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Building Information Modelling Execution in Administrative and Commercial Spaces in Iran – A Fuzzy-Delphi Criteria Prioritization

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A B S T R A C T

Building information modelling (BIM) is considered an innovative approach which is under development all over the world in architecture, engineering, and construction fields. Iran, among the developing countries, has the potential to adapt itself to achieve sustainable development, especially in building construction industry. Thus, this country is selected as the target of this research. In developing countries such as Iran, the construction industry is currently on progress, but in our best knowledge, there is no evidence for the effective and commercialized execution of BIM yet. The final aim of BIM application would be to make public and private projects more sustainable. Hence, in order to push this technology forward and provide more sustainable conditions for developing countries, such as Iran, this study emphasizes the main challenges and obstacles in the utilization of BIM in the construction industry. A Fuzzy-Delphi questionnaire was designed in order to acquire consensus among the scientific community about the criteria that may affect the implementation of BIM in constructions. The questionnaire was then analyzed by using SPSS (25.0). Results clearly demonstrated that the time required for BIM designing step, along with associated costs and lack of motivation among the involved parties are the main obstacles preventing the commercialized implementation of BIM in the construction projects.

1. INTRODUCTION

The first step towards sustainable building construction is to develop the architecture patterns and the construction industry in compliance with Building Information Modelling (BIM). BIM can be defined as a process used in the construction phase, which provides a management system of graphical data and information together with the full description of a given construction project by modelling and simulation of all the involving objects (Garyaeva, 2018; Reizgevičius et al., 2018; Zhao et al., 2017).

Considering the high costs involved in building and exploiting office and commercial spaces, as a main part of construction in any city (Rehm and Ade, 2013), BIM can play an important role in economic growth when used by the involved parties at large scales. On the other hand, energy consumption is one of the most important issues of recent studies, which has been discussed in various sections (Jahanshahi et al., 2019). BIM can be a helpful tool in many areas, namely energy management (Abanda and Byers, 2016). The strategic decision to implement such a new tool is directly related to the potential benefits, which the technique is likely to bring, and the attributed costs (Takim et al., 2013). BIM is considered a new process developed in architecture, engineering, and construction (AEC) activities in order to create virtual models of various building parts such as walls, floors, etc, as well as building materials by using numerical, textual and imagery data to detect the probable problems prior to construction. In this process, building parts are characterized by various numerical parameters such as dimensions (Pocobelli et al., 2018). Despite the importance of BIM in designing building structures, few studies have been performed on the application of this technique in real situations (Bosch-Sijtsema et al., 2019). In Iran, BIM has not yet been extensively implemented. The construction industry in Iran pays very little attention to BIM. This may raise a lot of issues for the construction industry in this country, in the future. Recent studies and the gathered information show that Iran's construction industry has significantly lacked this technology (Hosseini et al., 2018). The use of traditional and old methods in Iran have led to a lot of costly construction and eventually caused the inevitable delay in the delivery of the project. Most of the activists in this field have prevented the implementation of this technique by ignoring its benefits (Khanzadi et al., 2018).

It is worth mentioning that the effective implementation of BIM requires developing the relevant tools, protocols, and standards (Akponeware and Adamu, 2017). In this regard, there are some experiences in some developed and developing countries that can be used to facilitate the implementation of BIM. It has been also shown that there is a direct relation between the development level of the countries and the extent of BIM implementation (Jung and Lee, 2015). For instance, in China, many professional consulting companies are now providing consulting services on BIM, bringing a number of advantages such as optimization and minimizing the engineering costs as well as the reduction in the construction time (Herr and Fischer, 2019; Zhang et al., 2016). Although these advantages may also cause the application of BIM in reconstruction projects, BIM has not been sufficiently employed in such projects, specifically in developing countries (Pavlovskis et al., 2017). Various pieces of software have been already developed to facilitate the application of BIM. Autodesk Revit is one of the most popular software in this regard (Ferrandiz et al., 2018). All details in the Revit have multi-dimensional design capabilities and Fig. 1 (a and b) reveals a design example and virtualization of a building facade in Revit (Mostafavi et al., 2015). As it can be observed from Fig. 1, the provided model with BIM (a), includes all the details which have further been implemented in the constructed building.

