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Parallel impact of IPD and BIM approaches on facilitating constructability implementation

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Abstract

Constructability is a project management technique to review the construction process throughout the project before starting its implementation. This technique reduces project mistakes, delays, and also overflows through identifying possible barriers. It requires project agents' aligned cooperation and their early presence -particularly contractors- in the preliminary studies and design phases. Due to common contractual problems in the construction industry, aligned cooperation of stakeholders and project key agents is very restricted. Despite careful planning and cost estimations, we usually encounter lack of constructability of the plans, lack of integration and weak coordination in projects, due to anticipated and/or unanticipated reasons, some of which are because of the absence of key stakeholders in all phases of the project. In this regard, Building Information Modeling (BIM) is a new approach toward assurance of this integration. BIM replaces traditional methods of documenting and, through creating a virtual environment, makes possible cooperation and communication, which are far beyond the traditional processes. Yet, BIM is a means for facilitating the Integrated Project Delivery (IPD) approach, which tries to facilitate the constructability process through focusing on the contractual reforms. The aim of this study is evaluating the parallel impacts of IPD and BIM approaches on facilitating constructability implementation. Practically, these new approaches portray common objectives for various project stakeholders that prevent dissatisfactions in projects. Applied research method for this study is qualitative method. Literature review is used for in-depth data collection, reviewing previous studies and their interpretation; then data were classified through descriptive analysis. The necessity of conducting this study comes from this fact that a great deal of problems in projects -such as increased time and cost, lack of integration of the plan, and weak implementation system- are due to lack of information exchange and effective communication of design and construction people and ignoring the effects of design decisions on plan's constructability. In this study, through evaluating the parallel impact of IPD and BIM approaches on facilitating constructability implementation, common impacts are presented. This study highlights the significance of paying attention to both parallel impacts of technical and contractual aspects on facilitating constructability in construction projects.

Keywords: Building Information Modeling (BIM); Constructability; Integrated Project Delivery (IPD); Integration

Introduction

One of the measures of developing countries to improve their economic performance is implementing infrastructural civil projects. A large portion of country's budget is allocated to these projects, so proper planning for their plans is necessary in order to achieve the lowest cost to

efficiency ratio. Each year, a huge part of the country's funds and financial resources is used for investing in major infrastructure and civil projects [1, 2].

One of the issues raised in Iran during recent decades is the emphasis of policy makers and managers on the construction industry. In that, interdependencies between pre and post construction stages of the projects have mostly been neglected. Usually, management of the construction projects does not have basic assumption of a generalist view [3]. This technique reduces and/or prevents mistakes, delays and also costs overflows, through identifying barriers before project implementation. It requires aligned cooperation of project agents and their early presence, particularly construction contractors.

Due to common contractual problems in the construction industry, aligned cooperation of stakeholders is very restricted. Despite careful planning and cost estimations, many projects go beyond the redlines of time and cost, due to anticipated and/or unanticipated reasons, some of which come from the absence of key stakeholders throughout all project phases. In this regard, Building Information Modeling (BIM) is a new approach toward assurance of this integration, and focuses on the technical aspect of the project, and through creating a virtual environment, provides such communication and cooperation that is far beyond the traditional processes. On the other hand, the Integrated Project Delivery (IPD) approach also overshadows the its contractual aspect. The necessity to pay attention to BIM, as a means for implementing IPD approach, and the common role of their parallel application in facilitating the constructability process, have not been explored so far. Accordingly, the aim of this study is evaluating the parallel impact of IPD and BIM approaches on facilitating constructability implementation.

Early formation of the project team and participation of contractors in the design stage in the IPD approach causes design's completion before beginning the documentation phase and increasing plan's implementation. Such project coordination in the design phase leads to reducing duplications and time wastes in the construction phase [5]. Using IPD and BIM approaches, this study will present solutions to facilitate constructability implementation in the construction Projects.

1. Constructability

Constructability refers to principles used so far in various projects consciously or unconsciously, and have been discussed and studied frequently by various researchers and organizations as "optimal use of construction knowledge and experience in the conceptual planning stages, detailed engineering and construction to achieve projects' overall objectives" [6]. Throughout the construction projects, there are various phases including goals and tasks definition, planning, design, implementation, and operation. Constructability is a system for achieving optimal integration of knowledge and experience in planning, engineering, procurement, and the process of construction implementation, and creating balance in various projects and environmental restrictions to achieve the overall objectives [7].

In order to explain the principles of constructability before project implementation, integrating construction knowledge, experience, and skills in the initial planning and design is considered, which results in improved productivity and reduction of problems [8] and better team work in the project process and the implementation phase [9]. Such integration provides planners and designers a clearer view of the construction phase. This is more significant in the infrastructure projects, because there are often more complexities in such projects compared with those smaller ones. This issue can influence project success in terms of time and budget taken for completion [10].

