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Assessment of The Effective Factors on The Adoption of Modern Technologies in Industrial Construction in Order to Improve the Quality of Construction By Sustainable Development Perspective.(Case Study: Constructional Companies Providing Modern Technologies)

Omid Lajevardi: Master's degree student, Department of Civil Engineering,Shi.C.,Islamic Azad University,Shiraz,Iran

Mohammad Amir Sharafti*: Assistant Professor,Department of Civil Engineering,Shi.C.,Islamic Azad University, Shiraz,Iran

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Abstract

Population growth and the increasing demand for housing require a shift from traditional construction methods to industrialized approaches aligned with sustainable development. Using modern materials and technologies can lower costs, shorten construction time, and improve quality.This study reviewed literature and consulted experts to identify factors influencing the adoption of industrialized construction methods. A researcher-designed questionnaire was completed by 92 construction professionals, and factors were grouped into four main indicators. The Analytical Hierarchy Process (AHP) was applied to prioritize them.Findings showed that the urban management index, with a weight of 0.454, was the most influential factor. This index highlights environmental responsibilities and managerial commitments within the urban system. Its proper implementation can significantly reduce energy consumption and promote sustainable practices. Within this index, strict legislation, effective monitoring, and proper resource allocation (weight 0.15) were identified as critical sub-factors.The results stress the importance of urban governance in facilitating sustainable construction. By focusing on management and policy, decision-makers and construction firms can better integrate innovative technologies into housing projects. This study provides practical guidance for aligning industrialized construction with sustainability goals, improving efficiency, and reducing environmental impacts while meeting growing housing needs.

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* Corresponding author: Mohammad Amir Sharafti, Email: sherafati@pgs.usb.ac.ir

INTRODUCTION

Today, industrialization has played a role as one of the important factors in creating sustainability in the design and use of new construction techniques. Among these factors, reducing energy consumption, speeding up construction time, and reducing economic costs have attracted more attention from residents. In Iran, the need for safe, cheap, and long-lasting housing in construction has become important. Given the importance of technology in the engineering industry in the present era and its growing and evolving trend, understanding these technologies in mass volume and their increasing production and development can be one of the valuable things in this field. In the last few decades, the issue of sustainable development has received public attention. So much so that a global movement has been launched to pay attention and importance to it. Sustainable development indicators can create balance and harmony between the built environment and construction processes, and in architecture and urban planning, create environments and spaces that are healthy, interactive, and develop economic indicators. Sustainable development is not just about the environment, but also includes balancing the economic, social and environmental goals of society as the three dimensions of sustainable development and integrating them whenever possible, through policies and methods that are compatible with each other. In our country, the role of sustainable development has also been paid attention to for several years. Among these laws, we can mention the laws that have been considered for development projects. One of these laws is the resolution of the Supreme Council for the Environment regarding plans and projects subject to environmental assessment, approved on 29/03/1390.

Modern construction technologies in the world today are based on compatibility with nature, and the technologies used in construction and building technologies are such that energy consumption is saved and renewable fuels, solar panels, wind generators, etc. are used to protect the environment. In the current situation of the country, the most important necessity of using these technologies is due to its important role in sustainable development.

Iran has also made plans for this in line with its short and long-term strategies. The current economic downturn in the country has prompted planners and politicians to take steps to address issues related to quality, sustainability, and standardization in the construction industry to meet the country's construction needs. Despite these efforts, studies and evidence show that the construction industry in the country is still far from sustainable. Industrialization and development of new technologies in the implementation of building components and systems is the first research axis in the country's fourth five-year development plan in the field of construction, which is also a research priority of the Road, Housing, and Urban Development Research Center. The status of regulations has improved compared to previous years, but little has been done to study the conditions of different regions of the country due to climate and weather issues in order to correctly select new technology, and given the great potential of this field, attracting investors to enter this sector has also been low. On the other hand, the construction industry is one of the main industries in the country, with many dependent industries, each of which can play a serious role in sustainable development.

Given that different new technologies are being developed and expanded in the world, and every day we see more attention to these technologies in the construction industry, and given the increasing development of these technologies, we must pay attention to their effects from the perspective of sustainable development. Considering the above, the main goal is to determine the factors affecting the acceptance of new construction technologies and determine priorities from the perspective of sustainable development in construction companies and suppliers of new technologies, and to rank and prioritize them.

