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Paper paper

Identification and prioritization of factors influencing the increase in construction costs of building investments using factor analysis

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Abstract: A large portion of the credits and financial resources of countries is spent on the preparation and construction of building projects because their implementation would create housing, job opportunities, financial turnover, and economic prosperity. At present, many construction projects are under construction in developing countries, and most of these projects are facing rising costs. The local scope of this research is construction projects in Yazd city. This research is operational in terms of purpose and was carried out in a descriptive and survey manner with an analytical-mathematical method. Data collection was done by documentary and survey methods. The *Statistical Society* consisted of 150 managers and officials, contractors, and actors involved in construction projects. Data analysis by hierarchical analysis technique showed that the criterion of management factors with a weight of 0.582 has the highest priority in increasing building costs. The criterion of environmental factors with a weight of 0.309 is at the second priority. The criterion of legal and administrative factors with a weight of 0.109 is in the third priority. Therefore, a key element in increasing the cost of construction projects in the under-studied city is the management factor that can be reduced by establishing new management systems and improving the quality of construction projects.

Keywords: cost, construction projects, hierarchical analysis, Yazd city

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1. Introduction

One of the activities of developing countries is the provision of housing and the implementation of construction projects, so the essential planning about these projects is a necessity and requirement to obtain the minimum cost-to-product ratio [1]. A large portion of the credit and financial resources is spent on investing in construction projects annually.

In addition to achieving the desired goals and cost-effectiveness, the most critical indicator of the success of these projects may be the completion of these projects with the predicted costs [2]. An increase in costs of construction projects is undeniable due to their unique complexity that depends on many factors so that studies indicate that the most construction projects in the world are under the influence of various factors which face with more than a 50% increase in costs [3].

Under the influence of various factors, the cost of construction projects would be divided into the wage costs of construction agents and human forces (construction workers, technicians, engineers, materials and equipment, geographical conditions of the project zone, and its subdivisions) [4]. At the macro level, the influential factors in increasing the project's construction cost can be divided into categories of organizational, legal, administrative, and environmental aspects [5].

According to the information about construction permits issued by Iranian municipalities in 2019, the country cities are at several classes in construction projects. The Yazd city is located in the third class of the country cities, which was registered as the most historic and a world city of Iran on the UNESCO list.

This registration led to travel and visit by 448,000 domestic and foreign tourists to the historic city of Yazd in 2019, that number is predicted to reach one million by 1400 (excluding the corona virus crisis). So, due to the created potential and the need to increase construction projects and high profitability in the construction industry, most of the capital has been directed to the establishment of construction projects, and the factors affecting the cost of construction of buildings have been increased uncontrollably. Many types of research were done in the subject area; for example, Tariq and Manuel [6] investigated sustainable structure via the approach of identifying the reasons for high costs in Oman construction projects.

Štuheca et al. [7] developed a structural impact evaluation of construction costs using 3D construction models. The results of this study revealed that delays in the progress of the operation, in addition to prolongation of the operation time and spending high costs to restart or complete them, leads to imposing additional costs on economic sectors as well as to become unjustifiable the project in later phases; By this it means, time passing and technological developments and changes

in environmental and social requirements may make projects unjustifiable in the new conditions that at one time had a technical and economic justification in terms of cost.

Aničić1 and Aničić [8] introduced the concept of cost management and its evaluation methods in projects. The values measured in project selection and ranking are the factors such as market share, financial benefit, return on investments, customer relations, public opinion, etc. There are two types of selection methods, and they are mathematical models and benefit measurement methods. Mathematical models use linear, dynamic, non-linear, multi-channel, and integer programming in the form of algorithms, and they are all used in the case of large and complex projects. Cost-benefit analysis is one of the most frequently used methods, based on cost and benefit comparison for the organization in the project realization. The results of this study revealed that for project management, project cost estimation and financial control should be considered as well as project evaluation and selection methods to increase economic productivity. Memon et al. [9] developed factors affecting the time and cost of building projects in Pakistan. The collection of data for this study was carried out through structured interviews with the help of a questionnaire form. The participants were asked the level of relevancy for each factor using a 5-point Likert scale. The response of the participants for each factor was recorded and analyzed statistically using the Average Index. The findings of this study indicate that many factors affect the cost of building projects such as lack of communication among the parties, delays in obtaining permits from government agencies, and lack of technical personnel which has been reported in the top cases. To improve the situation, the appropriate monitoring and control system should be considered. Benjamin et al. [10] studied the cost impact of building construction projects. Data collected was analyzed using descriptive and regression analysis which led to the determination of the impact of various types on contract sum, cost of variation, percentage variation, and duration of projects. They stated that the costs would fluctuate several times during construction projects, and in rare cases, the cost changes occur once. This trend is directly related to the duration of the project and the contract price [10].

