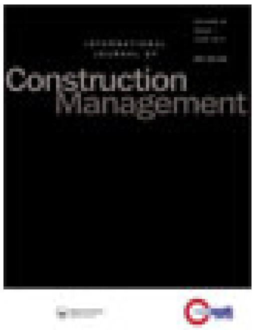

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Constructability obstacles: an exploratory factor analysis approach

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ABSTRACT

Constructability is a concept with relative and not absolute value to increase optimization capacity of resources such as workforce, time, cost, quality, and working environment conditions. Given the growing complexity of projects and the increased number of failed and abandoned projects, the necessity to implement constructability in projects has become more tangible. Although the effects of lack of quantitative definition of constructability role in the traditional construction approaches are evident and have led to lack of coordination in performance of construction projects, so far no comprehensive quantitative approach has been considered to analyze the obstacles to constructability implementation. This study aims to identify and categorize the obstacles to facilitating the presence of contractors in the early stages of planning and design to implement constructability. In this study a comprehensive list of obstacles to constructability implementation is developed as a questionnaire. This questionnaire was presented to the experts, active in the field of construction. Finally, its results were analyzed using exploratory factor analysis method. Totally, 63 obstacles were questioned, then they were categorized by some of the experts of this industry into five categories of macro factors, including contractual, environmental, managerial, technical, and organizational. The significance of this study is due to this fact that identifying and categorizing the key obstacles to constructability implementation provides a useful reference for managers and owners of the construction industry to identify and develop solutions to resolve them. Identifying the obstacles to the presence of contractors in the planning and design stage and having a quantitative view toward this issue affects project implementability. In this regard, one can present more effective solutions to facilitate the presence of contractors in the early stages of design and also improves the effectiveness of constructability.

KEYWORDS

Constructability; constructability obstacles; civil projects; construction industry; exploratory factor analysis (EFA)

Introduction

'Constructability the extent to which the design of a building facilitates ease of construction as well as the extent to which the adoption of construction techniques and processes affects the productivity level of building works' (Authority 2017). Constructability is one of the project management methods to evaluate the whole construction process. It is defined as a concept with relative, not absolute, value to increase optimization capacity of resources, such as workforce, time, cost, quality and working environment conditions. During a construction project from the early stage of planning up to delivery and maintenance there are many restrictions to implement constructability (Shin et al. 1989). Project success is not achieved unless through reviewing the construction process and integrating the design and implementation stages. Given the growing complexity of projects and the increased number of failed and abandoned projects, the necessity to implement constructability in projects has become more tangible (Wong et al. 2005).

Due to the designer's poor executive information, lack of presence of executive contractors in the early stages of study and design, leads to duplications, reduction of executive capacity of the plan, and increased time and costs (Saghatforoush 2014). Constructability achievements can be used for meeting future needs, including (Lueprasert 1996) identifying poorly designed structure due to mistakes and non-executive decisions of the plan in the conceptual studies phase. Executive engineers have problems with

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designer engineers during the construction process, often because it is not possible to implement the plan, and/or contradictory and non-executive plans (Hui-Hsuan et al. 2013). With regard to the study of constructibility literature, this is a long-term issue and should be continually pursued, and, as far as possible, it should be possible to eliminate and mitigate these problems, as well as facilitate the construction, before making it, taking into account existing barriers. Focus on focus (Yustisia 2014)

Studies conducted during 1960 to 1970, indicate that the origin of many complex problems in the construction industry is due to lack of integration of knowledge and experience in the framework of design and construction. This issue directly affects projects' time, cost and quality. Here, the necessity to apply constructability became more tangible (IPENZ 2008). Primary studies to find obstacles to facilitating constructability related to the United States construction industry, were conducted in 1979 by Faculty of Construction Industry Research using qualitative methods. Following that, most of the studies were conducted by qualitative methods and focusing on case studies e.g. (O'Connor 1994; O'Connor 1995; Zolfagharian et al. 2012; Saghatforoush 2014; Jadidoleslami et al. 2016). In addition, since the constructability concept is relatively a new idea in developing countries, most articles in this field are qualitative studies without quantitative data. Even though lack of quantitative evaluation related to the effects of constructability on the traditional approaches of construction was evident and led to lack of coordination in the performance of construction projects, till now there is no comprehensive quantitative approach to analyze the obstacles to constructability implementation (Zimmer 2006). Project success is not achieved unless through reviewing the construction process and integrating the design and implementation stages. Yet, such an approach provides an appropriate subjective context for experts and employers in this field to accept and implement constructability.

