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Prioritizing the most important criteria to selection the Sustainable Materials in Construction Projects based on Multi-Criteria Decision-Making Method

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Abstract:

In this paper, various applications for waste and resource-stakeholder management have been developed. Hierarchical and interactive dashboards allow for a thorough overview of materials across the economy, waste, and the flow of secondary resources. In addition, the system can track the flow of materials through production and consumption chain activities. By integrating with economic models, this system can predict possible overhead in the current waste management center and provide a decision-making support system for strategy design with a resource approach. The limitations of the current system are a stimulus for its further development in the future. Comprehensive modeling (construction of fuzzy anthology) In order to increase the content richness of the mentioned expert system and also to improve the process of its fuzzy inference for prioritization, the most important criteria for selecting provisions in construction projects.

key words: Prioritizing, Sustainable Materials, Construction Projects, Multi-Criteria Decision-Making Method

1. INTRODUCTION

Building materials play an important role in the development of architecture. Undoubtedly, the use of natural, local and local materials that have the most climatic adaptation and cultural familiarity with the surrounding environment can play an effective role in the development of architecture (Belousova, et. al., 2020). On the other hand, the meeting was defined for the first time in the UN World Commission on Environment and Development (Rafiei, 2017): Development requires meeting today's human needs without disrupting the ability of future generations to meet their needs. Naturally, in the processes of production and consumption, there are many environmental, economic, and social consequences that, beyond anything else, affect future borders and generations. The rate of extraction and destruction of non-renewable natural resources is a matter of concern. Environmental pressures related to extraction, processing or processing, transportation, use and disposal of materials affect environmental quality (such as air, climate, water, soil, biodiversity, landscape) and local ecosystem, region and human health (Mahmoudkelaye, et al. 2018;) and (Chen, 2019). The construction industry is one of the largest exploiters of natural resources. Materials extracted from natural resources used in buildings are often non-renewable and regenerative, so it is important to select and use emerging building materials. Research and development is about recognizing the spraying properties of materials and on the other hand the prospect of researching, designing and recognizing the process of processing raw materials to achieve accessible materials and the stage after their consumption according to regional, cultural, social and economic potentials. The design of footsteps in modern times has been accepted as one of the promising propositions in the development of the footpath movement (Rafiei, 2017). In recent years, the concept of sustainability has become a common interest of many disciplines (Kiani and Eghtedari, 2017). The concept of paved architecture or green buildings is the science and style of buildings built and designed with the principles of environmental compatibility, which these days have attracted the attention of many designers and architects, especially the use of the concept of paving in interior design. It brings visual and spiritual peace. Adverse effects such as air pollution, rising temperatures can be reduced by choosing the right materials (Ghosh, et al. 2019) and (Plati, 2019), in addition to the use of renewable and recyclable materials as well as local materials can to a large extent, it prevents damage to the environment. This requires that interior designers be familiar with the available materials and know the sources of production and their properties (Kiani and Eghtedari, 2017). In fact, the problems of this research can be considered the ambiguity and fatigue of the decision makers of construction projects based on the study of the effect of "economic factors on the selection of benefits"; "Environmental Factors in Selection of Fertilizers" and "Technical Factors in Selection of Fertilizers" in construction projects, using fuzzy AHP synthetic methodology. On the other hand, there is a need to use the multidisciplinary decision-making methodology to increase trust and confidence in decision-making, as well as the need for multiple expertise by simultaneously applying the knowledge of several experts in various fields to solve the most important criteria for project prioritization., There is. Given the main problem in this research, the main research question can be asked to better understand the research problem: What are the criteria for selecting the terms in construction projects?

2-BACKGROUND OF THE RESEARCH

Due to the increasing global concerns related to welfare issues, all industries should take special measures to advance the goals of welfare development (Sam and Shams Kia, 2018). The construction industry is not the only exception to this rule, but it can also play a more significant role in providing sustainable models in society. The construction sector can strive to improve its environmental performance by providing role models, and the use of sustainable materials with low energy consumption, cost and time to achieve the goals of environmental development is one of the positive ways to meet this need (Opon & Henry). 2019) and (Mahmoudkelaye, et al. 2018). The high number of materials, in addition to the complex relationships between different selection parameters, has often made the choice of materials in the construction industry a complex and difficult issue, which is associated with many uncertainties in the decision-making process. Analytical methods of decision making are the safest way to solve the problem of uncertainty and select the most appropriate criteria in complex problems (Sam and Shams Kia, 2018). Following the growth of population and increasing environmental pollution, the use of materials that only have the ability to be used once and their wastes remain in nature for many years, has also increased (Sheikhieh, 2015). But with the advent of energy saving and energy saving concepts, it's important to use materials that can be reused and returned to the normal cycle. In fact, the use of these materials is not new, but the use of natural and indigenous materials is evident in most of the buildings left in the world (Chen, 2019) and (Kappenthuler & Seeger. 2019). In Iranian architecture, this issue also manifests itself as one of the principles of Iranian architecture in the form of self-sufficiency. The benefits of indigenous use include economic efficiency and the ability to return to the natural cycle of the environment. Today, with the advancement of technology, in addition to materials that can be used mostly without the application of complex processes, materials have been produced that, in addition to having these features, have other unique features and are somewhat weaker than traditional materials.)

