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Evaluating the Need to Recognize and Measure the Reduction of Duplications in the Hospital Spaces Reform Projects using Building Information Modeling

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ABSTRACT:

Having so many old and burnout hospitals in third world countries is one of the major problems in the health sector. This issue besides low per capital hospital beds has led to many problems in the health department. In big cities, the possibility to provide land for the construction of alternative hospitals is very costly and non-economic and even impossible. Considering the complexities of building a new hospital, the only solution is making reforms in the hospitals through renovation or rebuilding the project. Moreover, increased general inflation and currency fluctuations in third world countries make most hospitals and medical centres into trouble, which this issue results in increased medical costs. Thus, cost savings in hospitals have a significant impact on their workflow and consequently patient satisfaction in terms of quality of services. Lack of proper implementation of hospital spaces reform projects has challenged realization of these savings. Building Information Modelling (BIM) is revolutionizing how to design and implement buildings. Moreover, it is not just a 3D tool in CAD, but it is a kind of database, which makes possible providing a wide range of information about features and relations among various sections of a building. This study aims to evaluate the need to recognize and measure the reduction of duplications in the hospital spaces reform projects using BIM, in order to make significant savings in waste of hospitals' resources. In-depth literature review method is applied to collect proper data aiming to introduce BIM as a tool to reduce costs of hospitals' reforms. This study helps project stakeholders in the field of health infrastructure to better understand the importance of BIM application to prevent various financial wastes in the projects and fulfil their decisions with better recognition.

Key words: Duplication; Spaces reform; Hospital construction; Building Information Modelling, BIM.

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1- Introduction

Hospital is an institute of medicine, which serves using diagnostic, health and medical, training, and research facilities for treatment and hospitalization. In fact, it is the most important service provider unit of each country and has at least 32 beds [1]. Currently, hospitals act in a competitive environment, which the quality of their services is improving. Of course no hospital can provide the best possible services in different areas of medicine; therefore, it should find ways to be able to offer a different strategy from other similar medical centres. According to the report of the Office of Physical Resources of the Ministry of Health, the cost estimation for reconstruction and repairs of old hospitals in Tehran is 120 percent. The process of positioning helps the centre to maximize its success. In order to achieve this superior position, it is required to identify the treatment market and know what our clients desire [2].

Nowadays, many hospitals old are and burnout in third world countries. It is one of the major problems in the health sector. This issue besides low per capital hospital beds has led to many problems in the health department. In big cities, the possibility to provide land for the construction of alternative hospitals is very

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costly and non-economic and even impossible. Figure (1) shows different stages for building a hospital from beginning to end. In Iran, as a third world country, this process takes about 10 to 15 years, which is a long time. So many stakeholders' demands of this section should be met through changing the uses of spaces and rebuilding.