The obtained results revealed that the factors related to the employer are included: overtimes created in the project, lack of timely supply of goods and materials, insufficient accuracy in selecting a contractor, failure to on-time resolve opponents, employer’s excessive procrastination in coordination with other urban systems, inadequate monitoring the performance of the contractor and consultant and improper distribution of project funding allocation. The factors related to the consultant include the consultant’s weakness in the initial evaluation, lack of enough executive experience of the planners, and the consultant’s weakness in judgment between employer and

contractor. The total of influencing factors related to the contractor includes low and incorrect price offer, weakness in project management, weakness informing the project executive organization, contractor's inability to identify project resources, and inability or inaccuracy to prepare the project schedule have increased the construction costs of social housing projects [11, 12]. Ahmadv and et al. [13] studied the presented the model to evaluate the factors that cause delays and increased costs in construction projects. The results revealed that the implementation of development projects is the same as any other task that requires planning and cost determination to become operational. As a result, the project implementation schedule is achieved, which clarifies to no small extent the practical way to obtain what is desired.

Ebrahimi Chamani et al. [14] have studied the most important causes of delays and increase in costs in road construction projects of Mazandaran province. The sampling method in this study was systematic random. After extracting the data from the questionnaire, the data were used to test the normal distribution of data of Kolmogorov and Smirnov test by SPSS software, and the research hypotheses were tested using regression test. The results showed that the contractor's financial capacity, failure to perform the employer's obligations on time, price fluctuations in the market, complex administrative bureaucracy, social issues along with the project procedure, and how to repair and maintain road construction equipment affect the project delays. Also, delays in project implementation will increase the cost of the project.

Hejazi and Norouzpour [15] developed the role of project integration management to reduce the costs of building projects. In their study, in the framework of one of the fields of project management, the area of integration management in lowering construction costs is investigated. The results show that considering the increasing growth of construction projects and the acquisition of new construction technologies, the importance of this area has become greater. Despite these improvements, unfortunately, the project management system still lacks optimal performance in reducing unnecessary project costs since the initial processes of the project. In most construction projects, costs are calculated at the end of the project, many of which unfortunately can not be compensated.

Rasouli et al. [16] compiled a simultaneous study of the factors affecting time delays and cost increases in hospital projects. The results of this study indicated that factors such as rework due to errors in operation, lack of identification and attention to project risks, the addition of new works and change of plan during the project, the lack of experienced contractor companies in the construction of the hospital, and changing bankers' policies in paying loans have an influential role in delaying time and increasing project costs.

Khalilzadeh and Mohammadi [17] compiled the factors affecting the increase in the cost of construction projects in building projects (Qazvin city). The results showed that one of the main parts of construction project management is project cost management including resource and human force planning, cost estimation, budgeting, and cost control. Weaknesses in any of these management elements can lead to an increase in the cost of the project compared to the approved budget, which can lead to many problems, including the complete failure of the project. A better view of controlling project costs can be achieved by identifying and accurately evaluating the factors affecting the price in each project work area.

In previous researches, the main focus of the studies was the relationship between cost, time, and quality of construction projects in Yazd, no research has emphasized explicitly identifying the factors affecting the increase in construction costs of building projects in the Yazd city yet. Therefore, in this study, the factors affecting the rise in construction costs of building projects in the city are identified and introduced. In future planning, all organs, responsible agencies, and responsible people would benefit from the results to progress their goals.