Table 1. Summary of research background

Row	Author	Year	Summary of research results
1	Sam and Shams Kia	2018	The purpose of this work is to provide an analytical decision support tool using network analysis method to achieve the goals of sustainable development in the decision-making process for the selection of sustainable materials in construction projects. The results show that in order to sustain the materials of a structure, attention to environmental factors such as saving energy consumption and compliance with energy and environmental standards of materials is of paramount importance.
2	Rafi'i	2017	The results show that the development in terms of recognizing the characteristics of materials sustainability and on the other hand the perspective of research, design and knowledge of the process of processing raw materials to achieve sustainable materials and their post-consumption stage according to regional, cultural, social and economic potentials. Is. The design of sustainable materials has been accepted in the present age as one of the promising propositions in the development of the sustainable movement.
3	Kiani and Ightedari	2017	In this research, first a brief definition of sustainable architecture approach, sustainable development goals and then sustainable materials are introduced. The nature of research is qualitative and the collection of information using library and Internet resources. Interior designers must be very careful and smart in choosing materials because all materials are easily available, but it is important to be able to find and choose the right materials that are environmentally friendly.
4	sheikhiyeh	2015	The results show that today, with the advancement of technology, in addition to these materials, which are often usable without the application of complex processes, materials have been produced that, in addition to having these properties, have other unique properties and are somewhat weak and age-old. They are not. In this research, these materials have been introduced in two general categories of native (traditional) materials and new materials so that architects can take a step towards achieving sustainable architecture by recognizing and using these materials.
5	Manhubi and Tehrani	2014	In this article, with the aim of protecting the environment and using materials that are in line with nature and emphasizing energy saving, first defines sustainable architecture as an architectural way out of environmental problems and emphasizes the construction method with two methods. Materials are adapted to nature and from a new perspective. First, the walls are made of super-clay and then the walls are made of non-degradable materials such as plastic soda bottles. The research method in this research is analytical and in the field of studies.
6	Mahmoud kelaye, et	2018	To establish the selection model, three alternatives, including brick and mortar wall, aluminum siding, and cedar siding, were proposed for exterior enclosure. The results revealed that aluminum siding is the best sustainable alternative while cedar siding represents itself as the least sustainable option. The importance of the criteria and sub-criteria in choosing sustainable materials was determined through this model.

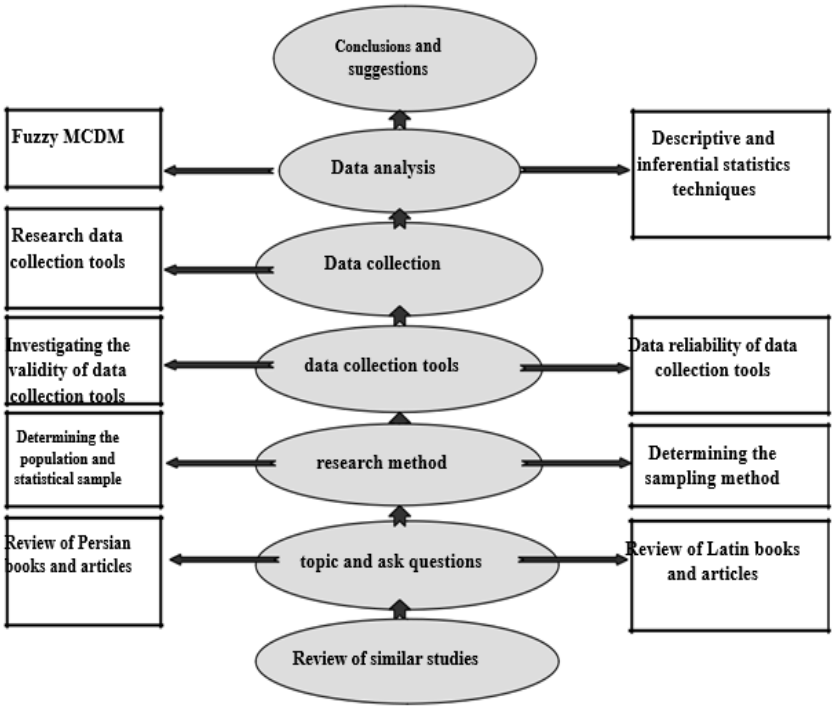
7	Ghosh, et al.	2019	A comparative study between conventional and recently developed advanced materials has also been included. Finally, the article shows how recent technologies, like electric cars, can be made more commercially efficient and eco-friendly.
8	Opon & Henry	2019	The results highlight the importance of integrating both sustainability perspectives in elucidating the trade-offs that exist between the facets of sustainability and the priority areas needing attention to enhance concrete sustainability. These are critical information in the need to balance the different facets of sustainability, and therefore support the decision-making strategies for concrete sustainability.
9	Plati	2019	In conclusion, considering the relative sources and cited literature, there is broadly a great potential for sustainable options and solutions, which can be effectively materialized. Nevertheless, further investigation field and adoption of sustainability standards are potentially promising considerations, from the perspective of future improvement.
10	Kappenthuler & Seeger	2019	Combining the evaluation of material performance with the analysis of factors affecting the respective long-term availability, it is possible to focus funding on specific areas and approaches where research and policy measures have the highest probability of providing long-term improvements to the construction industry. The applicability of the framework is illustrated with the evaluation of steel and stainless steel.
11	Chen	2019	This article discusses the latest techniques for utilizing the piezoelectric materials in energy harvesters, sensors, and actuators for various building systems. With advanced methods for improving the cementitious piezoelectricity and applying the material piezoelectricity for different building functions, more renewable and sustainable building systems are anticipated.

