Jurnal Teknologi

Full Paper

AWARENESS AND PREVALENCE OF INDUSTRIALIZED BUILDING SYSTEM (IBS) IN IRAN

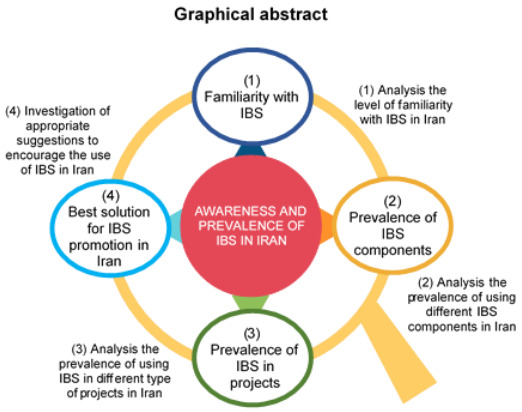
Roohollah Taherkhani[a*], A. L. Saleh[b]

[a]Department of Civil Engineering, Imam Khomeini International University (IKIU), 3414896818, Qazvin, Iran
[b]Faculty of Civil Engineering (FKA), Universiti Teknologi Malaysia 81310 UTM Johor Bahru, Johor, Malaysia

Article history
Received
9 March 2019
Received in revised form
7 July 2019
Accepted
15 July 2019
Published online
24 October 2019

*Corresponding author
taherkhani@eng.ikiu.ac.ir

Graphical abstract



Abstract

The introduction of modern technologies and development of building systems has influenced a fundamental transformation in many aspects of construction industry. However, still in major parts of building projects, conventional methods are being used in Iran. Traditional methods cause many problems such as project prolongation, low economic efficiency, too much stuff, and low quality of products. These shortcomings are more tangible in large-scale housing projects that require a vast domain of constructions; therefore, transformation from the current conventional building systems to the industrialized building systems (IBS) is needed more than ever. In order to this transformation it is vital that first the perceptions of the industry on these issues are adequately studied in this research. According to the lack of strategic plans and effective measures to promote IBS at country level, in addition to introducing the level of awareness and familiarity to IBS technical knowledge, the prevalence of both IBS components implementation and using IBS in different type of projects in Iran conducted. A Likert based questionnaire was designed according to the level of awareness and the prevalence of IBS was evaluated applying the mean index and average ranking method. Consistent with this study, only 2% of respondents are fully familiar with IBS and approximately 95% of respondents does not have acceptable awareness of this construction method. The average index of prefabricated components prevalence in Iran is 2.72 and sandwich panel is the most prevalent IBS components by mean index of 3.42. In other side, the estimation of the mean index of IBS method prevalence in different types of projects in Iran is 2.69 and marine structures are the most prevalent project type that is performed using IBS with the mean index of 3.89. Accordingly, the results indicate that the prevalence of IBS in terms of components and types of projects is not at significant level. This research examines the key suggestions to encourage IBS usage in Iran and the mandatory use of prefabricated systems by government is the best solution for IBS promotion by mean index of 3.96. This paper provides an overview of IBS current state in Iran. Clearly, this awareness will prompt construction industry practitioners to a deeper exchange of ideas and promoting IBS in the future.

Keywords: Industrial building system (IBS), conventional building system, construction method, construction industry, Iran

Abstrak

Pengenalan teknologi moden dan pembangunan sistem bangunan telah mempengaruhi transformasi asas dalam banyak aspek industri pembinaan. Walau bagaimanapun, masih dalam sebahagian besar projek bangunan, kaedah konvensional sedang digunakan di Iran. Kaedah tradisional menyebabkan banyak masalah seperti pemanjangan projek, kecekapan ekonomi yang rendah, terlalu banyak barangan, dan kualiti produk yang rendah. Kekurangan ini lebih nyata dalam projek-projek perumahan berskala besar yang memerlukan banyak pembinaan; oleh itu, transformasi dari sistem bangunan konvensional semasa ke sistem bangunan industri (IBS) diperlukan lebih dari sebelumnya. Untuk transformasi ini adalah penting bahawa terlebih dahulu persepsi industri mengenai isu-isu ini dapat dikaji dengan secukupnya

dalam penyelidikan ini. Menurut kurangnya rancangan strategik dan langkah-langkah berkesan untuk mempromosikan IBS di peringkat negara, selain memperkenalkan tahap kesedaran dan kebiasaan kepada pengetahuan teknikal IBS, kelaziman pelaksanaan komponen IBS dan penggunaan IBS dalam pelbagai jenis projek di Iran dijalankan. Soal selidik berdasarkan likert direka mengikut tahap kesedaran dan kelaziman IBS dinilai menggunakan indeks purata dan kaedah penilaian purata. Selaras dengan kajian ini, hanya 2% responden yang mengetahui sepenuhnya IBS dan kira-kira 95% responden tidak mempunyai kesedaran yang dapat diterima mengenai kaedah pembinaan ini. Indeks purata komponen prefabrikated prevalensi di Iran adalah 2.72 dan panel sandwich adalah komponen IBS yang paling lazim dengan indeks min 3.42. Di samping itu, anggaran indeks purata IBS kaedah kelaziman dalam pelbagai jenis projek di Iran adalah 2.69 dan struktur laut adalah jenis projek yang paling lazim yang dilakukan menggunakan IBS dengan indeks purata 3.89. Oleh itu, keputusan menunjukkan bahawa kelaziman IBS dari segi komponen dan jenis projek tidak berada pada tahap yang signifikan. Penyelidikan ini meneliti cadangan utama untuk menggalakkan penggunaan IBS di Iran dan penggunaan mandatori sistem prefabrik oleh kerajaan adalah penyelesaian terbaik untuk promosi IBS dengan indeks purata 3.96. Makalah ini memberikan gambaran mengenai keadaan semasa IBS di Iran. Jelas sekali, kesedaran ini akan mendorong pengamal industri pembinaan untuk bertukar idea dan mempromosikan IBS pada masa akan datang.