The aim of this study is evaluating the current obstacles related to the presence of contractors in the early stages of planning and design, and exploratory factor analysis (EFA) to implement constructability. The next section addresses the previous literatures conducted in this field.

Constructability

Five important rules for effective evaluation of constructability are considering project construction instead of focusing on problems, reviewing the interference of various applied systems in implementation, documenting primary information, focusing on significant factors, such as qualitative factors and team designing and finally allocating sufficient time for detailed reviewing of constructability in the project, Although, principal review of constructability may take several weeks and even months, for each time spent on planning and reviewing, significant amount of time will be saved in the construction stage. There is a wrong idea stating that at first, constructability studies should be done completely, while this is completely wrong and has a reverse effect (Smith 2013).

Constructability is a project management technique for reviewing the whole construction process. Before project implementation, it will reduce or prevent mistakes, delays, and overflow costs, through identifying the obstacles (Primer 1986). Due to constructability effect on costs and time progress to achieve optimum conditions, considering plan constructability in the early stages of project lifecycle is necessary (Griffith and Sidwell 1995).

Constructability program refers to integrating engineering design, and executive knowledge and experience to better achieve project objectives. However, partial comprehension of designers of construction and implementation requirements, and resistance of owners to constructability due to extra visible costs in the project, are main obstacles to its implementation. Generally, constructability results in a cost added to other expenses and may harm the company in the competition. An effective constructability program will begin during the planning phase and will continue conceptually to the end of construction (Arditi et al. 2002). Many of the problems and issues of constructability are because of lack of communication among employers, architects, designers, and construction companies before starting the project (IPENZ 2008).

Architects, engineers and designers—according to the specific nature of their performance—are not experts of executive methods. For this reason and also the reasons for sharing responsibility, most of the performance-based features and programs determine the final result and applications (Glavinich 1995). Lack of communication among designers and contractors cover overtly performance features. By integrating constructability in the design process in the early stages of the project, construction contradiction will be less, and consequently, project delivery will be more secure (IPENZ 2008). Resolving these obstacles require changing the methods, organizational culture

TABLE 1. The identified codes for constructability obstacles.

Code	(J O'Connor-1995)	(James T. O' Connor-1994)	(George Jergeas-2001)	(Zolfagharian. et al.-2012)	(James T. O' Connor-1988)	(By Deborah J. Fisher-2000)	(Thabet-2000)	(Franky et al. -2007)	(Trigunarsyah -2003)	(Li Jiang -2013)	(Eric J. Hanlon-2001)	(Sheehan -1991)	(FOX et al. -2010)	(Russell -1994)	(Scott D. Williams-2007)	(Malek-2011)	(Lewis-2001)
1. Resistance to change and the consent of the status quo																	
2. No official commitment for implementing																	
3. Dishonesty																	
4. Risk aversion and distrust to builders																	
5. misconception of this issue that constructability leads to delay in projects																	
6. Reluctance to innovation and creativity																	
7. Cultural barriers due to the traditional view and flexible vision																	
8. Lack of mutual respect between designer and builder																	
9. Weak support program																	
10. Irregular reports about the work trend																	
11. Delegating responsibilities to people with low risk taking																	
12. No encouraging program for promoting creativity and critical thinking																	
13. Lack of documenting																	

(*continued*)

TABLE 1. Continued.

Code	(J O'Connor-1995)	(James T. O' Connor-1994)	(George Jergeas-2001)	(Zolfagharian. et al.-2012)	(James T. O' Connor-1988)	(By Deborah J. Fisher-2000)	(Thabet-2000)	(Franky et al. -2007)	(Trigunarsyah -2003)	(Li Jiang -2013)	(Eric J. Hanlon-2001)	(Sheehan -1991)	(FOX et al. -2010)	(Russell -1994)	(Scott D. Williams-2007)	(Malek-2011)	(Lewis-2001)
experiences and knowledge of successful projects																	
14. Lack of applying promotional tools to sell plans to employers																	
15. Inappropriate methods of labor recruitment																	
16. Lack of enough information between designer and builder (poor communication skills)																	
17. Lack of coordination and cooperation in teamwork																	
18. Lack of focus of team on common objectives																	
19. Inability in identifying problems and opportunities																	
20. Lack of integrity among key members of project team																	
21. Separate managerial process in design and construction																	
22. Not paying attention to executive abilities in selecting																	

(*continued*)

TABLE 1. Continued.