Finally, after examining the theoretical foundations of the research and reviewing the background of the research, it was determined that due to the existence of research gaps in the field of analysis, "economic factors are the choice of evidence"; "Environmental Factors in Selection of Effects" and "Technical Factors in Selection of Effects" inspired by research (Ghosh, et al. 2019) and (Plati, 2019) and (Opon & Henry. 2019) and (Mahmoudkelaye, et al. 2018) and (Chen, 2019) and (Kappenthuler & Seeger. 2019); Also, the lack of a model to provide recommendations to the manager to decide on the prioritization of the most important criteria for selecting payments in construction projects in emerging construction companies can be innovated in the current article to address these research gaps.

3- RESEARCH METHOD

The type of research project is applicable here. Due to the priority of the most important selection criteria in construction projects, in the present study, a combined research methodology will be used. Rational Logic Using a Combined Approach In the present study, using a fuzzy hierarchical analysis process, it is stated that compositional methodologies are very suitable for success in environments where user participation is essential. In order to identify the problems of social-behavioral systems, the use of methods based on the combination of research paradigms has become important. Since the interactive nature of the research "prioritization of the most important criteria for selecting evidence in construction projects" requires a dialogue between the researcher and experts in the field of study, the researcher's misconceptions become awareness. The purpose of this research is descriptive-applied, because on the one hand, the concepts related to the selection of provisions in construction projects are accurately described, and on the other hand, the relationships between these concepts are evaluated and determined by experts in the field of construction projects. The data collection tools in the present study are: interview and study of documents and localization tools of the research components and the tool of MCDM flowchart pairwise comparisons. The research steps are as follows:

Diagram 1. Flowchart Stages of research



The study population can be divided into two general groups, including: the first group includes experts in the field; And the second group, which includes construction management specialists working in the country's leading construction companies, was categorized. Finally, it should be noted that the sample size of this research is available to individuals who are willing to cooperate in a total of two groups introduced in the statistical community. In the fuzzy hierarchical analysis for adaptation, two matrices (intermediate number and fuzzy number) are derived from each fuzzy matrix and then the compatibility of each matrix is calculated based on the clock method. In fact, multi-criteria decision-making methods to help decision-makers to make appropriate decisions, and taking into account the set of criteria, are widely used in various scientific fields. Almost all calculations related to the hierarchical analysis process are based on the initial judgment of the decision maker, which appears in the matrix of pairwise comparisons, and any errors and inconsistencies in the comparison and comparison of the results of the comparison between the choices and indicators are significant. (Kim & Kim. 2016) and (Saaty, 2008). The incompatibility rate is a tool that determines the compatibility and shows to what extent the priorities of the comparisons can be trusted (Habibi et al. 2014) and (Pourhejazy & Zhu. 2018). The process of hierarchical analysis for prioritization the most important criteria for selecting points in construction projects include four steps, which are:

Step 1) Build the model and model the structure: The problem must be clearly stated and analyzed with a logical system, such as a network. The structure can be obtained using decision makers and methods such as brainstorming or other appropriate methods. (Kim & Kim. 2016) and (Saaty, 2008)

Step 2) Pair comparisons of priority vectors: In the AHP hierarchical decision-making method, as well as the orderly method of hierarchical analysis, the decision elements in each section are compared with each other according to their importance in controlling the criteria in pairs. In the goal, they are compared in pairs. Decision makers are asked in the form of a series of pairwise comparisons of how two or two elements compare to each other in their upper-hand criteria. In addition, if there is an interaction between the elements of a part, using pairwise comparisons and obtaining the vector of the specific values of each element, it shows the effect of other elements on it (Habibi et al. 2014) and (Pourhejazy & Zhu. 2018.). Relative importance is obtained using a relative comparison. To do this, you can use a comparison of 1 to 9, while a score of 1 indicates the same importance of two elements, and a score of 9 indicates a higher value of an element (matrix line) compared to other matrix columns. The opposite is true: = 1 /, while aij (aji) indicates the importance of element R (j) in comparison with element j (R). In the decision-making method of fuzzy AHP hierarchical analysis, I use fuzzy values to perform pairwise comparisons. (Kim & Kim. 2016) and (Saaty, 2008)

Step 3) Super matrix: The concept of super matrix is similar to the Markov chain process. Super matrix is able to limit the coefficients to calculate all the priorities and thus the cumulative effect of each element on other elements in the interaction. When a network, regardless of purpose, contains only two clusters of criteria and options, the matrix approach provided by the clock can be used to deal with the dependencies of the elements of a system. These two statements are used to prioritize. Overall, in a system of interactions, local priority vectors must enter the specific columns of a matrix, here called a super matrix. A super matrix is actually

a segmented matrix, each of which represents the relationship between two groups (parts or Cluster) is in one system (Kim & Kim. 2016) and (Saaty, 2008)

Step 4) Choose the best option: If the super matrix formed in the previous step covers the entire network, you can find the priority weights in the options column in a normalized super matrix. On the other hand, if a super matrix only includes interconnected parts, more calculations are needed to achieve the overall priorities of the options. Before examining weighting and grading methods, an explanation of the fuzzy numbers used should be provided. In this study, verbal expressions have been used instead of definite numbers to determine the weight of the indicators as well as the ranking of the options. The following table presents the verbal expressions to describe the importance of the criteria for each other (Azar and Faraji 2010, p. 7) and (Elahi, Rashidi and Sadeghi. 2015):

Table 2. Verbal phrases for couple comparisons to express the degree of importance

Fuzzy number scale	Linguistic variable	Fuzzy number
(1 ،1 ،1)	Equal	1
(3 ،2 ،1)	Very little superiority	2
(4 ،3 ،2)	A little superior	3
(5 ،4 ،3)	Top	4
(6 ،5 ،4)	Good	5
(7 ،6 ،5)	Fair	6
(8 ،7 ،6)	Very good	7
(9 ،8 ،7)	Excellent	8
(10 ،9 ،8)	Absolute superiority	9