Kata kunci: Sistem bangunan industri (IBS), sistem bangunan konvensional, kaedah pembinaan, industri pembinaan, Iran

1.0 INTRODUCTION

Nowadays, with the momentary development of technology in construction industry, rapid execution is a fundamental principle that has taken into consideration in different parts of the world. In this case, the construction method that can manufactured under industrialized production technique in a controlled environment [1], [2], transported, and then installed in the site [3], [4] with minimum additional site workers could be the best rapid alternative, that is known as the Industrial Building Systems (IBS) [5], [6]. This new method of construction can increase productivity and quality of work through the use of better construction machinery, equipment, materials and extensive pre-project planning [7]. Among these numerous advantages, the high speed construction is one of the ultimate objectives [8], [9]. In the other side, dependency on unskilled workers may save some costs, but inefficient conventional construction process cause delay in projects, waste the materials, lead to low quality and efficiency in projects and totally increase financial losses [10], [11]. Due to these problems in traditional method and the need for modern technologies in construction, IBS was considered [12] to manage the cost, increase speed and improve quality of construction simultaneously. Investigating the available IBSs in country shows that most of these systems are able to implement structural system within short periods of time with suitable quality [13], [14]. IBS has changes the conventional execution of building design and construction [15] and attracted global concern due to its significant role in sustainable construction [16], [17]. In this regards, there has been a steady and growing interest within the construction industry in the adoption and development of off-site construction [18]–[20]. Many countries has encouraged the use of IBS, especially in new administrative and official buildings recently [21], [22]. For example, in Sweden the market share of prefabricated building systems in the housing industry was more than 80% [23].

IBS concept is new in Iran [24] and still public buildings are made using conventional methods. On the other hand, for the last decades the Iranian Building Industry has been heavily engaged with production of residential buildings [25]. The government of Iran emphasis on building more affordable houses with the economic benefits. Around 1.5 million residential homes need to be constructed annually to response Iran cumulative demand by 2025. Undoubtedly, conventional building methods cannot be responsive [26] but the lack of familiarity and ability to execute rapid prefabricated systems has led to an uneven acceleration in the supply and demand and delivery of low-quality buildings [27]. The problems associated with this rapid growth has not had much effect on the Iran construction industry. For example Iran construction contractors have not considered significant value for IBS to increase construction speed and ignore time [8]. Unfortunately, the government and construction practitioners has understood the need for new way of construction but there is no clear road map for this change. In order to remove this barriers it is vital that first the perceptions of the industry on these issues are adequately studied [28].

Therefore, according to the lack of strategic plans and effective measures to promote IBS at country level, in addition to introducing the level of awareness and familiarity to IBS technical knowledge, the prevalence of both IBS components implementation and using IBS in different type of projects in Iran conducted. This

study has pointed to investigating and selecting appropriate suggestions and options to encourage the use of IBS in Iran. This research contributes to better understanding of the IBS current state and can help construction industry's policy makers to target the right direction for IBS development in Iran. The paper is structured in three main categories: (a) research methodology, (b) results and discussion, and (c) conclusion. This research contributes to the discussion on the current state of IBS to uptake the opportunities for greater building systems in Iran. However, more importantly, it draws attention to industry perceptions on IBS and identifies specific gaps in this area.

2.0 METHODOLOGY

The target population of this study consisted of the people who are involved in construction or have related academic education. Respondents classified into four categories: contractors, designers/counselors, employers and academics. The sampling method was stratified sampling method in which the sample size randomly defined as six engineering firms and two universities contains 210 persons. According to Cochran's formula [29], 135 questionnaires distributed and 113 of them were completed. The questionnaire deals with the following sections: general information of respondents, respondents' level of familiarity with IBS, the prevalence of IBS implementation in Iran (this section asked from those respondents who practically involved in IBS-based construction projects), Investigating and selecting appropriate suggestions and options to encourage the use of IBS in Iran.

Respondents were required to rate the factors by stating their level of agreement or acceptance based on five ordinal measures from one (1) to five (5) known as Likert Scale. According to Corne and Knowles (2007) the best results were obtained from a simple average ranking (AR) method [30]. This method has been shown by mean index to be highly effective in providing sufficient selection [31], [32]. According to the scale, the questionnaire rating follows the five-point scale and it converted into relative important indices for each factor. These indices are adopted from the Relative Index (RI) ranking technique based on Equation 1 [33]

$$RI = \frac{n(1)\times 1 + n(2)\times 2 + n(3)\times 3 + n(4)\times 4 + n(5)\times 5}{N_{total}\times 5} \quad (1)$$

Where n (i) is the number of responses with scale, i (i=1,..., 5) and N is the total number of responses to each question. The maximum value for RI is 1, and the minimum is 0.2 accordingly. Totally, 113 questionnaires have been collected from respondents. As a final point, factors are ranked according to their Relative Index (RI). Reliability of questionnaire examined using Cronbach's alpha. It is defined as determining the internal consistency or average correlation of items in a survey instrument to gauge its reliability [34]. Cronbach's alpha coefficient estimated by SPSS. As shown in Table 1, the Cronbach alpha coefficient is 0.994, which indicates acceptable internal consistency reliability.

