.000001	0.000100	0.000000
Sound insulation (C5)	0.002500	0.000000	0.003400
Total	0.0035	0.00035	0.004
$S_i^+ = \sqrt{Total}$	0.0600	0.01900	0.063

Table 14. The alternative's distance from the positive ideal solutions (stage 3)-$(M_{ij} - Is^- j)$.

Alternatives flooring materials	Safety (C1)	Ease of maintenance (C2)	Health (C3)	Aesthetic (C4)	Sound insulation (C5)
A_1	0.000	0.000	0.008	0.009	0.008
A_2	0.014	0.029	0.000	0.000	0.060
A_3	0.001	0.019	0.006	0.010	0.000

Table 15. The alternative's distance from the negative ideal solutions (stage 4) - $(M_{ij} - Is^- j)^2$.

Criteria	A_1	A_2	A_3
Safety (C1)	0.000000	0.000190	0.000001
Ease of maintenance (C2)	0.000000	0.000840	0.000360
Health (C3)	0.000064	0.000000	0.000036
Aesthetic (C4)	0.000081	0.000000	0.000100
Sound insulation (C5)	0.000064	0.003600	0.000000
Total	0.00021	0.0046	0.0005
$S_i^- = \sqrt{Total}$	0.01500	0.0680	0.0220

Table 16. Relative importance of criteria.

Criteria	Safety (C1)	Ease of maintenance (C2)	Health (C3)	Aesthetic (C4)	Sound insulation (C5)
R_i	04.8	03.6	03.9	03.3	04.2
% Each	24.1	18.1	19.6	16.6	21.1

Table 17. The alternative's distance from the negative ideal solutions (stage 4) - $(M_{ij} - Is^- j)^2$.

Criteria	Porcelain tiles		Carpet		Granite tiles	
Safety (C1)	3.8	91.6	4.7	113.3	3.3	79.5
Ease of maintenance (C2)	4.1	74.2	3.5	63.4	3.7	67.0
Health (C3)	4.4	86.2	3.8	74.5	3.9	76.4
Aesthetic (C4)	3.1	51.5	4.6	76.4	4.5	74.7
Sound insulation (C5)	2.8	59.1	4.8	101.3	3.2	67.5
Q		363		429		365
C($)		020		022		032
$V_i = Q/C\%$		0.182		0.195		0.114

Based on the selection criteria for alternatives (floor materials) and according to the results from Tables 13and 14, the coefficient of relative closeness to the ideal option is computed as follows:
$A1(Porcelaintiles) = 0.015/(0.015 + 0.06) = 0.21$;
$A2(Carpet) = 0.068/(0.068 + 0.019) = 0.78$;
$A3(Granitetiles) = 0.022/(0.022 + 0.063) = 0.32$.
Using value engineering, the studied alternatives (flooring materials) can be evaluated on the basis of the criteria that were analyzed by finding the importance, relatively measured (Ri), of each of those criteria by evaluating them from

1 (lowest value) to 5 (highest value) as in Table 16. Then, the percentage for each criterion is obtained by distributing the weight of each criterion (relative importance) by the sum of the weights for the criteria.

After this stage, each of the studied alternatives is evaluated by weight and linked to the importance of the criteria that are relatively measured for the purpose of finding the value index (Vi) using Eq. 15, as reported in Table 17, note that the cost of materials for each square meter was taken from the local market.

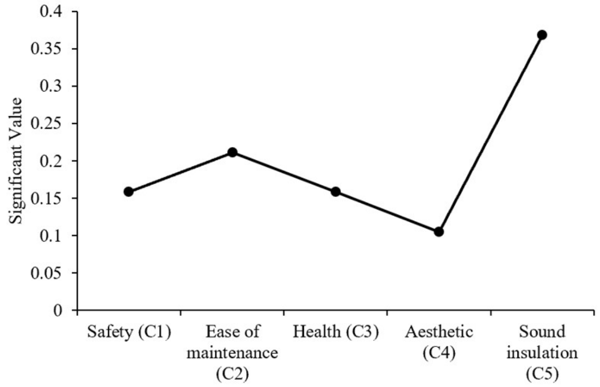

Figure 3. The Significance of criteria for selecting alternatives.