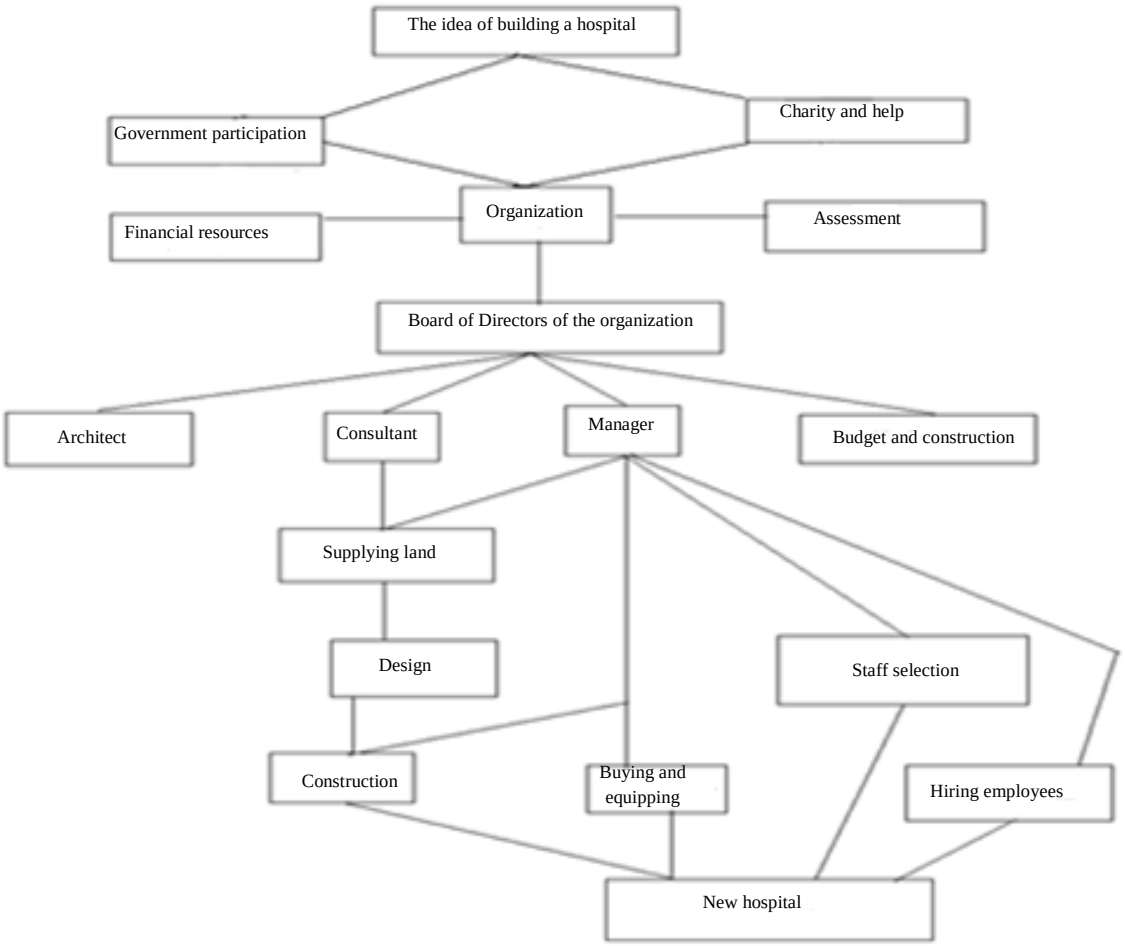

Fig. 1. Different stages for building a hospital from beginning to end [3]

Another problem for the Iranian health projects, particularly hospitals of Tehran, is lack of complete drawings due to their old age and losing their data during these changes over time [4]. Moreover, sometimes their data is lost due to repeated rebuilding and changing the use of these spaces and not drawing as-built maps when rebuilding, and changing their use and physical and spatial constraints. In addition, paying attention to the issue of modifying user spaces in the shortest possible time, accompanied with no disturbance in providing services by these centers to their patients and maintaining their quality and value for long time and reducing waste production are necessary [5]. One of the most time-consuming and costly sections in the issue of spatial changes and their rebuilding, is identifying and initial judgment and providing the necessary information from the existing structure for optimal decision making.

National Institute of Standards and Technology of the United States has estimated the loss of about $15.8 Billion due to lack of coordination among computer engineering designs and software systems for building operation and maintenance. The biggest reason for this problem is due to losses during operation and

maintenance that was about $9 Billion. Moreover, according to the report issued by the Office of Physical Resources Ministry of Health, cost estimation for changing user space and rebuilding old hospitals in Tehran is about 120 percent [6].

Currently, lack of complete maps of hospitals due to their old age and losing their data in these changes over time [4] and sometimes due to repeated rebuilding and changing the use of these spaces and not drawing as-built maps during rebuilding and changing their use and physical and spatial constraints, and also the issue of changing their use in the shortest possible time accompanied with no disturbance in providing services by these centers to their patients and maintaining their quality and value for long time and reducing waste production and increasing floating efficiency in changing medical spaces [5], have resulted in using a more accurate and efficient system. In addition, having a comprehensive database for building hospitals is necessary for better decision making processes in reform projects [5].