Fig. 1. Grayson House's geometry drawn in Autodesk Revit (a) Orchard Hill residential area (b) (Mostafavi et al., 2015).

The Fuzzy-Delphi methodology, as a useful tool for reaching consensus among the experts in the field (Jahanshahi et al., 2019; Kamali et al., 2015; Kamali et al., 2017) was used in this study in order to identify and rank the most important criteria influencing the implementation of BIM in building and construction activities. According to the criteria identified and prioritized, the main barriers and obstacles of BIM employment were critically addressed.

2. THEORETICAL BACKGROUND

Since the beginning of the 2000s, the AEC industry started to adopt BIM in projects (Succar, 2009). Various countries all over the world have contributed effectively to the rapid development and implementation of this tool. In a scientometric study covering the published papers between 2005 and 2016, Zhao et al. (2017) indicated that the United States (196 articles), South Korea (95 articles), China (71 articles), Australia (63 articles), and the United Kingdom (54 articles), had the highest research contributions in BIM globally. They also stated that currently there is a general lack of attention in the developing countries. In this study, some countries (Pakistan, Vietnam, Mongolia, Sri Lanka, Myanmar, Thailand, Indonesia, Malaysia, India) were taken under examination. In developing countries, especially in Asia, BIM technology has been underestimated. However, most of the above-mentioned countries have accepted the benefits of its implementation. Much more, challenges and obstacles to the implementation of BIM require considerable attention (Ismail et al., 2017). To examine the keywords development from 2005 to 2016, the scientometric method was applied. Fig. 2 is the output of the program Cite Space to represent this matter. A detailed analysis of the keywords used in the literature for BIM can also demonstrate a developing trajectory regarding the frequency of utilization in the literature. Keywords, such as "Building Information Modelling", "building information modelling" and "BIM", were merged over time into "building information modelling (BIM)" (Fig. 2). BIM was reviewed in several areas such ashistorical building management (Rodrigues et al., 2019), transportation infrastructure (Costin et al., 2018), bridge design and construction, construction management of railway tunnel (Chen, 2018), building and design of water supply and drainage (Wei et al., 2017), etc. All of the above-mentioned studies argue in favour of BIM.