Literature Review

Waqar et al. (2024) addressed sustainable leadership practices in building construction, barriers and challenges to industrializing sustainable building in Pakistan. The statistical population of this study included 86 male and 8 female construction project managers and university professors. The findings highlight the importance of using renewable energy, green building certification and standards, infrastructure monitoring and development, and incorporating sustainable technologies in construction, creating a balance between

economic development, environmental monitoring, and social equity (Waqar et al., 2024).

Shirish Jain et al. (2024) in their paper A Statistical Approach to Assess the Impact of Barriers on Green Building Development in North East India examined the challenges and barriers to the adoption of new technologies in the Indian construction industry. The study meticulously reviewed the available data and identified 18 potential barriers to green building construction. The results showed that green building development depends on various factors including advanced technology, environmentally friendly materials, suitable locations, scientific planning and design, and sustainable construction processes. However, green engineering management is an often overlooked yet pivotal element. As the green building movement gains momentum, owners and contractors are responsible for driving this forward (Jain et al., 2024).

Hafez et al. (2023) in their article Energy Efficiency in Sustainable Buildings: A Systematic Review with Classification, Challenges, Motivations, Methodological Aspects, Recommendations, and Directions for Future Research, reviewed 134 selected articles from 2014 to 2021 on the energy efficiency of sustainable buildings and conference and research papers related to environmental, social, and economic impacts. The findings showed that the need for sustainable buildings can be achieved by adopting measures such as the use of renewable energy sources, purchasing energy-efficient systems, using materials and equipment to reduce greenhouse gas emissions, and using software to design buildings to achieve higher energy efficiency. Adopting policies and regulations for the public to promote sustainable buildings, adaptive techniques such as energy-saving techniques to improve sustainable energy performance by reducing the building's energy demand for better overall performance, and using modern construction technologies (Hafez et al., 2023).

Table 1. Summary of research conducted

Author's name and year of publication	Article title	Description of results
Jane et al. (2024)	A statistical approach to assess the impact of barriers on green building development in Northeastern India.	The development of green buildings depends on various factors, including advanced technology, environmentally friendly materials, suitable locations, scientific planning and design, and sustainable construction processes
Waqar et al. (2024)	Sustainable leadership practices in construction: Building a resilient community.	The importance of using renewable energy, green building certification and standards, monitoring and developing infrastructure, and incorporating sustainable technologies into construction
Fernandez et al. (2023)	performance in public buildings supported by daylighting technology	Proper lighting design reduces energy consumption, toxic substances, and light pollution, and protects cultural and public buildings.
Chan et al. (2017)	Strategies for Promoting Green Building Technologies Adoption in the Construction Industry-An International Study, Management Strategies and Innovations for Sustainable Construction	The impact of accurate cost information and green construction on the acceptance of this type of construction
Boardeau et al. (2017)	Development and the Future of Construction	The importance of developed countries to sustainable development factors
Shan et al. (2017)	A Global Review of Sustainable Construction Project Financing	The importance of sustainable development in the construction industry
Al-Hatim et al. (2014)	Sustainable construction implementation requirements	Lack of full understanding of the implementation requirements of sustainable construction and lack of sustainable technologies are fundamental challenges for sustainable construction.
Samari et al. (2013)	Problems in the development and adoption of green construction technology	The essential role of the government in the development of green construction technology
Suliman et al. (2010)	Sustainable development and the construction industry in Malaysia	Compliance with sustainable development components by construction companies in works and contracts

Author's name and year of publication	Article title	Description of results
Abedin et al. (2010)	Perception in sustainable construction	Managers' favorable understanding of sustainable development and poor performance in its adoption and use
Crowley et al. (1999)	Challenges of implementing sustainable construction	Emphasizes the importance of green specifications as a critical factor in the success of sustainable construction projects

Research Methodology

The research method depends on the purpose and nature of the research study and its implementation facilities. Therefore, considering the nature of the subject of the present study, which is to evaluate the factors affecting the adoption of new technologies in the industrialization of construction in order to improve the quality of construction from the perspective of sustainable development, the research method is descriptive-analytical and is applied in terms of research purpose. In this study, a questionnaire has been prepared to collect the opinions of experts using library studies and discussions with experts. The process of achieving the research goal is presented in the diagram below.