Using modern systems and having access to more accurate information about the elements of a set, can meet some of these shortcomings in the section of changing user spaces and hospital rebuilding. The aim of this study is achieving the desired goals and improving management of hospital rebuilding projects, using Building Information Modelling (BIM). This has been discussed a lot and even was implemented in some European countries, but it is examined very limited in the field of rebuilding [7] [8].

Since in third world countries like Iran, there is severe issue of rebuilding and changing user spaces, particularly in old hospitals, presenting a new working style and model can significantly help these centers to control their time and cost. This study evaluates the need to recognize and measure the reduction of duplications in the hospital spaces reform projects, using BIM. Next section reviews the studies conducted in this field.

2- Literature review

2.1. Hospital reforms

Health is a commodity that cannot be priced. In other words, health is a commodity that should be supplied completely and absolutely, and its maintenance is more important than any other financial concern. Yet, maintaining health needs significant budgets, and available limited resources should meet these demands as much as possible [9]. Health promotion and maintenance is considered as a social-economic issue and political attitudes and designing service delivery systems and resources distribution play a significant role in this field [4]. Hospitals- as one of the institutes providing health services- have major significance in economics. This feature is more prominent in developing countries.

The issue of changing use and rebuilding hospitals in Iran goes back to past years. Such that Merritt Hawks from England came to Iran by ship in 1932. He, in his travelogue to Iran titled as “Iran: Myth and Reality”, confirmed this issue that the late Grand Ayatollah Sheikh Abdul Karim Haeri - Founder of Qom Seminary- built the first Iranian treatment center in Qom.

He wrote: “Two good hospitals are building in Qom; one of them is building by a man from Qom and the other one by a man from Tehran. Before the construction of these two hospitals, medical services were restricted to an old hospital with 30 beds, which was managed by the personal income of a great spiritual reference.” A history scholar and researcher in this field, believes that: Sina hospital is the first hospital in Iran and Tehran, which is now located in Imam Khomeini street. This building was created in the era of Naser al-Din Shah, called ‘State Hospital’, and a hospital space was built that was destroyed completely during the first Pahlavi era. From then until the second Pahlavi period, Sina hospital was rebuilt and developed. After a while, it was registered in the list of national works and the first medical reconstruction was performed [10].

Hospitals can be divided into the following groups: the small (up to 50 beds), medium (up to 150 beds), standard (up to 600 beds), and the large ones. Hospitals’ sponsors can be the government, charity or private

institutes or a combination of them. According to the type of hospitals' activity, they can be divided into general, specialized, and academic ones. General hospital is a health and treatment unit, and should have at least four hospitalization sections (Interior - General Surgery - Gynecology – Pediatrics) and sections of laboratory, pharmacy, radiology, medical emergencies (Emergency), and nutrition, all of which are essential parts of a hospital [11].

Starting, operation and continuing the activity of the general and specialized hospitals are subject to launching various sections of a hospital and medical emergencies. Employing technical authorities of the hospital, technical officials of paramedical department, and medical and paramedical staff looking for job in all sections of the hospital, is done after the approval of the legal commission and obtaining the necessary licenses from ministry's relevant units and in compliance with legal regulations and requirements stipulated in bylaw. In terms of ownership, hospitals are divided into three categories: public hospitals, private hospitals, and nonprofit (charity) hospitals. One of the important issues in hospitals both at the time of design and planning and during operation is the possibility to change its use and following that, developing the hospital. Factors such as population growth, increased volume of patients, increase in the mean age of the population, hospital recognition, etc. make the significance of paying attention to the performance and flexibility of the hospital double. In fact, inflexible building, in which the possibility of changing usage is very low, reduces the efficiency of the hospital in providing services. Therefore, it should be possible to change the use and future development of the hospital based on the needs of planning and design [12]. Moreover, changes and design and development can be divided into two categories: 1. Short term and temporary changes; 2. Long term and permanent changes [13].