The concept of constructability leads to improvements and savings in all aspects of a project, including its time and cost from beginning to its operation and maintenance phases. These advantages will be provided through creating contexts to facilitate the presence of implementation contractors in the initial phases of the project. According to literatures on the constructability concept, it is a long term issue and should be followed up continuously. Communication problems affect the constructability implementation severely. Due to the capability of constructability to affect costs and time progress to achieve optimum conditions, it is necessary to consider plan constructability in the initial phases of the project lifecycle [11]. Nowadays, existence of a clear constructability program in

each design company is necessary for enhancing the quality of services and more significantly, for surviving in the competitive market. Constructability program refers to integrating engineering design and implementation knowledge and experience for better achievement of the project's objectives. However, designer's partial understanding of construction and implementation requirements, and owners' resistance to constructability, due to additional costs visible in the project, are main barriers to its implementation. Usually, constructability program leads to creating a cost added to the design cost, and it may harm the company in the competition.

An ideal constructability program starts during the planning phase and continues conceptually to the end of construction [12]. This highlights the need to contractual arrangement to be made to ease such an early integration of project stakeholders. Next section discusses IPD as a solution for that.

2. Integrated Project Delivery (IPD) Method

IPD is an approach in the form of project implementation that integrates business factors and structures, systems, and people in a process. This participatory process uses collective talents and insights of all agents involved in the project to optimize project results, to increase project value for the employer, to reduce waste of resources, and to maximize efficiency of all phases of the project. IPD structure is applicable in a wide range of contractual forms. Integrated projects are distinguishable from other usual projects, due to the effective participation among team members in all stages of the project [2]. This system enjoys high participation and cross-functional teams, which are composed of stakeholders of project lifecycle; including employer, designer, contractor, engineers, and sellers. The prerequisite to achieve success through this method is that the team be formed as soon as possible, and all of its members have free and equal access to information, and project risks and rewards be divided equally among them. Relying on technical advancements in sharing information through world wide web, the team becomes stronger and even its members can cooperate with each other from any point of the world and complete the design and exploit the project faster and cheaper [13].

This method simply prevents many issues such as lack of alignment of people's success motivations with project success in the common systems of project implementation. Accordingly, it suggests that through concluding a multi-lateral contract, all agents share projects' profit and loss. IPD is a very participatory process that integrates skills and expertise of project teams in the initial stages of the project. Experts from different p[project phases attend throughout the project process to ensure that design decisions meet all of the needs of involved agents. In fact, IPD basic principles are involving key stakeholders and their benefits throughout the project and also sharing risks [3].

IPD method is based on cooperation and mutual trust. If there is a trust-based cooperation, the culture of focusing on project goals will be created instead of focusing on personal goals. IPD is threatened without trust-based cooperation, and project stakeholders remains in a hostile and incompatible communicative environment. IPD changes project results in a better way, if thinking of people involved in the project grows. Achieving the IPD benefits requires that all of the agents get involved in the project [14].

New buildings are like complicated machines that need skill, experience, and expertise of professional forces to be completed. The construction industry has used new systems, most of which are participatory, to facilitate communication, risk division/reduction, increased productivity and creating a context for earning effective experiences by project employers. IPD is one of these participatory systems [15]. Another incentive for moving toward applying IPD, are international issues, which increasingly will be affective on internal markets in future. Today, responding to changing economic conditions requires that architects and contractors change their working methods to increase productivity, and/or witness their destruction.

L-Academy 4 in its studies found that industry and university's experts not only emphasize on early involvement of main suppliers and builders in the internal conflict resolution system, but also they focus on extensive communication among team members and their leadership. In this study, he

introduced and identified ten approaches for successful development of projects' integrated contracts [13]:

- Developing project environment compatible with non-flexible decision systems
- Using autonomous project manager in all rules
- Applying external facilitators to help integrated implementation and resolving conflicts
- Integrated design process
- Developing integrated timing
- Early involvement of key suppliers and contractors in the project
- Applying open account or fixed price wages against percentile wages, which can encourage people to manipulate the expenses
- Reward and punishment for all participatory components
- Offering a clear and unambiguous view about growth
- Structuring internal conflict resolution processes that address resolving conflicts between parties without need to court or external references.

BIM is a tool that can simply enhance the technical aspect of integrating people in early planning and design phases. Next section focuses on this concept.

3. Building Information Modeling (BIM)

BIM is a new approach to ensure integrity and coordination in the project. In IPD, the need for coordination and communication is more tangible. On the other hand, exchanging project features among its stakeholders requires documenting such coordination. BIM replaces traditional methods, and through creating a virtual environment, realizes a level of communication and cooperation. This level of cooperation is far beyond the traditional processes [16].