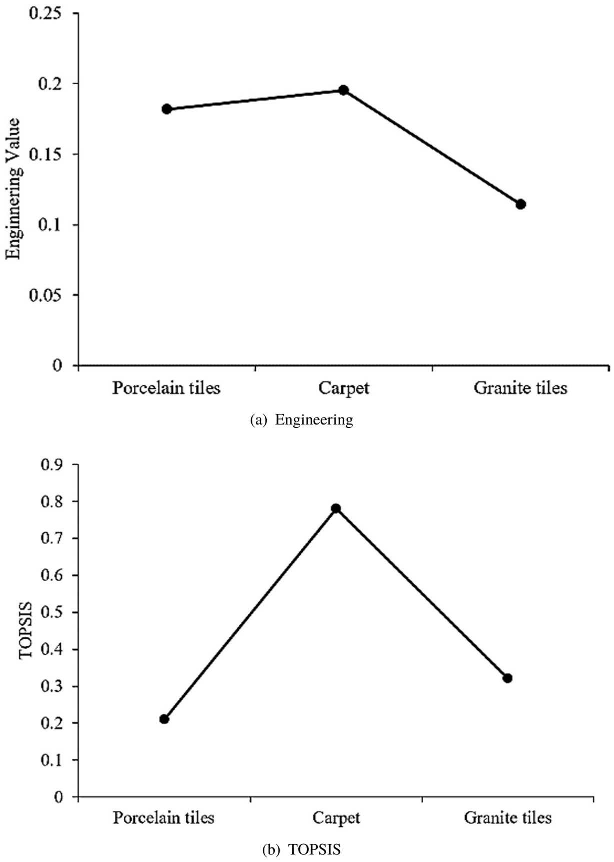

Figure 4. The importance of alternatives to flooring materials.

4. Discussion

It was found through the results that the alternative (carpet) had a coefficient of importance with a value of (0.78), which gave the greatest importance compared to the second alternative (granite tiles) with a value of (0.32) and the other alternative (porcelain tiles) with a value of 0.21 depending on the evaluation of the studied standards, which pushes decision-makers to the construction material that calculates technical, physical and environmental standards in consideration.

Using value engineering also, it was proven that the importance of granite material for the studied standards had the greatest importance with a quality index of (0.195), then granite with a quality index (of 0.182) and then porcelain with a value of (0.114), these results allow decision-makers and participants in construction projects to choose the appropriate construction materials for the floors of the halls, as well as taking into account the studied standards. In addition, the results showed that the acoustic insulation criterion had the highest specific weight of (0.368) when selecting finishing materials for flooring and then ease of maintenance (0.211) as in Table 8.

Adopting the standards of safety, aesthetics, ease of maintenance, sound insulation, and health as a basis for making comparisons between alternatives to flooring materials to evaluate them. Direct interviews and then the entropy technique showed that the sound insulation standard is more important and then ease of maintenance and safety, as in Fig. 3. It became clear through the answers of the sample members and using the similarity advantage technique (TOPSIS) as well as using the value engineering methodology that carpet as a material for finishing floors in large halls is more important than the rest of the alternatives. It also became clear through value engineering that although the cost of carpet is higher than the cost of porcelain tiles, its quality index is higher, and this is very important in terms of evaluating and selecting construction materials. Figure **??** shows the importance of the alternatives studied using the value engineering methodology and the (TOPSIS) technique. Although the limitations of the study address potential weaknesses and the studied problem, there are some limitations that faced the study, such as neglecting many of the responses to the questionnaire and the lack of adequate answers by the respondents, which led to the neglect of those responses as well, as well as the difficulty of using computer programs for the purpose of finding results when using similarity advantage technique (TOPSIS).