The main problem in providing health services is the economic issue. Hospitals are considered as one of the most important and costly units of the health system in any country. Hospitals as one of the main organizations providing health services have special significance in economy and health. In the study conducted at Queen Elizabeth Hospital during 1998 to 1999 to estimate costs, researchers, through step-by-step accounting procedure, demonstrated that the most costing factors are related to dialysis, work force, consumable requirements and overhead services and direct costs were 80.7 percent of total costs [14]. Another research shows that the largest share of costs is allocated to personnel costs and building costs, thus they are the most important priority in controlling costs [15]. Generally, hospital costs can be classified into five major groups: 1. building and permanent structures, 2. equipment, 3. personnel, 4. urban facilities, 5. materials and supplies [5]. However, according to information provided by the Cooperation and Welfare Fund of the Medical organization, factors such as reduced economic power of people and patients, refusal of supplementary insurance from the conclusion of a fair contract compatible with the current economic conditions of hospitals, uncertainty due to currency changes to supply imported consumables, intense growth of current and personnel costs and insurance payout delays, have caused problems in hospitals' administration. Despite the high costs, these hospitals should maintain their quality of services and equipment due to competitive issues and accreditation. Whereas if the growth of costs and treatment are the same, hospitals' efficiencies will be negative [11].

Having a smart multi-dimensional model that saves the project information, and serves as a common information source among the whole design and construction team, helps solving problems significantly [16]. Next section reviews the current literature on one of the most recent modeling techniques introduced for the construction industry.

2.2. Building information modelling (BIM)

BIM was raised since 2003 in the field of technology progress, and now –after passing more than a decade- it has reached a significant position at the international level. The philosophy of this method is based on construction and optimizing a comprehensive digital model of the building and applying it at all stages of the project lifecycle. It includes all elements of the final building and each element has its own special certificate [11]. BIM is a computer-aided modeling technology, which is used for management and production of building information and production-related processes and analyzing building information models [17]. There is no certain definition for BIM. There are various ways to state what is called BIM. According to the definition provided by National Standard for BIM in America, it is a digital representation of physical and applied specifications of a structure, and a common knowledge source for information related to a structure, and a reliable base for decision making during its lifecycle. BIM fundamental hypothesis is helping various stakeholders during different stages of a structure lifecycle.

Using BIM allows stakeholders to have a vision of future and see the final design as a multi-dimensional model, in order to find what will be delivered to them in reality. Knowing this issue and having a database in the building, is very useful for decision making to change its use or repair or possible future reforms during the operation of it. Moreover, it is clear that having a real model of the building based on BIM models, is very useful for the operation phase of the building, particularly in buildings with special usage such as hospitals [17].

This methodology has gained popularity among companies active in the construction industry. Yet, in some countries the acceleration of this move has been more than others. In North America and Europe, this method is relatively mature. Given that this idea was first raised in Europe, twelve percent of companies active in this field in Europe have a history of more than six years; particularly in England more than nineteen percent of active companies have a history more than ten years.

In countries like Japan, South Korea, Australia, and New Zealand, using this method is developing gradually. So far, several projects have been conducted using this technology; which we can refer to the development plan of Al-Murfaq Hospital in Abu Dhabi-United Arab Emirates that was started to increase its capacity and renovation and updating technology since 2011 [37], or Maryland Public Hospital in the United States as another example. However, there are some issues regarding BIM implementation. In fact, replacing a 2-D or 3-D environment with a BIM system requires actions more than just buying software and training it. Another problem of BIM is that its efficiency varies for large and small projects. In the present situation, maybe the best efficiency of BIM is in projects with medium size and complexity. It is noteworthy that in very small projects, traditional methods are more efficient; if they are done correctly. Another problem for proper BIM implementation is lack of a correct understanding of its capabilities. It is said that using BIM, increases costs of modeling and design, and in opposite, the amount of demands will be reduced. Maybe the reason of this issue is incorrect structure of teams and trends.

