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Study the Effects of Construction's New Techniques and Technologies on Time, Cost and Quality of Construction Projects from the Perspective of Construction Management

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ABSTRACT

The tendency to utilize the new technologies has increased due to ever increasing of the population and growing demand for housing as well as the ineffectiveness of traditional construction systems in our country. One of the main goals of using new methods, is to enhance the speed and improve the quality and structures' resistance, which is used in many projects in the world. It has been tried to investigate the effects of new construction technologies from the perspective of construction management on time, cost and quality of construction projects and also study their problems and development issues in the country. The subject's generalities and the literature review are expressed in the beginning of this research, and then the new methods in the world are presented briefly. Following this, the effects of this method on construction projects have been investigated using field studies and experts' opinions. The results of this study indicate that these methods will accelerate the projects time about 50%. Besides, construction costs have increased by about 30% in most individual projects and decrease the costs in mass projects. Most of the use of new construction technologies is in skeletal stage and installation of facilities. In recent years, the owners' tendency to new construction methods has increased in mass production projects. In recent years, the expertise of contractors has also grown and encouraging incentives from organizations like the municipality will lead to the development of these methods in the country. The greatest impact of modern technologies on construction operations is on the integrity and more stability of the structure, the long-term quality of that, the acceleration at the time of construction, better resistance to natural and environmental hazards, such as earthquakes, reducing the costs in massive construction scale, beauty and less harmful effects on the environment, more efficiency of installations and optimizing energy consumption.

Key words: New technologies, Construction, Time, Cost, Quality, Construction projects.

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1. INTRODUCTION

With increasing the population and growing demand for housing, as well as the ineffectiveness of traditional and conventional construction projects, approaching to new methods and utilizing the of modern technologies in production of the structures, seems necessary. One of the main goals in tendency to use new methods and technologies is to increase the speed and improve the quality of construction. In many executive planning, the speed of the execution operation plays an important role in choosing the construction method. Evaluation of traditional building systems in the country indicates that most of these systems are unable to implement the construction projects in a short time and with a suitable quality. The proper way that the government can control the housing market, is to use the

new construction methods. One of the reasons for not using these methods is lack of awareness about its details and benefits, which is unfortunately less common in all social strata, including engineers, authorities and ordinary people (1). Major researches on the application and impacts of new construction methods on time, quality and cost of projects has been as a practical and regular study on specific circumstances in each project. Following studies may be mentioned in this subject: Becchio et al (2) conducted a study about the industrialization importance of constructions and providing the necessary strategies for its development. The results of their research indicate that there have been plans for industrialization of construction in the country during the last decade, which did not succeed. Mehta et al (3) conducted a research on new methods of constructing a building with a tunnel method. The results of their research demonstrate that through industrial production not only the basic indicators of time and quality resources are managed, but also basic indicators such as safety, sustainability, optimal energy consumption, environmental considerations, recycling management, visual quality, architectural identity, etc., are realized, since the development of construction industry, today is one of the developmental attributes of the countries and considering that construction is one of the largest sectors of the country's economy. Nam et al (4) studied the industrial construction of the building via a permanent insulation system. In this research, they have investigated the industrial implementation of buildings using permanent insulation and considered the advantages and limitations of this method. Stucki et al (5) investigated the new ICF method and its role in industrialization. The purpose of this study is to review the concept of construction′s industrialization, introduce the ICF system, and to describe its benefits and limitations from different perspectives. Bainbridge (6) studied the potential of nanotechnology in modern construction materials. Different types of nanomaterials that have been used until today as well as their benefits, has been presented. Finally, the use of nanotechnology means saving the heavy costs of construction and maintaining the future buildings and creating more employment in construction industry. Huang studied the modern technologies and methods of industrialization in several cities in this country regarding the China's economic and social conditions. Some other researches have been done including the study which has done by Kamar KA (7) in 2009 in Netherlands. In this research, he evaluated the modern construction methods for residential buildings, the future of industrialization methods and their harmonization with different human needs. In 2001, Russell (8) reviewed the adaptation of modern constructional technologies with economic and social needs in Canada. Richard (9), examined the methods of industrialization and modern manufacturing technologies from the perspective of quality, economics and sustainable development. Lundvall (10) studied various industrial construction methods in terms of the quality of economics and technical issues and suggested some solutions to develop these methods in Iran. In another study by Sebestyen G et al (11), the industrialization strategy of buildings was studied during the next twenty years in the country. In this research, new used methods in building construction projects in the world in order to build the structures are first explored and following this, the effects of using these methods on time, cost, and quality of construction projects are investigated. In addition, some solutions to develop them in the country are presented .

2. SPECIFICATIONS OF NEW CONSTRUCTION TECHNOLOGY

The following characteristics are the prerequisites for success of using new technologies and industrialization of construction:

Centralization of Production
Mass Production
Standardization
Specialization
Good Organization
Integration

In order to achieve new technologies and industrialization of construction in all its aspects, the whole chain of construction should be considered. In construction chain, the first hoop is "design" which is categorized into four components: "design, architecture, structures, and facilities", and it is clear that urban design is their basis. In traditional construction chain, it is presented that after passing through the design stage and considering its output, more than about 300 building items commonly included in the plans; however, this number may vary depending on the size and scale of the project. These items include skeleton, wall, ceiling, door and window, stone, facilities, and so on (12). This large number of items, firstly, has a major problem with mass production and utilizing new technologies, and secondly, it leads to a reduction the overall performance of the construction process. For example, various studies have shown that large amounts of building's waste materials and a lot of work repeating in construction process are due to the lack of parts' assembly and also the lack of coordination between designer, producer and manufacturer in the construction chain. Therefore, the possibility of categorizing the building components within reasonable and limited ranges is created and the number of building items decreases by standardizing the components. Only in this case, the minimum required circulation for the optimal number of mass production and using new technologies are prepared. The mass production process and the brigading of components in the construction chain also carry a recursive path and the number of building items which decreased from about 300 to 50, has been made available to designers and they design brigaded items based on them. This back and forth process requires high coordination in the construction chain.

3. TYPES OF CONSTRUCTION METHODS

Types of construction methods may be classified into seven major categories:

3.1. Elementary Building System

This type of building has begun from the beginning of human history's construction, and continues until now, and still exists in some villages of the country and in the suburbs. In this method, the loaders are from clay and mud, wood and mud, mud and stone, or clay and brick, and their cover is made of a vault of bricks, or wooden beam and plant fibers. The used manpower in these buildings are sometimes unskilled or semi-skilled and use available traditional materials. Construction using such methods has the least resistance to natural disasters (earthquakes, floods, storms, etc.). It can only be used as a temporary shelter (13).