AIA [17] states that although achieving the IPD system is possible without BIM, the justification for this study is that using BIM is necessary for efficient achievement of the cooperation required for IPD system. Achieving success with this method requires that the team be formed as soon as possible, and all of its members have free and equal access to information. Involvement of builder from early stages of the project helps significantly in earning the sustainability desired by the employer [18]. Moreover, it guarantees observing constructability principles during the project design process. Since consultants are often not interested to resolve the problems related to constructability and cooperation, the need for contractual requirements is more tangible in terms of creating responsibility and team making as soon as possible [19].

In IPD, each person and group's profit depends on the other party. It means that at the end of the project, all agents together will win or lose. This feature will encourage the spirit of cooperation and teamwork. In IPD, the final model approved by design team will be evaluated by contractor in terms of constructability and possible implementation problems. Then some solutions will be presented about the identified defects by cooperation of the design team and the contractor. If there is no defect in the plan, the contractor will present some ameliorative suggestions by reviewing the model [20]. Such early presence in the design stage and increase of team work spirit in IPD approach, have direct effects on enhancing constructability and reducing duplications.

Managing infrastructure projects in developing countries is so difficult due to problems such as unreliable transport system, cultural differences, lack of access to some necessary equipment, and undeveloped delivery methods. Flexibility in projects provides appropriate opportunities for implementing constructability programs. These measures result in enhancing the quality of design and construction and long-term maintenance of a project. If the contractor and other executive agents learn to state their needs from the beginning of the project and the involved people understand each other's needs through cooperation, then common goals will be created. However, the owner's goal- creating an affordable project- may be against the contractor's motivation to earn profit. Meanwhile, IPD is an

appropriate way for covering constructability issues. Considering the direct impact of this approach on enhancing plan implementation, the next section will address the constructability studies.

4. Available barriers and solutions to facilitate constructability implementation

Available barriers and solutions to facilitate constructability implementation, have been evaluated and classified by researchers of this study through literature review method using Meta-synthesis technique earlier [1]. These problems have been classified and assessed in three groups of macro barriers as shown in the following figure.