In this study, triangular fuzzy numbers are presented to prevent ambiguity due to uncertainty in decision making at all stages. The table above is used to show the result of pairwise comparisons in AHP. A fuzzy triangular number denoted by Ã = (l, m, u) that has the following membership function. One of the most important reasons for using fuzzy logic in this research is that real-world problems typically have a complex structure, which indicates the existence of ambiguity and uncertainty in their definition and understanding. Linguistic components are expressed on the basis of linguistic (spoken) values, which are in the set of phrases (words / terms), and linguistic expressions are attributes for linguistic components. A fuzzy number is a special fuzzy set in the form of x, in which x accepts the true values of the member of the set R and is a function of its membership as $\mu\tilde{A}(x)$ follows: (Elahi, Rashidi and Sadeghi. 2015) and (Azar and Faraji 2010, p. 3)

Formula (1) $A' = \{(x, \mu_{\tilde{A}}(x)) \mid x \in X\}$

Non-fuzzy (diffuser): The diffuser converts the fuzzy output to a definite number. The non-fuzzy task is to specify the point that best represents the fuzzy set B'. The average central formula in the present study is as follows (Habibi et al. 2014) and (Pourhejazy & Zhu. 2018) and (Azar and Faraji 2010, p. 82).

$$DeFuzzifier = \sum_{ml=1} y\text{-}1\ Wl \,/\, \sum_{ml=1} Wl$$

In the research decision model, "prioritization is the most important criterion for selecting payments in construction projects", determines the relationship between variables and how this relationship. A good theoretical framework should include all the important variables that affect the problem and how they relate to each other.

4- Data analysis

The statistical population of the present study was limited to 124 people who were experts in the field of construction projects and construction management specialists working in the country's start-up construction companies, according to the distribution of 124 questionnaires and research tools for all members of the community (124 experts). Finally, it was possible to obtain the opinions of 120 of them. The statistical sample of the present study has been compiled by experts in the field of construction projects and construction management specialists working in the country's leading construction companies or similar positions, and since the expert must have sufficient knowledge on the subject of research to be involved in the discussion. Effectively, a total of 120 people who had to have two characteristics (first, familiar with the subject and second, with three years or more of work experience) were selected as potentially targeted sampling. Data related to data collection tools (hierarchical process analysis tools, ranking, selection, selection of construction projects in construction companies in the country's leading construction companies ") were collected in the period between February 2016 to May 2018 and in the first quarter of 2018. Process of four stages. The benefits of construction projects, especially of the country's leading construction companies using fuzzy MCDM, are as follows:

Step 1 - Modeling Causes of MCDM Relationships: There must be an issue to get started. Since the main goal of this research is to prioritize the most important criteria for selecting benefits in construction projects using hierarchical analysis. Criteria related to each of the determinants and then the tools for which the reliability of the test was tested were distributed. The pairwise comparison tool used for hierarchical and fuzzy analyzes is called the expert pairwise comparison tool. Each level of hierarchy provides a pairwise comparison tool. In fact, prioritization of the most important criteria for selecting evidence in construction projects using MCDM are: The cluster of "economic factors in selecting evidence" with hierarchical code (A) includes criteria such as: A); Operating force cost with hierarchical code (AB); Cost of services and maintenance of materials with hierarchical code (AC); Cluster of "Environmental Factors in Selection of Fences" with Hierarchical Code (B) includes criteria such as: Biological pollution in construction projects with Hierarchical Code (BA); Energy consumption in construction projects with hierarchical code (BB); Human Health in Hierarchical Code Building Projects (BC); Recycling in construction projects with hierarchical code (BD); Land warming in construction projects with hierarchical code (BE); The cluster "Technical Factors of Selection of Nodes" with hierarchical code (C) includes criteria such as: weight of materials and materials with hierarchical code (CA); Strength of materials with hierarchical code (CB); Expectations of the life cycle of materials and materials with hierarchical code (CC); Chemical resistance of materials with hierarchical code (CD); The following nine-point scale is used to score:

Table 3. Parallel multivariate decision-making pairwise comparison tools

Paired comparisons of multivariate decision-making methodology	Cost of transporting material	The cost of labor operations	Cost of services and maintenance of materials	Biological pollution in construction	Energy consumption in construction	Human health in construction projects	Recycling of materials in construction	Land warming in construction	Weight of materials	Strength of materials	Life expectancy of materials	Chemical resistance of materials
Cost of transporting materials	1	-	-	-	-	-	-	-	-	-	-	-
The cost of labor operations	-	1	-	-	-	-	-	-	-	-	-	-
Cost of services and maintenance of materials	-	-	1	-	-	-	-	-	-	-	-	-
Biological pollution in construction projects	-	-	-	1	-	-	-	-	-	-	-	-
Energy consumption in construction projects	-	-	-	-	1	-	-	-	-	-	-	-
Human health in construction projects	-	-	-	-	-	1	-	-	-	-	-	-

Recycling of materials in construction projects	-	-	-	-	-	-	1	-	-	-	-	-
Land warming in construction projects	-	-	-	-	-	-	-	1	-	-	-	-
Weight of materials	-	-	-	-	-	-	-	-	1	-	-	-
Strength of materials	-	-	-	-	-	-	-	-	-	1	-	-
Life expectancy of materials	-	-	-	-	-	-	-	-	-	-	1	-
Chemical resistance of materials	-	-	-	-	-	-	-	-	-	-	-	1