3.2. Traditional Building System

In this method, construction operations are performed using primary equipment by experts, semi-skilled and unskilled persons. Brick walls buildings are included in this category. Some of the involved professions in this method are simple workers, masons, plaster workers, painters, blacksmiths, plumbers, wire workers, work insulators, tile workers, asphalt workers, glaziers and so on. Currently, this method is used in most of the urban and non-urban areas around large cities or some specific buildings (schools and mosques in the villages, etc.). The most skilled craftsmen and traditional carpenters are found amongst these kinds of builders. Maximum allowed floors using this method of construction, is 4 floors with an authorized height of 12 meters. Because of tolerating the vertical loading of the building by the loader walls, the thickness of the lower floor walls is increased, which is one of the deterrent factors in increasing the number of floors or their height. By creating some arrangements such as horizontal and vertical concrete floats, earthquake damages can be reduced.

3.3. Advanced Building System

This method that is known as advanced or improved building, consists of: working by persons and experts who were mentioned in the previous method, which uses mechanical machinery and equipment to accelerate the work. Structures that have metal or concrete skeletons are included in this category. Some of the used instruments in buildings include: different types of fixed and portable cranes, electric lifts, metal scaffolding, concrete manufacturing equipment (fixed and portable), cement, color spray machines, welding machines, etc. The speed of construction in this method is average and about 20 to 48 hours per square meter of infrastructure. This means that the speed of construction operations can be greatly increased by using mechanical and electrical equipment. The number of floors and total building height can be predicted more than 50 floors and 150 meters due to the use of concrete and metal skeletons. The initial investment for using this method is significant according to the volume of construction operations and purchasing or renting the equipment. Stopping the work due to labor issues or financial problems is a disadvantage of this method and will result in the loss of the project. Now, most constructions in urban areas use this method and such residential or public buildings are built in less time and with more safety and security through training the specialists in related fields and innovate new equipment and instruments and utilizing modern technologies.

3.4. Industrialized Building System

Prepared components are used in this method, such as blocks, beams, prefabricated panels, concrete pillars, metal networks, gypsum and concrete elements, and so on. Most of the operations are mechanically done using the workshop equipment and accessories. Different types of integrated metal molds, such as sheet, tunnels, sliders molds, molded modules made of light materials, as well as plastic molds, slippers and sliders, are also used in this method in the whole year in order to fast concreting of the buildings. The number of specialties and workers in this method has less quantity than the previous methods, but in terms of quality, experts should be employed at a high level of technical skills and precision. The speed of the work in this method lasts from 9 to 14 hours per square meter. By proper planning and application of appropriate technologies, this method can compete with heavy predictive methods. However, the number of skilled and semi-skilled workers is more and the initial investment is less than the pre-fabricated methods. If more than 50% of components are made in the factory, it is referred to an industrial building system.

3.5. Heavy Weight Pre-Fabricated Systems

Using pre-fabricated heavy methods is about buildings with more than one floor, in which all building components such as walls, facades, ceilings and stairs, etc. are pre-made in a concrete factory, and transferred by heavy machines to all workshops and then shipped and installed. Carrying parts with a weight of more than 12 tons is done by a trilogy and their installation need fixed or mobile heavy cranes. Because of heavy weight of the components, the transportation distance of maximum 60 km from the factory site is economical, and for more distances the economic justification of it should be considered. The cost of constructing a factory or some kind of initial investment in the prefabricated heavy system is high and requires an accurate economic estimation. It has been proven that for the construction of pre-fabricated factories, at least one or two residential projects with about 1,000 units or any other project with an infrastructure of about 100,000 sq. m are required in a 60-kilometer operating radius (14). The Tehran concrete components factory, is an example of this method, which is an affiliate

of the National Land and Housing Agency using the German system.

3.6. Middle Weight Pre-Fabricated Systems

The maximum weight of the components is 5 tons, in this system. The skeleton is a metal or concrete structure. Roof and exterior walls are made from concrete units and internal separators are made from gypsum boards or wood. The weight and dimensions of the facade are considered in a way that light cranes can raise and install them. According to the metal skeleton or concrete loader that can be prefabricated in factory, there is no limit for the floors' height. The limitation of dimensions of the reinforced concrete columns in the lower floors is one of the determinants of the height of these skeletons and it is noticeable in buildings with more than 50 floors. The facade components should be installed because in the Armenian earthquake most of the prefabricated parts of the facade segregated and caused many problems.

3.7. Light Weight Pre-Fabricated Building Systems

This group of prefabrications is more used for one-story buildings or for high-rise buildings with metal or concrete skeletons. This method can be used to construct rural schools and houses, out-of-town resorts or mobile homes. The skeletal carrier of the building, the ceiling, and the external and internal walls are made of a material or a combination of materials and lightweight metals such as aluminum, wood, fiberglass, metal sheet, fiber, petrochemicals, porous concrete, lightweight concrete and so on. Lightweight prefabricated components are considered as integral parts or combinations of less than 2 tons, so transporting them via electric or mechanical lifters and small mobile cranes is possible. This method can be used properly, for temporary and emergency accommodation, gypsum houses, semi-temporary clinics and the establishment of workshop personnel. During the Iraq imposed war on Iran, using this type of procedure created appropriate conditions for saving time and the speed of spatial coverage. If the construction of the building using this method and utilizing the details is done carefully, the building can be opened with minimal damage and its parts can be moved to another place to reinstallation, after installation in a place and ending its performance. The prefabricated lightweight sandwich panels (3D Panel), which are one of latest technologies in construction industry, are the achievements that has accelerated the construction plans concurrent with increasing the need for housing. With preliminary studies that began in 1993, the pre-fabricated light industry in Iran and the world was investigated and subsequently the idea of using prefabricated light industry was developed that its main advantages are light weight building, speed, resistance and quality (15).