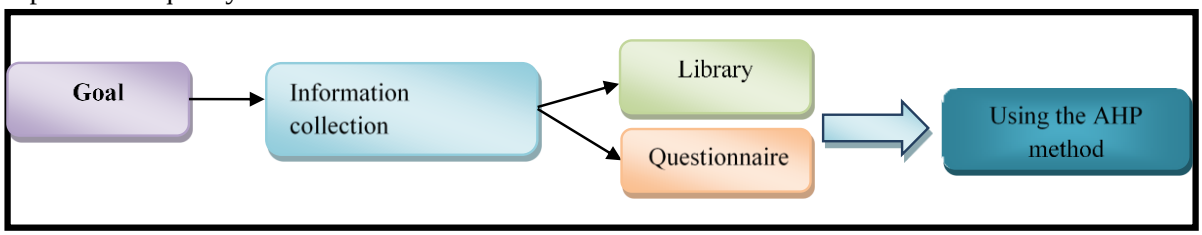


Fig 1. The process of achieving the desired goal in the present study

In the researcher-made questionnaire in this study, 42 indicators were introduced based on sustainable development parameters for approval, evaluation, and prioritization. These rankings were categorized into four main indicators or criteria as follows:

1- Ecological Design Management Index (8 sub-criteria)
2- Construction and Operation Management Index (7 sub-criteria)
3- Urban Management Index (16 sub-criteria)
4- Indoor Environment Management Index (11 sub-criteria)

The validity and reliability of the questionnaires were confirmed using the opinions of professors and Cronbach's alpha. Considering the purpose and subject of the present study, the statistical population of this study includes some managers, executives, employees and executive specialists in mass housing projects as well as a number of major suppliers in this field related to Fars province. A total of 110 questionnaires were distributed among the above individuals, of which 90 responded to the questions. Considering the number of parameters and respondents, Cronbach's alpha was determined to be 0.867, which indicates the desirable reliability of the research tool.

Research findings

Descriptive statistics

When a mass of data is collected for research, it is essential to first organize and summarize it in a way that is meaningfully understandable and relatable. Descriptive statistical methods are used for this purpose. Often the most useful and at the same time the first step in organizing data is to arrange the data according to a logical criterion, and then extract indicators of central tendency and dispersion, and if necessary, calculate the correlation between the two sets of data, and use more advanced analyses such as regression and prediction.

Gender distribution

Typically, the construction industry requires full-time work for architects and civil engineers. In case of problems or deadlines for completing some projects, they may need to work outside of normal hours. On the other hand, working on a project site is subject to varying weather conditions and usually involves business trips. For this reason, women engineers (especially in the civil engineering field) are usually employed in consulting or technical offices due to the above conditions, and few of these women engage in construction activities. Therefore, it is natural that the

majority of those who completed the questionnaire were men.

Table 2. Gender distribution

Gender	Abundance	Percentage
Number of men	74	82%
Number of women	16	18%
Total	90	100%

The results obtained from the research sample show that 82 percent of the people are men and 18 percent are women, which is due to the greater presence of men and easier access to them at the construction site level.

