A Comparative Study on BIM (Building Information Modeling) Implementation and Maturity across Different Countries with a Review on Iran

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Abstract

The importance of digitalization in all activities is common knowledge. In Iran, construction is one of the biggest economic sectors in a way that is related to 5% of Iran's GDP directly and 12% to 13% indirectly (Moezzi, 2013). Low productivity is still a major issue in Iran construction industry (Ghoddousi P. , 2012) . Bodies concerned with construction activities in the world, have been implementing BIM over past years. BIM is a new approach to manage and plan construction industry projects. By implementing BIM an increase in the efficiency of the project and a decrease in waste and undesired outputs can be achievable. This article looks into the reasons elaborate the tiers of BIM implementation that should be taken in to consideration in construction digitalization and its current status in Iran as well as some of the pioneer countries is studied. Eventually, suggested frameworks, efforts and bodies needed for implementing BIM in Iran is provided to seek the right path to maturity level suitable for Iranian construction market.

Keywords:

Construction Digitalization, Maturity, Building Information Modeling (BIM), Policy, Implementation, Iran

Introduction

Looking at figure 1, showing the productivity of construction versus other industries based on a study from Stanford University's CIFE department over 40 years from 1964 to 2004, the negative productivity of construction industry around 20% is noticeable. All other industry sectors experienced over 100% of productivity during this period.
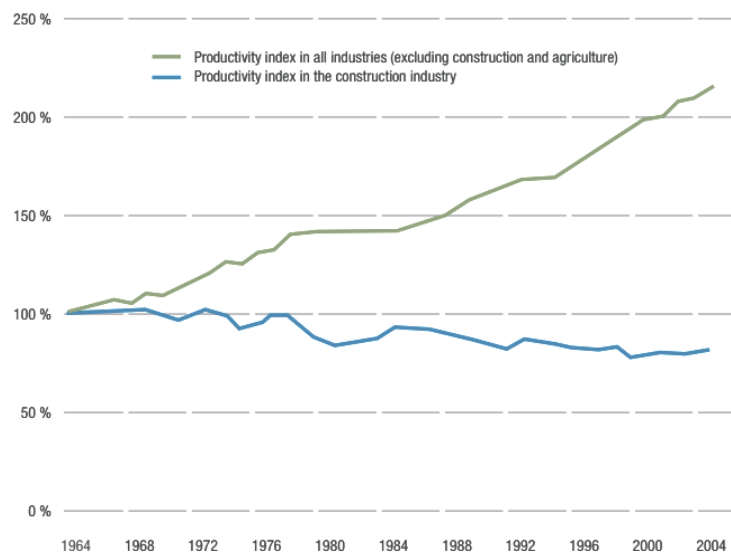

Figure1: productivity of construction versus other industries

A case study also carried out in Germany over a period of 24 years (1991 to 2015) shows productivity stagnation compared with an average of 70% in other German industries.

Construction productivity has been flat for decades, according to McKinsey research. In manufacturing, by contrast, productivity has nearly doubled over the same period, and continuous improvement has been the norm (Sriram Changali, 2015). Also, Global labor-productivity growth in construction has averaged only 1 percent a year over the past two decades, compared with growth of 2.8 percent for the total world economy and 3.6 percent in manufacturing (Filipe Barbosa, 2017) . In America less than 5% of builders work for construction firms that employ over 10,000 workers, compared with 23% in business services and 25% in manufacturing. Its profit margins are the lowest of any industry except for retailing (Economist, 2017). In another study, more than 90% of the world's infrastructure projects are either late or over-budget (Flyvbjerg, 2015). It is quite possible that one sector of construction, say, heavy construction, may be experiencing sustained growth in productivity while another sector, such as residential construction, could be experiencing the opposite. There is a need to understand how the growing trend of offsite productivity is impacting construction productivity (Teicholz, 2011). Declining productivity over last decades correlates with lack of new technologies. The total dollar amount of construction R&D in US is 30 times smaller than manufacturing R&D investment. According to research by Civil Engineering Research Foundation and National Science Foundation,

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$5.4 billion R&D investment in Construction comparison with $167 billion in Manufacturing. (Foundation, 2013).