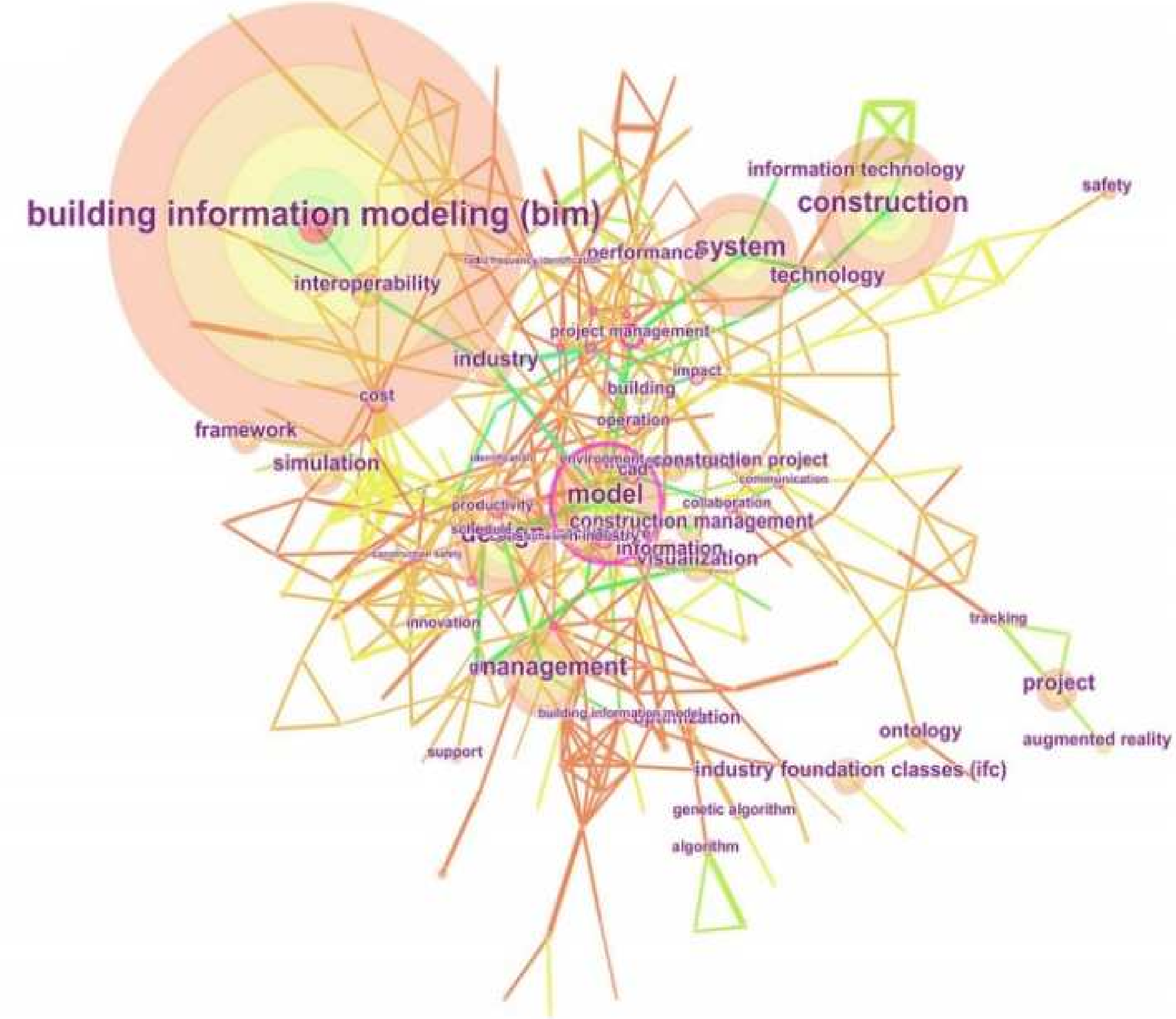

Fig. 2. The network of co-occurring keywords used in BIM research in the literature (2005-2016), with 278 nodes and 770 links, reprinted with permission of Zhao et al. (2017).

On the topic of this paper, there have been some studies in different countries to assess the conditions of their construction industries. Therefore, in Japan, architectural companies and general contractors, asproject customers, were not aware of the value using BIM in projects (Kaneta et al., 2017). In another executed study, soft and technical sections have proved to have a great influence on the use of BIM. For example, the Dutch trade associations were struggling to achieve this goal (Siebelink et al., 2018).

Over the past few years, BIM benefits have been acknowledged among private and public owners around the world. Even some governments spend a lot of money on developing this technology (Liao and Teo, 2019). It is of high importance to analyze the reasons, causing these countries to apply this technique less, thus, more research is required in this regard. In Iran, the lack of attention to BIM is noted and traditional techniques are still popular in the construction industry (Hosseini et al., 2016).

3. METHODOLOGY

3.1. Identification of criteria and sub-criteria

In this study, based on literature screening, some 15 criteria were identified for the development of BIM application in administrative and commercial construction projects in Iran (Table 1).

Table 1. Identified criteria and sub-criteria.