Code	(J O'Connor-1995)	(James T. O' Connor-1994)	(George Jergeas-2001)	(Zolfagharian. et al.-2012)	(James T. O' Connor-1988)	(By Deborah J. Fisher-2000)	(Thabet-2000)	(Franky et al. -2007)	(Trigunarsyah -2003)	(Li Jiang -2013)	(Eric J. Hanlon-2001)	(Sheehan -1991)	(FOX et al. -2010)	(Russell -1994)	(Scott D. Williams-2007)	(Malek-2011)	(Lewis-2001)
23. Lack of monitoring of matching design objectives and executive criteria																	
24. Contrast of objectives of organization and project																	
25. Weakness in the appropriate time of presenting inputs																	
26. Lack of motivation																	
27. Lack of sufficient knowledge																	
28. Existence of traditional contracts																	
29. Inappropriate contractual strategies																	
30. Weakness in engineering and construction quality																	
31. Lack of existence of systematic organizing structure																	
32. Lack of using ideas of project stakeholders																	
33. Inappropriate management practices in design teams																	
34. The absence of an appropriate database related to constructability in design offices																	

(*continued*)

TABLE 1. Continued.

Code	(J O'Connor-1995)	(James T. O' Connor-1994)	(George Jergeas-2001)	(Zolfagharian. et al.-2012)	(James T. O' Connor-1988)	(By Deborah J. Fisher-2000)	(Thabet-2000)	(Franky et al. -2007)	(Trigunarsyah -2003)	(Li Jiang -2013)	(Eric J. Hanlon-2001)	(Sheehan -1991)	(FOX et al. -2010)	(Russell -1994)	(Scott D. Williams-2007)	(Malek-2011)	(Lewis-2001)
35. Incorrect attitude to the Constructability of an investment opportunity																	
36. Resistance to the early builders in the initial stages of the project and financial investment																	
37. Lack of flexibility in contracts																	
38. High volume of change orders																	
39. Lack of knowledge of employers about benefits and advantages of applying constructability																	
40. Lack of surveillance on matching design objectives and executive criteria																	
41. Contractor's unwillingness to cooperate in the design phase of the project																	
42. Pre-implementation restrictions																	
43. Restriction in designs dependent on owner																	
44. Lack of effective reward and																	

(*continued*)

TABLE 1. Continued.

Code	(J O'Connor-1995)	(James T. O' Connor-1994)	(George Jergeas-2001)	(Zolfagharian. et al.-2012)	(James T. O' Connor-1988)	(By Deborah J. Fisher-2000)	(Thabet-2000)	(Franky et al. -2007)	(Trigunarsyah -2003)	(Li Jiang -2013)	(Eric J. Hanlon-2001)	(Sheehan -1991)	(FOX et al. -2010)	(Russell -1994)	(Scott D. Williams-2007)	(Malek-2011)	(Lewis-2001)
punishment standards																	
45. Lack of executive experience in design team																	
46. Lack of financial incentive for designers																	
47. lack of knowledge about construction technologies																	
48. Designer imagination of increasing responsibilities in implementing constructability principles																	
49. Lack of existence of timing program in design stage																	
50. lack of evaluating applicability of designs																	
51. Lack of integrating design science and executive experience																	
52. Reluctance of executive staff to offer pre-implementation consultation																	
53. Lack of applying development tools and equipment																	
54. Lack of flexibility in standards and regulations of design and implement																	

(*continued*)

TABLE 1. Continued.