Step 2 - Pair comparisons and weight determination of causal relationships MCDM- Hierarchical hierarchy between priority mapping maps the most important criteria for selecting points in construction projects using hierarchical analysis of hierarchy, based on expert opinion: The first pair of expert comparisons, based on the couple's comparison of the main criteria based on the goal, determine the ranking of each of the main criteria. Therefore, we must compare the criteria based on both goals. If the value of the element i on j is equal to n, the value of j on i is equal to 1/ n, and according to this point it is sufficient to fill in the following matrices only the values above the main diameter. The values below the main inverse diameter will be the values above the diameter. It should be noted that we must pay attention to the type of criteria. It is important to pay attention to the type of criterion in the method of calculating its weight. The following diagrams illustrate the weighting of the causal relationships of MCDM-hierarchical relationships between priority prioritization maps, the most important criteria for selecting points in construction projects using hierarchical analysis, based on expert opinions:

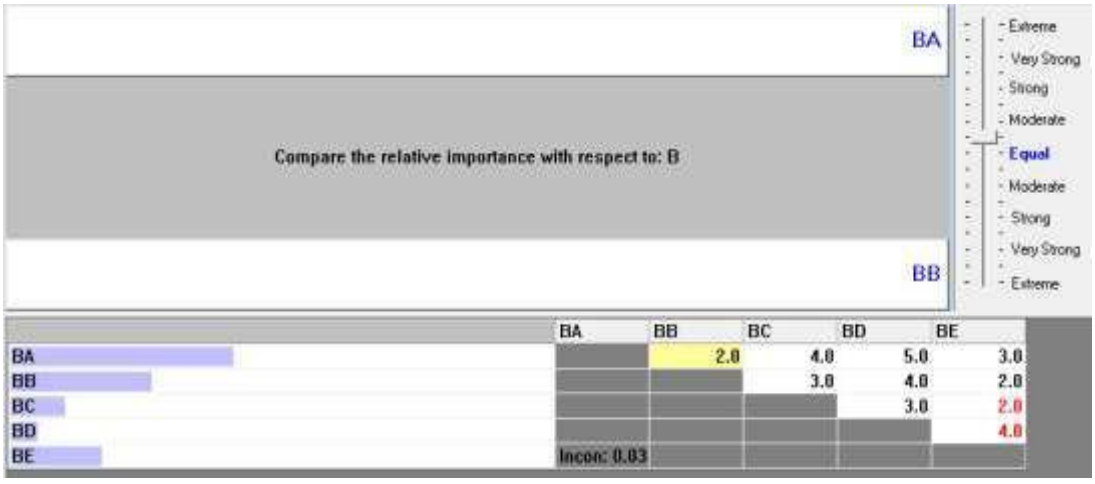


Figure 1. Paired comparisons and weight determination of causal relationships MCDM- "Environmental factors selection of selection"

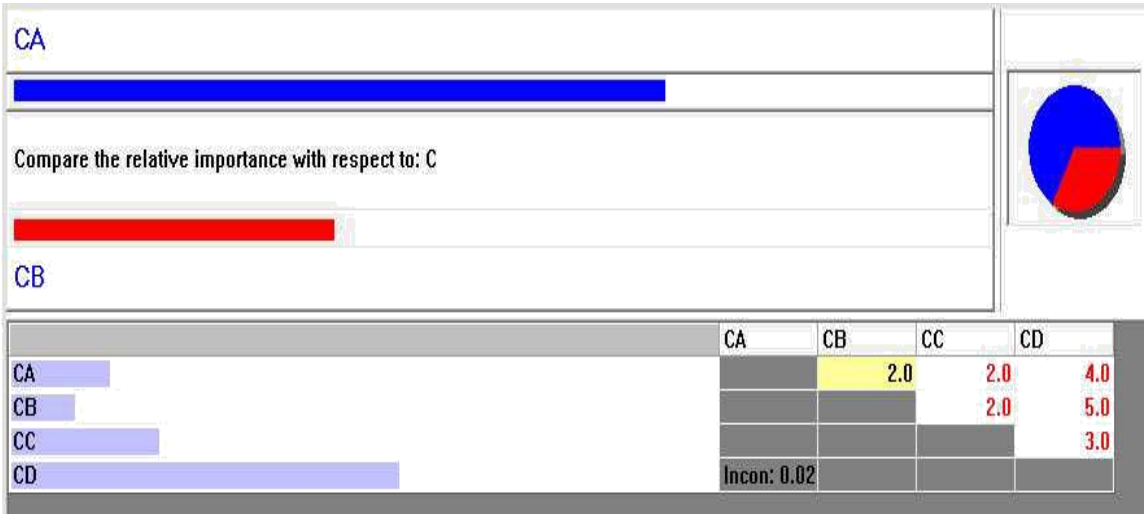


Figure 2. Couple Comparisons and Weight Determination of MCDM Causal Relationships - "Technical Factors of Selection of Effects"