Criteria	Sub-Criteria (Definition/ Description)	Identification	References
Technical	1- Insufficient knowledge on BIM enforcement systems in the senior executives.	CR1	(Kaneta et al., 2017)
	2- Lack of sufficient research projects on BIM	CR2	(Zhao et al., 2017)
	3- Lack of experts in the field of BIM	CR3	(Krivonogov et al., 2018; Migilinskas et al., 2013; Pavlovskis et al., 2017; Migilinskas et al., 2017)
	4- Lack of BIM training centers	CR4	(Krivonogov et al., 2018)
	5- Incompatibility of the existing software and hardware with BIM software system	CR5	(Mirarchi et al., 2018)
	6- Lack of proper training programs for the personnel to become familiar with BIM	CR6	(Krivonogov et al., 2018; Garyaeva, 2018)
	7- Insufficient information on BIM among the private sector	CR7	(Kaneta et al., 2017)
Social	8- Lack of incentives in governmental organizations to enforce BIM's performance factors	CR8	(Kaneta et al., 2017)
	9- Distrust of construction companiesinBIM efficiency	CR9	(Kaneta et al., 2017; Galieva et al., 2018)
	10- Distrust of consulting engineersinBIM efficiency	CR10	(Reizgevičius et al., 2018; Kaneta et al., 2017; Galieva et al., 2018)
	11- Distrust of construction contractors inBIM efficiency	CR11	(Kaneta et al., 2017; Galieva et al., 2018)
	12- Lack of transparency regarding BIM positive results with private sector activists	CR12	(Kaneta et al., 2017; Galieva et al., 2018)
	13- Unwillingness of contracting companies to use BIM system	CR13	(Kaneta et al., 2017)
Economic	14- High costs of purchasing BIM-related software	CR14	(Kaneta et al., 2017)
Timing	15- Lack of time to implement BIM	CR15	(Kaneta et al., 2017)

A professional questionnaire (see supplementary information) was elaborated based on these criteria and then employed to assist in collecting the opinion of a target expert group. The expert group was carefully selected by inviting experts in the field, with excellent academic and/or practical experience in the field of BIM. A total of 21 responses were received and analyzed to achieve the results of this study.

3.2. Fuzzy-Delphi Method

Delphi is one of the most popular methodology implemented so far for the identification and prioritization of the criteria and sub-criteria influencing a process (Okoli and Pawlowski, 2004; Kamali et al., 2017).

This method is normally implemented through summarizing expert opinions in a specific scientific domain. In the case of Delphi method, the choice of respondents is based on their level of experience and skill onthe subject. Respondents should have enough skill and expertise in the field. In this study, 21 specialists and researchers, construction experts and BIM experts, were selected. The number of respondents varies depending on the subject. In many cases, the Delphi method can be employed with fewer users. However, all respondents should be considered to be experts (Chang et al., 2000; Doyon et al., 1971; Yousuf, 2007). A fuzzy number is normally expressed as a fuzzy set defining a fuzzy interval in the real number R, often used to explain the uncertain information in the decision-making process (Ban and Coroianu, 2012).

As a type of fuzzy numbers, a triangular fuzzy number must be represented with three numbers, as follows: = (a_1, a_2, a_3). The membership functions that can be used to interpret this representation, hold the following conditions (Gani and Assarudeen, 2012):

$$y = m(x) = \begin{cases} 0 & x < a_1 \\ \frac{x-a_1}{a_2-a_1} & a_1 \le x \le a_2 \\ \frac{a_3-x}{a_3-a_2} & a_2 \le x \le a_3 \\ 0 & x > a_3 \end{cases} \quad \text{Eq. 1}$$

A number of reports exist in the literature for the effective application of the fuzzy-Delphi methodology for making sustainable decisions in various scientific fields (Hsu et al., 2010; Sánchez-Lezama et al., 2014; Tahriri and Mousavi, 2014). In the present study, the fuzzy-Delphi method was used in order to distinguish the criteria and sub-criteria affecting the implementation of BIM in the AEC industry and, afterwards, we attemped to rank these criteria from the most effective to least ones. According to Table 2, for the construction of the questionnaire, a fuzzy scale including seven linguistic variables and the respective triangular fuzzy numbers were used. The geometric mean (Eq. 2) (Hsu et al., 2010) was used to calculate the fuzzy weights of the criteria, where L, M, and U express the fuzzy number components. Eq. (3) was also used to defuzzy the values. Moreover, all criteria were defuzzied using Eq. (1) and defuzzied numbers were then employed to classify and prioritize the criteria.

$$L_j = Min_i\{L_{ij}\},\ M_j = \frac{1}{n}\sum_{i=1}^{n} M_{ij},\ U_j = Max_i\{U_{ij}\} \quad \text{Eq. 2}$$

$$df = \frac{1}{4}(L + 2M + U) \quad \text{Eq. 3}$$

Table 2. Linguistic variables and the relevant fuzzy scales for the relative importance of the criteria.