Code	(J O'Connor-1995)	(James T. O' Connor-1994)	(George Jergeas-2001)	(Zolfagharian. et al.-2012)	(James T. O' Connor-1988)	(By Deborah J. Fisher-2000)	(Thabet-2000)	(Franky et al. -2007)	(Trigunarsyah -2003)	(Li Jiang -2013)	(Eric J. Hanlon-2001)	(Sheehan -1991)	(FOX et al. -2010)	(Russell -1994)	(Scott D. Williams-2007)	(Malek-2011)	(Lewis-2001)
55. Competitive restrictions																	
56. Restrictions of selection in tender projects																	
57. Incorrect time, methods and criteria for the selection of contractors																	
58. Exerting personal tastes and restricting the final decision making right for the owner																	
59. The absence of communication tool and lack of transparency of information																	
60. The long process of dispute resolution																	
61. The absence of a realistic planning and feasibility studies																	
62. Lack of a culture of teamwork																	
63. Lack of sharing the consultant in project risk																	

and awareness of executive potential of issues at the level of organizations and projects (O'Connor 1995).

Constructability obstacles

In leading countries such as USA, Australia, Britain and Malaysia, various studies have been done to explain constructability and to resolve the obstacles to its implementation. A guidance for constructability was released by CII institute in 1986, in which constructability is defined as optimum use of construction knowledge and experience in planning, design, provisions and implementation to achieve project overall objectives. This institute has performed many studies about constructability. Given the studies conducted by this institute about the effect of constructability on costs and time progress to achieve optimum conditions, considering plan constructability in the early stages of project lifecycle is necessary (Griffith and Sidwell 1995). The introduced constructability principles by CIIA have advantages over other models, considering the best time of applying these principles in the project lifecycle.

James O'Connor in 1994, in the article titled '*Barriers to Constructability Implementation*', qualitatively categorized the obstacles to constructability implementation. Since then, most of the available projects refer to some of these obstacles, and none of which has presented a comprehensive list of them, or they have based their studies on O'Connor's study. In the studies about constructability, called *Advances in Constructability* (Candlish 1988), details of construction program are examined. Among constructability advances, a modular layout has been presented that improves implementation through separating buildings and services. In other studies, titled *Evaluation of the role of the contractor's personnel in enhancing the project constructability* (Nima et al. 2001), the role of contractors and their duties and commitments and limitations and the influence of their presence on enhancing project implement-ability have been evaluated. In another related study, called *Construability: The Key to Reducing Investment Risk* (Chasey and Schexnayder 2000), constructability and its relation to and differences with various managerial aspects such as TQM, value engineering, … were examined. Constructability concept, history, its expanded aspects, and advanced applied technologies have been presented in it.

After basic studies of O'Connor in 1994, the obstacles to constructability in the guidance released by *The Institution of Professional Engineers New Zealand Incorporated* under the title of *constructability* were categorized and updated in 2008.

Similarly, after evaluating the related studies, the codes for identified obstacles to constructability implementation in the construction industry have been shown in Table 1.

Given the tangible benefits of this concept, lack of attention to constructability has been identified as a significant problem during construction projects implementation. Although lack of quantitative evaluation of constructability effects on the traditional construction approaches are evident and results in lack of coordination in the construction projects performance, till now no comprehensive quantitative approach has been presented to analyze the obstacles to constructability implementation.

Usually, this problem is due to inappropriate designs without the possibility to implement them, poor decision making when designing, and lack of executive experience of the engineering design team. Executive engineers usually have problems with designer engineers during construction process, due to lack of plan implement-ability, and/or contradictory and non-executive plans. In this study, these obstacles are identified and categorized through studying and reviewing the previous literatures and using a quantitative method described in the next section.

Research method

In this study, a comprehensive list of obstacles to constructability implementation has been developed in the form of a questionnaire. The questionnaires were distributed to project managers, employers, consultants, and contractors active in the field of construction and mass production. Finally, the obtained results were analyzed through the EFA method. A 63 items questionnaire has been designed based on the identified obstacles for constructability implementation. The survey instrument asked the respondents to rate the importance of each 63 barriers using a nine-point scale with items ranged from 1 (strongly low) to 9 (strongly high) for conducting Robust EFA (Stenbacka 2001). The target of this study is different experts in this industry working in diverse areas, including owners, consultants and contractors. These people in turn have had many experiences in similar and divers projects. The features for respondents of this study include:

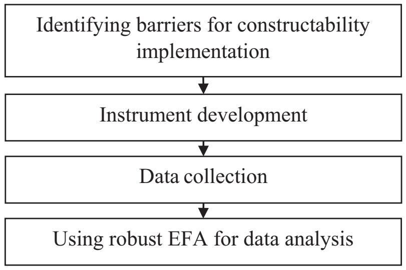

Figure 1. The research steps.