This paper addresses BIM potentials, and the effect of BIM on reducing costs. BIM has the potential to enhance many processes and patterns in the construction industry, although maybe it is not possible to use all its advantages.

BIM's potentials in the phase before starting the construction are:

1. Facilitating the discussion related to conceptual design, feasibility, and design; such that before starting the construction it can be understood that given the project size and quality and usage, with the intended budget it can be constructed or not.
2. Enhancing building's quality-performance; that early evaluation for various options of design will increase the overall quality of the structure through analysis and simulation tools.

3. Enhancing coordination among project agents through integrated project management system, which in fact is since starting the initial design, developing a common understanding of the project needs and cost estimation, facilitates design and of course there is no need to paper and map for communication of these agents.
4. More accurate and early presentation of design
5. Developing automatic corrections when making changes to the design
6. Producing consistent and accurate 2D maps at any stage of design
7. Extracting construction costs when designing

BIM can also be beneficial in the construction phase in different forms through:
1. Rapid response to the changes made in the design
2. Finding mistakes or omissions in the design before achieving the construction stage
3. Coordination between design and construction plan
4. Coordination of procurement with design and construction

BIM is also beneficial for the post-construction phase through:
1. Better project delivery by the beneficiary and employer, and accurate transmission of information
2. Better project management and operation

Although using all the benefits and uses of BIM maybe unattainable, one of the philosophies of using BIM is applying optimization techniques using joint meetings between beneficiaries and designers. It is achievable given the possibility of frequent repetitions from various designs and different options in short term. Because in this case, if a change is necessary, there is no need to prepare all of the designs and maps from beginning, and in fact, the best result is obtained out of the lowest cost. Also, preventing various factors such as wrong and inaccurate estimations, human mistakes, waste of materials, clashes among project teams, and arising claims, the demand to change due to flaw and errors in the initial design, preventing accidents and safety issues, inflation due to rush in the project completion, increased costs and overhead and duplications and repairs, reduce the project cost [17, 18].

For modelling BIM in the design, construction, and operation phases of project lifecycle, various software are used. One of these software is Navis works, which is worth noting that this software enables architects and building engineers to investigate an integrated model and also helps all project practitioners and stakeholders to achieve better outcomes, integration, analysis, and communication at the time of design and solving interactions and estimation. Moreover, it provides project schedule before construction or at the time of rebuilding and updating. This software, like most of Autodesk software, is multi-mode. Using this software, you can predict and prevent some of the potential problems before any construction, and minimize the construction costs [24]. This software originally designed by one of the subsidiaries “Light Work” in England, then in 2007 it was bought and developed by Autodesk Company [25]. It is expected in this study, this software help evaluating the need to recognize and measure the reduction of duplications in the hospital spaces reform projects using BIM, and can reduce many concerns about increased costs and time of medical projects for engineers and activists in the medical section.

3- Research methodology

The present study is a kind of scientific research. In terms of the aim of study, it is an applied one, because it aims to develop applied knowledge in a specific context. The progress of this study advances knowledge application. Therefore, it can be concluded that an applied research doesn’t look for the theory; however its aim is applying the previous theories [19]. This study qualitatively uses library study to fulfil the research objective. Given the nature of the subject and the purpose of the research, this study is a qualitative research. Most of the qualitative studies aim to examine events, to explain and compile assumptions, and to understand the relations among processes [20]. The present study is a survey study in terms of the applied purpose and the

nature of descriptive research. Generally, theoretical and library-based studies, whose data is collected through measurement tools related to taking notes, table, card and etc. are considered as qualitative studies [21]. The next section will analyze data collected through qualitative library studies. The research methodology used in this study is a descriptive one. Data collection tools used here, is reviewing library studies. In terms of reliability and validity, it has practical or empirical validity [19]. In the next section, we will analyse the data collected through qualitative library studies, and finally we will state the research conclusion.