5. Conclusion

Choosing flooring materials for large halls is a complex task that requires taking into account various aspects. Environmental sustainability, durability, aesthetic appeal, cost, safety, health, maintenance, and physical properties are all factors that should be considered when making a decision and choosing alternatives. Researching alternative materials will allow to better understand their advantages and disadvantages, and choose the best option for large hall flooring. Among the conclusions that were reached and deduced through the research are:

- The success of using the system preference technique in similarity to the ideal solution in evaluating flooring materials for finishing large halls, based on a set of main criteria, by conducting calculations of this technique between those alternatives. In addition to the success of the value engineering methodology in choosing the decision to adopt the quality and cost of these materials.
- The lack of knowledge of most engineers working on construction projects about the main techniques in dealing with the problems of decision-making tools and the extent of the usefulness of using them in choosing the optimal alternatives in construction work.
- It was found through a field survey of construction projects and works in Iraq that the process of evaluating alternatives to materials using the database is one of the most common methods that leads to distinguishing different hypotheses.
- Despite the complex nature of decisions to enter the labor market, the existing methods and tools for evaluating construction materials from all aspects and with different standards are preliminary and insufficient, and in general they depend on personal intuition or previous experience, both of which are easily affected by doubt and uncertainty. Therefore, construction companies need effective and comprehensive methods for qualitative analysis and evaluation of building materials, which protect them from labor market fluctuations.
- Make the process of determining the importance factors of the approved criteria distributed among the members of the Bid Analysis Committee and according to the specialization of each member. For example, comparing alternatives according to price (cost) and the financial situation of the supplier is the responsibility of the participating member from the financial department, and bilateral comparison of alternatives according to the quality standard is the responsibility of the participating member from the quality department (Quality) and so on, in order to distribute tasks among all members because this will serve the process of selecting the best and closest to the ideal solution, which will be studied in future researches.

As a suggestion for future research, the authors propose developing a holistic framework that integrates environmental sustainability, durability, aesthetic appeal, cost, safety, health, maintenance, and physical properties into a decision-making model. This framework could utilize advanced decision-making tools and methodologies, such as multi-criteria decision analysis to enhance the evaluation of flooring materials. For practical implementation, the authors suggest using the above-developed model that is validated using regional case studies for different areas to compare the effectiveness of various flooring materials in diverse environmental and economic contexts, this could help to identify the best practices and adaptable solutions for different geographic locations.

Authors' contribution

All authors contributed equally to the preparation of this article.

Declaration of competing interest

The authors declare no conflicts of interest.

Funding source

This study didn't receive any specific funds.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgements

The authors would like to acknowledge.

REFERENCES

[1] D. G. Sahlol, E. Elbeltagi, M. Elzoughiby, and M. A. Elrahman, "Sustainable building materials assessment and selection using system dynamics," *Journal of Building Engineering*, vol. 35, no. 2021, p. 101978, march 2021. [Online]. Available: https://doi.org/10.1016/j.jobe.2020.101978

[2] T. Maheswararao and P. Valli, "Evaluating the durability performance of concrete containing clastic sand and ggbs," *Al-Qadisiyah Journal for Engineering Sciences*, vol. 17, no. 2, pp. 128–134, 2024. [Online]. Available: https://doi.org/10.30772/qjes.2024.149157.1212

[3] G. Bertino, J. Kisser, J. Zeilinger, T.Fischer, and D. Österreicher, "Fundamentals of building deconstruction as a circular economy strategy for the reuse of construction materials," *Applied sciences*, vol. 11., no. 3, p. 939, 2021. [Online]. Available: https://doi.org/10.3390/app11030939

[4] A. Almusaed, A. Almssad, R. Z. Homod, and I. Yitmen, "Environmental profile on building material passports for hot climates," *Sustainability*, vol. 12, no. 9, p. 3720, 2020. [Online]. Available: https://doi.org/10.3390/su12093720

[5] S. Khoshnava, R.Rostami, D. Štreimikienė, A. Mardani, and M. Ismail, "The role of green building materials in reducing environmental and human health impacts," *International Journal of Environmental Research and Public Health*, vol. 17, no. 7, p. 2589, 2020. [Online]. Available: https://doi.org/10.3390/ijerph17072589

[6] A. T. Balasbaneh, D. Yeoh, M. I. Juki, A. Gohari, A. R. Z. Abidin, and A. K. B. Marsono, "Applying three pillar indicator assessments on alternative floor systems: Life cycle study," *The International Journal of Life Cycle Assessment*, vol. 26, pp. 1439–1455, 2021. [Online]. Available: https://doi.org/10.1007/s11367-021-01881-6

