Construction Technology Transfer: an assessment of the relevance of Modern Methods of Construction to housing shortages in Iran

by

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This thesis is being submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

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Abstract

The inability of the Iranian construction industry to satisfy the country's massive housing demand has transformed housing demand and supply into one of the major challenges facing the government. 1.15 million residential units need to be built each year for the next ten years.

The Iranian construction industry is suffering from various deficiencies such as low productivity, small and unprofessional developers, huge waste, skilled labour shortages, defective management, unstable economy, severe fluctuations in demand and supply etc. Considering the potential advantages of Modern Methods of Construction (MMC), the general belief is that the application of MMC will resolve many of the above issues.

MMC is a complex subject in which various issues including standardization, co-ordination, management, design, costs, sustainability and associated risks should be considered. Some of these have become more important than the others for the Iranian government and other stakeholders. Iran needs to learn from the experience of other countries such as the UK to avoid repeating their mistakes.

This study intends to investigate the viability and applicability of the UK's advanced construction systems in Iran. The history and current situation of the Iranian and UK construction industries with regards to housing shortages and currently applied methods of construction have been explored in detail. Several other subjects including building regulations and standards, practicality, economy, costs, culture, sustainability and design which are vital in the success or failure of a construction method are discussed and both countries have been compared with regards to these issues.

The results reveal important issues which should be considered prior to transferring UK's MMC to Iran. Although MMC can theoretically enhance the current situation, various concerns such as education and research, industry, economy and governmental planning and policies need to be addressed in order to ensure the successful application of MMC in Iran.

In this respect, it is important to establish organisations to undertake constant professional research on these issues. It is also vital to educate the society and stakeholders to increase the level of their knowledge on MMC advantages and risks.

The Iranian construction industry needs urgent consideration with regards to information delays, skilled labour shortages, regulations and standards, small and

unprofessional developers, infrastructure and industry capacity. In this situation, MMC which are not complex and do not require extensive skilled labour and heavy machinery will be more successful in Iran. At the same time, prevailing methods of construction should be optimised in terms of material and waste. The government should also review its supportive policies to increase the share of MMC within the construction industry.

In short, the Iranian construction industry is currently not fully prepared to adopt complex methods of construction successfully and it must be borne in mind that application of MMC is a long-term evolutionary process, not a revolutionary one.

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Chapter 1: Introduction

1.1 Introduction to the problem

The housing crisis is one of the greatest problems facing the Iranian government. Population growth, demolishing the old stock, inadequacies in the construction industry and destruction caused by natural disasters such as earthquake have resulted in a massive housing demand in Iran which is increasing year by year. For various reasons, traditional methods of construction have failed to answer the current demand. Several policies have been considered by the government to confront this dilemma. One of these is the application of advanced methods of construction. The general belief is that such methods can enhance the current situation and lead to a professional, dynamic construction industry.

During the recent decades, several attempts have been made by the government and individuals to introduce advanced methods of construction to Iran. Many of these have failed due to the lack of correct understanding of the Iranian circumstances, limitations and potentials. Housing is a challenge in which several criteria including the planning, economy, culture etc. should be considered beside the technology. Having several claimed advantages over traditional methods of construction, it has been argued that the application of Modern Methods of Construction (MMC) can potentially improve the current situation. However, the consequence of neglecting any of the above issues is likely to be defective plans which are doomed to failure.

Many of the current problems of the construction industry should be sought in the contemporary Iranian construction history. It was when the classic Iranian architecture transformed to the current miserable one. It was also when some fundamental issues such as mass building were introduced to the construction industry.

Moreover, planning policies such as the small building, mass building, new cities, land policies etc. have been less successful due to various reasons. Many of these need to be reviewed since they are unrealistic, ineffective and do not reflect the current situation of the construction industry especially when it comes to Modern Methods of Construction.

Iranian industry is also suffering from several shortcomings. Construction is only a small portion of the whole industry but being linked to many other industries, it is very influential on the whole system. Construction industry itself suffers from problems such as the low productivity, housing output, skilled labour shortage, unprofessional small developers, material and energy waste, defective management, lack of reliable and up to date information and many other deficiencies which should be addressed.

Meanwhile, the economy influences the housing market significantly. Iranian economy is unstable and suffers from high inflation and liquidity which in turn affect the housing economy, demand and supply considerably. Housing demand and supply should be considered in terms of the quality and quantity. Regarding the quality, housing supply does not follow the correct pattern and a significant portion of it falls outside the active demand. Supplied stock are either too big or too expensive resulting in many houses remaining empty while there is huge demand for small and medium size affordable residential units. With regards to the quantity, although crude housing demand is increasing, there are short-term and severe fluctuations in the active demand and supply. The consequence of these has been some irrational behaviours in the housing market.

All above issues are linked and influential on each other. These have limited broader application of MMC in the construction industry. Several other factors including the building regulations and standards, practicality, costs, culture, sustainability and design. should be considered in addition to the above to increase the share of MMC in Iran. All of these require much more in depth research. Indeed, application of advanced methods of construction will not be effective unless all above issues are considered in parallel.

Other fundamental principles such as standardisation, mass production, modular co-ordination etc. need to be considered in MMC. Iran does not seem to be fully prepared for the application of some Modern Methods of Construction since these are not very well established in the construction industry. Architects, engineers, contractors, clients and other stakeholders need to know more about the subject. MMC is relatively a new subject and differs from traditional methods of construction in terms of the risks, advantages and disadvantages, management and construction process. Much more research is required to prepare the base for the successful application of MMC in Iran. Meanwhile, some of the above issues have become more important than the others. It is important to mention that partial consideration of these will not be effective.

Meanwhile, it is necessary to study the experience of other countries to avoid their mistakes. The UK has been one the countries which have been dealing with similar issues such as the housing output and construction technology for decades. New methods of construction were broadly promoted and introduced to the UK during the 20th century. These were to address various issues such as the housing output, skilled labour shortage, productivity, costs etc. The government played an important role in this phenomenon. New governmental policies created a competitive environment where several national and international innovative methods of construction were developed and increased the share of new methods of construction considerably. Like Iran, the general belief was that application of advanced methods of construction would enhance the situation.

Although the UK housing problem has to some extent been resolved, some serious mistakes were made which resulted in various social, economic and environmental disorders. These resulted in the failure of such methods during the 1960s. The UK has not been able to recover from many of those mistakes yet. During the recent years, the UK government has been trying for the second time to promote MMC but they have been less successful due to several reasons some of which have roots in the previous century. It seems that the current situation of Iran is more or less comparable with the UK after the World Wars. Iran is making similar mistakes to those made by the UK. The quantity has currently become more important than the quality which may cause some unrecoverable damages to the construction industry.

This thesis aims to evaluate all the above issues. The results of the thesis reveal several important criteria which should be considered prior to any attempts to introducing MMC to Iran. Indeed, the current situation would probably get worse if these principles were neglected. Some recommendations have also been made to enhance the situation and to decrease the potential risks.