One hand the industry of construction has a long way to go to become digitized, on the other hand it faces a chronic problem of low productivity, the product of faulty planning and poor collaboration that cause delays and increase costs and affects project success criteria including time, cost, safety, environment, quality, efficiency, satisfaction of different members participating in project (Soleimani, 2019). Only about 50% of planned activities on a construction site are completed on schedule—no better than a coin toss. By applying digital lean methods at the construction site, it is estimated that companies can accelerate their plan completion rate to more than 70%.Lean can reduce budget costs and improve PPC from 50% to about 62% .(Merrow, 2011)

Globally, labor-productivity growth in construction has averaged only 1 percent a year over the past two decades, compared with growth of 2.8 percent for the total world economy and 3.6 percent in the case of manufacturing. (McKinsey, 2017)

These efforts and similar studies worldwide show a huge waste produced in construction industry. As an example, in the year 2014, it was estimated that construction activities generated 33.5 % of all waste in the European Union while contributing to only 5.4 % of the EU GDP. (Baldwin, 2019)

BIM, a newly addressed approach, is hoped to help people and organizations concerning the construction industry each country implements BIM according to its needs and roadmaps. One of the fundamental aspects that should be taken into consideration when it comes to BIM is the difference between the approaches of each person involved in the project. The difference between their specialties (Architecture, Engineering, Construction, Operators, Owners, etc.) most usually none of these entities have a comprehensive understanding of BIM implementation. Before initiating any discussion on the implementation of BIM the level of interest should be clarified to avoid any misunderstandings by any parties involved. This would allow Stakeholders to reach the same mindset and achieve their shared goal.

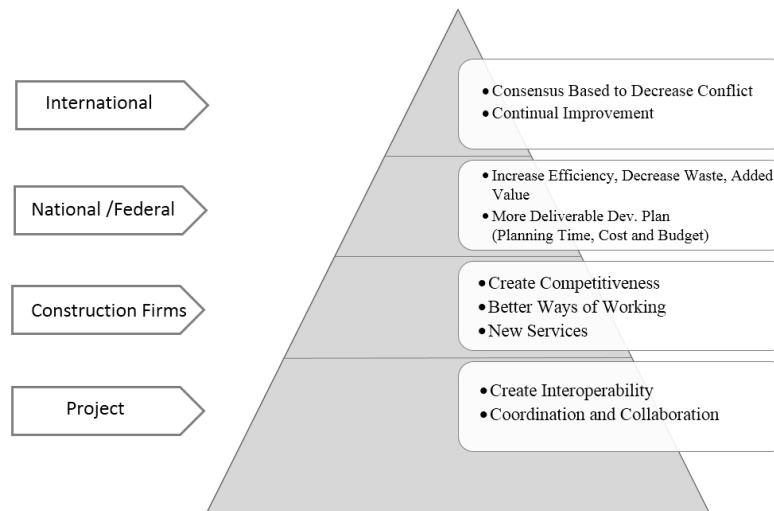## BIM Implementation in Iran

The level of BIM implementation in Iran is at the lowest level of BIM maturity. That is, 29.5% of construction companies are involved in some levels of BIM adoption whereas 56.8% have had no exposure to BIM and 36.4% do not even have any plans to adopt BIM in the near future (Hosseini, 2016).

There are some barriers to digitalize construction which can be mentioned as lack of support from policy makers and legal issues, lack of training and poor awareness and knowledge, lack of experts, resistance to change and high cost of training current and using trained staff (Hamda, August 2016).

Implementation of a methodology such as BIM can be done in different levels:

1. **International:** implementation to create consensus-based practices which can lead to continual improvement and decrease conflict;

2. **National:** implementation to add value, increase efficiency, decrease waste and make the Development Plan more deliverable (more efficient plan time, cost and budget);
3. **Construction Firms:** to create competitiveness and better ways of working, new services
4. **Projects:** to create effective interoperability, coordination and collaboration;

Picture 1: The advantages of BIM implementation in different levels

It is crucial to distinguish each level from the other, but it should be kept in mind that these levels are interdependent and therefore their maturity is related. The implementation of BIM in any of these levels requires a different type of strategy and policy. This article will look into construction digitalization in a nationwide scale. Different countries may have different roadmaps align with their local goals and situation.