- At least 10 years of work experience
- Undergraduate or higher education in the field of construction
- Having work experience
- Direct cooperation in the studied project

In order to gather data from the respondents, at first, the companies and related experts were identified, then they were asked to fill the questionnaire and finally, they filled and replied the questionnaires. Totally, 650 questionnaires were sent out to the respondents, 375 questionnaires were gathered and 330 usable questionnaires were used for the data analysis (response rate: 0.51). Sample size of 330 seems to be adequate for conducting robust EFA (recommended ratio of 5:1).

The research steps including identifying barriers for constructability implementation, instrument development, Targeting and reaching-out research sample, data collection, data analysis using the EFA technique and finally analyzing and discussing the results is shown in Figure 1.

EFA is a frequently used method to discover patterns of multidimensional constructs that are subsequently used for the development of measurement scales. Its major objective is to reduce a number of observed variables to fewer factors in order to enhance interpretability and detect hidden structures in the data. Here, robust EFA using IBM SPSS 25.0 was employed to perform the analysis. The aim of this method is quantitative categorization of obstacles to constructability implementation. Next section analyses the collected data from questionnaire survey performed.

Data analysis

Prior to running the EFA, a test was conducted to verify the adequacy of the data for FA. The Kaiser-Meyer-Olkin (KMO) was calculated to insure sampling adequacy. The KMO for the sample, is 0.75 which is above the 'Mediocre' threshold of 0.5 (Kaiser 1974). Furthermore, we also performed a Bartlett sphericity test, which was statistically significant ($p < 0.05$), indicating the eligibility of the data. Then, we used a Shapiro–Wilk test to determine whether our sample had a normal distribution. We found that none of our variables was normally distributed. Thus, principal component analysis was our choice for the factor extraction method as proposed in robust EFA. The rotation method should also be selected for the robust EFA purpose. Oblimin rotation, which is proposed in robust EFA was used in this research. Finally, the number of factors to be extracted from the data were determined based on Eigen values greater than one, and an absolute factor loading values greater than 0.6. As a result, 34 out of 63 factors were dropped from the initial pool and remained 29 factors were grouped into five components. The results can be seen from Table 2.

Extraction method used is principle component analysis and the rotation method used is Oblimin. To indicate the meaning of the components, they have been given short labels indicating their content. Since the results of this stage were open to several interpretations, we decided to use experts' opinions here. So, three project managers were invited and based on the discussions on the factors meanings in each component, five 'Organizational', 'Managerial', 'Environmental', 'Contractual' and finally 'Technical' labels were assigned to the extracted components. The final results are shown in the Table 3.

Discussion

Based on the percentage of variance shown in the Table 2, the order of effective factors is organizational, managerial, technical, contractual and environmental. According to the findings of researchers, organizational obstacles are the most significant ones. Resolving these obstacles require changing methods, organizational culture and awareness of the executive potential of issues at the level of organizations and projects. Due to the constructability to influence the cost-effectiveness and time progression to achieve optimal conditions, consideration of the design's in the early stages of the project life cycle is necessary (O'Connor 1995).

Many of the problems related to constructability are the result of lack of communication among employers, architect or designer and construction companies, before starting the project (IPENZ 2008). Architects and engineers and designers—given the nature of their performance—are not experts in the

TABLE 2. The results of robust EFA.