1.2 Aims and objective

This study intends to evaluate the extent to which the UK system building experience is relevant to Iran. The principal aims are to investigate the feasibility and applicability of advanced systems of construction in Iran, and to answer the question as to whether such methods would enhance the current situation of the Iranian construction Industry in general and the housing industry specifically.

In this context, the ultimate objective of the thesis is to have a systematic approach to establish a framework on which the feasibility of application of MMC in Iran can be examined. The objectives of the research could be classified as follows:

- To evaluate the history and current situation of the Iranian and UK construction industries and compare both countries with regards to Modern Methods of Construction.
- To clarify all relevant criteria, critical factors, limitations and potentials which should be considered to have successful application of MMC in Iran.

- To undertake a risk assessment and to identify the involved risks.
- To give some recommendations to decrease the involved risks.

1.3 Methodology

The methodology of the thesis is a qualitative and quantitative data analysis in which the relevant literature including books, journals, websites, papers, seminars etc. published by the Iranian and UK governments and other research bodies are collected and studied.

Since housing is a broad multi-side subject, various information including the planning, economy, technology etc. are required to validate the study and to have a pragmatic comparison between the Iranian and UK construction industries. The outcomes of the literature review are discussed to identify the critical factors based on which both countries are compared in terms of the feasibility of application of Modern Methods of Construction.

These criteria have also created the basis of a questionnaire which has been designed to explore the current situation of the Iranian architectural profession as a part of the whole construction industry with regards to offsite methods of construction. It is aimed to evaluate the important criteria, risks, constraints, potentials, and the level of knowledge of Iranian architects regarding the new offsite methods of construction. SPSS and Excel software have been used and descriptive data analysis has been applied using frequency and percentage to analyze the outcomes of the questionnaire. Chi-square test has also been applied to examine the significance and reliability of the results.

Some face-to-face and telephone interviews with Iranian construction experts, university lecturers and governmental bodies were also undertaken as complementary sources to fill the research gaps. The scope of coverage is fairly broad with more concentration on technological aspects of housing.

The results of the chapters in conjunction with the findings of the questionnaire are used to examine the research hypothesis and to give some recommendations as the conclusion of this thesis.

1.4 Limitations of the study

Application of new methods of construction is relatively a new subject in Iran. One of the major difficulties of this study was the lack of enough and reliable information on the subject. Unlike the UK, available data on the subject is extremely limited in Iran. In some cases the author had to refer to some sources such as the news which may not be classified as the reliable data. In several cases contradictory information, especially the published statistics by different governmental bodies, were confusing. It should also be mentioned that the majority of the literatures have been summarised and translated from Farsi to English.

The research commenced in 2004 when the 1996 national population and housing census was still in force and much available information was therefore based on it. The results of the new national census were published by the Statistical Centre of Iran (SCI) in 2006-2007 which indeed invalidated much of the collected data. Consequently, the author modified the information in several cases which was a time consuming process. This was however advantageous to the study since the study benefits from up to date data which helped to achieve more accurate and relevant results.

With regards to the questionnaire distribution, based on the sponsor's regulations, there was a limitation of maximum of one month for staying outside the UK for research purposes. Considering several difficulties such as the long distances, lack of cooperation in some cases, lack of enough information etc. the time was extremely limited.

1.5 Thesis construction

The thesis is comprised of two main parts and ten chapters which are explained briefly in this section. In Chapter 2 fundamentals of industrial building systems and various construction methods are discussed. Some basics such as the meaning of MMC, construction methods, standardisation, modular co-ordination and open and closed systems are explained in this chapter.

1.5.1 Part 1

In Part 1 of the thesis some basic issues such as the history, planning, economy, industry, demand and supply etc. are explained in sufficient detail to understand the Iranian housing market and its potentials and shortcomings.

Chapter 3 explains the history of the Iranian housing architecture and the phenomena which transformed the traditional Iranian house architecture. The current situation of Iranian architecture and the construction industry has roots in this period.

In Chapter 4 some fundamental issues such as the planning, economy and land are examined. Some planning policies such as small building, mass-building, application of new technologies etc. which are directly relevant to the feasibility of application of MMC are explained in this chapter. Housing economy and land policies which can influence the housing demand and supply and the feasibility of application of MMC indirectly, are also discussed in this chapter.

The Iranian industry, climate and housing demand and supply are explained in Chapter 5. The current situation of the construction industry, skilled labour, and building materials are explained under the industry section. The climate, which can influence the architecture, construction methods and materials, and the quantitative and qualitative aspects of housing demand and supply are also explained in this chapter.

1.5.2 Part 2

In part 2 of the thesis the fundamental criteria of Modern Methods of Construction and the history and current situation of MMC in Iran and the UK are explored.

Chapter 6 explains the history of the UK housing with regards to construction technology during the 20th century. The history of housing demand and supply and the events which resulted in broader application of new technologies in the UK construction industry after the World Wars are explained in this chapter. Various post war construction methods and the reasons for the failure of prefabricated methods of construction are also discussed in this chapter.

In Chapter 7, the current situation of MMC in the UK construction industry and also some fundamental issues which should be considered in the application of MMC are explained in detail. MMC building methods, advantages and limitations, costs, sustainability, risks and design issues are explained in this chapter.

Chapter 8 intends to explain the current situation of the Iranian construction industry with regards to Modern Methods of Construction. Currently applied methods of construction, building regulations and earthquake, construction process, material and energy waste, the history and current situation of MMC and the reasons of its failure are explained in this chapter. There are also some interviews which show the ideas of some experts regarding the current situation of construction technology in Iran.

All the previous chapters are brought together in Chapter 9. The Iranian and UK construction industries are compared and the feasibility of the UK Modern Methods of Construction in Iran is evaluated in this chapter. It intends to highlight the opportunities and limitations which may confront MMC in Iran. Various influential criteria in transferring a method of construction to Iran are clarified in this chapter. The feasibility of application of MMC in Iran is examined against these criteria: demand, building regulations & standards, practicality, costs, culture and public attitudes, sustainability, policy and planning, early adaptors, pioneers and stakeholders, construction industry and design. Construction industry and design have been selected as one of the areas which require more in depth research. Based on the above criteria, a questionnaire has been designed which intends to evaluate the Iranian architectural profession with regards to offsite methods of construction.

Based on the results of Chapter 9 and the findings of the questionnaire and the previous chapters, some recommendations have been made in Chapter 10 as the conclusion of this thesis.

Chapter 2: The Fundamentals of Industrial Building Systems

2.1 Introduction

The construction process is different from most manufacturing processes in several aspects such as the individuality and uniqueness of each project, different construction sites and environment, complex production process and involvement of many authorities and trades (typically 20 to 30 different trades) in the process. While manufacturing process is under the control of a single management, construction has historically been the outcome of several independent ideas of clients, designers, contractors and other involved bodies who have had their different inputs in different stages of construction. This situation makes the industrialisation of construction industry much more difficult than other industries (Warszawski, 1996, McEvoy, 1994).