4- Data analysis

Generally, various factors are effective on raising duplications during the operation phase in hospital projects, which identifying and evaluating them can play a significant role in improving the management of critical civil projects in the country. Therefore, in this section the most important factors effective on duplications are identified and discussed. The parameters extracted from literature are considered as research basic information and its main hypotheses were shaped accordingly. Then, sub-criteria related to each factor were identified and considered as research unknowns, including resources and material, building design and implementation parameters, and many other factors.

Independent variables include:

1. Factors related to the employer
2. Factors related to the contractor
3. Factors related to the designer
4. Other factors

Each of these factors is divided into a series of sub-factors, and is considered as dependent factors. Although these factors might look similar to each other, of course the severity and priority of their effects on sustainable development goals are not the same. Thus, considering criteria to prioritize the most important identified factors can facilitate achieving building industry productivity. These factors were identified qualitatively and quantitatively after reviewing current researches conducted on affective factors for creating duplications.

Accordingly, the most important identified factors were categorized in four groups, each of which is divided into sub-factors. These sub-factors are 33 items presented in the following table.

Table 1: The most important and effective factors on raising duplications in the hospital civil projects

Row	Factor	Sub-factor	Ref
1	Factors related to the employer	Insufficient information	[20]
		Lack of a clear plan in the implementation of study plans	[21, 22]
		Contractual weakness and as a result, not recognizing the claims	[13, 22]
		Executive weakness in communication and inconsistency among all sections of the project (contractor, consultant, and employer)	[23]
		Too much interference and commands to change from the employer	[24]
		Financial constraints encountered by the employer	[21]
2	Factors related to the contractor	Incorrect technical studies by the contractor during the bidding phase	[24]
		Failure to equip the workshop on time	[25, 26]
		Poor site management and supervision	[27]
		Weakness in contractor executive management	[28]
		Technicians with inappropriate expertise assigned to the project and insufficient experience of the contractor	[23]
		Equipment and materials problems	[25, 26]
		Poor project planning by the contractor	[29]
		Ineffective assurance/quality control by the contractor in resource allocation	[25]
		Financial problems encountered by the contractor	[30, 31]
		Lack of motivation for contractors to finish the project on time	[28]

		Inappropriate planning of the contractor in the tender phase	[28, 31]
		Using incorrect or outdated construction methods	[28]
3	Factors related to the designer	Poor management of contract and disputes and mistakes in the contract documents	[21]
		Defects in the preparation and approval of project plans	[20, 32]
		Incorrect design due to lack of familiarity with environmental conditions	[20]
		Lack of control of quality assurance	[20]
		Technical weakness and lack of executive view of designers	[20, 32]
		Poor coordination of the designer engineer with other plans involved in the project	[20]
		Not using the experience of previous projects	[27]
		Inadequate experience and poorly qualified engineers	[20, 32]
		Unrealistic inspection and testing procedures presented in the contract	[29]
		Inefficient use of equipment	[25]
		Poor control of subcontractors by the main contractor	[22, 23]
4	Other factors	Changes in laws and government regulations	[21]
		Severe weather conditions in the workplace	[20]
		Difficulty in obtaining work permits	[21]
		Unknown factors not predictable in the course of studies	[25]