In May 2011, the Government Construction Strategy was published by the UK government including a mandate for implementation of Level 2 BIM by 2016 on all government construction projects (Cabinet, 2011). Especially in infrastructure and public sector such as the Manchester Town Hall Building project which is one of the government's pilot BIM schemes (government, 2013). The intended goal for national BIM implementation can be different. The UK is aiming to reduce capital cost and the carbon burden from the construction, in the US several large federal agencies have implemented BIM mandates and the Federal Highway Administration recently launched a focused initiative to encourage BIM utilization among transportation departments in all states. Dodge's research shows that 89% of respondents use BIM on at least some of their projects, with 47% reporting that they use BIM on more than half of their projects (Goodman, 2019). Despite documentation and obligating, it is used in private and volunteer megaprojects such as pencil towers of New York City.

In China Besides software industries marketing BIM tools, the Chinese government has emerged as a major force promoting BIM adoption in China recently, with a guideline by the Ministry of housing and Urban-Rural Development aiming ambitiously for a national BIM adoption rate of 90% by the year 2020 (Thomas Fischer, 2019) the fastest gains are in China. Labor productivity is racing ahead at 7% a

year. Tightening labor supply has prompted firms to test automation. WinSun, a construction company, has built flats using 3D printing. Modular building is also on the rise, with one company erecting a 57-storey tower in 19 days (Economist T. , 2017).

Tremendous efforts should be made by contracting companies and policy makers to benefit from what other developed countries have achieved through technology transfer, and replacing traditional methods with new ones rapidly. This issue could be considered in the process of training engineers and operatives, since it is one of the dominant factors influencing on the productivity of construction projects in Iran (Ghoddousi, 2012). According to (Mostafa Khanzadi, 2018) construction companies in Iran switch from traditional approaches like CAD to new methods to return the investment. The priority for construction firms in Iran is more financial aims than quality and sustainability principles resulting from low rate of profit earning in these firms. Urban BIM projects are Mostly Concentrated in Tehran. It contains 17% of Iran's urban population (Dr.alvanchi, 2019) for instance the Iran-Mall projects is one of the world's top 5 malls and the number one in the Middle-East (Kharvari, 2018) Has used BIM in some of its projects phases. Atieh Gharb Hospital, a thirty-five-floor project (SOLUTIONS, 2018) has also used BIM. They have implemented in a higher maturity than the prior projects (organization, 2020). One the problems that the project faced was lack of local documents and legislation through the BIM implementation.

There are different parties involved in BIM maturity and implementation. The most important ones of which are Universities, legislators, R&D entities, Professional Associations, knowledge Enterprises, Construction Firms, startups, AEC Unions. To mandate BIM legislation in national scale an agile and interactive environment is needed to reach a common language. Countries who play an important role in BIM maturity and implementation made it possible by using "Management and Strategy consulting companies practices (Ball, 2020)". These companies pointed out the deficiencies of construction Industry and played a meaningful role connecting other entities mentioned above. In developed countries one other important role is played by "Professional Associations[1]". Some of these independent organizations for more than a century had a constructive role in developing building codes, regulations, standards, etc.

This interaction enables the industrialized countries to lead the road for BIM implementation and benefit earning to export BIM services to other countries. Since the developing countries lack such organizations and productive relations, they can't mandate legislations and policies according to their needs. This defect causes developing countries to mandate none-local policies.

Also, Countries not preparing their local roadmap will use other countries' resources and experience which might increase the risks involved in BIM implementation such as:
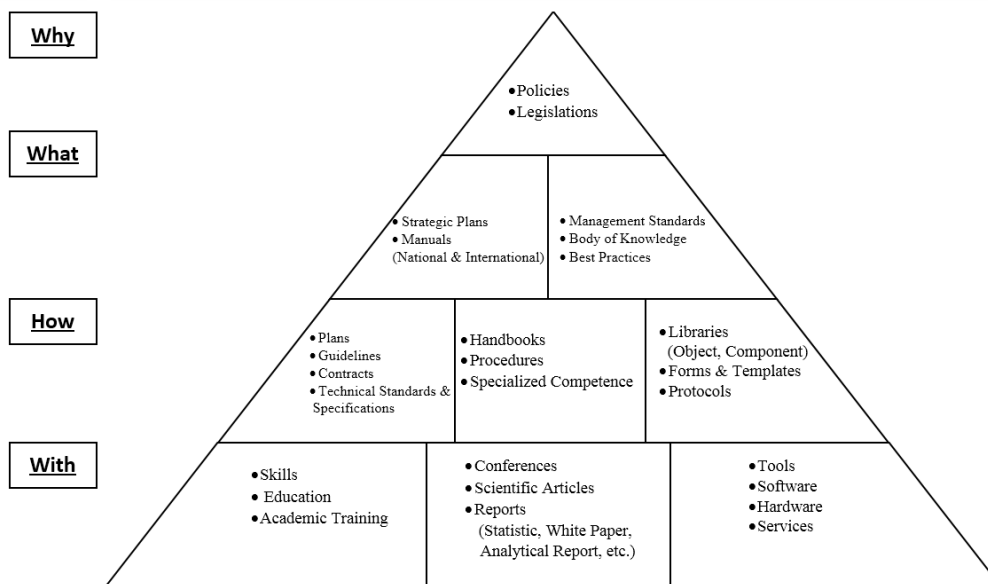
- Lack of using instructions, standards and experiences created by other countries (resource limits);
- Roadmap incompatibility with local needs and current rules;
- Increase in cost for implementation of non-local system and incompatibility with local framework and rules;