There are different methods of construction considering structural and fabrication issues. Industrialised building is one of several construction methods in which manufacturing becomes involved in the construction process.

There are several advantages and disadvantages associated with industrial methods of construction. However, according to research on some industrialised construction methods, there are not many evidences that such methods are cheaper or quicker than other methods of construction. It seems that the main advantage of using prefabricated components is the quality of the products (Osbourn, 1989, Osbourn, 1997).[1]

This chapter intends to clarify the fundamental issues of different construction methods and principles which should be considered in manufacturing and application of such methods. Different basic issues such as building methods, standardisation, modular co-ordination, open and closed systems and economic of building methods are covered in this chapter. These criteria make the basis of various industrial methods of construction. The broad meaning of MMC has also been explained in this chapter. It is vital to understand such basics prior to any attempts to introducing Modern Methods of Construction to Iran.

2.2 Building Methods (fabrication issues)

Historically there have been three major building methods in terms of fabrication and the use of machinery and labour (Riley and Howard, 2002):

[1] This is still the case in the UK construction industry as Modern Methods of Construction are still more expensive than traditional methods. This will be discussed in more detail in Chapter 7.

- Traditional Methods
- Post traditional methods (also known as conventional methods)
- Rationalised and Industrialised systems

In traditional methods building components are built from some small components to fit onsite. Therefore such methods are very slow and time consuming. Traditional methods are mainly limited by the availability of skilled labour and climate conditions which decrease the ability to work constantly and to achieve great accuracy. Such methods are so labour intensive and due to associated high costs, they are now limited to very few special building projects. They have, however, some advantages including great flexibility to ensure that all the components fit on site. The disadvantages of traditional methods resulted in creation of Post Traditional or Conventional methods of construction.

Post traditional method is a mixture of traditional systems with newer skills, methods and equipment. One of the major differences of post traditional methods, which distinguish them from traditional methods, is the application of mechanical plants in such methods. The plants used in post traditional methods are used for excavation, concrete mixing, lifting the components etc. Such machinery is now a fundamental part of the construction projects due to the scale of projects. Moreover, prefabricated components are increasingly used in such methods in a traditional approach using traditional workmanship such as plastering and joinery for finishes.

Rationalised and industrial building methods, as are known today, are other approaches toward construction in which manufacturing industries are involved as much as possible. Such approach does not necessarily mean the application of industrialised building systems but is actually applying the frequently used existing techniques in an organised planned way. The key fact in this method is the cooperation and involvement of design and manufacturing bodies in all construction stages to make the process cost effective and to achieve proper quality. This requires the construction process to be continuous by organised use of resources which can be, somewhat, achieved by efficient use of plant and application of prefabricated components which allow separate manufacturing from assembly and decreasing the use of labour on site.

Selecting any of these methods of construction depends on the availability of technology, building materials and also experienced designers (Osbourn, 1997). These are particularly important in Iran since some of the above requirements may not be met.

2.3 Building Methods (structural issues)

There are four major methods of construction with regards to structural and stability issues as follows (Osbourn, 1997):[2]

- Continuous structures
- Framed structures
- Panel structures
- Membrane structures

In continuous structures, continuous load baring walls transfer the loads and forces by the means of compression. Such walls are mainly constructed using brick, timber, stone and concrete and block. Therefore, on this basis it could be argued that continuous structures are the oldest type of construction method.

Frame structures are made from timber, steel or reinforced concrete creating frames from beams and columns. Panel structures are formed from coordinated prefabricated load baring panels used for walls, floors and roofs resulting in the elimination of columns and sometimes beams. They are similar to continuous structures but designed to resist their own load and other requirements. They could also be designed to integrate thermal insulation. Such panels are known as Sandwich Panels. Figure 2-1 shows an example of panel systems.

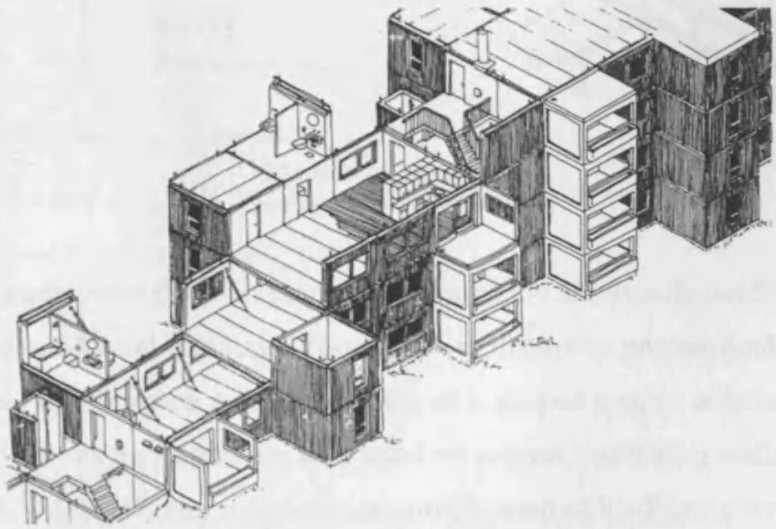

Figure 2-1: Panel system
Source: (Warszawski, 1996)

[2] Common methods of construction in Iran will be explained in Chapter 8.

Membrane structures are formed from non structural membranes which form the walls and roofs. An example of this system is a tent where timber or steel create the main structural support.

Although similar in principles, there are other classifications for construction methods on the basis of geometrical arrangement of their structural systems (Warszawski, 1996):

- Skeleton(column and beam) or linear systems
- Panel or planar systems
- Box or three dimensional systems

Figure 2-2 shows examples of the linear system which are mainly applied in garages and multi storey offices (Warszawski, 1996).