2. Method

This research is operational in terms of purpose and has been carried out in a descriptive and survey manner with the analytical-mathematical method. Data collection was done in addition to reliance on the rational analysis (qualitative analysis), and the statistical approaches (quantitative analysis) were applied. Data collection was done via two methods of the documentary, (article, book, magazine, websites, etc.), and survey (questionnaire, interview, and observation).

In the first stage, to identify the factors affecting the increase in construction costs of building projects in Yazd, field surveys and objective observations, as well as semi-focused interviews with experts and specialists, were conducted at the construction projects in the comprehensive and detailed plan of Yazd. Then, the identified factors were integrated using internal and external theoretical foundations and using the statistical principles of indexing, and compound data processing was included in the questionnaire.

The questionnaire validity was confirmed by the content analysis approach using the opinions of several experts and specialists. The questionnaire reliability was measured by applying SPSS statistical software and Cronbach's test that according to Table 1, the alpha value of all sub-factors is more than 0.75. So the questionnaire reliability was confirmed.

Table 1. Calculated Cronbach's alpha profile

The main factor	Number of sub-factors	Calculated alpha value
Managerial factors	10	0.891
Legal and administrative factors	10	0.887
Environmental factors	10	0.896

In this study, the statistical community was included: Managers and officials, contractors and agents involved in construction projects. In the present research, statistical samples were selected among the following individuals and groups to distribute the research questionnaire:

1) scientific and research background (number of published articles and presentations related to the research topic,
2) the relevance of work expertise to the research topic,
3) duration of activity (number of years of related activities),
4) degree of specialty and skills,
5) practical experiences and accurate knowledge related to the research topic.

This community had a large geographical size and area, so inevitably, some of them were selected as the sample. In this research, Cochran's statistical method is used to select the decision-making sample. The number of items in the sample (n) is determined according to Equation 1:

$$n = \frac{z^2 pq}{e^2} \tag{1}$$

z – the value of the standard variable (which for the 95% confidence level is obtained equal to 1.96 from the relevant table),

p – success ratio between sample people which is used due to unknown maximum value (0.5),

$q = (1 - p)$ – unsuccess ratio between the sample people has been used due to the unknown maximum value (0.5)

e – the amount of error occurred by the researcher in the study, which is usually chosen between 0.01 and 0.1 in the research that was considered equal to 0.08.

Using this method makes the selected sample large enough. The number of samples is equal to 150 by entering the relevant numbers in the above formula.

It should be noted that the Likert rank range has been used to evaluate the amount of sample size comments about each variable. The hierarchical analysis method with expert choice and Excel software as Fig. 1 has been used for data analysis.