3.8. Using new pre-fabricated technology

Due to the ductility of concrete, prefabricated pieces can be placed in various molds. The proper design of these templates can meet structural requirements on one hand and architectural needs on the other hand. As a result, elegant and durable structural elements can be designed simultaneously in a prefabricated concrete piece and easily executed. Precise control of concrete's quality in prefabricated parts (due to its mass production in production line of the factory) increases the confidence coefficient and, as a result, reduces the design and construction costs. Today, pre-fabrication and industrialization are of the new technologies in construction. The upward trend in using the prefabricated components in construction continues with an impressive acceleration using the current technology. These days, various types of prefabricated pieces are used in many buildings. This industry reveals its value especially in unexpected events and natural disasters. Today's buildings including residential and office buildings, metal skeleton towers, space structures, sports stadiums, industrial halls, parts of bridges and tunnels, building facades, non-carriage parts of the building, water supply and sewage networks, power lines, airports, multi-story car parks, retaining walls and hundreds of other examples are the most representative of this industry in the world. Using new materials with desirable qualitative characteristics concurrently with the growing trend of using steel and concrete in prefabricated structures, has led to reducing the cost, construction time, ease of implementation and variety of structural systems, and the building industry has faced an appropriate prosperity along with the beautiful architecture, and approaching the golden age of transformations.

4. NEW CONSTRUCTION METHODS AND TECHNIQUES

Perhaps the common conception of new construction methods may be different from its true definition, so if we want to have a more realistic definition, it can be said that the invention of any new method in construction with the goal of mass production and the reduction of various energies including labor, thermal, cooling, etc. are included. Therefore, it can be said that, principally, modern methods and technologies cannot be considered as an independent skeleton structure because the skeleton of these buildings are usually as either metal or concrete, or a combination of metal and concrete structures. Some of these methods are briefly introduced in Figure 1 .

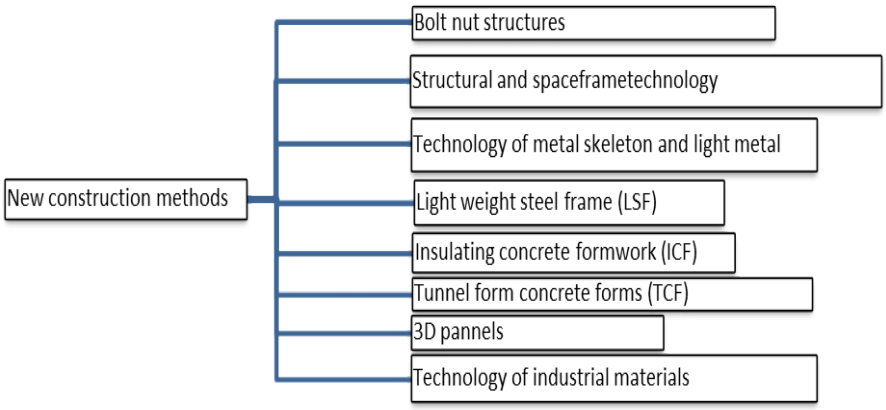

Figure 1. Some new constructions methods and technologies

4.1. Bolt nut structures: "B & N"

This method is in fact a kind of metal structure method in which instead of welded joints, bolt and nut joints are used and concrete is used for ceilings. As we know the main weakness of joints in the structures, is its welding which this fault is eliminated in bolt nut structures' method. The cost of implementing this method is higher than conventional metal structures due to the need to preparing standard metal profiles and installing joint bolts, but this increase may be lower than 3% for total cost of the building.

4.2. Structural and space frame technology

This method is commonly used in halls, courtyards and large covered areas. Its features are high speed and high quality, lightweight, component separation ability and high cost (Figure 2).

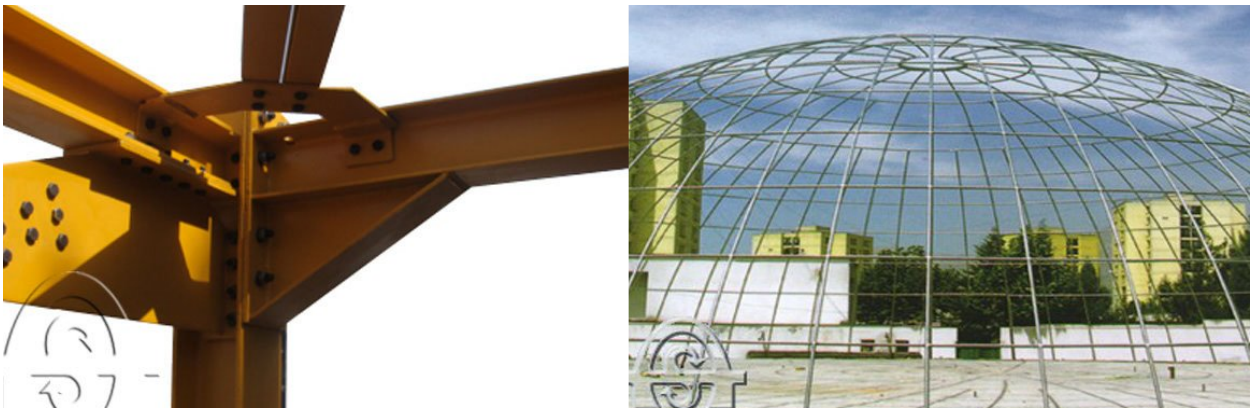

Figure 2. An example of structural technology and spacer roofs (right), Bolt nut structures (left)

4.3. Technology of metal skeleton and light metal

This method is used for construction of multi-story residential complexes and villa houses, in which the skeleton is from bolts and nuts, and light concrete is used in walls and ceilings.

4.4. Lightweight steel frame (LSF)

Lightweight prefabricated buildings or LSFs are mainly made using bolt joints and in a dry way (Figure 3). Easier design than other structures, prefabricated production, fewer operational works, quick installation, a significant reduction in building costs, less workforce, reduced energy consumption, a great deal of comfort in maintenance, suitable structural durability, seismicity behavior, the ability to change and move different parts of the structure and building easily, very easy demolition, the full recovery of all used materials and the lack of debris during construction and after the destruction are some of the benefits of this construction system. LSF structures have some limitations in height according to the type of the structural design and so they are not suitable for high-rise buildings and cannot be used as bearer structures.

Figure 3. A sample of LSF structures

4.5. Insulating concrete formwork (ICF)

The ICF method is one of the newest technologies for the industrialization of structures. This method, which has a completely concrete structure, has bearer reinforced concrete walls with a masonry wall that has polystyrene molds which remains in the structure (Figure 4). In addition to the role of molds in wall concreting, it acts as thermal and audio insulation in reducing energy consumption in accordance with the 19th provisions of building regulations. The maximum permitted height in this method is 15 meters and 4 floors, and the minimum thickness of the walls is 15 cm in different areas.