Linguistic variable	Fuzzy Scale (L, M, U)	$df = \frac{1}{4}(L+2M+U)$
Extremely High	(0.9,1.0,1.0)	0.975
Very High	(0.7,0.9,1.0)	0.875
High	(0.5,0.7,0.9)	0.7
Fair	(0.3,0.5,0.7)	0.5
Low	(0.1,0.3,0.5)	0.3
Very Low	(0.0,0.1,0.3)	0.125
Extremely Low	(0.0,0.0,0.1)	0.025

3.3. Analysis of results

In this research, SPSS v.25.0 was used for data analysis. It must be stated that the data used as the input of the software were the defuzzied numbers received from the expert group. Data were analysed using the descriptive-analytic method. Cronbach's alpha was used to assess the internal consistency of the answers provided by the experts. The Cronbach alpha coefficient is one of the common methods of measuring internal consistency (reliability), which is usually used to evaluate the reliability of the time scale of the questions (Béland et al., 2016). After reviewing the responses by the software, a coefficient was obtained, describing the correlation between the responses in the questionnaire and the variation between 0 and 1, based on the analysis of the responses. With a coefficient close to 1, the reliability of the indices is higher (Gottems et al., 2018). If the Cronbach's alpha coefficient is calculated higher than 0.7, it means that data is reliable for analysis (Pinto et al., 2014). The Kolmogorov–Smirnov (KS) test was also used to evaluate the inconsistency of the responses and to verify the normality of the data (Zhang and Chen, 2018). In this manuscript, KS was used in addition to the Shapiro-Wilk test to verify the normality of the collected data, due to the fact that the sample size is less than 2000.

4. RESULTS AND DISCUSSION

After the implementation of Fuzzy-Delphi method on the responses of the questionnaire, the results of simulation are depicted in Table 3 and Fig. 3. The numbers shown for every criterion were obtained using the Eq. 2 and 3.

Table 3. Linguistic variables and the relevant fuzzy scales for the relative importance of the criteria.

Criteria	Sub-Criteria identific.	Fuzzy Scale (L, M, U)	$df = \frac{1}{4}(L+2M+U)$
Technical	CR1	(0.0, 0.70, 1.0)	0.600
	CR2	(0.0, 0.70, 1.0)	0.598
	CR3	(0.0, 0.74, 1.0)	0.621
	CR4	(0.0, 0.68, 1.0)	0.588
	CR5	(0.0, 0.68, 1.0)	0.590
	CR6	(0.0, 0.64, 1.0)	0.569
	CR7	(0.0, 0.70, 1.0)	0.602
Social	CR8	(0.0, 0.65, 1.0)	0.576
	CR9	(0.0, 0.74, 1.0)	0.619
	CR10	(0.1, 0.72, 1.0)	0.635
	CR11	(0.0, 0.71, 1.0)	0.605
	CR12	(0.1, 0.76, 1.0)	0.656
	CR13	(0.0, 0.77, 1.0)	0.636
Economic	CR14	(0.1, 0.81, 1.0)	0.680
Timing	CR15	(0.3, 0.79, 1.0)	0.720

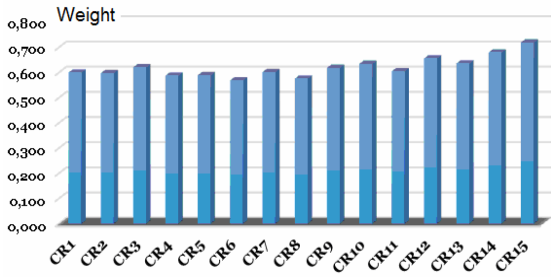

Fig. 3. Calculated weights of the criteria and sub-criteria for the development of BIM in AEC.