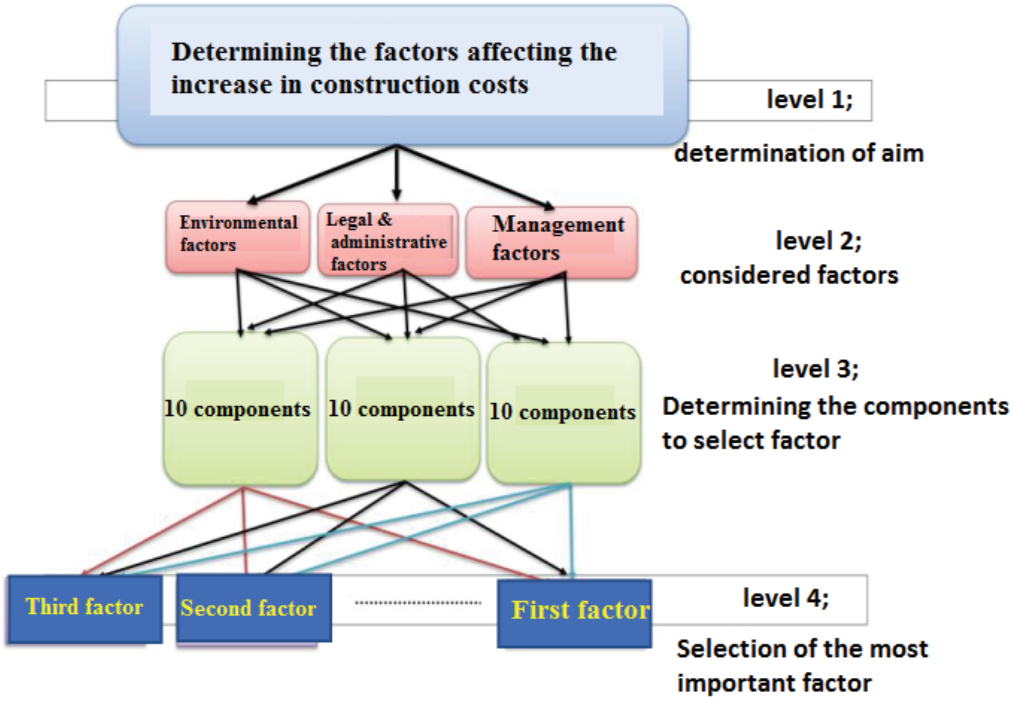

Fig. 1. Determining the factors affecting the increase in construction costs

3. Results

3.1. Demographic findings

To get acquainted with the people who participated in the statistical sample and fulfilled the questionnaire, 17.3% of the participants are under 25 years old, and 49.3% of them are between 25 and 50 years old. Also, 33.3% of the participants are over 50 years old. 60% of the participants have a bachelor's degree and 31.3% of the participants have a master's degree. 8.7% of the participants also have a Ph.D. 53.3% were active in the field of operation, 32% in the area of supervision, and 14.7% in the field of design. The area of study is mostly civil engineering (41.3), followed by urban development (33.3%) and architecture in the third rank (20%).

3.2. Prioritize model elements applying the AHP technique

The multi-criteria programming made through the use of the Analytic Hierarchy Process (AHP) is a technique for decision making in complex environments in which many variables or criteria are considered in the prioritization and selection of alternatives or projects.AHP was developed in the

1970s by Thomas L. Saaty and has since been extensively studied, and is currently used in decision making for complex scenarios, where people work together to make decisions when human perceptions, judgments, and consequences have long-term repercussions. The application of AHP begins with a problem being decomposed into a hierarchy of criteria to be more easily analyzed and compared independently. After this logical hierarchy is constructed, the decision-makers can systematically assess the alternatives by making pair wise comparisons for each of the chosen criteria. This comparison may use concrete data from the alternatives or human judgments as a way to input subjacent information [18].

This method is based on the decomposition rules, comparative judgments, and synthesis of priorities that involves basic mathematics. Comparative judgments are needed for pair-wise comparison of criteria, sub-criteria, and alternatives to achieve the criteria weights and relative priorities of alternatives. According to the judgments, the priorities of alternatives and the criteria for weights are eventually combined into an overall rating to reach the best alternative [19]. The relative 1–9 importance values of Saaty's scale are as follows: (1) as equal importance, (3) as weak importance, (5) as essential or strong importance, (7) as demonstrated importance, (9) as absolute importance, (2, 4) as intermediate values between the two and (6, 8) as adjacent judgments [20].

In this paper, concerning the AHP advantages such as simplicity, the ability to prioritize, and identifying, this method was chosen used to determine the weight of the criteria and indicators of the model. In this research, implementing AHP consists of four rudimentary steps includes Model building, Pair-wise comparison of categories and criteria, Pair-wise comparison of alternatives, and Alternative ranking. Generally, Problem modeling, Pair-wise comparisons, Judgment scales, and Priorities derivation are the main steps of the AHP technique [20]

3.2.1. Weighted harmonic mean

There are several types of averages in mathematic theory the tone of them is the "Harmonic Mean" or "Sub-Contrary Mean". The harmonic mean, as one of the three Pythagorean means, can be used in the assessing process when the average rate of the assessment system is required. The harmonic mean (H) of the positive real numbers $x_1, x_2, \ldots, x_n > 0$ is defined in Eq. (2) as follows [21].