Figure 4. Samples of constructed structures using ICF

If we evaluate this method economically, we will see that the cost for this type of building is more than concrete and metal structures, and has limitations for the number of floors. Moreover, more walls' thickness reduces the useful level of the building according to calculate the concrete and polystyrene molds than steel and concrete structures and other industrial methods. Energy savings because of using two layers of polystyrene in the walls can be considered as the point of strength, and the lack of proper bonding to the polystyrene layer and also its soft underneath and the problems caused by soft polystyrene layer that is placed underneath the whiteness is the main weak point of this method. More cautions are needed because of these issues.

4.6. Tunnel form concrete cons

This new method is a completely concrete structure that its walls and ceilings as reinforced concrete, reinforcement, molding and concreting are done, which the final result of the structure is fully integrated with the highest earthquake resistance compared to other methods. Non-portable walls and stairs can be usually prefabricated and installed after concreting the loader walls and the roof. The cost of implementation is more than other methods and the facilities, doors and windows must be installed before the concreting because the implementation of all walls is in the form of reinforced concrete simultaneously. The cost of implementation in this method is more than other industrial and none-industrial methods due to the implementation of all structures as reinforced concrete, so it has more resistance than other methods in terms of strength. Because of the implementation of all walls in the form of reinforced concrete at the same time, all facilities, doors and windows, should be installed before concreting, because it is almost impossible to modify and move it after implementation. Besides, these structures are weaker than the other structures in terms of saving the audio and thermal energy according to the 19th provisions of building regulations and therefore they are not suitable for cold and hot regions.

4.7. 3D panels

In this method, the prefabricated is installed with a middle layer of polystyrene (5 to 9 cm in thickness) as thermal and audio insulation and a rebar and then the concrete is sprayed on both sides. Constructing this type of building is possible symmetrically up to 7 meters in two floors and in all regions, but if it combined with metal or concrete structures, the number of floors can be increased (Figure 5, Figure 6). The cost of implementing this type of structures is relatively high and has limitations about the floors and height.

Figure 5. The details of implementing the structure using TCF method

Figure 6. The details of implementing the structure using 3D panel

4.8. Modern materials technology

Preparing new materials is also considered as new methods' discussions, including light concrete and light gas concrete blocks. These materials are often used as non-load bearing walls (Figure 7).

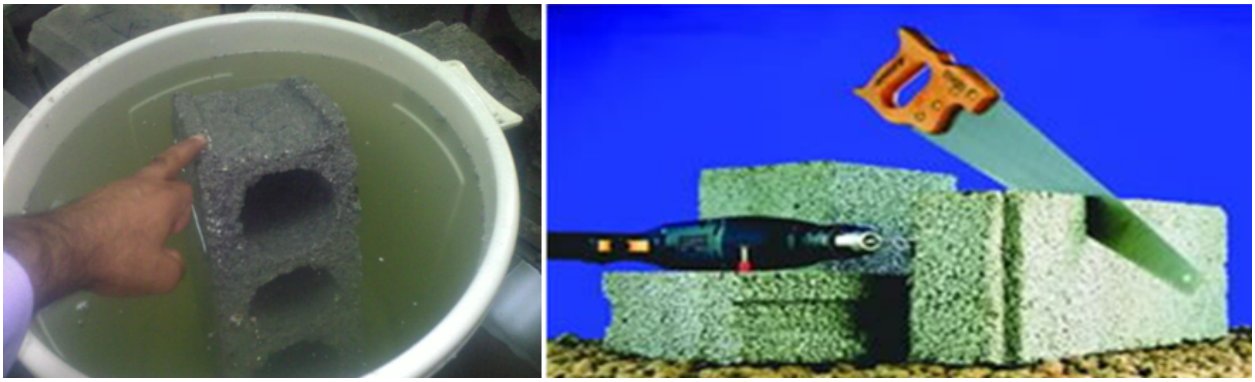

Figure 7. Using modern materials

5. RESEARCH METHODOLOGY

Due to the lack of comprehensive information about this subject, it is tried to use different methods for the research to make the results of this study more comprehensive and

accurate. These methods are generally including:

1- Personal interviews and getting expert advices about the construction.
2. Field studies and using the statistics
3. Preparation of the questionnaire and the AHP hierarchical analysis model

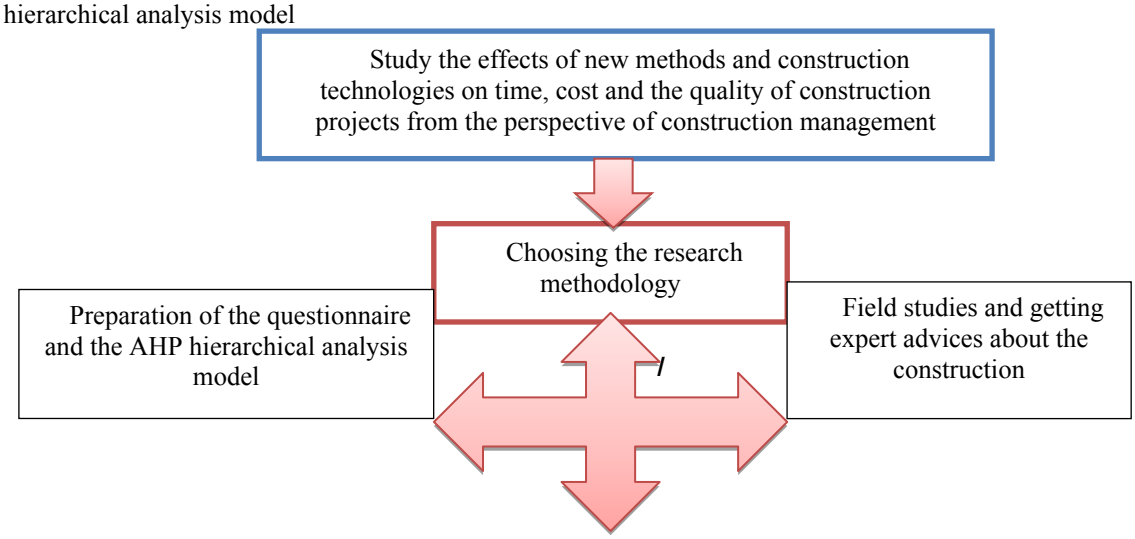

Figure 8. The used method in this research

A suitable method for this research is to interview with construction's experts and implementation teams of the projects in the country. They are the best persons to get the information in this field as they have enough expertise and experience (Figure 8). In this section, it is tried to determine the status of construction projects and their affecting factors using statistic information from different resources.