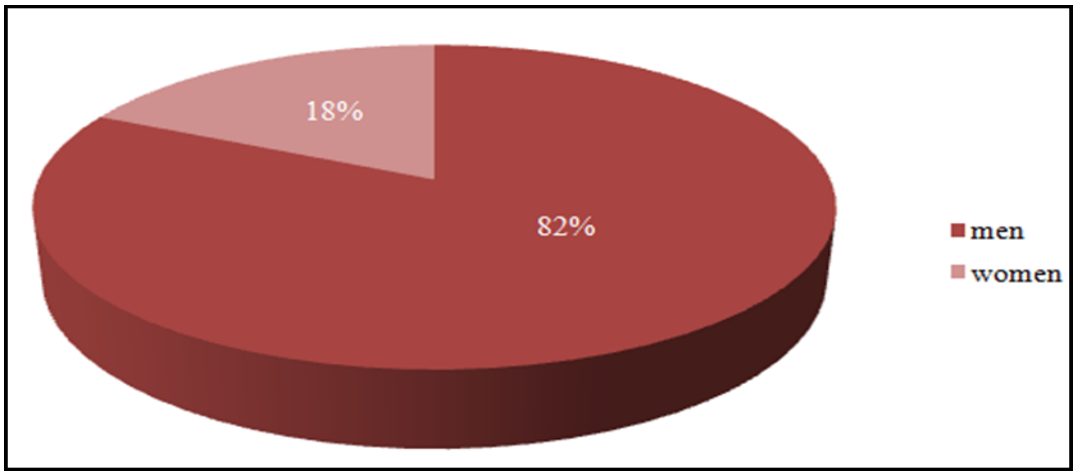


Fig 2. Gender distribution

Distribution of education levels

Training and developing the knowledge and skills of engineers is one of the most important parameters for empowering the construction industry. Up-to-date education and knowledge in the field of construction and familiarity with new materials and up-to-date laws in this field can help the construction industry to optimally use new materials and construction methods.

Table 3. Distribution of educational attainment

Level of education	Abundance	Cumulative frequency	Percentage
Associate degree	8	8	8.89%
Bachelor	45	53	50%
Master	32	85	35.56%
PhD and above	5	90	5.55%
Total	90	-	100

The results obtained from the research sample show that about 50% of the people have a bachelor's degree and on the other hand, most of the age distribution is in the 25 to 35 age range. These two indicate that relatively young experts and executive managers with appropriate academic knowledge are present in construction projects.

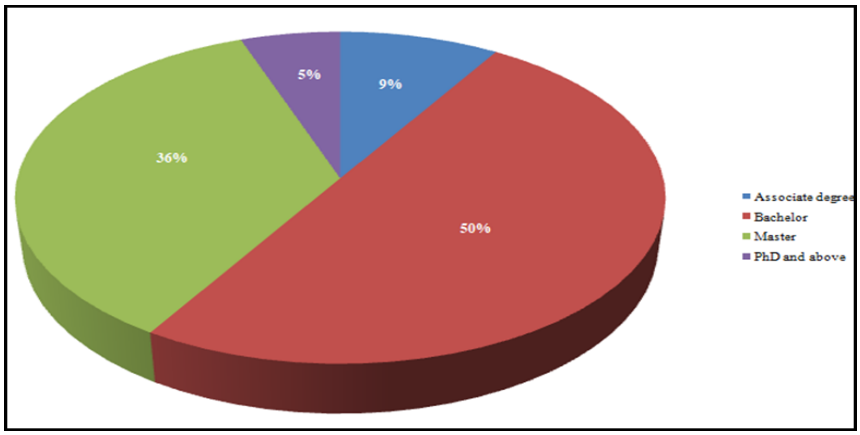


Fig 3. Distribution of education

Distribution of activity history

Activity in the field of construction in addition to the knowledge of the day requires experience in this field. In general, people in the building industry have a better understanding of the conditions and how to use modern materials and the rules and regulations around the industry, and the choice of these people to answer the questions can double the validity and value of the questionnaire reviewed.

Table 4. Distribution of activity history

Distribution of education	Abundance	Cumulative frequency	Percentage
Less than 3 years	18	16	20%
3 to 5 years	24	41	26.67%
5 to 10years	33	75	36.67%
More than 10 years	15	90	16.66%
Total	90	____	100%