(2)
$$H = \frac{n}{\frac{1}{x_1} + \frac{1}{x_2} + \ldots \frac{1}{x_n}} = \frac{n}{\sum_{i=1}^{n} \frac{1}{x_i}} = \frac{n \prod_{j=1}^{n} x_j}{\sum_{i=1}^{n} \frac{\prod_{j=1}^{n} x_j}{x_i}}$$

Considering Eq.(2), if a set of weights w_1, ..., w_n, is associated with the dataset x_1, ..., x_n, the weighted harmonic mean can be defined by Eq. (3) [21].

$$H = \frac{\sum_{i=1}^{n} w_i}{\sum_{i=1}^{n} \frac{w_i}{x_i}} \tag{3}$$

The harmonic mean method calculates the average rates when many criteria are working together. Also, the harmonic mean is the reciprocal arithmetic mean, which is a conservative value [21]

3.2.2. Determining the normalized weight vector

There are several methods to achieve the final scores of criteria for a MADM problem. One of the objective weighting measures, which has been proposed by researchers, is Shannon's entropy method. The concept of Shannon's entropy can be used to find a general measure of uncertainty. So, this technique has been developed in various scientific fields such as construction, physics, and social sciences. The input data of decision-making analysis cannot be determined precisely in many real life problems. Also, Shannon's Entropy is an effective method for non-deterministic data. In other words, when data are non-deterministic, the method must be modified to show the correct results [22]. Shannon's entropy, as one of the most powerful multi-criteria decision-making methods is a measure of uncertainty associated with the source of information. The information uncertainty is addressed in Shannon's entropy technique using probability theory [23]. The greater the value of the entropy corresponding to a special attribute, which implies the smaller weight, the less the discriminate power of that attribute in the decision-making process [18]. In this method, to calculate the weight of parameters, we should operate in the following manner. When the data of a decision matrix is fully specified, the entropy method can be used to estimate the weights. In the decision matrix, entropy can represent the distribution of index values. For the possible variables with the probability values of Pi, the uncertainty (entropy proposed by Shannon) can be obtained as Eq. (4). As noted before, Shannon's entropy is a recognized method to achieve balanced weights, especially when it is not possible to determine an accurate weight based on the preferences and decision – making experiments. The main procedure of Shannon's entropy includes the following steps [23, 24].

Step 1:To normalize the decision matrix, set Eq. (4), $j = 1, ..., n$, $i = 1, ..., m$.

(4) $$p_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$$

The raw data are normalized to eliminate anomalies with different measurement units and scales. This process transforms different scales and units among various criteria into common measurable units to compare the different sets of criteria.

Step 2: To compute entropy E_j as Eq. (5), $j = 1, ..., n$.

(5) $$E_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij}$$

Where k is the entropy constant is equal to $k = 1/\ln(m)$ and if $p_{ij} = 0$ then "$p_{ij} \cdot \ln p_{ij}$" is defined as 0.

Step 3: To determine the entropy of each index, set $d_j = 1 - E_j$ as the degree of diversification for $j = 1, ..., n$.

Step 4:To set Eq. (6)as the importance degree of attribute j.

(6) $$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}$$

Step 5: To set Eq. (7)as the importance degree of attribute j, attribute j with the weight equals to λ_j.

(7) $$w_j = \frac{\lambda_j d_j}{\sum_{j=1}^{n} \lambda_j d_j}$$

In the first step, the main criteria are selected. The main criteria are: managerial, legal and environmental, and in the second step, the weight of each sub-criterion is determined based on the

main criterion. The criteria and sub-criteria have been named with a numerical index to be easily detected and studied during the research, which is shown in Table 2.