Table 1 Cronbach's alpha coefficient

Reliability	
Cronbach's alpha	**Number of questions**
.994	54

3.0 RESULTS AND DISCUSSION

3.1 Analysis of General Information

The sample consisted of 113 respondents. As Table 2 shows the distribution of respondent's general information, approximately 64% of whom were men (n=72), while the rest were women (n=41). Analysis of respondents' general information shows about 30% indicated their role as designers/consultants, followed by contractors and employers at 26%. The remaining respondents was academics (19%) with the lowest abundance. Correspondingly 64% of the statistical population are men and 36% are women and 63% of them have a master degree and higher.

Table 2 Distribution of respondent's general information

Profile	Frequency	Percentage
Gender		
Male	72	64%
Female	41	36%
Age		
Minimum	24	
Maximum	60	
Average	32	
Education		
Bachelor and lower	42	37%
Master and higher	71	63%
Occupation		
Employer	29	26%
Contractor	29	26%
Designer/Counselor	34	30%
Academics	21	19%
work experience		
Less than 5 years	41	36%
5 to 9 years	45	40%
10 to 19 years	25	22%
More than 20 years	2	2%
IBS project-based work experience		
Yes	53	47%
No	60	53%

In other side, the average age of 32 years old and the high frequency of work experience between 5 to 9 years (40%) indicates a tendency to young and graduated people in this segment of construction industry. The profile also showed an estimated 47% of respondents experienced IBS-based projects.

3.2 Analysis the Level of Familiarity with IBS

3.2.1 Level of Awareness Regarding IBS

Table 3 below shows the distribution of the respondents' awareness level in terms of industrial building systems.

Table 3 Statistical indexes related to level of awareness regarding IBS

Variable	Frequency	Percentage	Cumulative frequency
Very low	15	13.3%	13.3%
Low	36	31.9%	45.1%
Average	53	46.9%	92.0%
High	7	6.2%	98.2%
Very high	2	1.8%	100.0%
Total	**113**	**100**	

As can be seen in Figure 1, only 2% of respondents are fully familiar with IBS and approximately 95% of respondents does not have acceptable awareness of this construction method. Therefore, educational programs, professional courses, seminars and conferences can be the key priority field of activity to develop IBS in Iran.

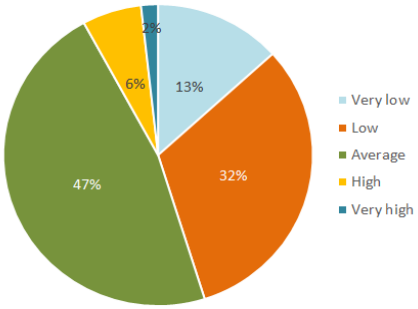


Figure 1 Level of awareness regarding IBS

3.2.2 Respondents' Ways to Become Familiar with IBS

The statistical characteristics related to respondents' ways to become familiar with industrial building systems presents in Table 4.

Table 4 Statistical indexes related to the respondents' ways to became familiar with IBS method

Variable	Frequency	Percentage	Cumulative frequency
Articles	30	26.5%	26.5%
Internet	51	45.1%	71.7%
Work experience	28	24.8%	96.5%
Other	4	3.5%	100.0%
Total	113	100.0	

According to Figure 2, the largest group of respondents are familiar with IBS through internet by 45%, followed by articles at 27%. The minimum level source was work experience. These percentages indicate that practitioners are more likely to know this method in theoretical resources rather than practical terms.

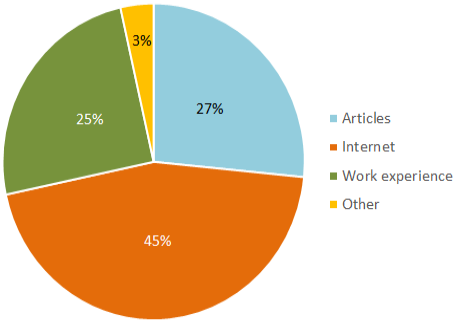


Figure 2 Respondents' ways to became familiar with IBS method

3.2.3 The Rate of Defined Standards to Use IBS in Iran

The existence of the defined standards to use IBS was another item that examined. The statistical characteristics shows in Table 5 below.

Table 5 Statistical indexes according to the rate of defined standards to use IBS in Iran

Variable	Frequency	Percentage	Cumulative frequency
Very low	43	38.1%	38.1%
Low	36	31.9%	69.9%
Average	25	22.1%	92.0%
High	6	5.3%	97.3%
Very high	3	2.7%	100.0%
Total	113	100.0	

Figure 3 illustrates despite all the advantages of prefabricated systems, Iran is in a very low position in terms of the level of standards defined for the use of industrial building systems.

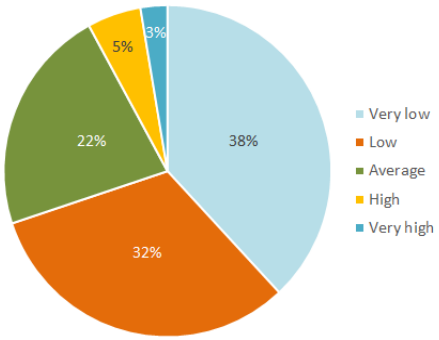


Figure 3 Rate of defined standards to use IBS in Iran

3.2.4 Respondents' IBS-based Design and Building Experience

Refer to Table 6 there is low level of IBS-based design and building work experience through respondents.