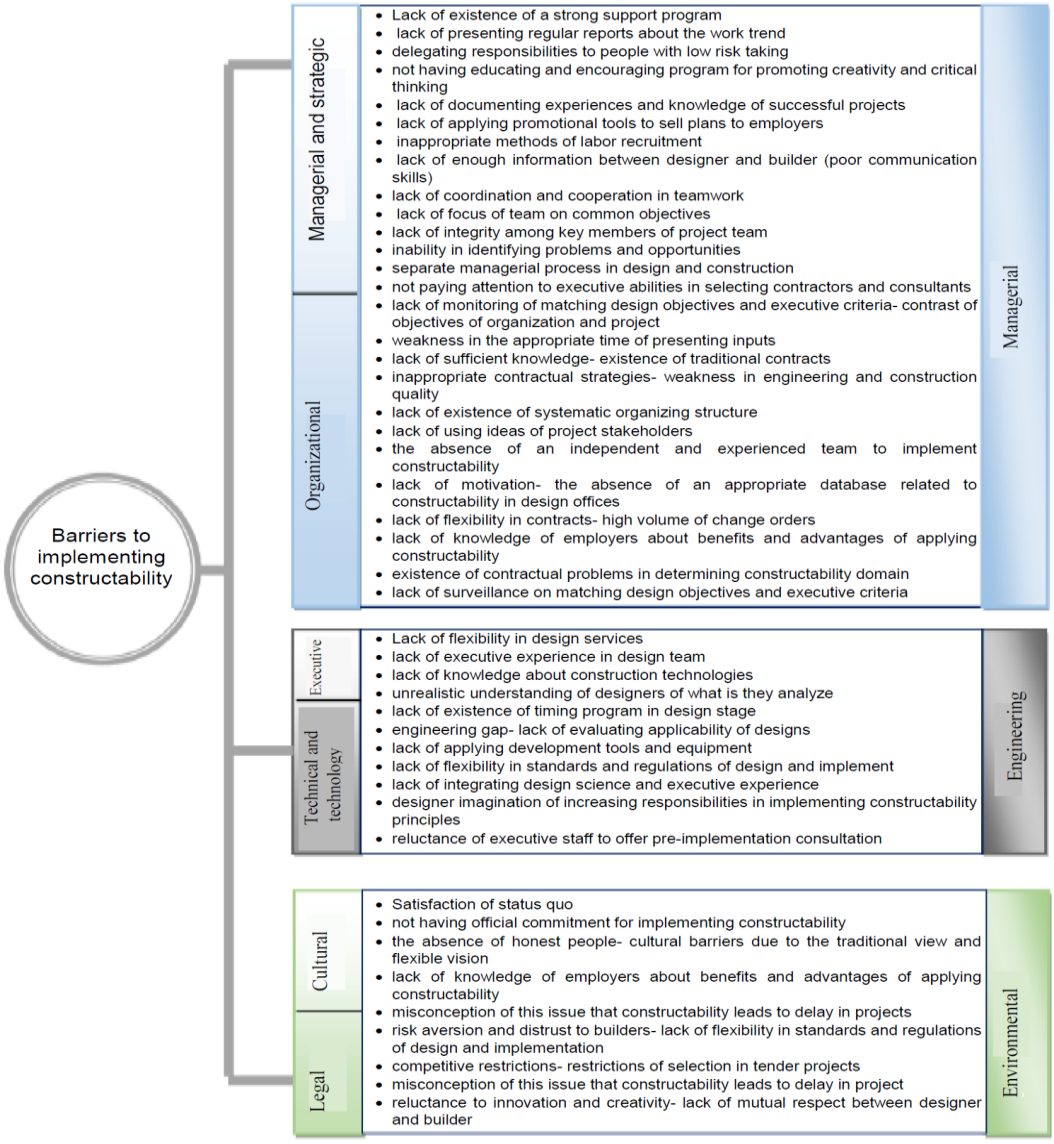

Figure 1: Conceptual framework of the barriers to constructability [1]

Some solutions are also offered for resolving the barriers to constructability implementation [2]. They are classified in the same way and are shown in the Figure 2. The presented solutions may potentially have the capability to resolve several barriers in the field of facilitating constructability implementation, so they should not be considered as restricted solutions.

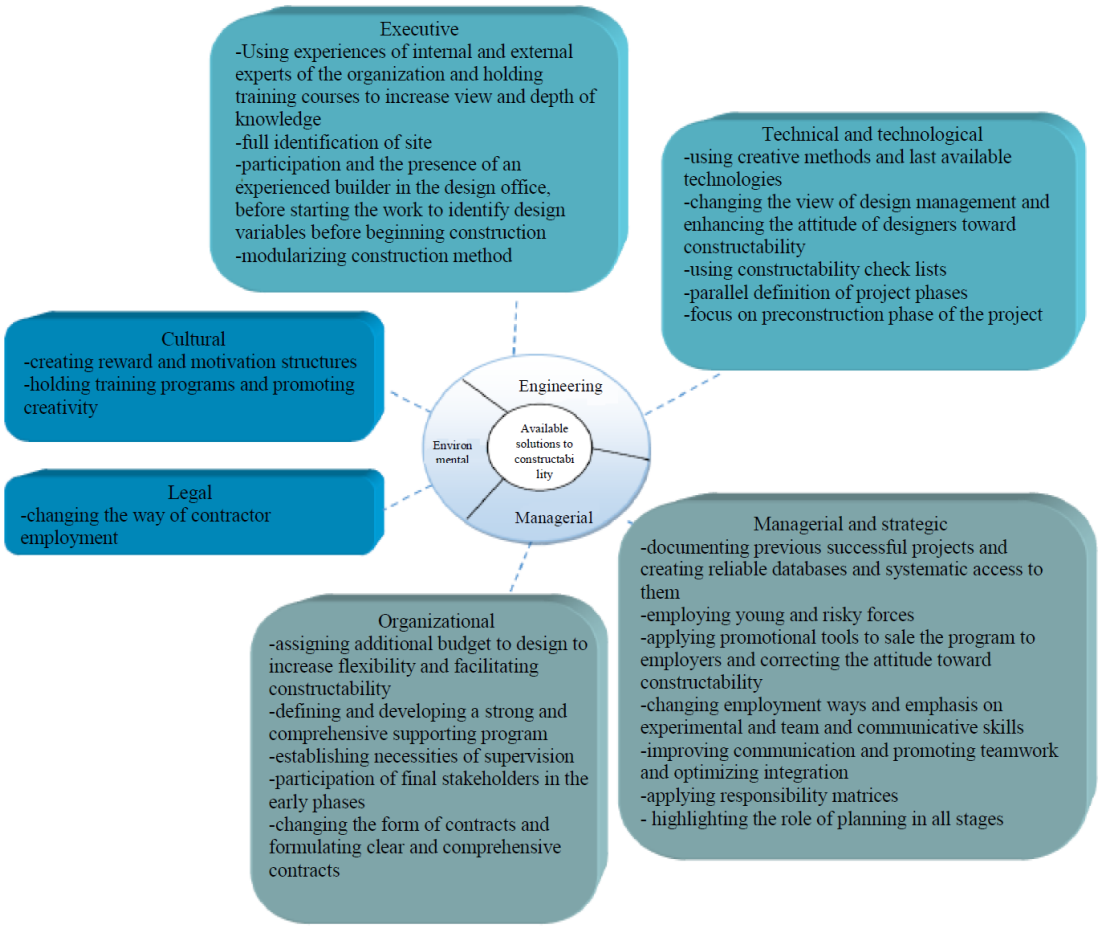

Figure 2: Available solutions to resolve the barriers to constructability [2]

Having the list of barriers and solutions in hand, this research uses the following methodology to find out the parallel impact of IPD and BIM on facilitating constructability implementation in construction projects.