The results of robust EFA	1	2	3	4	5
Resistance to change and the consent of the status quo	0.81				
Reluctance to innovation and creativity	0.73				
Cultural barriers due to the traditional view and flexible vision	0.75				
Lack of sufficient knowledge	0.80				
Lack of existence of systematic organizing structure	0.79				
Resistance to the early builders in the initial stages of the project and financial investment	0.70				
Lack of effective reward and punishment standards	0.71				
Reluctance of executive staff to offer pre-implementation consultation	0.75				
Lack of existence of a strong support program to promote creativity		0.73			
Lack of presenting regular reports about the work trend		0.70			
Lack of documenting experiences and knowledge of successful projects		0.76			
Inappropriate methods of labor recruitment		0.8			
Contrast of objectives of organization and project		0.71			
Not having the correct attitude to the constructability of an investment opportunity		0.78			
The absence of communication tool and lack of transparency of information		0.80			
Weakness in engineering and construction quality			0.73		
Lack of executive experience in design team			0.80		
Lack of knowledge about construction technologies			0.81		
Lack of applying development tools and equipment			0.79		
Lack of flexibility in standards and regulations of design and implement			0.72		
Not paying attention to executive abilities in selecting contractors and consultants				0.73	
Existence of traditional contracts				0.75	
Inappropriate contractual strategies				0.71	
Lack of flexibility in contracts				0.88	
Incorrect time, methods and criteria for the selection of contractors				0.81	
The long process of dispute resolution				0.75	
Lack of knowledge of employers about benefits and advantages of applying constructability					0.81
Contractor's unwillingness to cooperate in the design phase of the project					0.88
Exerting personal tastes and restricting the final decision making right for the owner					0.87
% **of variance**	**21.54**	**17.92**	**15.13**	**13.41**	**11.07**
Cumulative %		**39.46**	**54.59**	**68.00**	**79.07**

TABLE 3. Extracted components and their related factors.

Component name	Factors
Organizational	Resistance to change and the consent of the status quo
	Reluctance to innovation and creativity
	Cultural barriers due to the traditional view and flexible vision
	Lack of sufficient knowledge
	Lack of existence of systematic organizing structure
	Resistance to the early builders in the initial stages of the project and financial investment
	Lack of effective reward and punishment standards
	Reluctance of executive staff to offer pre-implementation consultation
Managerial	Lack of existence of a strong support program
	Lack of presenting regular reports about the work trend
	Not having educating and encouraging program for promoting creativity and critical thinking
	Lack of documenting experiences and knowledge of successful projects
	Inappropriate methods of labor recruitment
	Lack of coordination and cooperation in teamwork
	Lack of integrity among key members of project team
	Contrast of objectives of organization and project
	Lack of motivation
	Lack of using ideas of project stakeholders
	Inappropriate management practices in design teams
	Not having the correct attitude to the constructability of an investment opportunity
	The absence of communication tool and lack of transparency of information
Technical	Weakness in engineering and construction quality
	Lack of executive experience in design team
	Lack of knowledge about construction technologies
	Lack of applying development tools and equipment
	Lack of flexibility in standards and regulations of design and implement
Contractual	Not paying attention to executive abilities in selecting contractors and consultants
	Existence of traditional contracts
	Inappropriate contractual strategies
	Lack of flexibility in contracts
	Incorrect time, methods and criteria for the selection of contractors
	The long process of dispute resolution
Environmental	Lack of knowledge of employers about benefits and advantages of applying constructability
	Contractor's unwillingness to cooperate in the design phase of the project
	Exerting personal tastes and restricting the final decision making right for the owner

construction executive methods. For this reason and other reasons, sharing responsibilities determines most of performance-based features and programs, the final result and applications (Glavinich 1995). Lack of communication between designers and contractors usually covers performance features in a hidden or explicit form. By integrating constructability in the design process in the early stages of the project, construction disputes will be reduced, and as a result, project delivery will be more secure (IPENZ 2008).

Considering managerial obstacles, it should be mentioned that managerial factors usually originate from internal forces of the organization, special obstacles, challenges, orientations and determinant effects (Bullen 1981). Therefore, it is reasonable that they follow organizational obstacles in terms of significance.

In terms of technical obstacles, an overview shows that most of these obstacles are due to lack of knowledge and experience of teams involved in the project, especially the design team. The plan of constructability to better achieve project objectives is integrating engineering design and execution, and executive knowledge and experience. However, designer's partial understanding of construction and execution requirements and owners' resistance to constructability due to extra costs of the project are main obstacles to its implementation. The barriers and technical challenges in the classification given in this paper are important and relevant factors such as 'Lack of mutual respect between designer and builder', 'Lack of enough information between designer and builder', 'Separate managerial process in design and construction', 'Lack of monitoring of matching design objectives and executive criteria', 'Lack of executive experience in design team', 'lack of evaluating applicability of designs' and 'Lack of integrating design science and executive experience' are evaluated.