As it is observed, in this study the most significant factors and affective sub-factors on raising duplications in the hospital civil projects are investigated and classified. Studies conducted in the UK show that more than one third of employers are dissatisfied with the performance of contractors in sustaining the costs and scheduled time, solving problems and delivering projects with the required quality. Moreover, more than one third of employers are dissatisfied with the performance of consultants in coordinating the design team, providing fast and reliable services, and creating value for the capital. This dissatisfaction is due to this fact that in the construction industry, more than 50% of the construction projects are encountered with delays and cost increase, and more than 30% of completed projects are accompanied by problems and shortcomings. In addition, about 30% of constructions suffer from duplications [33]. Studies show that changes and duplications impose maximum additional costs on the project. Such that in Canada, the cost of changes and duplications is 10% of the total project costs and 25% of the construction phase costs (implementation). According to a study conducted in Australia, direct costs of changes and duplications are 6.4% of total project value and its indirect costs are 5.9% of total project value. In Sweden, duplications include 4.4% of the building value that add 7.1% to the working time [34]. According to the findings stated, it is obvious that change commands play a major role in large projects and can affect project success positively or negatively. Particularly, in the project implementation phase (considering the high number of change commands in the construction projects) there is a significant need to investigate and manage changes.

One of the most time consuming and costly sections of buildings repair and restoration is identifying and providing the necessary information from the available structure for optimal decision making. At this stage, studying the history and specifications of the plan, measuring structure elements (resistance of bars, concrete,…) and also examining the quality of beams and columns of the building and studying the geotechnical reports of soil and technical specifications maps are among the more necessary actions. At this point, if information of the building and structural components are not sufficiently available, repeated visits of the structure and using nondestructive methods such as Schmidt hammer, ultrasonic method, coring and many other methods and tests will be inevitable for determining the resistance of various parts of the building. This is while more accurate information on the building and its structural components are available, the time and cost necessary to identify and judge correctly the way of repairing the building are to be dramatically reduced [35].

Using BIM as a new technology in building construction, different building information can be collected from structure and architecture to building facilities and infrastructure information. In fact, in this way we can prevent the stages of evaluating, identifying, sampling, and reviewing in building restoration and renovation

projects. During BIM implementation, all information about the number and size of structural and non-structural components, their resistance, type of material used in detail, type of soil and its conditions, analysis and design conditions are collected in digital files. This collection with advanced information, which is considered as an electronic ID for the building facilitates the job. For example after the earthquake, for buildings restoration, the least time is spent for identifying buildings, and just by referring to the building BIM files in less than a few minutes, the required information about the structure, architecture and facilities of the building are extracted. Thus, time and cost of repair and reform operations in buildings are reduced significantly, and this issue is so vital in the event of a crisis.

BIM technology, relying on visualization of building information in the form of multi-dimensional graphic models and integrating comprehensive qualitative and quantitative information of the building and its structural components and facilities, construction methods and materials used, besides the results from technical tests are considered as a reliable source and database for buildings. It can omit the process of identifying buildings at the time of repair, and facilitates restoration, reinforcement, and reform operations in a building or infrastructure.

Moreover, using BIM a proper estimation the amount of damage to buildings and the required time and cost for their restoration is calculated. As an example, having a multi-dimensional BIM file of a building damaged earlier by the earthquake significantly help to predict the amount of damage, the time required for restoration and the ways to repair them. Applying this capability, particularly in the high-value buildings and security ones, is very useful for providing optimal and rapid decisions at the time of restoration and reinforcement and/or crisis.

5- Conclusion

In this study, the necessity to identify the solutions to reduce duplications in hospital spaces' reforms was raised using BIM. Moreover, the effective factors on duplications of hospital spaces' reform projects were determined, and thus the significance of assessing the need to identify the solutions to reduce duplications in the hospital spaces' reform was proposed using BIM. Given the benefits of BIM, presenting solutions to manage duplications in the executive tasks using BIM for all stakeholders of the project, makes them to apply this technology in their projects with more willingness and to prevent many duplications and wastes of project time and cost. In future, researches such as identifying the factors causing the increase in workload in the hospital spaces' reform projects and also identifying the main potentials of this system in reducing duplications in the hospital spaces' reform projects will be performed by the author.

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