[7] R. M., D. C., K. LR., S. M., and S. S., "Life-cycle and environmental impact assessments on the processing of plant fibers and its bio-composites: A critical review," *Journal of Industrial Textiles*, vol. 51, no. 4, pp. 5518S–5542S, 2022. [Online]. Available: https://doi.org/10.1177/1528083720924730

[8] A. R. A. Orabi, M. A., and K. S. Al-Gahtani, "A framework of selecting building flooring finishing materials by using building information modeling (bim)," *Advances in Civil Engineering*, vol. 2022, no. 1, p. 8556714, 2022. [Online]. Available: https://doi.org/10.1155/2022/8556714

[9] C. O. Folorunso, "Analysis of the effectiveness of wooden floor finishes in some residential buildings in lagos, nigeria," *International Journal of Building Pathology and Adaptation*, vol. 39, no. 5, pp. 756–765, 2021. [Online]. Available: https://doi.org/10.1108/IJBPA-11-2019-0100

[10] M. Demertzi, J. Silvestre, M. Garrido, J. Correia, V. Durão, and M. Proença, "Life cycle assessment of alternative building floor rehabilitation systems," *Structures*, vol. 26, p. 237–246, 2020. [Online]. Available: https://doi.org/10.1016/j.istruc.2020.03.060

[11] T. G. Townsend and M. Anshassi, "Construction materials and their properties," *Construction and Demolition Debris. Cham. Springer International Publishing*, vol. 2339, no. 11, pp. 29–71, 2023. [Online]. Available: https://doi.org/10.1007/978-3-031-25013-2_2

[12] R. Vagtholm, A. Matteo, B. Vand, and L. Tupenaite, "Evolution and current state of building materials, construction methods, and building regulations in the uk: implications for sustainable building practices," *Buildings*, vol. 13, no. 6, p. 1480, 2023. [Online]. Available: https://doi.org/10.3390/buildings13061480

[13] A. Bhuiyan, M. Masfiqul, and A. Hammad., "A hybrid multi-criteria decision support system for selecting the most sustainable structural material for a multistory building construction," *Sustainability*, vol. 15, no. 4, p. 3128, 2023. [Online]. Available: https://doi.org/10.3390/su15043128

[14] D. Al-Ali and G. M. I. Kamoona, "Effectiveness of nanomaterial in the roof of the building to achieve energy conservation for indoor environment of the building," *Journal of Engineering*, vol. 27, no. 2, pp. 126–148, 2021. [Online]. Available: https://doi.org/10.31026/j.eng.2021.02.09

[15] J. Kanters, "Circular building design: An analysis of barriers and drivers for a circular building sector," *Buildings*, vol. 10, no. 4, p. 77, 2020. [Online]. Available: https://doi.org/10.3390/buildings10040077

[16] D. G. Sahlol, E. Elbeltagi, M. Elzoughiby, and M. Abd Elrahman, "Sustainable building materials assessment and selection using system dynamics," *Journal of Building Engineering*, vol. 35, p. 101978, 2021. [Online]. Available: https://doi.org/10.1016/j.jobe.2020.101978

[17] M. Yadav and M. Agarwal, "Biobased building materials for sustainable future: An overview," *Materials Today: Proceedings*, vol. 43, pp. 2895–2902, 2021. [Online]. Available: https://doi.org/10.14424/ijcscm110221-166-194

[18] A. Szennay, Z. Major, R. Horváth, H. Czédli, and C. Szigeti, "Providing decent, affordable, and sustainable housing: Analysing environmental impacts of family houses built with conventional and unconventional building materials," *Energy Footprint and Sustainability: Case Studies. Cham: Springer Nature Switzerland*, pp. 105–126, 2024. [Online]. Available: https://doi.org/10.1007/978-3-031-63057-6_6

[19] E. Yadegaridehkordi, M. Hourmand, M. Nilashi, E. Alsolami, S. Samad, M. Mahmoud, A. Alarood, A. Zainol, H. D. Majeed, and L. Shuib, "Assessment of sustainability indicators for green building manufacturing using fuzzy multi-criteria decision-making approach," *Journal of cleaner production*, vol. 277, p. 122905, 2020. [Online]. Available: https://doi.org/10.1016/j.jclepro.2020.122905