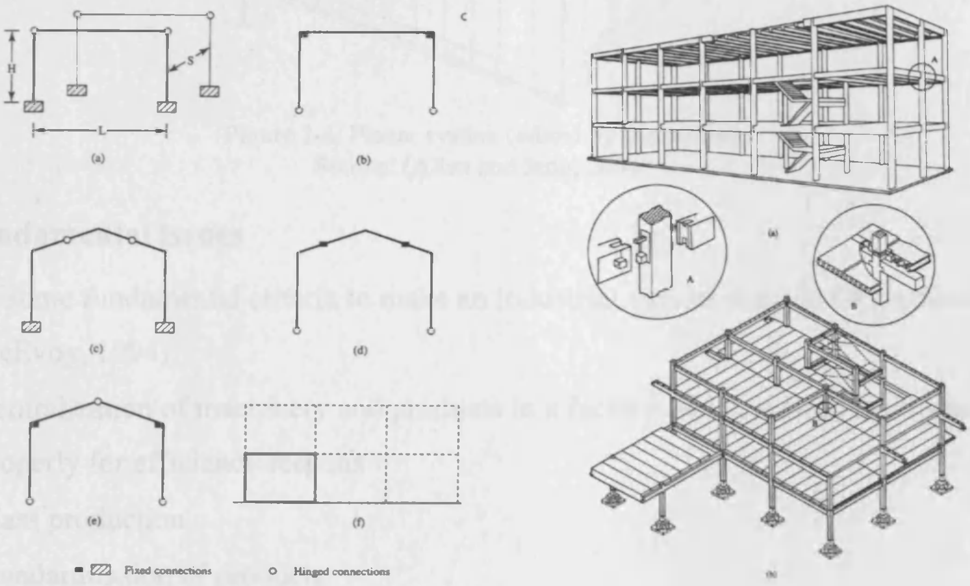

Figure 2-2: Linear system
Source: (Warszawski, 1996)

Figure 2-3 demonstrates different planar systems which are usually used for different buildings such as residential buildings. Figure 2-3 (a) illustrates precast double tee components being supported on a skeleton frame of L shaped precast columns and beams. In Figure 2-3 (b) hollow core slabs are supported on precast loadbaring walls. Figure 2-3 (c) shows double tee slabs being supported on combination of loadbaring walls and linear system of precsast columns and tee beams. The size of planar components is governed by the layout, structural system and architectural issues. Also the weight of such components is restricted by the lifting capacity of the cranes (Warszawski, 1996, Allen and Iano, 2004).

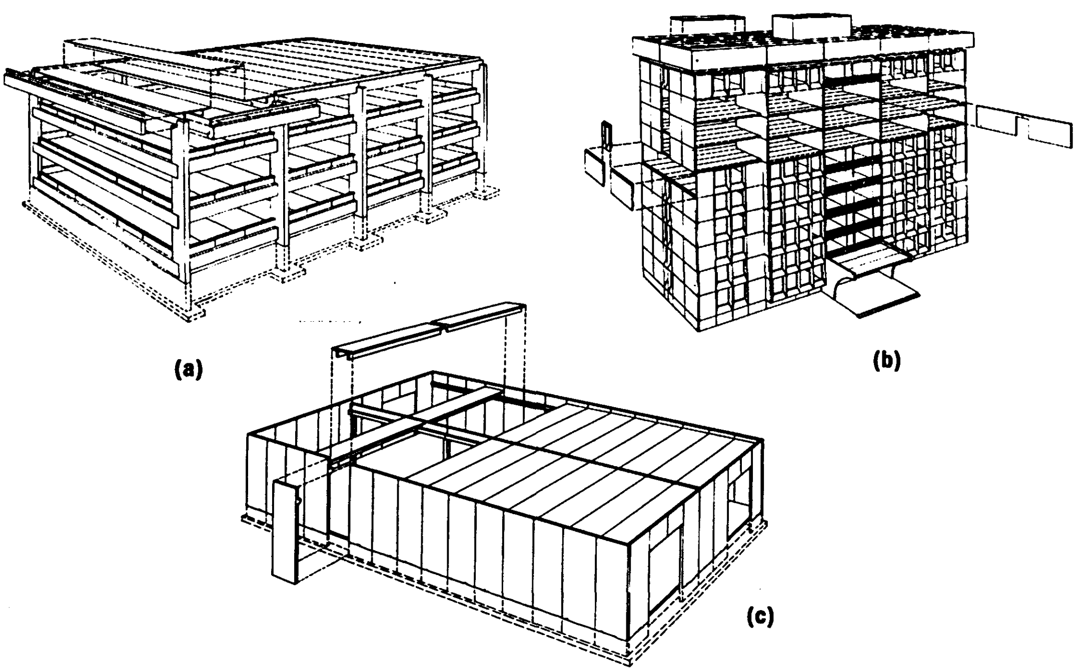

Figure 2-3: Planar system (edited by the author)
Source: (Allen and Iano, 2004)

2.4 Fundamental issues

There are some fundamental criteria to make an industrial system feasible (Warszawski, 1996) (McEvoy, 1994):

- Centralization of machinery and products in a factory which is sized and located properly for efficiency reasons
- Mass production
- Standardization of products
- Organization: to organise the design, production and marketing under the supervision of a single management

In addition to the mentioned criteria, there are other issues such as long-term demand associated with enough investment and development programmes and also availability of a reliable transportation system to create a successful system (Osbourn, 1989).[3]

Meanwhile, there has always been a fundamental question among sponsors, designers and contractors as to what degree standardisation should be to avoid monotony and to make the products aesthetically acceptable even with the price of rather less efficiency. The current attitude, in developed countries at least, is to support standardisation as long as

[3] All these issues should be considered when transferring MMC to Iran. As discussed previously and will be discussed in chapter 8 and 9, the risk of application of some MMC may be too high since many of these issues are not available or require more research in Iran.

it does not affect the aesthetic quality of the system. The current architectural and technical challenge of building industrialisation is standardisation of individual buildings without affecting the design freedom.

Apparently applying computer aided design and manufacturing (CADCAM) systems has created an opportunity to have significant variety in the products without affecting the construction feasibility (Warszawski, 1996).

2.5 History of modular co-ordination

Many of the sizes of today's building components have roots in history and are related to human scale, or so-called anthropometrics. For example, during the medieval period the dimensions of brick clay were standardized with regards to its weight. This would enable the labourer to lay the brick easily with one hand while the other hand was free. The clay brick standards have been now translated to 215mm x 102.5mm x 65 mm (Osbourn, 1997). Figure 2-4 illustrates the use of brick module for sizing the building elements.

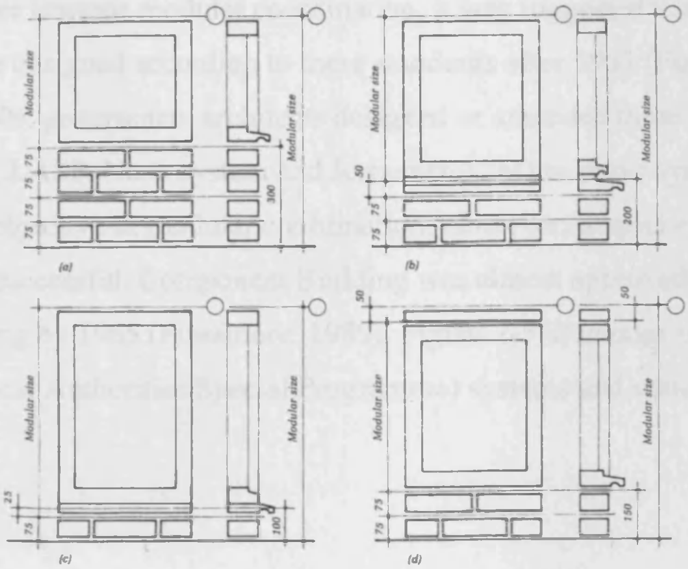

Figure 2-4: Brick Module
Source: (Blanc, 1994)

Before and after the Second World War there were some attempts toward standardisation of building components however the theory of standardization was not very welcomed by the government (Finnimore, 1989). Theorists of the Modern Movement such as Walter Gropius and Albert Farwell Bemis did some work on modular coordination theory (Kelly, 1951).