5. Research Methodology

This study evaluates the parallel impact of IPD and BIM approaches on facilitating constructability implementation, and finally addresses the common impacts to enhance integrity of the construction projects and the significance of paying attention to the effectiveness of both technical and contractual aspects of facilitating constructability in the construction projects.

In order to determine these parallel impacts on facilitating constructability, qualitative method of literature review is used. Its aim is to classify available parallel and common impacts on applying IPD and BIM to implement constructability in the urban construction processes. For that, available barriers and solutions to implement constructability process -identified in the previous studies by these researchers trough Meta-synthesis approach- were considered as the basis of this article.

Finally coding process was performed through descriptive and pattern analyses of data using the NVivo Software. To ease the data analysis process, they are classified through descriptive analysis of

collected qualitative data using the NVIVO software. Next section highlights analyses of qualitative data collected. In the NVivo software, which is used for analysis of texts in the qualitative studies, after entering data obtained from interviews, there is the possibility of coding the text. This software is also used for checking the existing codes and their relationship with characteristics of participants. This software allows users to follow research ideas. Next sections describe the analysis process applied using this software.

6. The necessity to parallel application of IPD and BIM to facilitate constructability implementation

Constructability refers to optimal use of construction experience and knowledge in planning, design, procurement, and implementation to achieve the overall objectives of the project. This technique -before project implementation and through identifying barriers -will result in reducing and/or preventing mistakes, delays, and also costs overrun. It requires simultaneous cooperation of project agents and early presence of them, particularly contractors, in the preliminary studies and design phases. Although up to now, the construction industry has grown significantly in different aspects, it still it suffers many problems. Due to the common contractual problems in the construction industry, the possibility of parallel cooperation of stakeholders and project key agents is very limited. Despite careful planning and cost estimations, many projects pass the red lines of time and costs, due to anticipated and unanticipated reasons, most of which are because of lack of presence of key stakeholders in all phases of the project. This issue results in financial losses and dissatisfaction of the employer and lack of constructability of the plan. So far there is no study to focus on increasing implementation in the construction industry and facilitating constructability by reforming contracts and also correcting and improving project implementation method, which lead to reduction and/or removal of many duplications. This study exclusively is focused on resolving constructability barriers and facilitating its implementation by using IPD and BIM, in order to reduce and even to remove the problems of constructability implementation.

In the traditional project delivery methods, contractors were often not considered until the completion of the design phases. This issue does not allow contractors to enter data in the project, and usually design is controlled by the design team until the time of implementation. This issue is not true about the IPD system. Because this system depends on using BIM and cooperation processes of all team members throughout the project. However, due to lack of evolution of IPD system, there are few studies applied this system. After 2009 that Texas State decided to use BIM in all of its projects, this idea arose that through using BIM, they can expect to reduce changes. This is a warning expectation for design companies that are responsible for costs incurred by changes in their contracts [21]. In Table 1, overlapping of IPD and BIM features is specified [17].

BIM features	**IPD features supported by BIM**
Sustainability and accuracy of information	Collaborative decision making and control/objectives developed jointly.
Design visualization	Collaborative decision making and control/objectives developed and enforced jointly.
Ease of supply	Divided risk and reward/ objectives developed jointly.
Cooperation of several users	Early presence of project people/ objectives developed and enforced jointly./ multilateral contract
Energy efficiency and sustainable development	Collaborative team making and control/ objectives developed and enforced jointly./ divided risk and reward
Reporting	Collaborative team making and control/ objectives developed jointly./ divided risk and reward

Table 1. Overlapping BIM and IPD features

BIM has the capability to facilitate high level of cooperation required for IPD system. Using 3D visualization abilities, modeling of integrated system enables early identification of potential problems in the design phase. In the following, some of the benefits of using BIM in implementing IPD and/or projects with IPD approach are identified:

1) **BIM and legal aspect of using IPD:**
Using BIM in projects doesn't have any direct impact on legal issues. These need making changes in the law and regulations to help selecting services and processes of risk allocation for implementing IPD system. However, BIM can recognize the significance of IPD system and supports using IPD system to achieve maximum profit by using such advanced technology [22].

2) **BIM and organizational aspect of IPD implementation:**
In terms of organization, BIM helps reducing problems related to IPD implementation. Therefore, in organizations developed for matching BIM, organizational changes will be created in an integrated form and changes in the workflow occurred due to IPD system, are easier than those changes not having any background in using BIM [23].

3) BIM and technological aspect of IPD implementation:
BIM can operate as a technological catalyst to stimulate changes. Organizations invest in the field of infrastructures inclined to BIM, will not need investing in additional resources. Therefore, this is one of the benefits of such organizations and provides them a place nearer to implementing IPD through saving extra expenses of IT infrastructures. The result of this information integration is enhanced coordination, reducing mistakes and wastes, and finally increasing work quality [17].