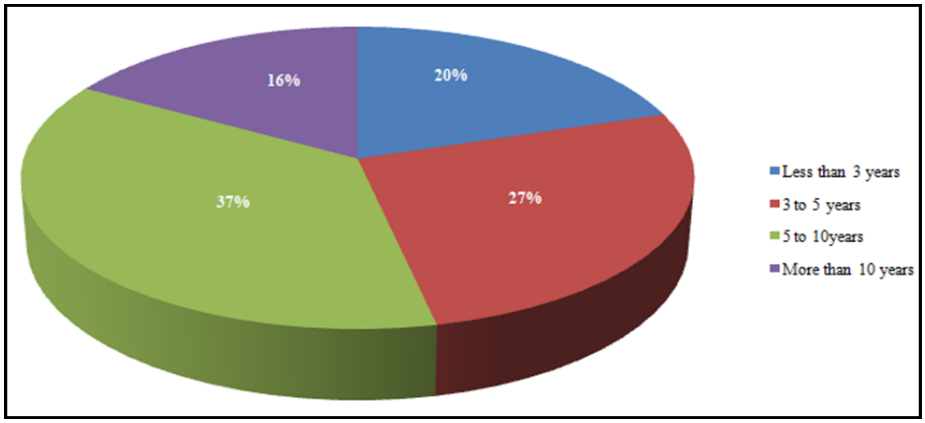


Fig 4. Distribution of a history of activity

The results of the sample individuals show that 37% of people have a more than 5 years of work experience. As a result, the comments and responses provided by them will have a good empirical and practical support.

Inferential Statistics

As mentioned at the beginning of the study, the main purpose of the research is to "rank new technologies in building industrialization based on sustainable development parameters", so the Kolmogorov-Smirnov test is used for normal data distribution.

H_0: There is no difference between observed and expected abundance (there is normal distribution).

H_1: There is a difference between observed and expected abundance (not normal distribution).

Table 5. Data normalization test

Variable	The type of distribution used	Significant level	The amount of error	Confirmation of the hypothesis	result
New building technology	Normal	0.001	0.05	H_0	It is normal
Sustainable development goals	Normal	0.001	0.05	H_0	It is normal

Given the amount of Kolmogorov-Smirnov statistics, it can be deduced that the expected distribution is not significant for all variables and therefore the distribution of these variables is normal. Therefore, parameter statistics should be used to test hypotheses.

Determining the factors affecting the adoption of new construction technologies from the perspective of sustainable development

In this study, 42 rankings are based on sustainable development parameters for approval, evaluation and prioritization, which are categorized into four main management indicators, after completing the questionnaire and using the marshes for each index parameters, first extracting the weight of each opportunity, and then the priority. Finally, using the couple comparison of the main indicators to the goal, we extract the weight of each index and identify one index as the superior option. According to research, various factors and parameters are influenced by the use of modern technologies and green materials in the construction industry. Each of these factors has been analyzed and concluded in previous articles, to what extent each of them is effective in achieving sustainable development goals. Therefore, by studying these articles and determining the factors affecting the admission of new technologies, 42 parameters of the most important questionnaire were prepared and provided to experts. The four main indicators and the following criteria are as follows.

1) Ecological Design Management Index

The parameters related to this index relate to the proper design of buildings based on sustainable development indicators and environmental protection and evaluate their impact on building industrialization in line with sustainable development. Eight parameters for this section are as follows:

ECO1- Building architecture based on sustainable and environmental development indicators

ECO2- Design of buildings to avoid or reduce the consumption of toxic substances and produce them

ECO3- How to design the building to reuse and recycle materials

ECO4- Long Life of buildings or improve their quality

ECO5- Consider climatic issues and use native materials

ECO6- Building architecture based on optimization and reduction of energy consumption

ECO7- Proper project location in terms of environmental protection and preventing it from being destroyed

ECO8- Maximum utilization of climatic conditions to reduce energy consumption

2) The Management Management Index of Implementation and Construction

The parameters listed in this index mostly evaluate the new methods and practices of project implementation operations to reduce energy consumption. Seven parameters for this section are as follows:

OP1- Requires rules and criteria for reducing energy consumption in the process of implementation

OP2- Requires rules and criteria for accuracy in the use of materials and materials

OP3- Using new technologies

OP4- Analytical review of all construction operations in terms of resource and energy saving

OP5- Introduction to Structural Systems, Members or Modern Connections in Structures

OP6- Use Lightweight Methods in Today's Buildings

OP7- Applying lightweight concrete as a type of modern building material

3) Urban Management Index

The options related to this index mostly reflect the duties and management of the environmental and the commitment of managers in the urban system, which will allow for a significant reduction in energy consumption in construction projects if

implemented at the level of companies active in construction. Sixteen parameters are introduced and numbered in this section as follows:

UM1- Teaching engineers to reduce the harmful effects of construction on the environment

UM2- Existing structures of engineering, municipal and related institutions for creativity and innovation in the design and implementation of buildings

UM3- The existence of innovative and committed to the country's ecosystem

UM4- The seriousness of legislation, implementation, supervision and accuracy of opinion and control and supply of general resources in the field of executive

UM5- Updating the National Building Regulations and its implementation as the main foundation of construction rules

UM6- Culture in the use of modern materials

UM7- Ranking buildings and monitoring structures

UM8- Transfer and Development of Technology in Modern Building Materials

UM9- Introducing lightweight and thermal insulation materials to reduce the risks of earthquake and reduce energy consumption

UM10- Scientific planning and management of courses and seminars related to materials and products.