6. ANALYTICAL HIERARCHY PROCESS

In statistics, it has been several years that the decision making method with several indicators are appeared to examine the effects of different factors in which the ranking or prioritization of the various factors' impact are valued. Analytical Hierarchy Process (AHP) has been used more than any other methods in management science. An Analytical Hierarchy Process can be used when the impact of several factors is important or decision-making is faced with several competing choices and decision criteria. The proposed criteria can be quantitative and qualitative. The basis of this decision-making method lies in paired comparisons. These comparisons show the weight or impact of each factor in line with evaluated competing options. Finally, the logic of the hierarchical analysis process combines the matrices which are derived from the paired comparison with each other to determine the effect of the different factors quantitatively. Regarding the subject of this research, which influences various factors on the construction; this method is appropriate and has been selected.

7. CHOOSING THE STATISTICAL POPULATION OF THIS RESEARCH

The statistical population was chosen among the experts who are involved in these projects, including employers, consultants, contractors and construction project owners, and we were informed about their comments through meeting them, telephone or email. Firstly, 70 experts were selected, but some of them were not available, and some were reluctant to cooperate and provide information. Subsequently, about 57 comments from experts were received, some of questionnaire were either misleading or incorrectly filled out. Finally, 50 valid questionnaires were selected.

8. THE RATE OF USING NEW CONSTRUCTION METHODS IN THE COUNTRY

About this subject, most of the statistical community experts have mentioned that in almost 25-50% of the construction projects under their responsibility, new methods and technologies have been used. About 12% of them consider this as between 75% and 100% of the projects. In field studies, it was discovered that using the modern methods and technologies are more in mass projects, and traditional methods are more common in individual projects or personal buildings. The main reason for this subject is the higher cost of more new methods compared to traditional methods in individual or personal projects, according to expert's opinions (Figure 9, Figure 10).

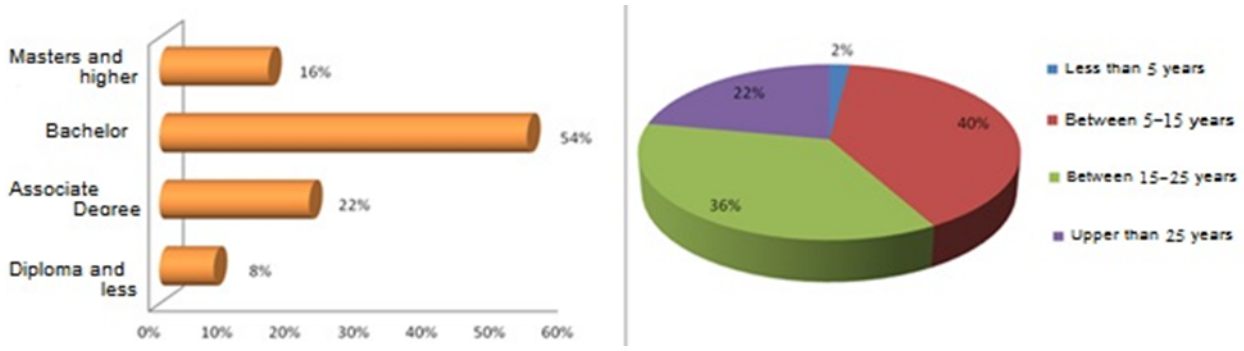

Figure 9/. Statistical population of this research

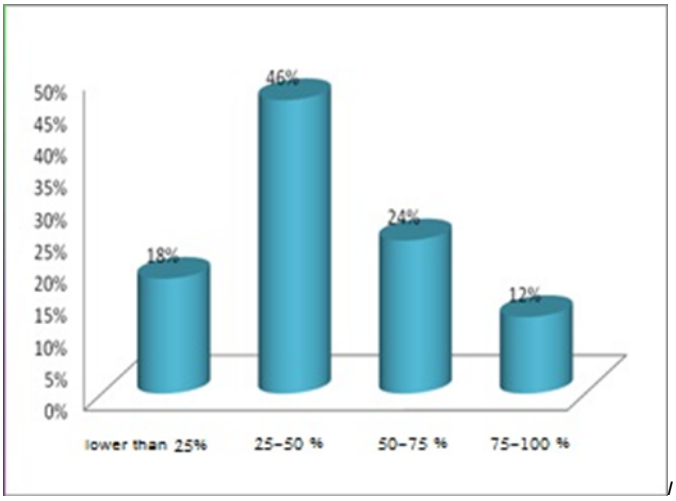

Figure 10. The rate of using new construction technologies in the country

9. THE IMPACT OF NEW TECHNIQUES AND TECHNOLOGIES ON PROJECTS TIME

Most experts of statistical community believed that using modern methods and technologies accelerated the time of projects compared to traditional methods, which is about 50 to 75% (Figure 11). The important point in this question is that no one in the statistical community is considered as delaying factor, which is one of the important advantages of modern methods and technologies in construction projects. One of the main drawbacks of the traditional methods of construction the buildings, especially at the time of the skeleton′s construction, is that after the laying and decommissioning of each roof, bases and retaining jacks must be under the ceilings for a long time, so that the concrete can reach the sufficient resistance, and this is one of the weaknesses of traditional methods in Iran, as there is often a limited number of bases and jacks in work teams, while in modern methods, problems which are caused by the required time for molding and concreting are usually faster than traditional ones.

Figure 11/. Comparing the of Traditional and New Techniques

10. EFFECT OF NEW CONSTRUCTION TECHNIQUES AND TECHNOLOGIES ON PROJECT COSTS

While most experts have believed that these methods increase about 30% of the project costs, others also believed that these methods had reduced them. Some of the reasons of the experts who believed that these methods would raise the costs is as follows:

Using modern methods requires more equipment and materials

which needs more cost than conventional methods.

The cost of executive teams is higher, regarding the specialized work than traditional ones.

It is not economical in individual projects and small buildings.

Some of the reasons for experts who believed that these methods have reduced costs are as follows:

Considering that these methods reduce the project time, the total cost is reduced regarding the indirect costs such as costs of the workshop, personnel, technical office, workers, etc.

The project will be operated sooner.

Due to the prediction of necessary arrangements for transferring the facilities such as water pipes, electrical wiring, etc., to prevent rebuilding and to increase the costs during the installation, and the amount of materials will be minimized.