Table 6 Statistical indexes related to respondents' IBS-based design and building experience

Variable	Frequency	Percentage	Cumulative frequency
Very low	56	49.6%	49.6%
Low	43	38.1%	87.6%
Average	6	5.3%	92.9%
High	4	3.5%	96.5%
Very high	4	3.5%	100.0%
Total	113	100.0	

As it shown in Figure 4, the largest group of respondents, about 90% consists low/very low work experience in IBS and since the questionnaires were randomly distributed among respondents, the results show that prefabricated system was not enough popular and this is one of the challenges of constructions in Iran.

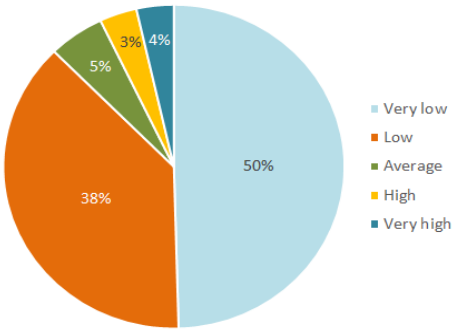


Figure 4 Respondents' IBS-based design and building experience

3.2.5 The Amount of Usage Pre-fabricated Systems in Respondents' Projects

Based on information in Table 7 the usage of IBS in respondents' projects is provided.

Table 7 Statistical indexes regarding the usage of IBS in respondents' projects

Variable	Frequency	Percentage	Cumulative frequency
Less than 15%	62	54.9%	54.9%
15 to 30%	36	31.9%	86.7%
31 to 50%	12	10.6%	97.3%
51 to 70%	2	1.8%	99.1%
More than 70%	1	0.9%	100.0%
Total	113	100.0	

About 97% of respondents do not have any significant experience in using IBS and only 3% of them had expertise and implement high level of IBS in their projects. Statistics show the prefabricated components do not have any acceptable level in Iran construction industry. From the experts' perspective, this is due to the lack of awareness regarding this new building systems.

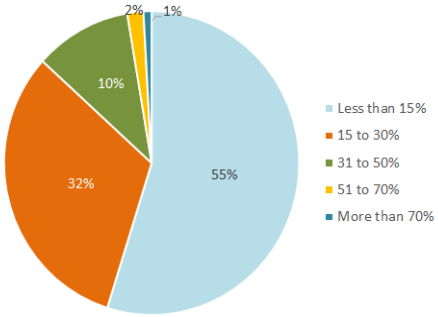


Figure 5 The amount of IBS usage in respondents' projects

3.2.6 Manpower Reduction in IBS Method

From the Table 8, the result indicated more than half of respondents agree with work force reduction in prefabrication method. Most respondents confirm that IBS equipment, components and method can reduce dependency on work force in compare with conventional methods of construction (refer to Figure 6).

Table 8 Statistical indexes related to manpower reduction in IBS method

Variable	Frequency	Percentage	Cumulative frequency
Absolutely disagree	2	1.8%	1.8%
Disagree	7	6.2%	8.0%
To some extent	36	31.9%	39.8%
Agree	53	46.9%	86.7%
Absolutely agree	15	13.3%	100.0%
Total	113	100.0	

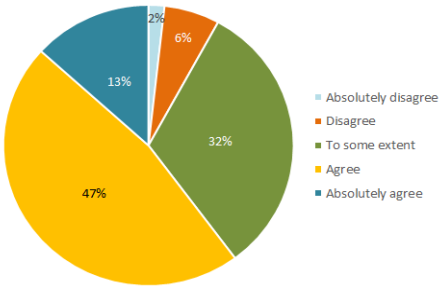


Figure 6 Manpower reduction in IBS method

3.2.7 Construction Quality Control in IBS Method

The evaluation of the respondents' comments on the construction quality control in IBS method is shown in Table 9. Based on information provided in questionnaire.

Table 9 Statistical index of construction quality control in IBS method

Variable	Frequency	Percentage	Cumulative frequency
Absolutely disagree	2	1.8%	1.8%
Disagree	7	6.2%	8.0%
To some extent	21	18.6%	26.5%
Agree	70	61.9%	88.5%
Absolutely agree	13	11.5%	100.0%
Total	113	100.0	

Figure 7 shows more than 90% of respondents admit that using the IBS method will increase construction quality control.

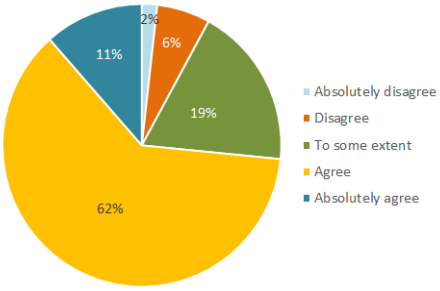


Figure 7 Construction quality control in IBS method

3.2.8 Construction Safety in IBS Method

The data in Table 10 indicate statistical characteristics related to the agreement of respondents in applying IBS (prefabricated) and its impact on increasing safety in construction.

Table 10 Statistical index of construction safety in IBS me

Variable	Frequency	Percentage	Cumulative frequency
Absolutely disagree	0	0.0%	0.0%
Disagree	9	8.0%	8.0%
To some extent	22	19.5%	27.4%
Agree	64	56.6%	84.1%
Absolutely agree	18	15.9%	100.0%
Total	113	100.0	

According to Figure 8 most of the respondents believe the application of IBS method can increase the level of safety in the construction projects.