UM11- Quality control of building materials in the form of technical certification of products and products

UM12- Building and ranking building in terms of compliance with national building regulations

UM13- Encouraging and providing facilities to executives for buildings that adhere to the state-of-the-art standard

UM14- Engineers and executives' awareness of the green building problem

UM15- Support factories with new and green technologies by purchasing their products

UM16- How much do our current construction fits in to the stable standards

4) Index of internal environment management

The parameters related to this index mostly represent the tasks and commitment of corporate executives, which, if implemented at the level of mass companies, will be able to use new quality materials and create new construction systems in construction projects. The ten parameters in this section are as follows:

IEM1- Existence of energy or ecosystem on the materials and materials to the workshop

IEM2- Introduction to Sustainable Development Goals in Building Industrialization

IEM3- Introduction to the concept and application of building industrialization

IEM4- High quality of materials and use of green and environmentally friendly materials

IEM5- New Methods in Building Industrialization

IEM6- Nanotechnology and Nanotechnology Place in Building to improve the quality of building materials

IEM7- Earn Environmental Certificate

IEM8- Construction workers' skills in the field of industrialization

IEM9- Introduction to Building Ranking System by Standard LEED

IEM10- Research on the production and application of lightweight materials in the building industry

IEM11- Housing quality produced, and its resistance to natural disasters

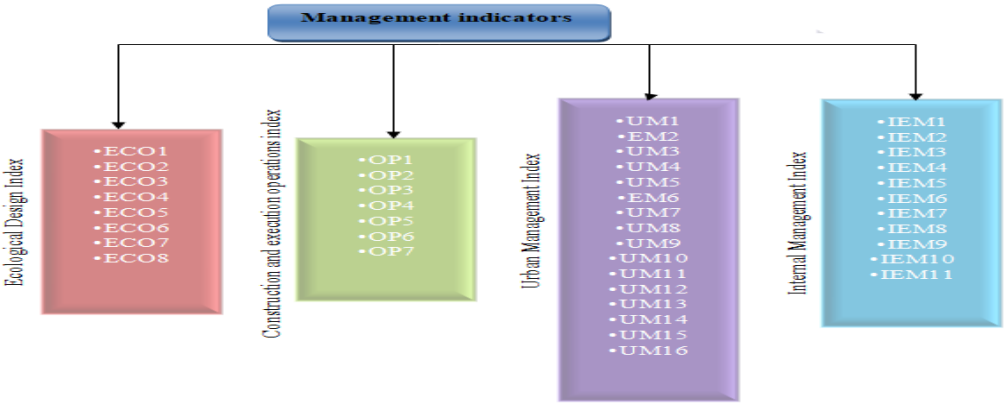


Fig 5. Management indicators and sub-criteria

Pairwise comparison of the main indicators against the target and selection of the superior indicator for factors affecting industrialization towards sustainable development were carried out using Expert Choice software.