According to Modern Movement theory, modular coordination was a fundamental issue to any attempts toward mass production in prefabrication. During the 1950s, modular coordination became more important in the UK governmental policies (Finnimore, 1989).

School building development in the 1950s, although not very successful, was the basis of the theory on which some sort of modular components were developed. Such attempts shifted from schools toward housing since standardisation of schools was more complicated due to their much bigger sizes (Finnimore, 1989).

Modular coordination idea was moved to an international agency (European Productivity Agency) in 1954 to be studied more comprehensively. In 1961 the agency published its second report recommending a 10cm module for metric and 4ins for imperial countries which was approved by the International Organisation of Standards (ILO, 1968).

During 1963-68 many documents were published by the Ministry of Public Works and Building promoting vertical and horizontal dimensions for different building types including commercial, educational, industrial, housing and public buildings. To encourage the industry to move towards modular coordination, it was suggested that all governmental buildings would be designed according to these standards after 1963 (Finnimore, 1989).

In the early 1960s, government architects designed or amended three methods of construction (5M CLASP, Nenk system and Jespersen 12M) to move system building more towards the objective of modular coordination. However, despite expectations, none proved to be very successful. Component Building was almost approved as the next stage of industrial building by 1965 (Finnimore, 1989). Figure 2-5 illustrates the CLASP4 (Consortium of Local Authorities Special Programme) systems and various components applied in it.

[4] 100mm module (M) is the basic module used in CLASP system. 300x300mm grid is used as planning module and 1.8x1.8m (18M) is used as structural grid.

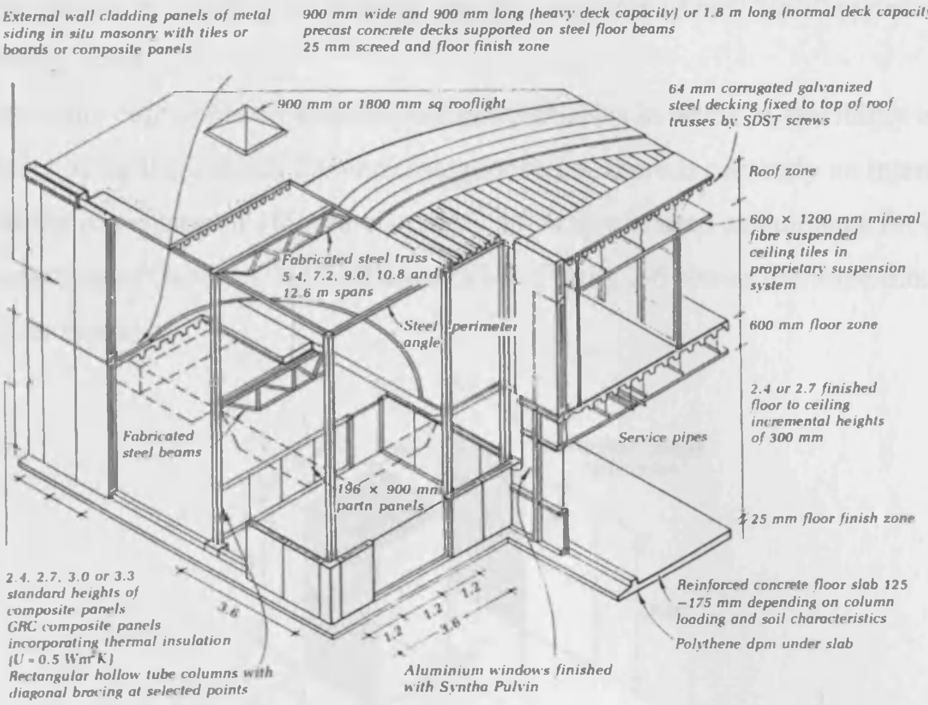

Figure 2-5: CLASP system
Source: (McEvoy, 1994)

Metric House Shell was published in April 1968 by the National Building Agency proposing the standardisation of all housing designs based on some modular external wall dimensions. The application of Shell recommendations associated with the plans for shifting housing dimensions to metric system became the official policy of the government in the next year (NBA, 1969).

2.6 Dimensional co-ordination

Accuracy is one of the major issues in big construction projects where the number of individual components increases considerably.[5] The accuracy can sometimes be enhanced by modularisation of the components. Modularisation also in turn is affected by dimensional coordination which is based on a national three-dimensional grid of basic modules within which the maximum and minimum sizes of components are defined (Riley and Howard, 2002, Blanc, 1994).

Dimensional co-ordination is a system of arranging the dimensional framework of a building so that standardised components can be used within the framework in an interrelated pattern of sizes. In this way it can be closely connected with the overall

[5] As we will see in next chapters, accuracy is one of the major concerns in Iran. This should address since it will increase the associated risks of MMC considerably.

development of building technology and the evolution of new building processes (Blanc, 1994).

Despite many comments on dimensional co-ordination in terms of feasibility and acceptability of such standards between manufacturers, there is currently an international basic modular dimension of 100mm so-called 'M' which is used as guidance for designers and manufacturers (Osbourn, 1997, Blanc, 1994). Figure 2-6 shows the three dimensional grid of basic modules.

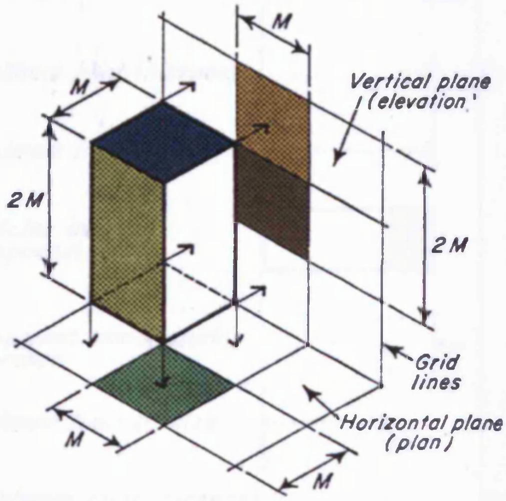

Figure 2-6: Basic module grid
Source: (Osbourn, 1989)

British Standards recommend some manufacturing dimensions based on modular dimensions of 3M, 6M, 12M, 15M, 30M, and 60M. There are also some sub-modular dimensions of either 50mm (the first sub-module recommended) or 25mm (the second sub-module recommended). This system allows UK manufactured components to be used in conjunction with international ones. These modular sizes are not the exact or working size of the components. Modular components are usually needed to be combined with non modular components (Blanc, 1994).