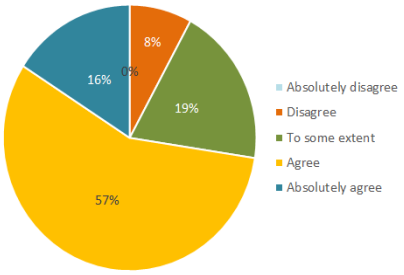


Figure 8 Construction safety in IBS method

3.2.9 The Degree of IBS Compatibility with Environmental Protection

In Table 11, the agreement level of experts in applying prefabricated components in protecting the environment is shown.

Table 11 Statistical index based on compatibility level of IBS in protecting the environment

Variable	Frequency	Percentage	Cumulative frequency
Absolutely disagree	2	1.8%	1.8%
Disagree	6	5.3%	7.1%
To some extent	11	9.7%	16.8%
Agree	77	68.1%	85.0%
Absolutely agree	17	15.0%	100.0%
Total	113	100.0	

As Figure 9 shows only 7% does not know IBS as an environmental friendly option. This can be due to an idealistic assessment or lack of familiarity.

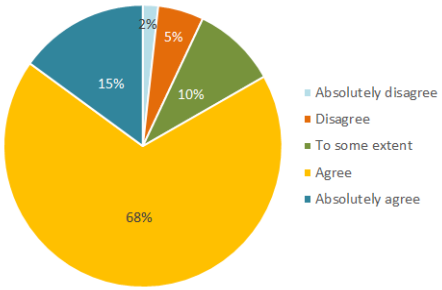


Figure 9 The degree of IBS compatibility with environmental protection

3.2.10 IBS Climatic Adaptation

Table 12 indicates statistical characteristics related to the agreement of experts with using prefabricated system in different climatic condition based on information provided in questionnaire.

Table 12 Statistical indexes related to IBS climatic adaptation

Variable	Frequency	Percentage	Cumulative frequency
Absolutely disagree	1	0.9%	0.9%
Disagree	4	3.5%	4.4%
To some extent	38	33.6%	38.1%
Agree	58	51.3%	89.4%
Absolutely agree	12	10.6%	100.0%
Total	113	100.0	

As can be seen in Figure 10, more than half of respondents agree with IBS adaptation in different climatic conditions because prefabricated components manufacture in a controlled environment and then assemble at the site.

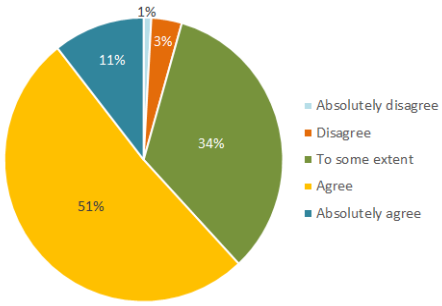


Figure 10 IBS climatic adaptation

3.3 Analysis the Prevalence of IBS in Iran

In this section, 53 respondents who have experiences in the context of IBS were asked an additional questions to investigate the prevalence of using different prefabricated components and tendency of IBS implementation in different type of projects in Iran.

3.3.1 Prevalence of Prefabricated IBS Components in Iran

Table 13 shows the average prevalence of using different prefabricated components in Iran. According to the results of the questionnaire, the most prevalent IBS components in Iran is sandwich panel by mean index of 3.42 (RI=0.68). Sandwich panels are suitable insulation against heat, cold, humidity, and sound. Next item is steel formwork systems by mean index of 3 (RI=0.60). This system, due to its high costs is not most popular such as sandwich panel. Moreover, steel formwork systems is a modern technology and there is a tendency to remain among the most widely used IBS components.

Table 13 Mean index of prefabricated components in Iran

Prefabricated components	Frequency distribution of respondents					Mean index	Relative Index (RI)	Classification
	1	2	3	4	5			
Sandwich panel	0	2	33	12	6	3.42	0.68	1
Steel formwork systems	3	9	31	5	5	3.00	0.60	2
Permanent forms	9	17	11	10	6	2.75	0.55	3
Prefabricated forms for wall	3	26	9	14	1	2.70	0.54	4
Prefabricated frames	1	32	11	7	2	2.57	0.51	5
Load-bearing wall panels	8	20	15	7	3	2.57	0.51	6
Ceiling and floor panels	20	5	17	7	4	2.43	0.49	7
Prefabricated forms for beams and columns	19	14	6	10	4	2.36	0.47	8

The table followed by permanent forms and prefabricated forms for wall at nearly 2.7. Prefabricated frames, load-bearing wall panels and ceiling and floor panels are the next options of respondents. Finally, the prefabricated forms for columns and beams is rarely used in Iran. As it shows in Figure 11, the prevalence of prefabricated IBS components in Iran is very low. According to the estimation, average index of prefabricated components prevalence is 2.72.

3.3.2 Prevalence of Using IBS in Different Projects in Iran

The data in Table 14 clarify the average prevalence of using prefabricated components in different types of projects. The projects identified by respondents are the most used of IBS methods in Iran construction projects. According to the results, the most prevalent project type that is performed using IBS is related to marine structures with the mean index of 3.89 (RI=0.78), followed by bridge (3.32), ports (3.23) and airports (2.62). Continuing this trend, commercial and residential units by 2.13 (RI=0.43), transportation by 1.89 (RI=0.38) and lastly dam projects by 1.74 (RI=0.35) mean index are in the lowest rate of using IBS implementation (refer to Figure 12).