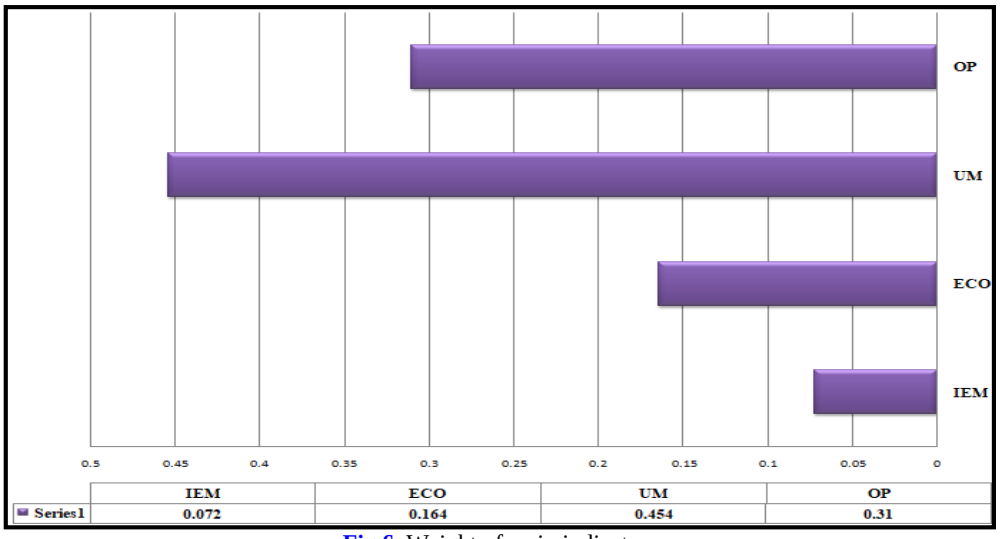


Fig 6. Weight of main indicators

According to the results of data analysis, the urban management index with a weight of 0.454 was determined as the superior index. In the following, we will discuss the pairwise comparisons under the criteria of the main indicators and present three parameters of each main indicator.

Table 6. Top parameters under the main indicators criteria

Ecological Design Management Indicators(ECO)	Operations Management Index (OP)	Urban Management Index(UM)	Internal environment management index (IEM)
Paying attention to climate issues and using local materials	Using modern manufacturing technologies	Seriousness in the field of legislation, implementation, and supervision, and careful consideration, control, and provision of general resources in the executive field.	Introduction to the building rating system based on the LEED standard
How to design a building to reuse and recycle materials	Requirement of rules and criteria for accuracy in the use of materials and supplies	Training engineers to reduce the harmful effects of construction on the environment	Necessary skills of construction workers in the field of industrialization
Building architecture based on energy consumption optimization and reduction indicators	Using lightening methods in modern buildings	Building a culture of using new materials	High quality materials and use of green and environmentally friendly materials

In order to determine the superior sub-criteria in each main indicator, the three sub-criteria in Table (6) are analyzed by pairwise comparisons and the superior sub-criteria in each indicator is determined. The results of pairwise comparisons in Table (7) show that attention to climate issues and the use of local materials, the use of modern construction technologies, familiarity with the building rating system based on the LEED standard, and seriousness in the field of legislation, implementation and supervision, and carefulness and control and provision of general resources in the executive field constitute the most important parameters of the management index.

Table 7. Ranking under the main indicators criteria

Management indicators	Number of parameters	The most important parameter	Weight of criteria
internal environment	11	Introduction to the building rating system based on the LEED standard	0.215
Urban	16	Seriousness in the field of legislation, implementation, and supervision, and careful consideration, control, and provision of general resources in the executive field.	0.150
Construction and implementation operations	7	Using new manufacturing technologies	0.304
Ecological design	8	Paying attention to climate issues and using local materials	0.330

Results

The purpose of this research is to rank new building industrialization technologies based on sustainable development goals. According to the results of data analysis, the urban management index with a weight of 0.454 was determined as the superior index. Therefore, urban management will have a significant contribution to reducing energy consumption towards sustainable development goals in the construction and operation stages.

In the ranking section, the following criteria for each parameter index were determined as the most important parameters of the management index, attention to climate issues and the use of local materials, the use of modern construction technologies, familiarity with the building rating system based on the LEED standard, and seriousness in the field of legislation, implementation and supervision, and thoroughness, control, and provision of general resources in the executive field, with weights of 0.330, 0.304, 0.215, and 0.15, respectively.