4) **BIM and team making aspect of IPD:**
Project team is the blood artery for IPD. In this method, all agents of the project come together as an integrated team with an ambitious goal for designing and building a successful project. In the traditional projects, if there is a problem, people prepare themselves for encountering a period of problems, communications are damaged and the project struggles to save itself from failure. In contrast, in IPD projects, when there is a problem, it requires that everyone cooperate with each other. Therefore, project team prepares abilities of team members for making up a new method and coordinated teamwork, in such a critical situation. Permanent and coordinated interaction of all working groups and bold role of IBM in facilitating and accelerating these interactions are undeniable. In forming team, capabilities, simultaneous working capability, communications, creating honesty and agreement for the integrated process are considered. The process of team making and team forming should successively include evaluation, diagnosis, and communication training for forming a strong team with separate components. When a team is formed, an environment should be created to allow cooperation and communication grows. Defining cumulative goals for the project and metrics for measuring concurrent performance during adjusting models adapt individual success with project success can create incentives for team work [13].

7. Data Analysis

In this study, available barriers to implement constructability process have been studied and classified through descriptive analysis of data using the NVIVO software [1]. The result of this analysis is presented in the Table 2 with classification of barriers to constructability implementation and solutions provided by IPD approach, and in parallel to that, by using BIM solutions given to resolve

these barriers. This table shows how important it is to look at both contractual and technical aspects of easing the constructability implementation in construction projects. Lack of attention to any of these two important aspects may cause delays in proper integration of knowledge from construction phase to the planning and design phases.

Row/ Title	Barriers	IPD-Solutions [13]	BIM-Solutions
1	Incorrect time, method, and criteria adopted for contractor selection	The necessity of early presence of all project agents through mentioning it in the integrated contract	Realistic simulation of project information by using BIM and the likelihood of reducing errors [20, 24]
		Establishing relations based on mutual respect and trust	Enhancing assurance of the contractor's abilities regarding transparency of type of performance and project scope depending on BIM [21]
		The contribution of the consultant and the contractor in the project profit and loss and paving the way for building trust	Using BIM by providing conditions for a safe working environment with least mistake, duplications and wastes, and earning maximum profit and the least cost, paves the way for selecting the correct contractor [23]
2	Lack of mutual trust and respect among project agents	Establishing relations based on mutual respect and trust	BIM performance as a common source of information between whole of design team and building components and reducing conflicts [21, 25]
		The contribution of the consultant and the contractor in the project profit and loss and paving the way for building trust	
		Emphasis on the existence of free and transparent relations	
		Main stakeholders are committed to each other equally.	
		The necessity of participatory decision making in IPD approach	
3	Exerting personal tastes and the monopoly of the right to make the final decision for the employer	The necessity of participatory decision making in IPD approach	Managing changes due to matching with BIM [22]
		The necessity of free and transparent relations	
		Formation of target criteria collaboratively	More understandable impacts due to applying custom changes on the suggested design regarding its visualization and 3-dimensional feature for the employer and stakeholders, and the probability of reducing or adjusting these changes [25, 26]
		Early definition of goals	
		The necessity of existence of organization and leadership based on projects' abilities and value and objectives	
4	Lack of communication tools and lack of transparency of information	Establishing relations based on mutual respect and trust	Creating a clear view toward improving the decisions for reducing mistakes and enhancing the quality of the product [27]
		The necessity of free and transparent relations	
5	The long process of dispute resolution	Ignoring the claims between parties as one of the IPD contractual principles	BIM performance as a common source of information between whole of design team and building components will result in conflict prevention [28, 29]
		Sharing risk and reward according to project outcomes	
		Participatory decision making	
		Formation of target criteria collaboratively	
6	Lack of realistic planning and full justification studies	The necessity of early presence of main stakeholders and agents involved in the project	Using BIM and project information simulation will led to realistic planning and reducing the likelihood of errors [20, 24]
		Planning improvement as one of IPD principles	

7	Lack of effective encouraging and punishing regulations	Existence of an encouraging mechanism with a fair and acceptable rewarding approach	
		Sharing risk and reward according to project outcomes	
8	Existence of managerial conflicts and lack of integration	The necessity of clear management and decisions	Integrating technology by using BIM for more analysis [20]
		Participatory decision making	Existence of an array of information related to various activities and tasks of construction management in BIM performance, due to its 3-dimensional physical nature [25, 28]
		Matrix design determining the range of services and tasks	
		Project team assures that tasks, responsibilities, and the scope of authorities and services are determined as soon as possible and are defined clearly.	
9	Lack of interaction culture and team work	Establishing relations based on mutual respect and trust	Permanent and coordinated interaction of all working groups and the determining role of BIM in facilitating and accelerating such interactions [20, 30]
		Formation of target criteria collaboratively	
		Participatory decision making	
		The desire for cooperation and participation	
		Free communications	
		Expert and ability-based organization and leadership	
10	Lack of proper participation of the consultants in project risk allocation process	Equal commitment of main stakeholders	Reducing risks due to changes or incompatibility or incorrect designs by the consultant because of project information simulation [25, 28]
		It is defined based on the clarity of scopes and share of people in risk taking	
11	Not using updated technologies and lack of knowledge	Specifying the type of applied technology at the beginning of the job	Technology type catalyst for stimulating changes [22, 26, 31]
		The necessity of using appropriate technology for accelerating and improving communications	
12	Lack of awareness of employers about benefits of team work	Early presence of agents and team work are supported by the employer	Due to complete modeling of project details, understanding its nature and structure will be clear from the beginning for the employer and stakeholders [21]
		The desire for cooperation and participation	