It should also be mentioned that the variation in component sizes is inevitable for several reasons including manufacturing inaccuracies, associated high costs of great accuracy, inaccuracies of component locations on construction site and also physical nature of materials which for instance may cause contraction or expansion. For these reasons building components are not designed with exact dimensions to fit in a space but there is some tolerance allowance in jointing areas in the case of inaccuracies on site (McEvoy, 1994, Osbourn, 1997, Riley and Howard, 2002) .

Modular construction systems, for various reasons which will be explained later, have limited structural spans and different ranges of external and internal finishes (McEvoy, 1994). Figure 2-7 illustrates the component tolerance and inaccuracies which are covered in jointing elements.

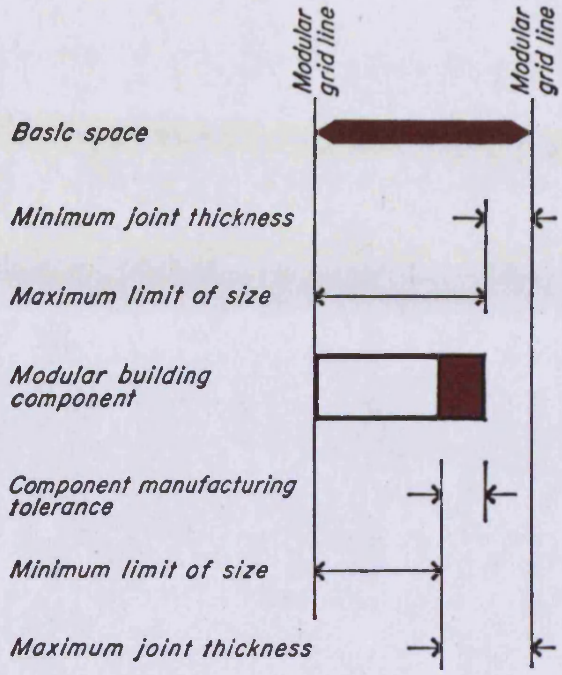

Figure 2-7: Component Tolerance (edited by the author)
Source: (Blanc, 1994)

2.7 Open and closed systems

During the 20th century and especially in the 1960s huge demand associated with the need to build fast and economically developed some industrialised building methods which ended the reliance on traditional building methods. Such industrialised methods of building which introduced standard prefabricated compensates to the construction industry are usually referred to as System Building. There are two main approaches in system building (also known as industrialised building)(Riley and Howard, 2002):

- Open System
- Closed system

Open and Closed systems have roots in the fact that the construction industry has not been as efficient as other industries. The uniqueness of different building projects makes the involvement of several authorities including sponsors, designers, engineers and contractors inevitable in the construction process. This situation decreases the efficiency of the system. The need for bringing all the authorities under a single management is more obvious for industrialised systems than conventional building methods.

There have been two solutions to resolve this problem. First: to merge the design, production and marketing activities under the authority of one industrial system known as Closed System. Second: to create an Open System in which standard components such as floor slabs and beams, produced by different manufacturers, are applied in different building projects by any designer who is familiar with the shapes and sizes of the components (Warszawski, 1996).

Open System is also known as component building which applies different standard components manufactured by different manufacturers to create a building. This allows the designers to choose from a wide range of products which are extendable in different types of buildings. However, the success of this system depends greatly on the degree to which the products follow standardisation, dimensional co-ordination and international jointing system. Open system is great in economic terms however there may be some material waste. Also, attempts in some Scandinavian countries to create open systems based on a national standard have not been very successful elsewhere due to aesthetic rejection and associated costs (Riley and Howard, 2002).

Such methods of construction are much faster than the traditional methods due to their approach toward the construction process. In such methods of construction, time saving is achieved by overlapping different tasks while in traditional methods this is not possible as a result of linear system of design and construction. However problems appear when two or more systems are put together. Resolving such practicality problems is the major role of designers (McEvoy, 1994). Open systems also rely greatly on skilled labour which may be different for different applied components whereas closed systems usually rely on only one single skill which is proper for the system (Osbourn, 1989).

In Closed System, components are manufactured for an individual building and are not exchangeable with other buildings or systems. Closed systems are fast and efficient in assembly on site however they are not very adaptable to design which make them so restrictive especially when design alternation is needed due to change of occupants. Meanwhile the designers' choice of products is limited to what is manufactured in the chosen system. These problems and limited flexibility of buildings built by using closed systems have caused general rejection of Closed System in favour of Open System (McEvoy, 1994, Riley and Howard, 2002).

The problems of both closed and open systems resulted in introduction of what is so-called Flexible (close/open) system. Flexible systems include some fixed components which can be mixed with each other in an approved order however they offer great flexibility in layout arrangement. Some of the Flexible systems are only structural systems to which cladding and finishes are attached using conventional on site methods (McEvoy, 1994).

2.8 Advantages and disadvantages of prefabrication

Prefabrication has some perceived advantages which are listed below (McEvoy, 1994, Warszawski, 1996, Harvey and Ashworth, 1997):

- Better quality due to enhanced quality control in the factory environment
- Labour saving up to 40-50% especially skilled labour since up to half of the costs on site is the labour when applying conventional methods. Meanwhile, it has been argued that although there is onsite labour saving in industrialised methods, saving is offset by the additional labour required in the factory.
- less construction time

In addition, when the construction site is not easily accessible and it is expensive to take the labour to site, applying prefabricated components is considered as a solution (Vale, 1995).

Despite the advantages of prefabricated systems, the share of industrialised building systems in the construction industry does not increase in many countries due to the following reasons (Warszawski, 1996):

1. Low demand especially in developed countries which makes the investment in such methods more risky compared with conventional methods
2. Negative public attitudes as a result of bad memory of previous attempts at industrialisation that resulted in monotonous dull buildings which suffered from many defects which were the consequence of lack of enough technical expertise and quality control.
3. Lack of flexibility when design is needed during building lifetime.
4. Prefabricated building systems and required knowledge of technology, design and organization never became a part of the education system for architects and engineers.

Meanwhile, there are some disadvantages associated with prefabricated systems including (McEvoy, 1994):

- Limitation of component sizes for transportation reasons
- Being economically feasible just for big projects
- Big and heavy components need to be positioned using cranes which may affect the applied materials and form of the building

For example, there are various issues which should be considered when choosing precast concrete as the method of construction. Precast structural concrete components are heavy which limits the size of such components due to transportation and erection issues. For these reasons the maximum width of precast components should be as large as the maximum official vehicle (12-14 feet or 3.66-4.27 meters). Also the sculptural and flexible characteristic of insitu concrete is not available in precast components (Allen and Iano, 2004).