[20] I. Atta, E. S. Bakhoum, and M. M. Marzouk, "Digitizing material passport for sustainable construction projects using bim," *Journal of Building Engineering*, vol. 43, p. 103233, 2021. [Online]. Available: https://doi.org/10.1016/j.jobe.2021.103233

[21] Z. A. Jalil, H. I. Naji, and M. S. Mahmood, "Developing sustainable alternatives from destroyed buildings waste for reconstruction projects," *Civil Engineering Journal*, vol. 6, no. 1, January 2020. [Online]. Available: https://doi.org/10.28991/cej-2020-03091453

[22] Y. Xintian, "Research on the sustainable materials in building construction," *Applied and Computational Engineering*, vol. 60, pp. 2755–2721, 2024. [Online]. Available: https://doi.org/10.54254/2755-2721/60/20240855

[23] E. Adriana and P. Milan, "Environmental analysis of two building material alternatives in structures with the aim of sustainable construction," *Clean Technologies and Environmental Policy*, vol. 17, pp. 75–83, January 2015. [Online]. Available: https://doi.org/10.1007/S10098-014-0758-Z

[24] T. Ros-Dosdá, I. Celades, L. Vilalta, P. F. i Palmer, and E. Monfort, "Environmental comparison of indoor floor coverings." *Science of The Total Environment*, vol. 693, p. 133519, 2019. [Online]. Available: https://doi.org/10.1016/J.SCITOTENV.2019.07.325

[25] X. Zhong, D.-S. Hu, M., and et al., "Global greenhouse gas emissions from residential and commercial building materials and mitigation strategies to 2060," *Nature Communications*, 2021. [Online]. Available: https://doi.org/10.1038/s41467-021-26212-z

[26] N. Murtagh, L. Scott, and J. Fan, "Sustainable and resilient construction: Current status and future challenges," *Journal of Cleaner Production*, vol. 268, p. 122264, 2020. [Online]. Available: https://doi.org/10.1016/j.jclepro.2020.122264

[27] B. Huang, X. Gao, X. Xu, T. Fishman, H. Kua, and J. Nakatani, "A life cycle thinking framework to mitigate the environmental impact