Table 4 presents the results of the consistency test by the Cronbach's Alpha achieved after analysis of the responses in SPSS. Results indicated that the responses with the Cronbach's Alpha=0.792 were considered to be consistent and reliable. Kolmogorov-Smirnov and Shapiro-Wilk tests were also used to evaluate the normality of data. As shown in Table 5, all the outputs had values of less than 0.05. Hence, the obtained responses were determined to be non-normalized and non-parametric.

Table 4. Case processing summary (SPSS 25.0 software).

Analysis		N	(%)	No. of Items	Cronbach's Alpha
Cases	Valid	21	100	15	
	Excluded	0	0	0	
	Total	21	100	15	**0.792**

Table 5. Normality test results.

Shapiro-Wilk			Kolmogorov-Smirnov			Criteria
Sig.	df	Statistic	Sig.	df	Statistic	
0.002	21	0.830	0.002	21	0.248	CR1
0.010	21	0.871	0.002	21	0.243	CR2
0.000	21	0.783	0.001	21	0.249	CR3
0.005	21	0.852	0.001	21	0.261	CR4
0.000	21	0.790	0.001	21	0.259	CR5
0.008	21	0.867	0.001	21	0.257	CR6
0.009	21	0.868	0.014	21	0.213	CR7
0.020	21	0.887	0.014	21	0.212	CR8
0.000	21	0.753	0.000	21	0.291	CR9
0.039	21	0.903	0.041	21	0.192	CR10
0.001	21	0.809	0.001	21	0.264	CR11
0.003	21	0.841	0.000	21	0.285	CR12
0.000	21	0.782	0.000	21	0.309	CR13
0.000	21	0.782	0.000	21	0.313	CR14
0.008	21	0.864	0.003	21	0.237	CR15

Considering that the sum of responses was non-parametric, the Kruskal-Wallis test was also used to verify the uniformity of the perceptions of the respondents. Table 6 presents the achieved results. The output of the test was calculated to be 0.535, which is higher than the threshold (0.05) and, thus, the perceptions of the respondents about the criteria are almost identical and there is almost no difference in the clearness of questions, which means that all respondents have gotten the same impression from the questionnaire. This test was used to compare the average of two or more than two groups of samples. The assumptions in this test are based on the statistical comparison of the existence or absence of differences between groups and according to the responses. The value of the number is 0.05, which means that if the output of the program for this test is less than that, then, there is a difference between the groups of the respondents (Maimaiti et al., 2019).

Table 6. Kruskal-Wallis Test (SPSS 25.0 software).

Test Statistics	Answer
Kruskal-Wallis H	12.891
df	14
Asymp. Sig.	0.535

Table 7 and Fig. 4 present the final ranking of the mentioned sub-criteria. Based on the results achieved, "*the lack of time to implement BIM*" was identified as the most important parameter while the "*lack of proper training programs for the personnel to become familiar with BIM*" was identified as having the minimum impact on the development of BIM in developing countries like Iran.

The absence or lack of familiarity with BIM software and hardware, the lack of adequate training and insufficient and costly data were investigated in a study in Malaysia (Mohammad et al., 2018); in another study, the lack of familiarity and trust of employers, designers and contractors in BIM and also the required time to design BIM have been investigated (Migilinskas et al., 2017). However, the ranking of criteria from the least to most significant is in compliance with the listed order in the table based on the situation of the constructing industry in Iran. By the comparison among different executed studies in different countries, it can be comprehended that the ranking criteria utilized in all studies in literature are similar, while the significance that they are given varies from one country to another. According to experts' opinions, the lack of time for the implementation of BIM is the most important obstacle for the use of BIM method in Iran, and specifically in administrative and commercial projects in Iran. In design phase, more time must be devoted if BIM method is added to this process, but, as it has been proven repeatedly, it will result in shorter time at the project operation stages. One of the reasons is the elimination of interferences and operational barriers resulting from overlapping of various design sectors. For instance, the facilities designed by the consulting engineers can interfere with the designed structure, which is a frequently occurring problem in the construction projects, and if the problem could be predicted at the pre-design stage by the software and the as-built drawings were redesigned based on the relevant solutions, the operations would not be interrupted. Consequently, the project would not be needed to be rescheduled even during the operational stage. Hence, while observing the whole project, required construction time is shortened in case BIM is implemented. The time consumed in the design stage via the utilization of BIM method is considerably shorter compared to the time spent on interruptions during the constructing procedure.