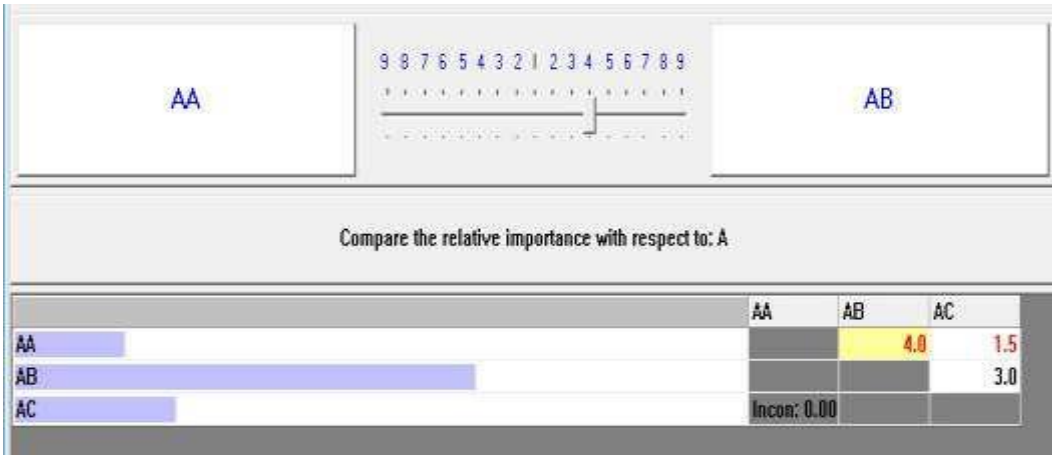


Figure 3. Pair comparisons and weight determination of causal relationships MCDM- "Economic factors of choice of provisions"

In the above figures, based on the instrumental pairwise comparison tools, determining the weight of causal relationships between MCDM-hierarchical relationships between cluster mapping "economic factors in selecting observations" with hierarchical code (A) includes criteria (AA) criteria such as: cost of attack ; Operating force cost with hierarchical code (AB); Cost of services and maintenance of materials with hierarchical code (AC); Cluster of "Environmental Factors in Selection of Fences" with Hierarchical Code

(B) includes criteria such as: Biological pollution in construction projects with Hierarchical Code (BA); Energy consumption in construction projects with hierarchical code (BB); Human Health in Hierarchical Code Building Projects (BC); Recycling in construction projects with hierarchical code (BD); Land warming in construction projects with hierarchical code (BE); The cluster "Technical Factors of Selection of Nodes" with hierarchical code (C) includes criteria such as: weight of materials and materials with hierarchical code (CA); Strength of materials with hierarchical code (CB); Expectations of the life cycle of materials and materials with hierarchical code (CC); Chemical resistance of materials with hierarchical code (CD); Provided.

Step 3 - Ranking Based on Causal Relations MCDM - Hierarchy between Prioritization Maps The most important criteria for selecting payments in construction projects using MCDM: The concept of normalization is used to determine rank. After normalization, the weight of each option will be obtained based on the desired criterion. In other words, calculate the specific value of each line by estimating the geometric mean: the geometric mean of that line to the sum of the geometric mean of the lines. We do the same pairwise comparisons for other criteria. In this way, we calculate the rank of each person based on each criterion, such as the above. The important thing is the same rank. The following figure and table show the ranking based on the causal relationships of MCDM-hierarchy between mapping selection schemes in construction projects:

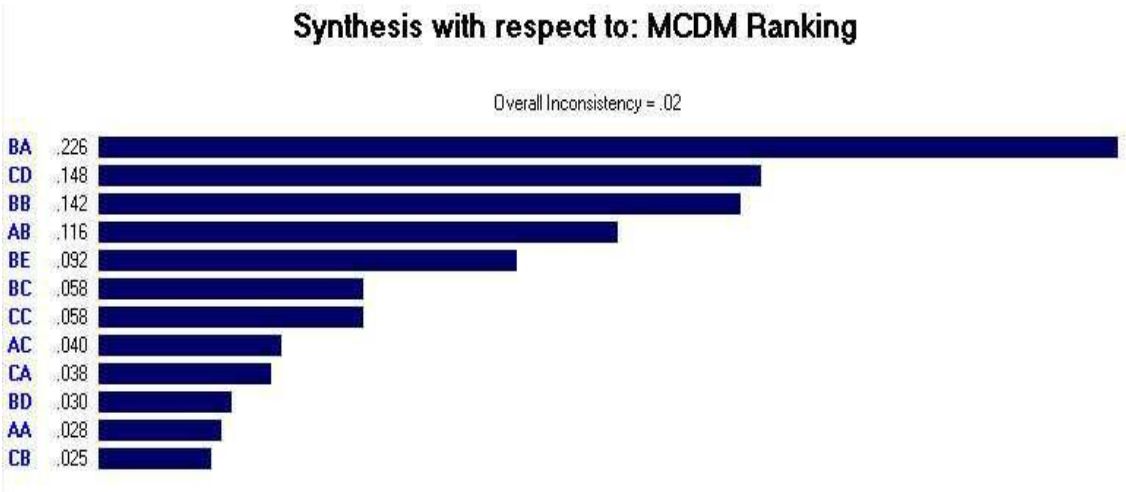


Figure 4. MCDM Causal Relationship Ranking - Hierarchical Hierarchy of Selection Statements in Construction Projects

The inconsistency rate in the present study is a tool that determines the compatibility and shows to what extent the ratings obtained from the comparisons can be trusted. The above forms, the final analysis, and the prioritization of the most important criteria for selecting payments in construction projects are given with the lowest level of incompatibility, ie 0.02.

Table 4. Ranking The most important selection criteria

Criterion weight	Research criteria	Rank
0.226	Biological pollution in construction projects	1
0.148	Chemical resistance of materials	2
0.142	Energy consumption in construction projects	3
0.116	The cost of labor operations	4
0.092	Land warming in construction projects	5
0.058	Human health in construction projects	6
0.058	Life expectancy of materials	7

In the above figures and table, based on the hierarchical ranking of the criteria, the most important criteria in the cluster "Economic factors of selection of notes" with hierarchical code (A), "cost of labor operations" with hierarchical hierarchy (AB) 0.116; The most important criteria in the cluster were "environmental factors, selection of data" with hierarchical code (B), "biological pollution in construction projects" withhierarchical code (BA) with a hierarchical weight of 0.226 hp; and "energy consumption". Hierarchical code (BB) with hierarchical weight equal to 0.142; Were calculated. On the other hand, the most important criteria in the cluster "Technical factors of selection of data" with hierarchical code (C), "Chemical resistance of materials" with hierarchical code (CD) with hierarchical weight equal to 0.148; It was ranked.