These methods are affordable in large-scale projects and large buildings.

The fact is that in small projects and individual structures, using of these methods leads to increase the costs, but rather accelerates the project time and, in particular, improves the quality that may not be important for some employers and owners, regarding the current housing market in Iran. The economic aspect of the project is more important for them. In large-scale projects and large buildings, using of these methods is also economical and will increase the quality and reduce the time lag of the project, and also the installation of facilities such as pipes and electrical installations will be done more quickly (Figure 12).

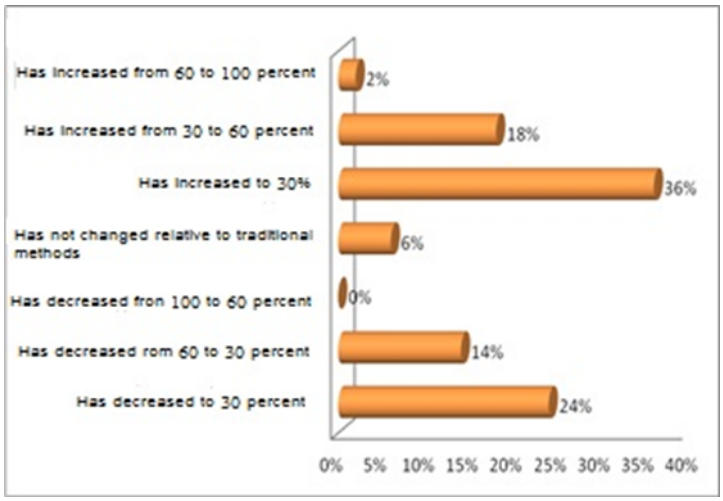

Figure 12/. The impact of new techniques and technologies on project costs

11. USING MODERN METHODS AT DIFFERENT STAGES OF CONSTRUCTION

The results indicate that in our country, the greatest use of

modern methods and technologies is currently related to the skeleton and ceiling stages (Figure 13). After that, it is in the installation phase of the facility, including the use of elevators with advanced facilities such as 3 VF. The least use of new methods is in the operation phase, including intelligent controlling and operation systems of the Buildings which are used in less projects in Iran.

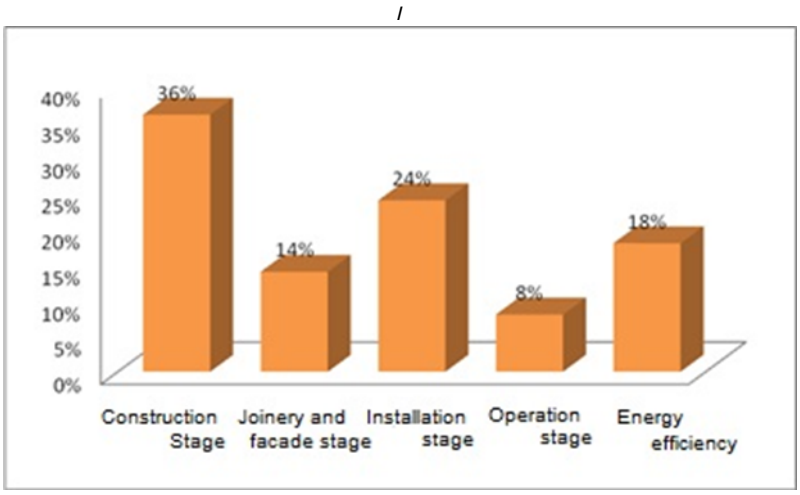

Figure 13. The results of using new technologies at various stages of construction

12. THE DEGREE OF TENDENCY OF EMPLOYERS AND OWNERS IN NEW WAYS

Most results indicate that a small percentage of owners and employers tend to use the new methods and technologies. Some important factors are as follows:

The employers' desire for large projects is more than small projects with a small number of units (Figure 14).

Most owners considered the increased costs as the reason of their unwillingness.

Insufficient attention to the quality of the market in Iran is one of the reasons for the lack of willingness (Figure 15).

Many owners and employers do not have enough information about new methods and technologies.