Table 2: The barriers to implementing constructability, IPD solutions for resolving the available barriers

According to the above table, theoretical advances in BIM are not only useful for geometric modeling of building information, but also they can be used in managing construction projects. One of its aspects is parallel application of BIM and IPD, which leads to increasing the capability of constructability and resolving the barriers to its implementation.

8. Discussion

Many problems of the construction projects are due to separation and lack of integration in the project phases and lack of a realistic view about its final result and output. Using IPD approach, practically common objectives are defined for various stakeholders of the project that prevents dissatisfactions in the project. In this regard, BIM - as a means for facilitating IPD approach- plays a significant role in reducing these problems [20]. One of the most obvious usages of BIM, both for designers and contractors, is exchanging design decisions with members of working team and the employer. One of the significant benefits of BIM is that it allows the contractor and his/her team to analyze and test several procedures and its required equipment before the operation begins. This feature results in

timely reveal of major and small problems, which if they are discovered late, they will cause serious challenges. After discovering the executive problems, the contractor will discuss about the issue with the designer to amend the plan. On the other hand, this working review can lead to approval of quality standards and evaluating safety of the construction.

Previous studies refer to BIM as an IPD facilitator [25-27], and IPD is also recognized as one of the ways of facilitating constructability [32]. However, what is not addressed so far, is evaluating the parallel impact of simultaneous usage of BIM and IPD for facilitating constructability. Since many project problems, such as increasing time and cost, lack of plan integration and weakness of executive system, are due to lack of exchange of information and effective communication of the design and construction phases and ignoring design decision impacts in the plan constructability, more effective context should be presented for enhancing the construction projects' integration, through evaluating the parallel impact of IPD and BIM on constructability implementation.

9. Conclusions

In order to implement IPD approach and using BIM as a facilitator for its implementation to reduce the problems of constructability and duplications, through a closer look at the findings of this study, we find that after contractual problems, cultural issues are among the most challenging barriers, which resolving them is the basic prerequisite of education and cultural improvement and requires revision of the rules.

Factors such as poverty of decision making, lack of knowledge about details of designing components of a project, poor coordination among agents, incorrect estimation of time and cost, unclear structure of responsibilities and tasks of agents, lack of applying updated technology, lack of realistic planning and insufficient feasibility studies, not equal participation of the consultant and the contractor in the project profit and loss, legal and contractual processes of selecting the contractor, lack of awareness of employers about benefits of teamwork and cultural poverty in the field of teamwork and weakness in the participatory thinking and decision making, are among items determined during research as barriers to constructability implementation [1].

According to research findings and studies conducted about IPD and applying BIM and the parallel impact of applying these two approaches, if they are localized in cases such as resistance to technological changes and a tendency toward traditional performance, and also political and legal restrictions, most of the barriers to constructability implementation will be covered. It is evident that simultaneous usage of IPD approach and BIM in terms of teamwork and collaboration of project agents can result in reducing mistakes and finally duplications and facilitating constructability implementation.

It is recommended that future studies focus more on real case studies trying to consider both contractual and technical aspects of making such integration happen in construction projects in order to measure more tangible outcomes.

References

1. Jadidoleslami, S., et al., Provide solutions to increase constructability based on principles of constructability of the Construction industry. 3rd National & 1st International Conference in applied research on Civil Engineering, Architecture and Urban Planning, 2015.
.2 Jadidoleslami, S., et al., Assessing Barriers to the implementation of the concept of constructability in the construction industry. 3rd International Congress on Civil Engineering, Architecture and Urban Development-29-31 December 20 ,15Shahid Beheshti University, Tehran, Iran, 2015.