Step 4 - Phase Ranking and Final Analysis of Selection of Objects in Construction Projects Based on Matlab Software Analysis: Table and Form of Linguistic Variables, Fuzzy Values, as well as Triangular Function Numbers and Endowment Traits of Weekly Tastes Related to Terms and Conditions Fuzzy logic demonstrates:

Table 5. Linguistic variables related to research variables

Functions of triangular and trapezoidal numbers	Language variable
(0/05.02500)	Unimportant
(0/150/100.05)	Very weak
(0/30/20/1)	Weak
(0/70/50/3)	Medium
(0/90/80/7)	Good
(0/950/90/85)	Very Good
(110/950.925)	Excellent

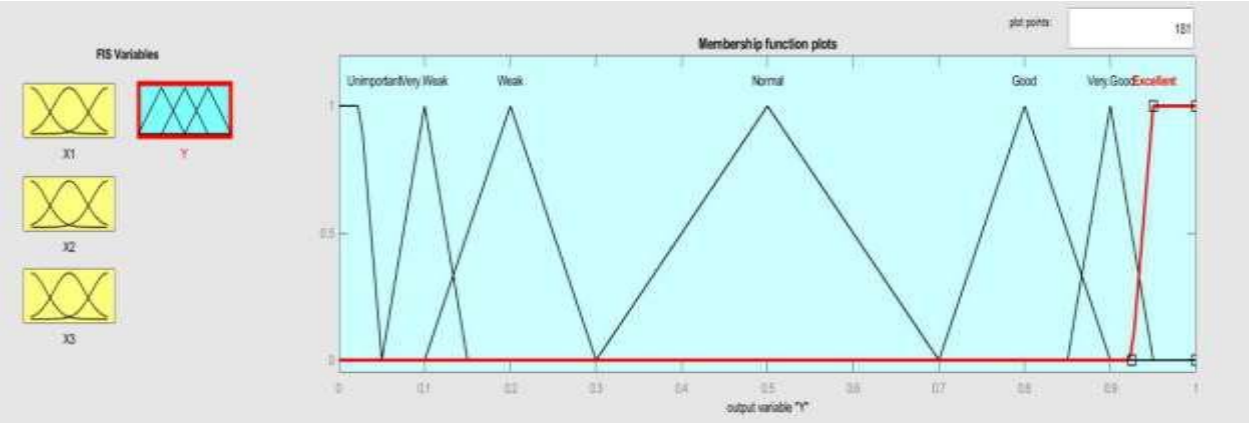


Figure 2. Separation of criteria and determination of fuzzy values related to language variables (membership functions of triangular and trapezoidal numbers)

The following table shows the fuzzy weights and fuzzy rankings of the criteria for selecting points:

Table 6. Fuzzy Ranking of Measurement Selection Criteria

The final weight of the criterion	Fuzzy weight (based on linguistic variables)	Criterion weight (Based on MCDM)	Research criteria	Rank
0.191445	0.8471	0.226	Biological pollution in construction projects	1
0.122633	0.8286	0.148	Chemical resistance of materials	2
0.119692	0.8429	0.142	Energy consumption in construction projects	3
0.096118	0.8286	0.116	The cost of labor operations	4

In the table above, the final weight of the criteria for selecting the criteria, especially for the country's leading construction companies, is the product of the weight of the criteria based on the MCDM * fuzzy weight (based on language variables). Finally, according to the fuzzy calculations related to the selection of provisions in construction projects in the table above, the most important criteria in the cluster "Economic factors of selection of provisions" with hierarchical code (A), "labor cost operation" with hierarchical code (AB) It has a fuzzy hierarchical weight of 0.096; And the most important criteria in the cluster "environmental factors of selection" with hierarchical code (B), "biological pollution in construction projects" with hierarchical code (BA) with the weight of the hierarchy of phase construction "project" and 0.191; With a hierarchical code (BB) with a fuzzy hierarchical weight of 0.120; Were calculated. On the other hand, the most important criteria in the cluster "Technical Factors of Selection of Nodes" with hierarchical code (C), "Chemical resistance of materials" with hierarchical code (CD) with fuzzy hierarchical weight equal to 0.123; It was ranked because it has the highest fuzzy rank based on multi-criteria decision-making technique and fuzzy logic calculations.