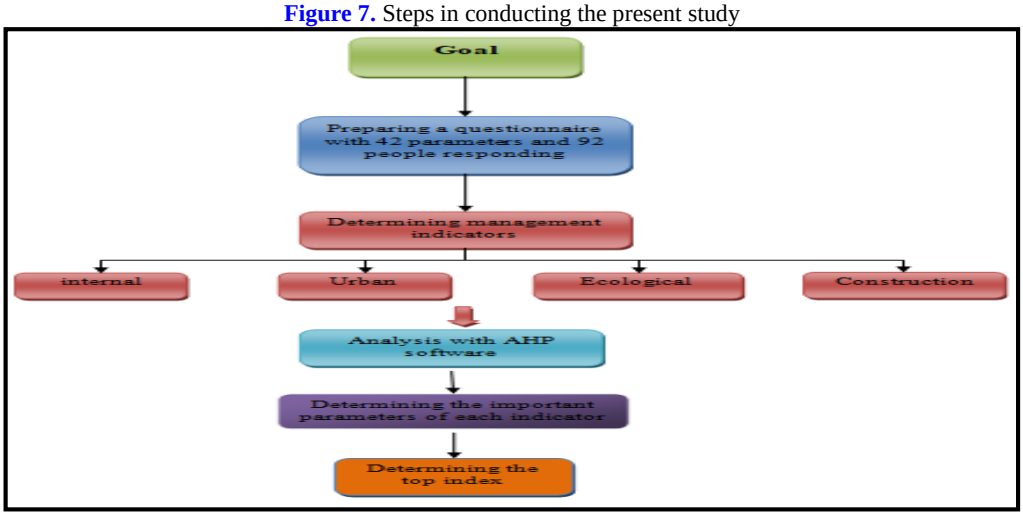
One of the most important differences between indigenous materials and new materials is in the production stage. The production of new materials is associated with high energy consumption and pollution, while most indigenous materials only require a simple initial processing. Many indigenous materials are obtained from renewable resources. Also, by changing traditional construction methods and utilizing new technologies and new construction materials to increase the speed of implementation, increase the useful life, reduce construction costs, and as a result, improve the quality and quantity of housing construction, effective steps can be taken to solve the problem of waste and excessive consumption of energy and, as a result, achieve sustainable development goals in the field of housing construction and operation. So far, no written plan has been prepared to achieve sustainable development in the energy production sector and in the construction sector. In the National Building Regulations, which are the basis of the technical regulations for construction, basic attention has not been paid to climate issues and the conditions and criteria for using different types of energy and the type of design in accordance with the climate and the protection of energy resources, which are the principles of sustainable development. These regulations are not in line with technology and current issues in the world in this field, and perhaps the only law related to sustainable development; The Consumption Pattern Reform Law, in Article 18 of which, explicitly refers to the construction of green buildings, which is a sub-branch of sustainable development, but unfortunately, it has not been implemented in the country so far. In general, the formula for achieving sustainable development at the national level is the construction of green buildings in accordance with the regional climate, the prerequisite of which is compliance with the national building regulations and the law on reforming the energy consumption pattern, and for these cases to be implemented, the need for building branding in accordance with the principles of green architecture and sustainable development is needed. Providing green building certificates, which are the completed structure of the building energy label and the main basis of which is compliance with the 22 topics of the national building regulations and the executive regulations of Article 18, as well as the building energy label standards, can transform the current construction into a quality, branded, environmentally friendly, comfortable and safe construction, in which

case the result will be a win-win for everyone, including the government, the manufacturer, the community, the operator and all stakeholders.

Summary

This research aimed to rank new technologies in building industrialization in order to achieve sustainable development goals. A summary of the research process is presented in Figure 7.

Figure 7. Steps in conducting the present study



Finally, it should be noted that the government, as one of the most powerful executive organs of the country, can contribute significantly to advancing these goals by providing incentive and support tools, including reducing licensing costs, tax exemptions or exemptions, fees, congestion, licensing, or providing appropriate traffic access to green complexes, providing facilities for passing through green neighborhoods (such as walking or cycling facilities), partnering with the banking system in providing free or very low-interest loans, providing comprehensive support to material recycling plants, cooperating with the Engineering System Organization to reduce the costs of design, supervision, and relevant builders, reducing energy consumption tariffs for green buildings, and other such things.

The results of this study can send a clear message to officials of companies and organizations, especially construction companies, so that they can make better plans to give importance to the issue of sustainable development. This includes solutions to make the construction industry more environmentally friendly, as well as providing the necessary training to students as the future builders of society, and familiarizing construction engineers with the latest developments in the construction industry in the direction of sustainable development

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