In the roadmap to our expected maturity level, government document hierarchy can help us support better corporate governance by creating a shared understanding of the key tools used to establish

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[1]CIOB, Building Smart Institute, Lean Construction Institute, AIA, RICS, RIBA, ICE, CIBSE, NBS, etc.

strategic priorities, maintain activities and operations and to control risks. (Feuerriegel, 2018) According to picture 1, governance documents can be prepared and used in different levels. While willing to implement BIM in different levels, different tiers of governance documents are required.

Picture2: governance document hierarchy

The above pyramid demonstrates specific measures that have to be taken, to be able to move in a desired roadmap.

Why: There are governing organizations such as The Planning & Budget Organization which can create our policy to demonstrate the reason to move through this roadmap.

What: There are frameworks, standards, strategies, manuals and so on, to answer what we are going to meet and how we are going to do it.

How: Specifications, Handbooks expand a Standard, Plan into an explicit set of technical requirements, activities or designs. Plans and Roadmaps contain a defined set of objectives, actions, time frames, performance measures and deliverables.

With: Including tools and practical documents, academic educations, university researches and etc. which is achievable by suitable interaction between professional societies, institutes, universities, relevant firms, forums and other practical bodies.

These levels are completely related in a way that improving one tier can lead to the development of the others. For instance, academic skill and training is needed to use technical tools such as firms' methodologies, technical standards ant etc. And this knowledge and skill can form the needed basis for upper level organizations to develop proper roadmaps and visions.

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Since these governance documents are logically connected, Stakeholders can have access to them. This can mean that efforts from educational and executional organizations can create the basis of BIM implementation. These organizations are working based on needs, researches and education. Organizations concerned with such issues can form the basis for further efforts in higher portions. As well as successful practices and interaction between other practical and educational bodies can help people and organizations concerning BIM implementation. To create documents of the higher tier in the pyramid. And in the path to intended continual maturity, the activities from the lowest and the highest tiers can lead to formation of middle tiers such as management standards and contracts in higher levels of maturity.

When the lowest tier creates the tools and feeds, the basis is formed and thus the prerequisite for the next tier of the hierarchy is available.it is evident that the measures that need to be taken in the highest level of the pyramid is not possible unless the lower levels reach their relative maturity.

Considering the lowest tier, in Iran related tools, software and services are being used by construction firms. As a result, people working in the construction field are familiar with software and tools but not with BIM implementation tools and principals such as procedures, documents etc. The field of education, is limited to some enactments from The Ministry of Science and Research. BIM has been placed in the organization of science, research and technology's educational syllabus under "Construction Engineering and Management" field from 10 years ago (Research, 2013) but it hasn't been worked in a documented and planned way and limited to personal attitude of tutors and there aren't any official courses or educational fields in this area. In research field, some articles, conferences and researches are done by people and organizations especially non-governmental organizations. Lack of active "Consulting Management Firms", "Professional Associations" and "Technical Societies", such as the sample mentioned from the UK, has made the process of creating local standards, roadmaps and visions slower. This can get the implementers import practiced samples from other pioneer countries. This might not be exactly what is needed for our setting.

On the top of the pyramid, strategic planning is needed from governmental organizations. These organizations can shape the upper tiers and facilitate other organizations to create the lower tiers. The fallowing organizations should fulfill their roles to move through the correct roadmap as mentioned in table 1.