of building materials," *One Earth*, vol. 3, no. 5, pp. 564–573, 2020. [Online]. Available: http://dx.doi.org/10.1016/j.oneear.2020.10.010
[28] M. A. A. R. A. Orabi and K. S. Al-Gahtani, "A framework of selecting building flooring finishing materials by using building information modeling (bim)," *Advances in Civil Engineering*, no. 1, p. 8556714, 2022. [Online]. Available: https://doi.org/10.1155/2022/8556714
[29] F. I. Emoh, "An evaluation of factors affecting the choice of the different floor finishes in the building industry within abia state of nigeria," *International Journal of Latest Engineering and Management Research*, vol. 02, no. 03, pp. 54–58, 2017. [Online]. Available: https://www.academia.edu/34111696/AN_EVALUATION
[30] M. A. A. Alorabi, K. S. Al-Gahtani, and I. A. Alhammad, "Proposed systemic method for selecting finishing materials for building flooring using building information modeling (bim)," *In Towards Implementation of Sustainability Concepts in Developing Countries Springer International Publishing*, no. 1, pp. 165–170, 2021. [Online]. Available: https://doi.org/10.1007/978-3-030-74349-9_13
[31] K. G. K, D. O.E., and M. P.K, "Risk assessment using fuzzy topsis and prat for sustainable engi-neering projects," *Sustainability*, vol. 11, no. 3, p. 615, 2019. [Online]. Available: https://doi.org/10.3390/su11030615
[32] A. E. D. El-Alfy, "Design of sustainable buildings through value engineering," *Journal of Building Appraisal*, vol. 6, no. 1, pp. 69–79, 2010. [Online]. Available: https://doi.org/10.1057/jba.2010.14
[33] B. Altay and E. Salcı., "Exploring designers' finishing materials selection for residential interior spaces," *Architectural Engineering and Design Man .*, vol. 20, no. 2, pp. 269–286, 2023. [Online]. Available: https://doi.org/10.1080/17452007.2023.2181753
[34] C. O. Folorunso, "Analysis of effectiveness of wooden floor finishes in some residential buildings in lagos, nigeria," *International Journal of Building Pathology and Adaptation*, vol. 39, no. 5, pp. 756–765, 2021. [Online]. Available: https://doi.org/10.1108/IJBPA-11-2019-0100
[35] M. K. Ansah, X. Chen, H. Yang, L. Lu, and P. T. Lam, "An integrated life cycle assessment of different façade systems for a typical residential building in ghana," *Sustainable Cities and Society*, vol. 53, p. 101974, 2020. [Online]. Available: https://doi.org/10.1016/j.scs.2019.101974
[36] G. Sadeghi Esfahani, "Sustainability of interior design materials for 5* hotels in the uae. diss." *The British University in Dubai (BUiD)*, no. 1, 2020. [Online]. Available: https://bspace.buid.ac.ae/handle/1234/1803
[37] Y. N. Yang and et al, "Integrated qualitative and quantitative methodology to assess validity and credibility of models for bridge maintenance management system development," *Journal of Management in Engineering*, vol. 27, no. 3, pp. 149–158, 2011. [Online]. Available: https://doi.org/10.1061/(ASCE)ME.1943-5479.0000051
[38] E. Ebrahimi and M. R. F. S. M. Sobhani, "A modification of technique for order preference by similarity to ideal solution (topsis) through fuzzy similarity method (a numerical example of the personnel selection," *Journal of applied research on industrial engineering*, vol. 10, no. 2, pp. 203–217, 2023. [Online]. Available: https://doi.org/10.22105/jarie.2022.296088.1359
[39] N. A. S. F. S. A. W. S. Khofiyah, "Supplier selection using technique for order of preference by similarity to ideal solution (topsis) method: A case study," *Procedings of the International Conference on Industrial Engineering and Operations Management*, no. 1, 2021. [Online]. Available: https://doi.org/10.46254/AN11.20210409
[40] R. I. Widjaja, H.and Desanti, "Decision support system for home selection in south tangerang city using topsis method," *IJNMT (International Journal of New Media Technology*, vol. 7, no. 2, pp. 76–81, 2020. [Online]. Available: https://doi.org/10.31937/ijnmt.v7i2.1300
[41] I. Siregar, "Supplier selection by using analytical hierarchy process (ahp) and techniques for order preference methods with similarities toideal solutions (topsis)," *Journal of Physics: Conference Series. IOP Publishing*, vol. 1339, no. 1, p. 012023, 2019. [Online]. Available: https://doi.org/10.1088/1742-6596/1339/1/012023
[42] A. Lapidus, I. Abramov, T. Kuzmina, A. Abramova, and Z. AlZaidi, "Study of the sustainable functioning of construction companies in the conditions of risk factors," *Buildings*, vol. 13, p. 2282, 2023. [Online]. Available: https://doi.org/10.3390/buildings13092282
[43] K. Zhang and J. Dai, "A novel topsis method with decision-theoretic rough fuzzy sets," *Information Sciences*, vol. 608, pp. 1221–1244, 2022. [Online]. Available: https://doi.org/10.1016/j.ins.2022.07.009