Table 2. Criteria and sub-criteria [1, 25]

Sub-criteria	Symbol	Criteria	Symbol
Selection of a capable designer and consultant	A1	Management factors	A
Selection of a capable contractor	A2		
Payment method of project staff's wage	A3		
Payment method to buy project branches	A4		
Procurement of operating machinery and equipment	A5		
Accurate material measurement and accurate project volumes estimates	A6		
Preparation of complete 3D digital model of projects with a financial approach	A7		
Existence of proper communication between management with consultant and contractor	A8		
Investigation of contractor supervisors' reports by managers	A9		
Managers' Correct and on time decision	A10		
Quality and type of insurance	B1	Legal and administrative factors	B
Method and type of tax	B2		
Method and type of value-added	B3		
Method and type of banking facilities	B4		
Method and type of contract	B5		
Obtaining a permit from the municipality	B6		
Obtaining a license from the engineering system	B7		
Obtaining employee's certifications	B8		
Holding inquiries and tender's arbitration	B9		
Complex administrative bureaucracy	B10		
Geographical conditions of the project environment	C1	Environmental factors	C
Regional land prices	C2		
Zone conditions of the Workshop and labors	C3		
The recycling rate of waste and scrap materials	C4		
Durability and durability of materials	C5		
How to load and unload materials	C6		
Supply Chain of materials	C7		
Department of warehousing and optimal maintenance of materials	C8		
Conditions for establishing a workshop and labors	C9		
Modern hardware and software facilities for communication between project agents	C10		

3.3. Purpose based prioritize criteria

The AHP technique is a ranking technique, and it is done based on the pair wise comparisons in this technique. Pair wise comparison is straightforward, and all elements of each cluster should be compared in pairs. Pair wise comparisons were performed from the perspective of an experts' group, and the experts' views were aggregated using the geometric mean technique. The pair wise comparison matrix resulting from the aggregation of experts' opinions is presented in Table 3:

Table 3. Pair wise comparison Matrix of research criteria toward the target

	Management factors	Legal & administrative factors	Environmental factors
Management factors	–	5	2
Legal and administrative factors	–	–	3
Environmental factors	–	–	–
	Compatibility rate; 0.0035		

In the next stage of the analysis, the criteria' ranking is based on the extracted weights, which are graphically specified in the following diagrams. As shown in Fig. 2, the criterion of management factors with a weight of 0.582 has the highest priority in increasing building costs. The criterion of environmental factors with a weight of 0.309 is the second priority. The criterion of legal and administrative factors with a weight of 0.109 is the third priority.

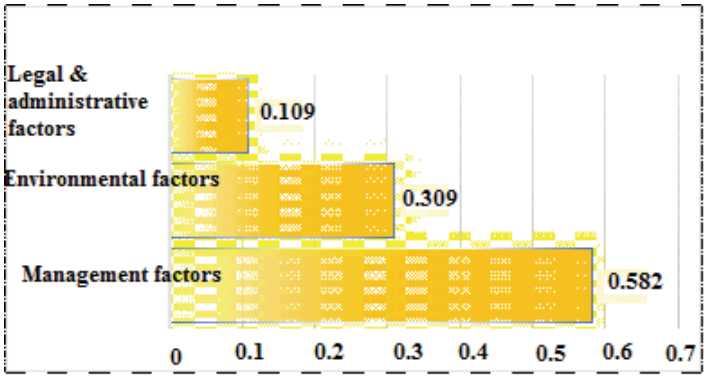

Fig. 2. Graphic representation of the priority of research criteria toward the goal

The compatibility rate is used to validate the results. Incompatibility rate is an index that measures the experts' consistency degree of responses to pair wise assessments and comparisons. In this research, the incompatibility rate was calculated automatically via the software and simultaneously as the questionnaire data were entered into expert choice. According to Mr. Saati, the founder of the AHP method, if the incompatibility rate is less than 0.1, the compatibility of the comparison matrix will be approved and accepted. But if the inconsistency rate is more signi*cant than 0.1, it indicates a discrepancy in the experts' evaluations and judgments. It should be noted that the incompatibility rate of the comparisons was 0.0035, which is smaller than the boundary limit of 0.1. So, it can be said that the performed comparisons were trusted.

3.4. Prioritization of sub-criteria of managerial factors

In the next step of the AHP technique, the sub-criteria related to each criterion has been compared in pairs.The following table shows the priority and managerial sub-criteria rank. As shown in Table 4, the sub-criteria to select a capable designer and consultant weighing 0.155 is the highest priority. The Sub-criterion for choosing a qualified contractor with a weight of 0.135 is the second priority. Sub-criterion of payment method of project staff wages with a weight of 0.131 is the third priority. Also, it should be noted that the incompatibility rate of the comparisons was 0.07which is less than the boundary limit of 0.1. Therefore, it can be said that the performed comparisons are reliable.