Table 7. Final ranking of the studied sub-criteria.

Sub-Criteria	Identification	De-Fuzzy values	Rank
Lack of time to spend for BIM implementation	CR15	0.720	1
High costs of purchasing BIM-related software	CR14	0.680	2
Lack of transparency regarding BIM positive results with private sector activists	CR12	0.656	3
Unwillingness of contracting companies to use BIM system	CR13	0.636	4
Distrust of consulting engineers inBIM efficiency	CR10	0.635	5
Lack of experts in the field of BIM	CR3	0.621	6
Distrustof construction companies in BIM efficiency	CR9	0.619	7
Distrust of construction contractors in BIM efficiency	CR11	0.605	8
Lack of sufficient information on BIM among the private sector	CR7	0.602	9
Insufficient knowledge of senior executives on BIM enforcement systems	CR1	0.600	10
Insufficient research projects on BIM	CR2	0.598	11
Incompatibility of the existing software and hardware with BIM software system	CR5	0.590	12
Lack of BIM training centers	CR4	0.588	13
Insufficient incentives to enforce BIM's performance factors in governmental organizations	CR8	0.576	14
Lack of proper training programs for the personnel to become familiar with BIM	CR6	0.569	15

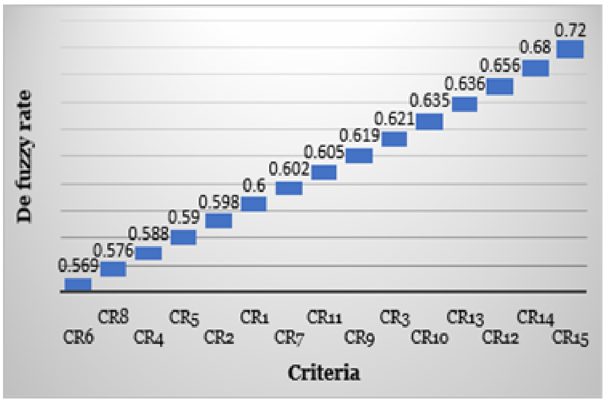

Fig. 4. Final ranking of the criteria.

BIM has a significant potential to improve the productivity and efficiency of civil engineering at all construction stages. Management of facilities and elimination of barriers to enhance the performance and utilization of the existing technologies in computer design are among its main advantages. This model has a communicating database that can hold all the information even after the construction phase and during the time that the building is accommodated, enabling it to create a mechanism for a wide-range collaboration among designers, engineers, constructors and facility managers. Another aspect of BIM is that information is put together once and it prevents its repetition, resulting in fewer errors, greater compliance, clarity, accuracy, and ultimately saving time (Kivits and Furneaux, 2013). All of these explanations illustrate the significant effects of this method in the prevention of time-wasting procedures and repetition of operations at the implementation stage.

The high costs of purchasing BIM-related software, was ranked second among the studied criteria. The relevant software and related hardware are expensive; meanwhile, one of the biggest advantages of BIM method is cost-saving throughout the project. What should be considered is whether the costs of purchasing software and hardware by the consulting companies are comparable to the possible cost-savings provided by this method. The advantageous application of BIM to eliminate the occurrence of unpredicted incidents, which most likely trigger delays in the construction process and supplementary expenses, is considered to compensate, cost-wise, for the investments in its relevant and costly software and hardware. However, the lack of acquaintance with BIM concept and its advantages among stakeholders can be a reason for of the low level of willingness towards using it. We have to keep in mind that the recent advancements in BIM technology provide a starting point to develop significant solutions, specifically, in planning and management (Enshassi et al., 2016).