Mainly, a constructability program causes a cost that is added to the design cost, and may harm the company in the competition. And effective constructability program begins during planning phase and conceptually continues to the end of construction (Arditi et al. 2002). Most of the categorized obstacles in this group refer to inappropriate plans without the possibility to implement them. Executive engineers usually have problem with designer engineers because it is not possible to implement the plan and/or contradictory and non-executive plans (Hui-Hsuan et al. 2013).

Because of inappropriate contractual strategies in the construction industry, project stakeholders and key agents' cooperation is too limited. This issue causes lack of constructability of the plan and also financial losses (Jadidoleslami et al. 2016). In the conventional contractual structure, information flow and entrance of various project agents are done discontinuously, and the employer states his/her objective, consultants develop and design it, public contractors receive the plan and partial contractors construct it. Many experts believe that this method is very ineffective and leads to wasting a lot of resources and costs and prevents optimum implementation of the project. As a principle, the expense of making any changes in the project increases over time, whether this change is toward plan optimization, or correcting its deficiencies (JadidolEslami et al. 2016). Effective factors such as 'Existence of traditional contracts', 'Inappropriate contractual strategies', 'Lack of flexibility in contracts', and 'contrast of objectives of organization and project' presented in Table 2 show the relevance and importance of this issue.

Environmental factors originate from major environmental effects, such as economic conditions, technological advancements, etc. that are beyond our control to a large extent. Factors related to competitive strategy, stabilize or grow the situation of industry or technology in the market through better quality or lower cost (Bullen 1981). Yet, environmental obstacles to implement constructability have overlapped with managerial obstacles, which indicate that focusing on improving management or changing managerial performance can provide appropriate direction for studies to find solutions to resolve these obstacles (Jadidoleslami et al. 2016).

Major obstacles to organizational and managerial performance have emphasized improvement of experience in the design team. Employers' lack of awareness and traditional view toward benefits of constructability, are also among major obstacles considered by researchers in the evaluated studies. Other factors, such as traditional contracts, engineering gap, and lack of supervision and incentive plans are among the obstacles that have been considered less and it seems that they require more discussion and attention to realize facilitation of implementing this concept. Given the undeniable benefits of constructability, finding these obstacles in the construction projects, provides a clearer view to the construction stage for planners and designers. Moreover, identifying these obstacles, efforts can be done to resolve them.

Conclusion

In this study, at first a comprehensive list of obstacles to constructability implementation was developed as a questionnaire using literature review and examining projects applied constructability. Then, this questionnaire was offered to project managers, employers, consultants and contractors active in the field of construction and mass production. The obtained results were analyzed by EFA method. From 63 asked items, 35 items were about obstacles to constructability implementation in the construction industry. Then, they were categorized by some of the experts of this industry into five groups of macro factors, including: organizational, technical, contractual, environmental and managerial.

This study shows that organizational macro factors are the most significant obstacles to constructability implementation in Iran. What is important is that ignoring the effects of poor design or decision making can seriously result in incompatibility in the performance of construction projects such as increased costs and time of construction, and reduced quality. Successful construction projects without simultaneous review and reform of the design process and construction and parallel applying of knowledge and experience are impossible. Examining the available conditions and problems related to facilitating the presence of contractors in the early stages of study and design to improve constructability, will pave the road for implementing this concept in the mentioned projects.

As a potential for future works, researchers may follow qualitative research methods such as case studies to investigate obstacles to constructability implementation in similar or other settings. Case study is a useful method in studying such a subject. Moreover, future works could focus on more specific areas such as contractual, environmental, project management, organizational obstacles and alike, so that more detailed and in-depth information or deep-rooted obstacles could be identified. Moreover, future researches can move beyond listing obstacles and could explore the interrelationships between them or the effect of these obstacles on projects' outcome. Furthermore, future studies might focus on finding solutions to solve these obstacles for constructability implementation through taking conditions of the construction industry into account, applying expert opinions, and considering the identified obstacles and their significance. Particularly, scholars should try to find a functional model to implement this concept in the urban construction projects.

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