Table 14 Mean index of prevalence of using IBS in different construction projects in Iran

Different construction projects	Frequency distribution of respondents					Mean index	Relative Index (RI)	Rating
	1	2	3	4	5			
Marine structures	3	8	7	14	21	3.89	0.78	1
Bridge	4	10	6	31	2	3.32	0.66	2
Ports	5	6	16	24	2	3.23	0.65	3
Airport	8	10	30	4	1	2.62	0.52	4
Residential and commercial buildings	9	32	8	4	0	2.13	0.43	5
Transportation	30	8	8	5	2	1.89	0.38	6
Dam	29	13	8	2	1	1.74	0.35	7

The estimation of average IBS method application in projects in Iran is 2.69. This is a low rate of IBS adoption. Most of construction projects are limited to residential and commercial buildings. Therefore, due to lack of awareness and knowledge, IBS does not have any desirable place in Iran construction projects.

3.4 Data Analysis and Results in Encouraging IBS

In Table 15 suggestions and opinions to encourage the use of IBS are collected. These alternatives ranked according to frequency and average index, based on respondents' replies. The investigations shows, mandatory use of prefabricated systems at least in limited percentage of constructions by government is the best solution for IBS promotion (RI=0.79).

Table 15 Suggestions and opinions in encouraging IBS

Suggestions and opinions	Frequency distribution of respondents					Mean index	Relative Index (RI)	Rating
	1	2	3	4	5			
Mandatory use of prefabricated systems at least in limited percentage of constructions	3	15	18	25	52	3.96	0.79	1
Preparing IBS Standards, guidelines and regulations	2	19	17	26	49	3.89	0.78	2
Using media to make people familiar with the IBS advantages	2	9	34	36	32	3.77	0.75	3
Government supportive programs by offering facilities with a minimum profit to set up IBS manufacturing factories	15	4	24	27	43	3.70	0.74	4
Compilation the price schedule for the prefabricated systems	10	13	15	43	32	3.65	0.73	5
Setting up technical courses and offering IBS certificate and diploma	15	11	22	32	33	3.50	0.70	6
Holding workshops, seminars, and conferences to encourage and promote IBS	16	15	24	41	17	3.25	0.65	7

Consistent with the responses, followed by preparing IBS standards, guidelines and regulations (3.89), there are not sufficient documents about IBS and the government has to move in this regard. Media play the main role to make people familiar with the advantages of IBS with the mean index of 3.77 (RI=0.75). Government supportive programs and presenting price schedule for prefabricated systems are the next suggestions. Offering IBS certification through technical courses by 3.50 (RI=0.70) and holding IBS workshops, seminars and conferences by 3.25 mean index (RI=0.65) are the respondents' options to develop IBS in Iran (refer to Figure 13).