5- CONCLUSION

Here is a general summary and conclusion of the research "Ranking of criteria affecting the selection of benefits in construction projects, especially the country's start-up construction companies using hierarchical analysis" in two areas for both scientific and applied fields. The findings and changes are due to the fact that incorrect construction methods in the community have caused the disease of the surrounding environment and has created an unhealthy biological system. Materials used in buildings play an important role in creating the right builder and preserving the environment. Choosing the right building materials reduces energy consumption and ensures greater environmental health. Because these materials reduce fuel consumption to heat buildings. This reduces the emissions of air pollutants and greenhouse gases. The use of natural resources is also declining, and society is moving closer to the standards of sprawling. Many environmentally friendly building materials are highly durable and will greatly reduce the cost of maintaining buildings that have used these materials. The use of appropriate materials will lead to a new architecture. One of the most important results of the article is the prioritization of the most important selection criteria for construction projects, especially the country's leading construction companies using MCDM, which is the most important criterion in the business classification of "economic factors". Work "with hierarchical code (AB) with phase hierarchical weight 0.096; And the most important criteria in the cluster "environmental factors of selection" with hierarchical code (B), "biological pollution in construction projects" with hierarchical code (BA) with the weight of the hierarchy of phase construction "project" and 0.191; With a hierarchical code (BB) with a fuzzy hierarchical weight of 0.120; Were calculated. On the other hand, the most important criteria in the cluster "Technical Factors of Selection of Nodes" with hierarchical code (C), "Chemical resistance of materials" with hierarchical weight equal to 0.123; It was ranked because it has the highest fuzzy rank based on multi-criteria decision-making technique and fuzzy logic calculations. Finally, the scientific uses of this research and the suggestions for other researchers to continue the work are mentioned. One of the advantages of using case study in research is that case study is a systematic way of examining events, collecting data, analyzing and analyzing information, and reporting results to prioritize the most important criteria for selecting deadlines in construction projects. In particular, the country's start-up development companies are focusing on the management of waste materials on the dynamics of materials in economic and environmental activities to optimize consumer efficiency and reduce the impact of environmental impact. The web-based information system has been developed to analyze issues related to resource consumption and waste production, and has enabled countries to manage resources and waste from a long-term perspective. This pioneering system features a four-layer framework, which integrates information into the material flow of economic activities by calculating the flow of materials and analyzing the input and output of wastes. In this context, various applications for waste and resource-stakeholder management have been developed. Hierarchical and interactive dashboards allow for a thorough overview of materials across the economy, waste, and the flow of secondary resources.

References

1. Kiani, Mojtaba and Ali Eghtedari, 2017, A Study of the Necessity of Selection of Furniture in Interior Design of Buildings, 2nd National Conference on Civil Engineering and Visual Development, Estahban, Islamic Azad University, Estahban Branch

2. Sam, Sina and Nasser Shams Kia, 1397, Evaluation of the most important criteria for selecting building materials in civil engineering structures by network analysis method, National Conference on Civil Engineering and Architecture in 21st Century Urban Management, Karaj, Permanent Secretariat of the Conference

3. Manhoubi, Nazanin and Iraj Shahrooz Tehrani, 2014, Study of Creative Footsteps, National Conference on Architecture and Urban Landscape, Mashhad, International Institute for Architectural and Urban Studies, Mehraz Shahr

4. Sheikh Gol Zardi, Hamidreza, 2015, The Use of Pedestrian Materials in Architecture, International Pedagogical Congress in Contemporary Architecture and Urban Planning in the Middle East, UAE-Dubai, Islamic Azad University, UAE Branch

5. Rafiei, Manizheh, 2017, Design of Building Materials, Fifth International Congress of Civil Engineering, Architecture and Urban Development, Tehran, Permanent Secretariat of the Conference

6. Azar, Adel and Hojjat Faraji. 2010. Fuzzy Management Science. Institute of Kind Book Publishing. Iran Center for Management and Productivity Studies (affiliated to Tarbiat Modares University). fourth edition

7. Elahi, Sha'ban; Mostafa Rashidi and Mahmoud Sadeghi. 2015. Design of a fuzzy expert system for the top manager of privacy in the field of e-government exchanges and business. Knowledge Technology Management Magazine. Article 4, Volume 7, Number 3, Fall 2015.

8. Habibi, Arash et al. 2014. Fuzzy Multi-Criteria Decision Making. Gileh Inscription Publications: Simai Danesh, Azar, Print: 2014

9. Opon, Joel & Michael Henry. 2019. An indicator framework for quantifying the sustainability of concrete materials from the perspectives of global sustainable development. Journal of Cleaner Production, Volume 218, 1 May 2019, Pages 718-737

10. Mahmoudkelaye, Samira, et al. 2018. Sustainable material selection for building enclosure through ANP method. Case Studies in Construction Materials, Volume 9, December 2018

11. Plati, Christina. 2019. Sustainability factors in pavement materials, design, and preservation strategies: A literature review. Construction and Building Materials, Volume 211, 30 June 2019, Pages 539-555

12. Ghosh, Manojit, et al. 2019. Renewable and Sustainable Materials in Automotive Industry. Reference Module in Materials Science and Materials Engineering, 2019

13. Chen, Jiayu, 2019. Piezoelectric materials for sustainable building structures: Fundamentals and applications. Renewable and Sustainable Energy Reviews, Volume 101, March 2019, Pages 14-25

14. Kappenthuler, S. & S. Seeger. 2019. From resources to research—a framework for identification and prioritization of materials research for sustainable construction. Materials Today Sustainability, In press, uncorrected proof, Available online 13 March 2019

15. Pourhejazy, Pourya & Qinghua Zhu. 2018. A fuzzy-based decision aid method for product deletion of fast-moving consumer goods. Expert Systems with Applications, Volume 119, 1 April 2018, Pages 272-288

16. Saaty, Thomas L. 2008. Decision making with the analytic hierarchy process. Int. J. Services Sciences, Vol. 1, No. 1, 2008

17. Kim, Suwon & Seongcheol Kim. 2016. A multi-criteria approach toward discovering killer application in Korea. Technological Forecasting and Social Change, Volume 102, January 2016, PP. 143-155

18. Belousova, N. A., Korchemkina, Y. V., Matuszak, A. F., Fortygina, S. N., Shulgina, T. A., Kovtun, R. F., & Permyakova, N. E. (2020). Digital environment components for the formation of students' information and analytical skills. Journal of Advanced Pharmacy Education & Research, Volume 10, no. 4, PP. 118-125.