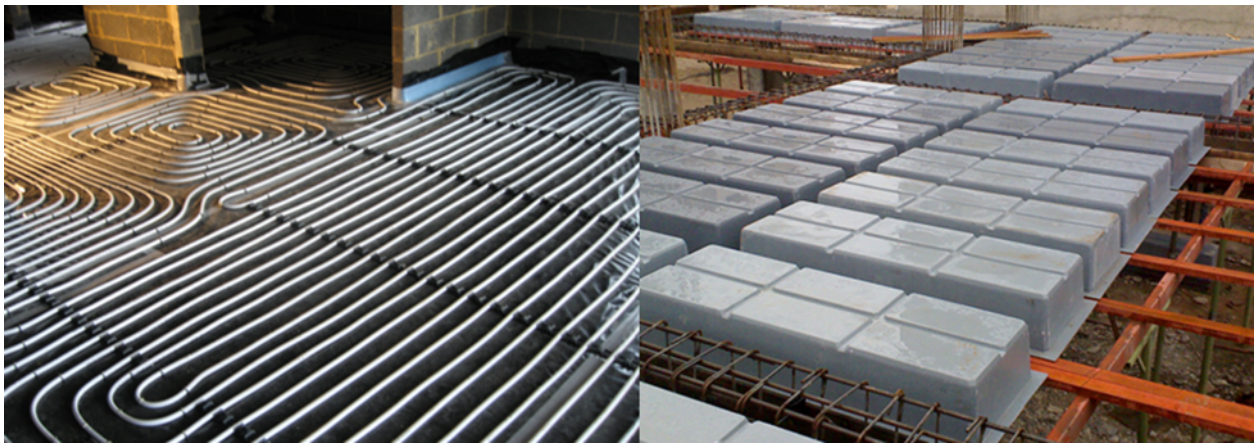

Figure 14/. Examples of new technologies at the skeleton and installation stage

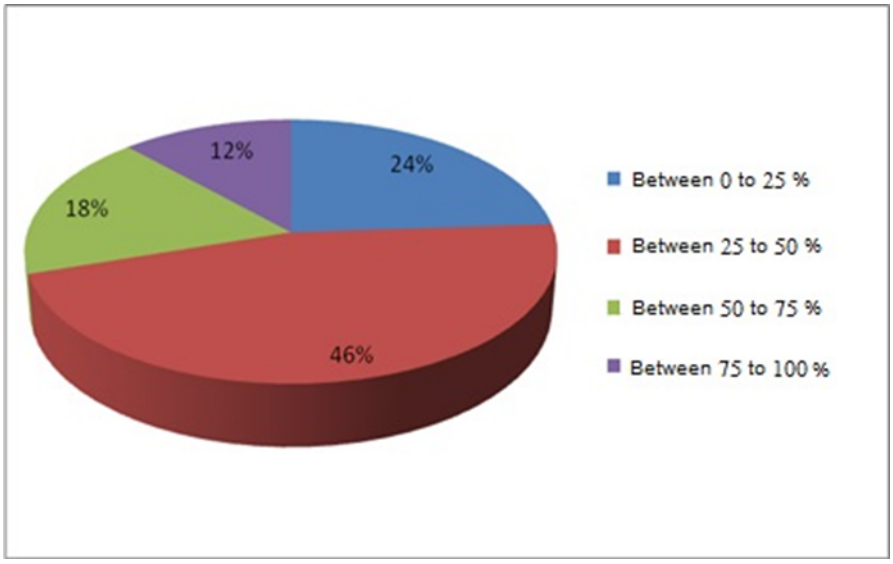

Figure 15/. The willingness rate of owners and employers to new methods and technologies

13. THE DEGREE OF EXPERIENCE AND CONVERSANCE OF CONTRACTORS IN NEW METHODS AND TECHNOLOGIES

One of the other issues that have a direct impact on using the modern methods and technologies in building, is the experience and conversance of work teams and contractors. The more experienced contractors are in applying these methods, the better quality and performance of the structures and its facilities, and also the less reinstallations. The results show that, fortunately, the level of expertise and experience of teams and contractors in applying new methods and technologies has improved in recent years, and owners and employers have a relative satisfaction with this situation. Some of the reasons for this are:

Increasing the number of contractors and their ability to provide better services

Inappropriate performance of traditional methods

Increasing the level of culture and expectations of buyers of building units

Specialization of modern construction technologies

14. THE ROLE OF MONITORING SYSTEM

The degree of dominance of the monitoring engineers and systems, has a direct impact on application and development of these new methods and technologies. This is important in two respects (Figure 16). Firstly, the more control of the monitoring systems, the better quality of the operations performed, and hence prevent the use of traditional methods, which sometimes have lower quality. This issue is evaluated in the next section, and the results are presented below.

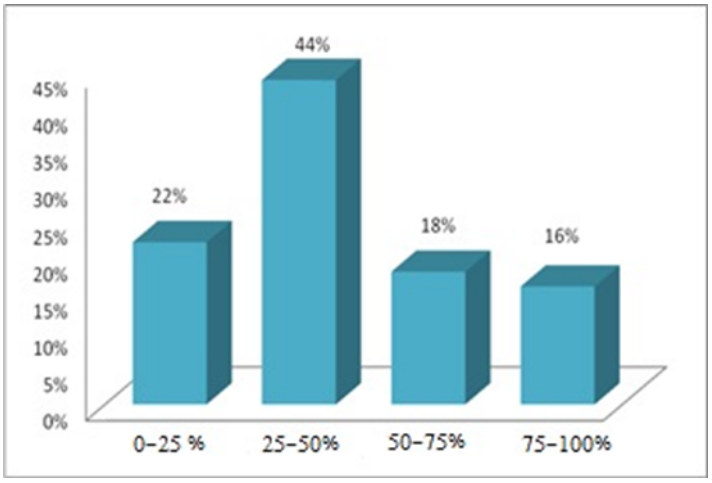

Figure 16/. The degree of relative domination of consultants and the monitoring system to new methods and technologies

The degree of relative domination of consultants and the monitoring system to new methods and technologies.

15. THE IMPACT OF RELEVANT ORGANIZATIONS SUCH AS THE MUNICIPALITY AND ENGINEERING SYSTEM

The discussion about the impact of relevant organizations and institutions, such as municipalities and engineering organizations, is also important in implementing and expanding the application of new methods and technologies (Figure 17). These institutions can:

Firstly, familiarizing the owners and employers with the benefits of these methods, by developing the culture and learning proper practices.

Secondly, creating a good incentive for other projects in the country to expand the application of these methods by making incentives such as forgiving or mitigating the effects of projects that are built with these methods.

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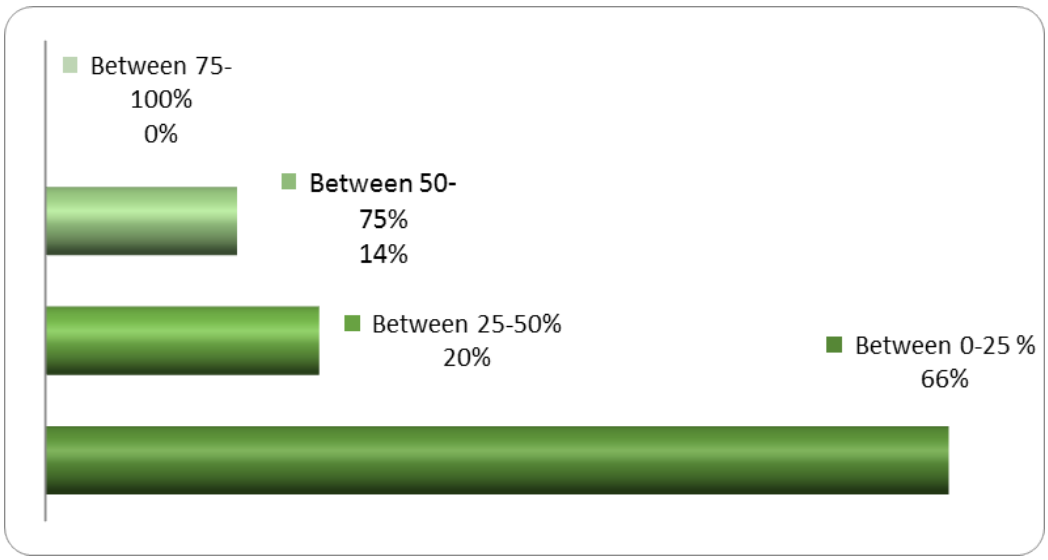

Figure 17. The level of cooperation and assistance of responsible organizations, such as municipalities, in developing the new methods

The results indicate a serious weakness in this section. The fact is that there have not been any proper steps to develop the culture and teach these methods, so far. There are also no encouraging incentives for development of these methods and the building industry qualification. For example, buildings using traditional and low-quality methods should pay the same costs and expenses that buildings constructed with modern and quality methods, and indeed there is no proper incentive to expand these methods.