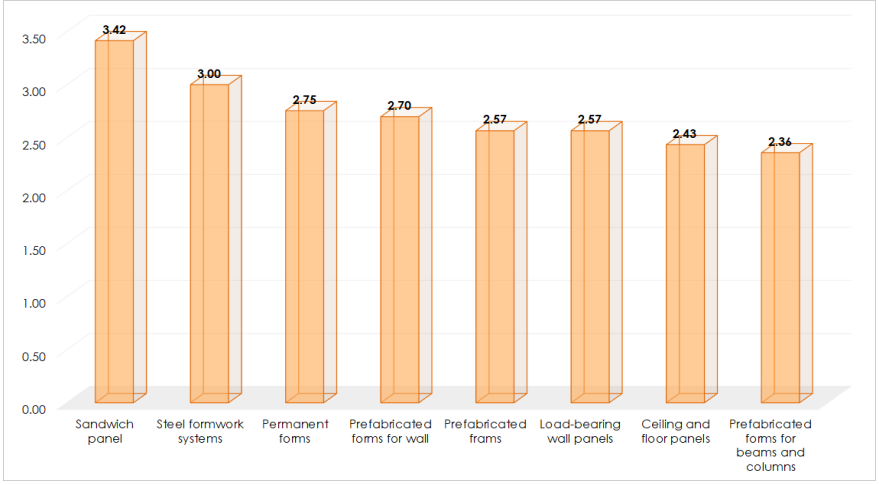


Figure 11 Prevalence of prefabricated IBS components in Iran

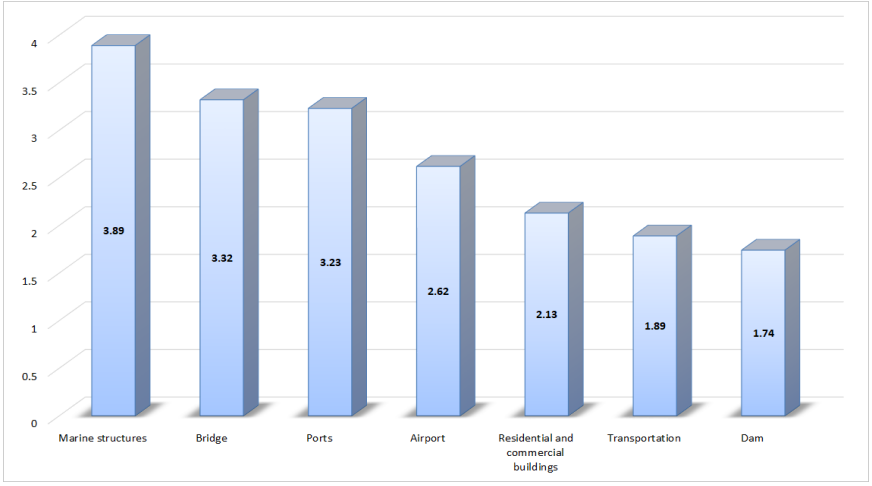


Figure 12 Prevalence of using IBS in different projects in Iran

Figure 13 Suggestions and opinions to encourage IBS usage

4.0 CONCLUSION

The study indicated one of the challenges of constructions in Iran is the lack of IBS work experience among construction practitioners. Only 2% of respondents are fully familiar with IBS and approximately 95% of respondents does not have acceptable awareness of this construction method. About 75% of this improper level of familiarity achieved by internet and articles. This percentage indicate that practitioners are more likely to know IBS method in theoretical resources rather than practical terms. However, there is a main gap in terms of the level of IBS defined standards in Iran. These factors caused about 97% of respondents do not have any significant experience in using IBS and only 3% of them had expertise and implement high level of IBS in their projects. In spite of this, approximately 90% of respondents consider due to IBS manufacturing process in a controlled environment, this method can increase the level of quality and safety and reduce dependency on work force in compare with conventional methods of construction. In addition, IBS is very suitable for different climatic conditions and only 7% does not know IBS as an environmental friendly option. This can be due to an idealistic assessment or lack of familiarity. In the other side, according to the current study the most prevalent IBS components in Iran are respectively: sandwich panel, steel formwork systems, permanent forms, prefabricated forms for wall, prefabricated frames, load-bearing wall panels, ceiling and floor panels, prefabricated forms for beams and columns. In terms of projects types IBS method are respectively use in marine structures (3.89), bridge (3.32), ports (3.23), airports (2.62), commercial and residential units (2.13), transportation (1.89) and lastly dam projects by 1.74 mean index. According to the investigation carried out in this research, average index of prefabricated components prevalence is 2.72. The results also indicate the mean index of IBS method prevalence in different types of projects in Iran is 2.69. Generally, the prevalence of IBS in terms of

components and types of projects is not at significant level.

Regarding the IBS above situation in Iran, expertise asked about the suggestions and opinions to encourage the use of IBS methods. The respondents believe the below steps can help to promote IBS implementation in Iran construction industry.

- Mandatory use of prefabricated systems at least in limited percentage of constructions by government
- Preparing IBS standards, guidelines and regulations
- Using media to make people familiar with the IBS advantages
- Government supportive programs by offering facilities with a minimum profit to set up IBS manufacturing factories
- Compilation the price schedule for the prefabricated systems
- Setting up technical courses and offering IBS certificate and diploma
- Holding workshops, seminars, and conferences to encourage and promote IBS

In accord with developed countries' experiences, transformation from conventional building system to industrial building system can improve many aspects of construction industry in terms of time, cost, quality and building sustainability aspects. These profound impacts intensify the necessity to prevalence and promote IBS in Iran and all rest of the world. Therefore, as this study contributed, understanding the current situation of IBS and prioritizing suitable solutions to its development constitute a fundamental step toward IBS implementing prevalence in country level.

References

[1] Parid, W. 1997. Global Trends in Research, Development and Construction. *Proceedings of the International Conference on Industrialized Building System (IBS 2003)*. 10-11 September 2003. CIDB. Kuala Lumpur. Malaysia.

[2] Badir, Y. F., M. R. Kadir. and A. A. Ali. 1998. Theory of Classification on Badir-Razali Building System Classification. *Bulletin of Institution of Engineers*. Malaysia. October.

[3] M. S. S. Kamar, K. A. M., Hamid, Z. A., Azman, M. N. A., and Ahamad. 2011. Industrialized Building System (IBS): Revisiting Issues of Definition and Classification. *Int. J. Emerg. Sci.* 1(2): 120-132.

[4] K. M. Nawi, M. N. M., Lee, A., and Nor. 2011. Barriers to Implementation of the Industrialised Building System (IBS) in Malaysia. *Built Hum. Environ. Rev*. 4: 22-35.

[5] W. M. A. Azman, M. N. A., Ahmad, M. S. S., and Wan Hussin. 2012. Comparative Study on Prefabrication Construction Process. *Int. Surv. Res. J.* 2(1): 45-58.

[6] M. N. M. Nawi, A. Lee, M. N. A. Azman, and K. A. M. Kamar. 2014. Fragmentation Issue in Malaysian Industrialised Building System (IBS) Projects. *J. Eng. Sci. Technol.* 9(1): 97-106.

[7] N. A. Haron, I. S. Hassim, M. R. Abd. Kadir, and M. S. Jaafar. 2005. Building Cost Comparison Between Conventional and Formwork System: A Case Study of Four-storey School Buildings in Malaysia. *Am. J. Appl. Sci.* 2(4): 819-823.

[8] N. Blismas and R. Wakefield. 2009. Drivers, Constraints and the Future of Offsite Manufacture in Australia. *Constr. Innov*. 9(1): 72-83.

[9] A. Baharuddin, A. Rahman, and W. Omar. 2006. Issues and Challenges in the Implementation of Industrialised Building Systems in Malaysia. *Proceedings of the 6th Asia-Pacific Structural Engineering and Construction Conference (APSEC 2006). September*. 5-6.