The third-ranked criterion in the questionnaire was devoted to the lack of transparency about the positive results of BIM for the private sector activists. Improvement in the construction industry is one of the most important factors in the development of developing countries. Naturally, any method that can pave the way of development should be welcome. However, having uncertainty about the new methods will make them less attractive. On the other hand, in order to make them more attractive, the advantages of these methods should be more clearly presented. This has forced activists to employ BIM method by acknowledgement of its effectiveness and positive outcomes. Nevertheless, BIM is not as popular as it is expected in many developing countries, especially in Asia (Ismail et al., 2017). The fourth rank criterion among the considered criteria is the contracting companies' unwillingness towards BIM implementation. One of the biggest barriers on the way of BIM acceptance is the lack of demand. Some of the most important users of this method are the contractors. It should be taken into account that when BIM advantages are widely introduced to stakeholders, private sector customers of BIM will also increase (Chan, 2014).

Ranked fifth among the criteria is the disbelief of designers and consultant engineers in BIM. The designers have an important role in representing the various aspects of new construction technologies, but first, they should have enough motivation to develop, extend, and accept the risks regarding the useof new methods. This can be materialized by a better understanding of the advantages of this method and the advancements in technology. Contractors must understand that, during the construction period, increasing the productivity of BIM is necessary, and providing reliable information for better decision-making processes can be a major contribution to progress (Lin et al., 2018).

It should be noted that there are some other factors and criteria analysed in the questionnaire such as: 1 - the lack of experts and expertise in BIM, 2 - the disbelief of construction companies and contractors in the effectiveness of BIM, 3 - insufficient information on BIM in the private sector, 4 - lack of knowledge on BIM operational systems specifically among the executives, 5- insufficient research projects on BIM relative to other research areas and articles in Iran, 6 - inconsistency of software and hardware in companies and organizations with BIM software systems, 7 - lack of BIM professional training centers outside offices and companies, 8 - lack of motivation on behalf of government agencies to implement BIM and lack of regulation regarding its implementation in subordinated institutions, and finally, 9 - lack of suitable training programs for the personnel to make them familiar with the BIM.

It proves difficult to change the mindset of the private sector, and this has made operational users avoid the use of BIM. On the other hand, the government should be the largest user in the construction industry, and if the BIM demand increases on the governmental side, it will ultimately expand to the construction community, as well. In general, barriers to the BIM can be divided into management barriers and training barriers, which are mostly related to the lack of knowledge and technology. As discussed, the lack of information onthe BIM has resulted in misunderstanding or underestimation of BIM potential and advantages (Muller et al., 2016). In the end, by considering all the studied criteria, Iran may also exploit the promising advantages of BIM in close future. In fact, governmental incentive plans as well as holding technical class for engineers for free may help in this regard.

5. CONCLUSIONS

BIM is a new methodology in the construction area, which designs and implements the project in multidimensional software to fix probable issues, deficiencies and interferences and, finally, to achieve a coherent comprehensive design with the least possible defects. This method has been accepted in the developed countries and it is considered as one of the main factors in the construction projects; however, in the developing countries, this methodology has been insufficiently employed. The present paper studies the causes and factors that have prevented the commercialized use of BIM technique in Iran, especially in the construction of the administrative and commercial complexes. This was performed by a questionnaire that was distributed among the experts and researchers of this area. According to the experts, additional time needed at the designing level, a high cost of purchasing equipment, and lack of information on various advantages of BIM among users in the private sector and construction contractors, were the most important barriers. Moreover, it was comprehended that, by combining the educational and incentive plans as well as highlighting all benefits of the application of this method for all engaged people, the path towards productive and efficient building construction will be paved. In addition, in the public sector, the endorsement of relevant regulations in the construction system of the country and promoting enough investments in this area can prevent the waste of valuable resources at the national scale.

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