Table 4. Ranking management sub-criteria

Symbol	Sub-criteria	Sub-criteria weight	Sub-criteria rank
A1	Selection of a capable designer and consultant	0.155	1
A2	Selection of a capable contractor	0.135	2
A3	The payment method of project staff's wage	0.131	3
A7	Preparation of complete 3D digital model of projects with a financial approach	0.076	7
A8	Existence of proper communication between management with consultant and contractor	0.071	8
A9	Investigation of contractor supervisors' reports by managers	0.065	9
A10	Correct and on-time decision of managers	0.034	10
Incompatibility rate		0.07	

3.5. Prioritization of the legal and administrative sub-criteria

As shown in Table 5, the sub-criterion of method and type of insurance weighing 0.210 is the second priority. Sub-criteria of the method and type of bank facilities with a weight of 0.116 is the third priority. It should also be noted that the incompatibility rate of the comparisons was 0.07, which is less than the boundary limit of 0.1. Therefore, it can be said that the comparisons are reliable.

Table 5. Ranking legal and administrative sub-criteria

Symbol	Sub-criteria	Sub-criteria weight	Sub-criteria rank
B1	Method and type of insurance	0.210	1
B2	Method and type of tax	0.201	2
B4	Method and type of value added	0.116	3
B3	Method and type of bank facilities	0.106	4
B6	Method and what type of contract	0.082	5
B5	Obtaining a permit from the municipality	0.071	6
B7	Obtaining a license from the engineering system	0.062	7
B8	Obtaining employee certificates	0.06	8
B9	Holding inquiries and tender's arbitration	0.05	9
B10	Complex administrative bureaucracy	0.43	10
Incompatibility rate 0.07			

3.6. Prioritization of sub-criteria of environmental factors

As shown in Table 6, the sub-criterion of the geographical conditions of the project environment with a weight of 0.278 is the first priority, and the sub-criteria of the regional price of land with a weight of 0.159 is the second priority. The sub-criterion of recycling waste and scrap materials with a weight of 0.115 is the third priority. It should also be noted that the incompatibility rate of the comparisons was 0.09 which is smaller than the boundary limit of 0.1. Therefore, it can be said that the comparisons are reliable.

Table 6. Ranking environmental sub-criteria

Symbol	Sub-criteria	Sub-criteria weight	Sub-criteria ranking
C1	Geographical conditions of the project environment	0.278	1
C2	Regional land price	0.159	2
C4	Waste and scrap recycling rate	0.115	3
C5	Durability of materials	0.101	4
C3	Prices of materials	0.092	5
C7	Supply Chain Materials	0.068	6
C6	How to load and unload materials	0.059	7
C8	Optimal storage and maintenance of materials	0.049	8
C9	Conditions for establishing a workshop and workers	0.041	9
C10	Modern hardware and software facilities for communication between project agents	0.037	10
Incompatibility rate 0.09			

3.7. Determination of final weight of elements via AHP technique

In this part of the research, the final weight of the identified criteria has been evaluated and studied based on the main goal. The results of the estimates and the weights of the indexes are shown in table 7. According to the calculations, it is possible to determine the final priority of the criteria. Accordingly, the selection index of a competent designer and consultant with a total weight of 0.108 is the most important among all available indexes. The index of selecting a capable contractor with a total weight of 0.094 is the second priority. It should be noted that the last rank and importance is related to the sub-criteria of modern hardware and software facilities for communication between project factors with a final weight of 0.008. Also, the total incompatibility rate has been calculated at a very desirable and acceptable level of 0.06.