[10] E. N. Onyeizu and A. H. A. Bakar. 2011. The utilisation of Inustrialised Building System in Design Innovation in Construction Industry. *World Appl. Sci. J*. 15(2): 205-213.

[11] K. A. M. Kamar, Z. A. Hamid, and M. Alshawi. 2010. The Critical Success Factors (CSFs) to the Implementation of Industrialised Building System (IBS) in Malaysia. *CIB World Congress*.

[12] R. Taherkhani *et al.* 2012. The Bullwhip Effects in Industrialized Building System Supply Chains. *Adv. Sci. Lett.* 13: 811-812.

[13] N. A. Haron and M. S. M. Rahim. 2013. Construction Cost Comparison Between Conventional and Formwork System for Condominium Project. *Int. J. Adv. Stud. Comput. Sci. Eng.* 2(5): 19-25.

[14] R. Taherkhani. 2014. A Strategy towards Sustainable Industrial Building Systems (IBS): The Case of Malaysia. *J. Multidiscip. Eng. Sci. Technol*. 1(4): 86-90.

[15] Y. Chang, X. Li, E. Masanet, L. Zhang, Z. Huang, and R. Ries. 2018. Unlocking the Green Opportunity for Prefabricated Buildings and Construction in China. *Resour. Conserv. Recycl.* 139: 259-261.

[16] J. Hong, G. Q. Shen, Z. Li, B. Zhang, and W. Zhang. 2018. Barriers to Promoting Prefabricated Construction in China: A Cost–benefit Analysis. *J. Clean. Prod.* 172: 649-660.

[17] C. S. P. L. Jaillon. 2008. Sustainable Construction Aspects of Using Prefabrication in Dense Urban Environment: A Hong Kong Case Study. *Constr. Manag. Econ.* 26(9): 953-966.

[18] M. R. Hosseini, I. Martek, E. K. Zavadskas, A. A. Aibinu, M. Arashpour, and N. Chileshe. 2018. Critical Evaluation of Off-site Construction Research: A Scientometric Analysis. *Autom. Constr.* 87(October): 235-247.

[19] M. A.-H. T. Salama, A. Salah, O. Moselhi. 2017. Near Optimum Selection of Module Configuration for Efficient Modular Construction. *Autom. Constr*. 83: 316-329.

[20] R. H. M. Arashpour, R. Wakefield, B. Abbasi, M. Arashpour. 2017. Optimal Process Integration Architectures in Off-site Construction: Theorizing the Use of Multi-skilled Resources. *Arch. Eng. Des. Manag.* 1-14.

[21] A. S. M. A. Zakari, IbrahimAwal, R. Zakaria, A. H. Abdullah, and M. Z. Hossain. 2017. Application of Industrialized Building System A Case Study in Kano State, Nigeria. *Int. J. GEOMATE*. 13(39): 80-86.

[22] M. R. Mohamed. 2018. The Issues and Challenges of Small and Medium-sized Contractors in Adopting Industrialised Building System. *Int. J. Eng. Technol.* 7(3.25): 432-436.

[23] S. Navaratnam, T. Ngo, T. Gunawardena, and D. Henderson. 2019. Performance Review of Prefabricated Building Systems and Future Research in Australia. *Buidings*. 9(38).

[24] M. Samari, N. Ghodrati, and M. W. M. Bin Shafiei. 2012. The Implementation of Industrialized Building System (IBS) in Iran Construction Companies. *IOSR J. Mech. Civ. Eng.* 1(3): 19-24.

[25] H. Arbabian and N. B. Sarmadi. 2004. Improvement of Iranian Construction Industry. *The 38th International Conference of Architectural Science Association ANZAScA*. November: 396-403.

[26] A. Hashemi. 2015. A Survey on the Current Status and Risks of Offsite Construction in Iran. *J. Civ. Eng. Archit.* 9: 141-152.

[27] M. N. . Nawi, F. A. A. Nifa, S. Musa, and M. D. Sudirman. 2007. A Preliminary Survey of the Application of IBS in Malaysian Construction Industry: Barriers to implement in Kedah and Perli. *Conference on Sustainable Building South East Asia*. November: 5-7.

[28] M. Dave, B. Watson, and D. Prasad. 2017. Performance and Perception in Prefab Housing: An Exploratory Industry Survey on Sustainability and Affordability. *Procedia Eng.* 180: 676-686.

[29] W. G. Cochran. 1963. *Sampling Techniques*. New York:

Wiley.
[30] Corne, D. and J. Knowles. 2007. Techniques for Highly Multiobjective Optimisation: Some Nondominated Points are Better than Others. *GECCO '07 Proceedings of the 9th Annual Conference on Genetic and Evolutionary Computation*. July 2007. ACM Press. London, UK. 1: 773-780.
[31] Y. N. Ishibuchi, H., N. Tsukamoto. 2008. Evolutionary Many-objective Optimization: A Short Review. 2424-2431.
[32] Kukkonen, S. and J. Lampinen. 2007. Ranking-dominance and Manyobjective Optimization. *Proceedings of 2007 IEEE Congress on Evolutionary Computation (CEC 2007)*. 25-28 September. Singapore. 3983-3990.
[33] Kometa, S. T., P. O. Olomolaiye, and F. C. Harris. 1994. Attributes of UK Construction Clients Influencing Project Consultants' Performance. *Constr. Manag. Econ.* 12: 433-443.
[34] L. J. Cronbach. 1951. Coefficient Alpha and the Internal Structure of Tests. *Psychometrika*. 16: 297-334.