Organization	Expected Duty
The Planning & Budget Organization	- Strategic planning and legislation for contractors sectors can create suitable roadmap and plans.
Provincial Management and Planning Organizations	- As a responsible for qualification, ranking and measurement of subcontractors, consultants and experts can consider BIM implementation for this ranking
Ministry of Housing and Urban Development	- legislator for private urban construction

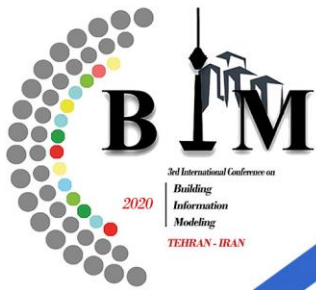| Road, Housing & Urban Development Research Center[2]	- Promulgation and promotion for using new construction methods - Responsible in construction legislation R&D
Provincial Construction Engineering Organizations	- Training and Promulgation Consulting the policy maker
Iran National Standards Organization	- Communication with International standardization bodies - Participation in revising new standards - Documentation and promulgation of technical and management standards - Monitoring and mentoring certification bodies and concerned people
Iranian Society of Consulting Engineers	- As the representative of FIDIC, and by using public and private participation, can help in promoting new agile contracts suiting with BIM environment and needs.
Association of Building Information Modeling	- Gathering BIM experts and role players to share experience and create knowledge and improvement

Table1: Organizations Involved in BIM Implementation

To this aim some efforts have been done. For instance, Tehran Management and Planning Organization is permitted by Iran Organization of Budget & Planning to work on a vision document by means of provincial technical and executive system.

Iran's Road, Housing & Urban Development Research Center has been done researches on construction over the past decade and supported conferences and events about construction digitalization. This organization has also held courses on software related to BIM.

The Ministry of Housing and Urban Development has released the draft of the vision for implementing digitalization. (Development, 2020) They are also the legislator for private urban construction, they will be limited to this section in developing practical document, while the Organization of Budget and Planning has been authorized for strategic planning and legislation for contractors sectors (projects in Transportation, Industrial, Energy, public service etc.) and has a wider range of authorities which can lead BIM to a correct roadmap and continual changes. This organization can help construction digitalization reach a proper roadmap for the intended maturity levels by continual

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[2] The idea of establishing BHRC was formed in 1971 in the framework of "United Nations Development Program (UNDP)", until 1973, which is the beginning of BHRC formal activities, research duties on building and housing were being fulfilled by "the department of building studies and regulations" at the Ministry of Housing and Urban Development (MHUD). In 1971, this duty was transferred to the BHRC based on an agreement between "MHUD" and "UNDP". In 1973, BHRC started its formal activities after completion of construction activities of BHRC administrative building and laboratories for physics and chemistry of materials. (Developement, n.d.)

measurement and changes. According to their announcement in presentation meetings they have achieved 35% progress in planning BIM implementation.

[Scientific] Association of Building Information Modeling has been established since May 2020 with the license of the Ministry of Science, Research and Technology gathering 17 university tutors is expected to fulfill the gap appeared in the ministry's duties by using experts and experiences (Modeling, 2020).Is association can fill the gap the is filled for BIM in academic Section of Iran. According to research by McKinsey's Digital Academy, investing in talent increases the odds of digitization success by 2.5 times. Investing in talent requires balancing the entrepreneurship DNA, industry knowledge, and business acumen to build business unit from scratch—but the talent pool is small when it comes to balancing these three skill sets.

Provincial Construction Organizations as one of the main role payers in training and promulgation has done some efforts such as forming BIM Committee, holding related conferences and preparing educational topics for training courses related to BIM.

It is needed in Iran that high-level bodies ratify laws, create roadmaps, support and fulfill their legal duties and the pressure of the private section of construction industry and accompany the general services and infrastructure projects done under the supervision of government to be accomplished in an efficient way.

Conclusions

Due to slow growth and low efficiency of construction industry in comparison with other industries, the need to utilize a new approach based on technology is obvious. Developing a roadmap and policy for construction digitalization implementation in Iran needs educational and operational infrastructures which can prepare the knowledge, understanding and feeling the need to change in firms concerning construction. Therefore, bodies undertaking training and propagation primarily and then, consulting management organizations can act as propellants to this movement.

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