.3 Alikhah, F., Assesment of sotial impact: Ghavin-Rasht Highway. 10th Conference on Science and Research, Gilan University, 2009.
.4 Yustisia, H., The evaluation of constructability towards construction safety (Case study: Kelok-9 Bridge project, West Sumatera). 2014.
.5 Amirhossein Arjmandi, Tahmasb Mazaheri, and M. Eghtedari, Evaluation Integrated Project Delivery and compared to the existing contractual agreements. 6th National Congress on Civil Engineering, May 20 ,11Semnan University, Semnan, Iran, 2011.
.6 Saghatforoush E, et al., Effectiveness OF Constructability Consept in The Provision of Infrastructure Assets. 1st International Postgraduate Conference on Engineering, Designing and Developing the Built Environment for Sustainable Wellbeing, Brisbane QLD 4000, Australia, 2011.
.7 IPENZ, Constructability. The Institution of Professional Engineers New Zealand Incorporated (IPENZ), 2008. ISSN 1176–0907.
.8 Fischer, M. and C.B. Tatum, Characteristics of Design-Relevant Constructability Knowledge. Journal of Construction Eng. & Management, 1997: p. p. 253-260.
.9 Radtke, M.W., & Russell, J. S, Project-level model process for implementing constructability. Journal of Construction Engineering and Management, 1993.
.10 Saghatforoush, E., Extension of Constructability to Include Operation and Maintenance for Infrastructure Projects. 2014.
.11 Griffith, A., & Sidwell, T., Constructability in building and engineering projects. Wiltshire: MACMILLAN, 1995.
.12 David Arditi ,M.A.A.E.a.Y.C.T., Constructability Analysis in the Design Firm. ASCE Journal of Construction Engineering & Management, 2002. 10.1061/(ASCE)0733-9364~2002!128:2(117).
.13 Council, A.I.o.A.a.A.C., Integrated Project Delivery: A Guide. (2007.
.14 Glaser, G.S., 1967; Strauss & Corbin ,1990.
.15 AIA&AGC, A.-. Primer on project delivery. New York: AIA and AGCA, 2011.
.16 Shahhosseini, N., Hajaroasvadi, Barriers to the use of integrated delivery project items in Iran. 2013.
.17 Nida Azhara, Y.K., and Irtishad U. Ahmada, Factors Influencing Integrated Project Delivery in Publicly Owned Construction Projects: An Information Modelling Perspective. ScienceDirect, 2014.
.18 AIA, C.C. and M.H. Construction, Integrated Project Delivery: A working Definition. 2007.
.19 Wong, F., et al., A Review of Buildability Performance in Hong Kong and Strategies for Improvement. Surveying and Built Environment, 2006. 17(2), 37-48.
.20 Vahid Shahhosseini, H.H., Amirnojan Naderi, Alireza Joshaghani, taking advantage of building information modeling technology integrated in the delivery of project items a novel approach to sustainable construction. 2014.
.21 Samir Emdanat; Robert Mauck, A., P.E.; and Matthew Jogan, AIA, IPD, BIM, and supply chain optimization Bottom-line benefits of 3D-enabled lean delivery for AEC projects
Professional Development Advertising Section — Bentley Systems, Inc., 2010.
.22 Thomassen, M., BIM Collaboration in the AEC Industry. Thesis in Master of Science in Engineering in Management in the Building Industry (Cand. Scient. Techn.), Department of Mechanical and Manufacturing Engineering, Aalborg University, Denmark., 2011.
.23 Brynjolfsson, K.a.O.R., Governing the implementation of BIM. Chalmers University of technology, 2013.
.24 Hui-Hsuan, Y., Meng-Hsing, Lee1, Fu-Cih, Siao2, and Yu-Cheng, Lin3, Use of BIM for Constructability Analysis in Construction. 2013.

.25 Eastman, C., Teicholz, P., Sacks, R. and Liston, K., BIM handbook: a guide to building information modeling for owners, managers, designers, engineers, and contractors. Wiley, New Jersey, 2011, 2011.

.26 Academic Resource Center, I., Conceptual approach for Integrated Project Delivery (IPD) & Building Information Modeling (BIM).

.27 Ahad Nazari and S.S. Ashtiani, Analysis of lean management model integration (. LEAN MNG) and Building Information Modeling (BIM). 9th International Conference on Project Management, 2013.

.28 Benedict, I.a.D.J.K.D., Building Information Modeling and Integrated Project Delivery in the Commercial Construction Industry :A Conceptual Study. Engineering, Project, and Production Management, 2012.

.29 Bullen, J.R.a.C., A primer on critical success factors. Center for Information Systems Research Working Paper No 69. Sloan School of Management, MIT, 1981.

.30 Trigunarsyah, B., The key to successful implementionproject management of sustainable infrastructure provision Sustainable urban and regional infrastructure development Hershey. New York: Information Science Reference Publication, 2010.

.31 Othman, A.A.E., Constructability for Reducing Construction Waste and Improving Building Performance. Built Environmental Journal, 2011. Vol. 8, No. 2, 31-54, 2011.

.32 Jadidoleslami, S., Ehsan Saghatforoush, and A. HeraviTorbati, Using the Integrated Project Delivery (IPD) to Reduce Reworks and Ease the Constructability Implementation in the Tehran Mass-Construction Projects. A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Art in Project Management/ MEHRALBORZ Virtual University, 2016.