16. CASE COMPARISON OF A TRADITIONAL METHOD WITH A NEW TECHNOLOGY

In order to clarify the subject's dimensions, a case study of a traditional technology with a new one is considered in

this study. This case study is about how the roof is constructed utilizing the traditional method of using concrete and foam aggregates and new cobiax technology (Figure 18). The traditional method of using joists and foams and is common today in most construction projects in the country and most contractors and engineers are familiar with this method. The case study is a 6-story building with a total area of about 1200 meters. A sample of these two methods is shown in the following pictures:

Figure 18/. Cobi ax technology images and the traditional way of concrete joist and foam

Table 1. Comparison of cobiax costs with traditional method of concrete joist and foam

Approximate estimated cost of building the concrete joist and foam roof				
Cost	Unit	Amount	Unit'S Cost (Rial)	Total cost (Rial)
Used concrete	Cubic meter per square meter of roof	0.55	1200000	660000
Used rebar	Kilogram in square meter of roof	65.5	18000	1179000
Accomplishment's pay	square meter of roof	1	200000	200000
Design, construction and delivery the joists and foam materials	square meter of roof	1	460000	460000
	Total			2499000

Approximate estimated cost of building the Cobiax roof				
Cost	Unit	Amount	Unit'S Cost (Rial)	Total cost (Rial)
Used concrete	Cubic meter per square meter of roof	0.45	1200000	540000
Used rebar	Kilogram in square meter of roof	50	18000	900000
Accomplishment's pay	square meter of roof	1	300000	300000
Design, construction and delivery the joists and foam materials	square meter of roof	1	390000	390000
	Total			2130000

In this case, the price difference for the building with an area of about 1200 square meter is equal to (Table 1):
(2499000- 2130000)*1200= 442800000 Rial
Besides, the time for constructing each roof (without considering the time for tightening the concrete) for the ceiling with traditional concrete joists and foam is about 7 days, and for the ceiling with a new Cubic ax method is about 5 days, which will be shorter for about 12 days regarding the six roofs. In this case, it will be noted that using new Cobiax method, will save the construction time of the roofs about 28% and will save up to 15% of the costs.

17. THE IMPACT OF NEW METHODS AND TECHNOLOGIES

Considering that the effects of new methods and technologies on time, costs and quality of various construction projects are different, the hierarchical analysis method and the AHP model were used in order to investigate the effects of each of the above mentioned factors a their ranking. For this purpose, Table 2 was prepared as follows, and experts were asked to assign a numerical factor from 9.1 to 9, depending on the effect of each factor on the other factor. The average rating given for each factor is as follows. This scoring method is used to determine the relative weight of the various options, form the options′ matrix and to examine the impact of each factor.

Table 2. Prioritizing the effects of new methods and technologies using the AHP method

	More integrity and strength of the structure	Better resistance to natural hazards and accidents such as earthquakes	Accelerating the construction time	Better quality at the time of operation and longer building age	Reducing the costs	Better efficiency of the facilities and energy efficiency	Beauty and less harmful effects on the environment
More integrity and strength of the structure	1	5	3	2	7	9	6
Better resistance to natural hazards and accidents such as earthquakes	1.5	1	1.2	1.4	2	5	3
Accelerating the construction time	1.3	2	1	1.2	5	6	4
Better quality at the time of operation and longer building age	1.2	4	2	1	4	8	5
Reducing the costs	1.7	1.2	1.5	1.4	1	3	1.2
Better efficiency of the facilities and energy efficiency	1.9	1.5	1.8	1.6	1.3	1	1.5
Beauty and less harmful effects on the environment	1.6	1.3	1.4	1.5	2	5	1

After doing the necessary calculations and developing the relevant matrices, The results will be as follows if we would like to compare the effects of new methods on the safety and security projects.

1- The integrity and stability of the structure with relative weight of 0.3676 have the greatest impact

2. Better quality and longer age of the building with a relative weight of 0.2445 has the greatest impact, in the second place

3. Accelerating the construction time the with relative weight of 0.1636

4. Resistance to natural hazards such as earthquakes with a relative weight of 0.0947

5. Reduced expenses with relative weight of 0.0458

6. Beauty and less damaging effects on the environment with a relative weight of 0.0608

7. Better utilization of the facility and optimization the relative energy consumption of 0.0227

In this case, the compatibility indicator or CI is equal to 0.063, which is appropriate and indicates the consistency of the given responses by the experts.

18. CONCLUSION

Most statistical community states that in approximately 25-50% of the construction projects which are under their responsibility, new methods and technologies have been used. About 12% of the respondents consider this as an amount between 75% and 100% of the projects. The time of projects is reduced compared with traditional methods, and this amount is considered as 50 to 75%. The important point in this question is that none of the people in the statistical society has considered the use of these methods as a delaying factor, which is one of the important advantages of new methods and technologies in the construction of projects. Regarding the impact of new methods and technologies on project costs, most experts have believed that these methods have contributed to an increase of about 30% on project costs, but others also

believed that these methods have reduced the costs. Regarding the use of new methods and technologies in different stages of construction, the greatest impact is related to the skeleton and frame, and then in the installation phase and optimization of energy consumption, including a variety of methods of double-decompression and new piping like floor heating. The degree of tendency of owners and employers to new methods and technologies in large projects is more than small projects with a small number of units. Many owners do not have enough information about new methods and technologies. The level of expertise and experience of contractors in applying new methods and technologies has happily improved in recent years, and property owners and employers are relatively satisfied with this situation. The degree of mastery of the monitoring organizations and engineers to the new methods and technologies also has a direct impact on the application and development of these methods. The results indicate that many supervisory engineers and monitoring organizations do not have enough familiarity with new methods and technologies and are unaware about the benefits and uses of these methods. This requires a culture′s development, and related devices like engineering system organizations should take more practical steps in this issue. Concerning the level of cooperation and assistance provided by responsible organizations such as municipalities in expanding new methods, the results indicate a serious weakness in this section. The fact is that there have not been any proper steps to develop the culture and teach these methods, so far. There are also no encouraging incentives for the development of these methods and the development of the building industry in the country. It is hoped that the content presented in this study will be useful in expanding the use of modern methods and technologies in the country's construction projects.

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