2.9 Building materials

In 1991 about £20 billion was spent on construction materials in the UK. About 40% of the construction cost for new buildings is accounted for by building materials. In large projects, material costs could go up to 60% of building costs and when it comes to maintenance the cost for building materials could be as little as 15% of total costs (NEDO, 1978).

Until some time ago, building materials were selected based on their structural strength and durability. The situation has changed now since the building materials are mainly selected based on the health and environmental issues. The latest factor in selecting building materials is their energy consumption during manufacturing process. It means that the most energy intensive materials (per unit) such as paints, metal and glass are the most expensive materials which are used more carefully in construction. In turn those materials which are less energy intensive such as brick, plaster and cement are less expensive per unit. At the moment durable building materials are usually chosen by the construction industry based on their cost and availability (Harvey and Ashworth, 1997).

It should be borne in mind that to increase the construction production modestly in national scale, there should be a substantial investment in production of raw materials, such as brick and cement, and may be substructures including transportation to create a new capacity. However, the investment on such materials should be based on the future demand for them (Harvey and Ashworth, 1997). It means that supply is a fundamental issue when considering mass production.[6]

2.10 Economic and cost issues

Economic criteria are fundamental when establishing a prefabrication factory. In order to produce components economically, there is an optimum number of manufactured components and applied plants in the process. Even in standardised production systems there are inevitably some components that should be manufactured non-standard. Non-standard components are more difficult to manufacture in systems which are more automated and therefore such components would be more expensive and would take longer to be delivered. In this respect, in long term, those manufacturing methods which are capable of producing components economically and in a broader range will be more successful (Blanc, 1994).

In terms of construction process, some factors which may reduce the total cost are listed below (Harvey and Ashworth, 1997):

- "Complete design at tender stage
- Teamwork
- Construction as a manufacturing process
- Increase standardization and prefabrication
- Reduce changes to the design
- Optimize specifications
- Improve design cost effectiveness
- Apportion risk efficiently
- Improve productivity
- Reduce waste
- Use of cost-efficient procurement arrangements
- improve the use of high technology for both design and construction"

The use of prefabricated building components should in theory be much cheaper due to mass production of such components. However this is not always true in actual construction.

[6] This is also one of the main issues which should be considered in Iran. Introduction of Modern Methods of Construction to Iran may resolve some problems and may increase the housing output but it may also increase the demand for raw materials. Therefore to avoid prices from being pushed up, it is necessary to increase the industry capacity to satisfy the demand for raw materials when required.

In traditional buildings, the cost of basic building materials accounts for about 50% of total material used in such buildings. In prefabrication systems the cost of storage, transportation and assembly of manufactured components should also be considered. This process in turn results in the need for additional material and details for handling to protect them against damages which again results in higher costs. For example, precast concrete panels require extra reinforcement to protect them during transportation and assembly. They also needs a rather complicated jointing system for connection with other components on site. The erection process should also be undertaken very carefully to avoid damaging the panels. These factors result in higher associated costs for on site handling and management. Therefore, the cost of prefabricated components increases considerably compared to similar components which are fabricated traditionally on site. Yet, the key advantage of industrialised methods is the quality of products which is the result of taking advantage of factory environment and involvement of designers during early stages of construction (Osbourn, 1989, Osbourn, 1997)

Prefabrication became less attractive than other building systems mainly due to the failure of designers and manufacturers to make products economical and aesthetically attractive. They also failed to consider the systems as a whole and not just as individual components. This resulted in less demand and consequently higher costs compared to other systems. Now however, because of possibility of automation of building industrialization process with the help of modern information technology, computers and new machinery, prefabricated building products have become more competitive with other systems and products (Warszawski, 1996).

2.11 MMC definition

MMC has been described by various names such as "pre-fabrication, off-site production and off-site manufacturing (OSM). But while all OSM is MMC not all MMC is OSM" (Burwood and Poul, 2005).

Commission for Architecture and the Built Environment (CABE) has explained MMC as to enhance quality, reduce on-site time, improve on-site safety and addressing skilled labour shortage (CABE, 2004).

The Barker 33 Cross-Industry Group report in 2005 describes MMC as both improved product and process: "Modern methods of construction are about better products and processes. They aim to improve business efficiency, quality, customer satisfaction, environmental performance, sustainability and the predictability of delivery timescales.

Modern methods of construction are, therefore, more broadly based than a particular focus on product. They engage people and process to seek improvement in the delivery and performance of construction."(Barker 33 Cross-Industry Group, 2005) Therefore, MMC must be seen not as an end in itself, but as a means to achieving:(Barker 33 Cross-Industry Group, 2006, National Audit Office, 2005)

- Greater business efficiency
- Enhanced design and quality
- Improved customer satisfaction
- Enhanced building performance
- Increased housing supply meeting the aspirations of the market as a whole (open market, social and affordable)
- Enhanced environmental performance with reduced impact

It is important to bear in mind that MMC cannot be a replacement for traditional methods of construction and it should only be seen as a complementary source of construction beside conventional methods. In a report of British Urban Regeneration Association (BURA), MMC has also been explained as a process not only a method of construction. It continues that MMC should be seen as an evolution, not revolution, in the construction industry (Burwood and Poul, 2005).

2.12 Conclusion

There have been several attempts toward industrialisation of construction industry however the nature of construction industry such as the involvement of several stakeholders and difficulties to bring them under a single management, make it difficult to achieve this goal (Warszawski, 1996, McEvoy, 1994). Basic issues such as centralization, mass production, standardisation and organisation should be considered to make industrialisation feasible (Warszawski, 1996, McEvoy, 1994).

There are two main manufacturing systems known as open and closed systems. In open system different components from different manufacturers are put together to form the final component which could be used in different buildings whereas in closed systems different components are manufactured and assembled by one manufacturer and the components are not exchangeable with other buildings (Warszawski, 1996, McEvoy, 1994, Riley and Howard, 2002).

Closed systems are fast and efficient but not flexible (Riley and Howard, 2002) whereas open systems are more flexible but rely more on the availability of skilled labour (Osbourn, 1989).

Industrialised systems have some advantages such as enhanced quality, saving skilled labour and faster construction on site (Vale, 1995). Apparently there is not much cost saving in applying such methods of construction despite the fact that they are mass produced. It seems that the main advantage of using industrialised systems is the quality of products (Osbourn, 1997, Osbourn, 1989).

Industrialised methods of construction have also some disadvantages such as limitation in component sizes, due to transportation and assembly issues, and feasibility of applying such methods in small projects not being economical (McEvoy, 1994).

The application of offsite construction methods especially in developed countries has not been increasing for various reasons including low demand, negative public attitude, lack of flexibility and the fact that architects and engineers are not very familiar with such methods. However it seems that the situation is changing since some of the mentioned issues do not exist anymore. Moreover, offsite components have become more and more economical and competitive with other building products thanks to application of computer, new machinery and information technology (Warszawski, 1996).