Table 7. Determining the final priority of indexes with the AHP technique

Symbol	Main criteria	Weight	Sub-criteria	Symbol	Criteria Weight relative to its criteria	Final weight	Final rank
A	Management factors	0.582	Selection of a capable designer and consultant	A1	0.155	0.108	1
			Selection of a capable contractor	A2	0.135	0.094	2
			The payment method of project staff's wages	A3	0.131	0.091	3
			How to buy project branches	A4	0.118	0.082	4
			Procurement of machinery and operational equipment	A5	0.115	0.08	5
			Existence of proper communication between management with consultant and contractor	A8	0.099	0.069	6
			Accurate measurement of materials and precise estimation of project volumes	A6	0.076	0.053	8
			Preparation of complete 3D digital model of projects with a financial approach	A7	0.071	0.05	9
			Investigation of contractor supervisor reports by managers	A9	0.065	0.046	10
			Correct and on time decision of managers	A10	0.034	0.023	13
B	Legal &administrative factors	0.109	Quality and type of insurance	B1	0.210	0.020	15
			Method and type of tax	B2	0.201	0.019	16
			Method and type of bank facilities	B4	0.116	0.011	20
			Method and type of value-added	B3	0.106	0.010	21
			Obtaining a permit from the municipality	B6	0.082	0.008	24
			Method and type of contract	B5	0.071	0.007	26
			Obtaining a license from the engineering system	B7	0.062	0.006	27
			Obtaining employee certificates	B8	0.06	0.006	28
			Holding inquiries and tenders arbitration	B9	0.05	0.005	29
			Complex Administrative Bureaucracy	B10	0.43	0.004	30
C	Environmental factors	0.309	Geographical conditions of the project environment	C1	0.278	0.058	7
			Regional land price	C2	0.159		11
			The recyclingrate of waste and savematerials	C4	0.115	0.033	12
			Durability of materials	C5	0.101	0.024	14
			Prices of materials	C3	0.092	0.021	17
			How to load and unload materials	C6	0.059	0.014	19
			Storage section and Optimal maintenance of materials	C8	0.049	0.012	22
			Conditions for establishing a workshop and workers	C9	0.041	0.010	23
			Modern hardware and software facilities for communication between project staffs	C10	0.037	0.009	25

4. Conclusion

In this research, the factors affecting the increase in construction costs of building projects in Yazd were identified and ranked. According to the investigations, managerial factors, legal, administrative and environmental factors were identified as the most important factors in increasing the construction costs in the under-studied city. Data analysis via hierarchical analysis technique indicated that the criterion of management factors with a weight of 0.582 is in the highest priority in increasing building costs in Yazd. The criterion of environmental factors with a weight of 0.309 is the second priority, and the criterion of legal and administrative factors with a weight of 0.109 is the third priority. The results reveal that in the city of Yazd, management factors should be at the top of the construction, because due to the size of construction projects, especially building projects. With the wide range of details of the design stage, implementation and operation, the need for available management and planning staff is palpable. The result of this section same as the research, ref. [6, 9, 11, 12, 14, 15, 16], because in each of the studies, the role of management factors was significant in building costs.

In the sub-criteria of the managerial factor, the sub-criterion of selecting a capable designer and consultant with a weight of 0.155 is the highest priority. The Sub-criterion for choosing a skilled contractor with a weight of 0.135 is the second priority. The result of this part of the research is aligned with the studies by ref. [6, 11, 12, 16, 17] because in the mentioned studies, the role of selecting a contractor in increasing the construction costs have been emphasized. In legal and administrative factors, the quality and type of insurance with a weight of 0.210 are the highest priority. Sub-criterion of method and type of tax with a weight of 0.201 is the second priority. Research such as ref. [9, 12, 14] also confirms administrative and legal factors increasing building costs.

In terms of environmental factors, the geographical conditions of the project environment with a weight of 0.278 are the first priority, and the regional land price sub-criterion with a weight of 0.159 is the second priority. The findings of this part of the research are similar to and aligned with the results of ref. [8–10, 12].

The final weight of the sub-criteria indicates that the criterion of selecting a competent designer and consultant with a total weight of 0.108 is the most important among all available criteria. The index of choosing a capable contractor with a total weight of 0.094 is the second priority. It should be noted that the last rank and importance is also related to the sub-criteria of developing instructions and holding training courses for project staff with a final weight of 0.004.

The factors affect cost overrun in other regions and a different project can be studied in the future researches.

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