[44] K. G., D. O., and M. P.K., "Risk assessment using fuzzy topsis and prat for sustainable engi-neering projects," *Sustainability*, vol. 11, no. 3, p. 615, 2019. [Online]. Available: https://doi.org/10.3390/su11030615
[45] E. Sekhavati and R. Jalilzadeh Yengejeh, "Assessment optimization of safety and health risks using fuzzy topsis technique (case study: construction sites in the south of iran," *Journal of Environmental Health and Sustainable Development*, vol. 6, no. 4, pp. 1494–1506, 2021. [Online]. Available: https://doi.org/10.18502/jehsd.v6i4.8154
[46] P. Rani, A. Mishra, A. Mardani, F. Cavallaro, M. Alrasheedi, and A. Alrashidi, "A novel approach to extended fuzzy topsis based on new divergence measures for renewable energy sources selection," *Journal of Cleaner Production*, vol. 257, no. 1, p. 120352, 2020. [Online]. Available: https://doi.org/10.1016/j.jclepro.2020.120352
[47] M. Khorram, M. Sheibani, and S. Niroomand, "A decision framework based on integration of dematel, qfd, topsis and vikor approaches for fuzzy multi-criteria supplier selection problem," *Journal of Uncertain Systems*, vol. 17, no. 01, p. 2440002, 2024. [Online]. Available: https://doi.org/10.1142/S1752890924400026
[48] H. Singer and Şükrü Özşahin., "Prioritization of laminate flooring selection criteria from experts' perspectives: a spherical fuzzy ahp-based model," *Architectural Engineering and Design Management*, vol. 18, no. 6, pp. 911–926, 2022. [Online]. Available: https://doi.org/10.1080/17452007.2021.1956421
[49] J. A. P. Amorocho and T. Hartmann, "A multi-criteria decision-making framework for residential building renovation using pairwise comparison and topsis methods," *Journal of building engineering*, vol. 53, p. 104596, 2022. [Online]. Available: https://doi.org/10.1016/j.jobe.2022.104596
[50] F. Kutlu Gündoğdu and C. Kahraman, "Optimal site selection of electric vehicle charging station by using spherical fuzzy topsis method," *Decision making with spherical fuzzy sets: Theory and applications Cham: Springer International Publishing*, vol. 392, no. 1, pp. 201–216, 2020. [Online]. Available: https://doi.org/10.1007/978-3-030-45461-6_8
[51] V. Liern and B. Pérez-Gladish, "Multiple criteria ranking method based on functional proximity index: Un-weighted topsis," *Annals of Operations Research*, vol. 311, no. 2, pp. 1099–1121, 2022. [Online]. Available: https://doi.org/10.1007/s10479-020-03718-1
[52] S. R. Alketbi, "Effective implementation of value engineering in the housing construction programmes of the uae," *University of Wolverhampton*, no. 1, 2020. [Online]. Available: http://hdl.handle.net/2436/623758
[53] M. A. Al-Ghamdi and K. S. Al-Gahtani, "Integrated value engineering and life cycle cost modeling for hvac system selection," *Sustainability*, vol. 14, no. 4, p. 2126, 2022. [Online]. Available: https://doi.org/10.3390/su14042126
[54] A. M. Saud, K. S. Al-Gahtani, and A. M. Alsugair, "Exterior walls selection framework using building information modeling (bim)," *Cogent Engineering*, vol. 9, no. 1, p. 2088642, 2022. [Online]. Available: https://doi.org/10.1080/23311916.2022.2088642
[55] J. Lee, "Indexing model based on vector normalization available for value engineering in building materials," *Applied Sciences*, vol. 11, no. 20, p. 9515, 2021. [Online]. Available: https://doi.org/10.3390/app11209515
[56] X. Li, C. Wang, and A. Alashwal., "Case study on bim and value engineering integration for construction cost control," *Advances in Civil Engineering*, vol. 2021, no. 1, p. 8849303, 2021. [Online]. Available: https://api.semanticscholar.org/corpusID:234022863
[57] S. H. Khahro., A. H. Memon., N. A. Memon., Z. A. Memon., and R. Naresh, "Influence of social and economic factors on construction project performance in pakistan," *Sustainability*, vol. 15, no. 3, p. 2469, 2023. [Online]. Available: https://doi.org/10.3390/su15032469
[58] A. Lapidus, I. Abramov., T. Kuzmina., A. Abramova, and Z. AlZaidi, "Sustainable activity of construction companies under the influence of destabilizing factors on the duration of implementation of investment-construction projects," *Buildings*, vol. 13, no. 11, p. 2696, 2023. [Online]. Available: https://doi.org/10.3390/buildings13112696

How to cite this article:
Zaid Ali K. Alzaidi, Salam Maythem Al-Obaidi, Hasan Hadi Kraidi, Jaafar Salman Abdulsada , and Bin Xi. (2025). 'Evaluating alternative construction materials used in the floors of major halls in Iraq', Al-Qadisiyah Journal for Engineering Sciences, 18(3), pp. 290-297. https://doi.org/10.30772/qjes.2024.153625.1388