Finally it is very important to bear in mind that MMC is about better product and process (Barker 33 Cross-Industry Group, 2005) and it should not be seen as a complete replacement for conventional construction methods and that MMC is an evolutionary process in construction not a revolutionary one (Burwood and Poul, 2005).

Several important criteria in industrialisation and the broad meaning of MMC were discussed in this chapter. The following chapter aims to explain the influence of the Modern movement on the Iranian housing architecture which transformed the traditional Iranian architecture.

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Part 1: Iranian Housing

Chapter 3: Iranian Housing History

3.1 Introduction

Housing architecture has a long history in Iran. In Iranian culture a house is not just a shelter, it has always been a holy place; it is the home not just a house. However, Modernism almost transformed this concept in many aspects. Iranian educated architects, international architects and the government had an important role in this process.

This chapter aims to define the traditional and contemporary Iranian housing architecture and explain briefly what happened during the last century which changed the previous rich Iranian house architecture to the current provision of steel and concrete framed apartments of almost uniform appearance.

The current situation of the Iranian architecture, society, culture and also theories such as the mass-building and industrialisation have roots in this period.

3.2 Principles of Iranian housing architecture

3.2.1 Iranian traditional house

The definition "Khaneh" (house) used to be called "Otagh" and private "Otagh" was called "Vostakh" or "Vosagh". Nowadays definition "Sara" is used as "Khaneh" (Pirnia and Memarian). The traditional house was shaped during centuries based on human needs at the time. The living system in the Iranian culture was mostly based on the central courtyard which was surrounded by various spaces such as rooms. Twisted alleys and houses with their central courtyards were very well combined in a meaningful way and with their own identity. Although there was a huge variety in houses, none were exactly identical. The reason for such proper combination was application of the architectural principles and specified methods.

The house was introverted and the introversion by not paying attention to the external but paying attention to internal appearance was the character of Iranian houses. The house was introvert to protect it from strangers. The house was the centre of family activities a place where the wife and children were living and. The courtyard was a small garden because there were no trees or gardens outside and there was a pool which was clean and pure and manifested the sky.

Around the pool, there were flowers and trees and around the courtyard, rooms (so-called Se-dari, Panj-dari, Talar) with coloured windows and glasses were situated. The arrangement of levels and access from outside (Anbirooni) to inside (Andarooni) was an arrangement, which was based on the Iranian culture, and maked the living space a peaceful and safe space for the family.

Gradual changes in space from public spaces such as squares, bazaar, mosques and districts with allays, gates and lobby (Hashti) and corridors to the most private spaces in the house from the Anbirooni's courtyard to Andarooni's courtyard and rooms were formed based on Iranian needs during many centuries.

The region and climate conditions were of principles, which created this order. In a traditional house, spaces around the central courtyard were indeed designed based on four seasons. On the north of the house, sunny rooms which could be used during the whole year especially during winter were situated. On the south which is shady, the summer part was formed. On the eastern part, which is faced to the violent sunset light, unimportant rooms such as storage, were situated. Based on these criteria and harmony with the region and climate conditions (sun and wind direction, storms) the "Roon" or house direction would shape.

Module was another principle based on which traditional house was built. All parts of the house were based on "Peymoon" which is the width of the door. There were two kinds of "Peymoon". The first one was small "Peymoon" which was 93.3 centimetres and was used in small houses. The most beautiful houses were built based on small "Peymoon". The second module was big "Peymoon" that was 120 meters. These dimensions and modules were based on the Iranian human scale.

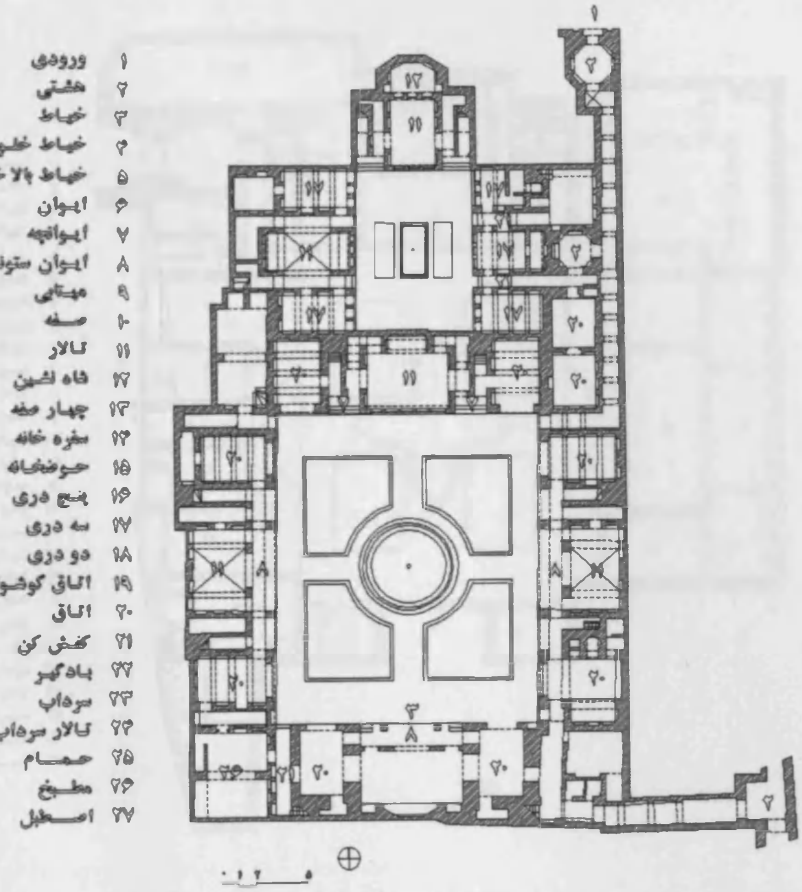

Figure 3-1: Sharif house
Source: (Khodadadi, 1999) (Edited and drawn by the author)

A typical traditional house was made of some basic components (Figure 3-1) (Pirnia and Memarian, 1992): Sardar (the gate),Hashti (entrance lobby), Rahro (corridor), Eyvan (patio), Hayat Markazi (central courtyard), Otagh (room, chamber).[7]

7

1. Sardar (the gate): Most of the traditional houses especially luxury houses had a gate. External walls were usually covered with plaster of clay and straw and only the gate was made luxurious. Two beside platforms, so-called "Pakhoreh", were built as sitting area for the visitors who were not supposed to go inside the house.
2. Hashti (entrance lobby): Following the entrance gate, people would enter the "Hashti" which usually had eight sides in plan. Although, "Hasht" in Farsi (Persian) means "Eight", here it meant a place, which connected outside to the inside world. "Hashti" also existed in different shapes such as four, five, and six sides.
3. Rahro (corridor): "Rahro" which was also called "Dehliz" or "Dalan", was used to connect and enter different spaces such as guest room and "Andarooni". Twisted corridors were called "Dalan".

3.2.2 Charmi House

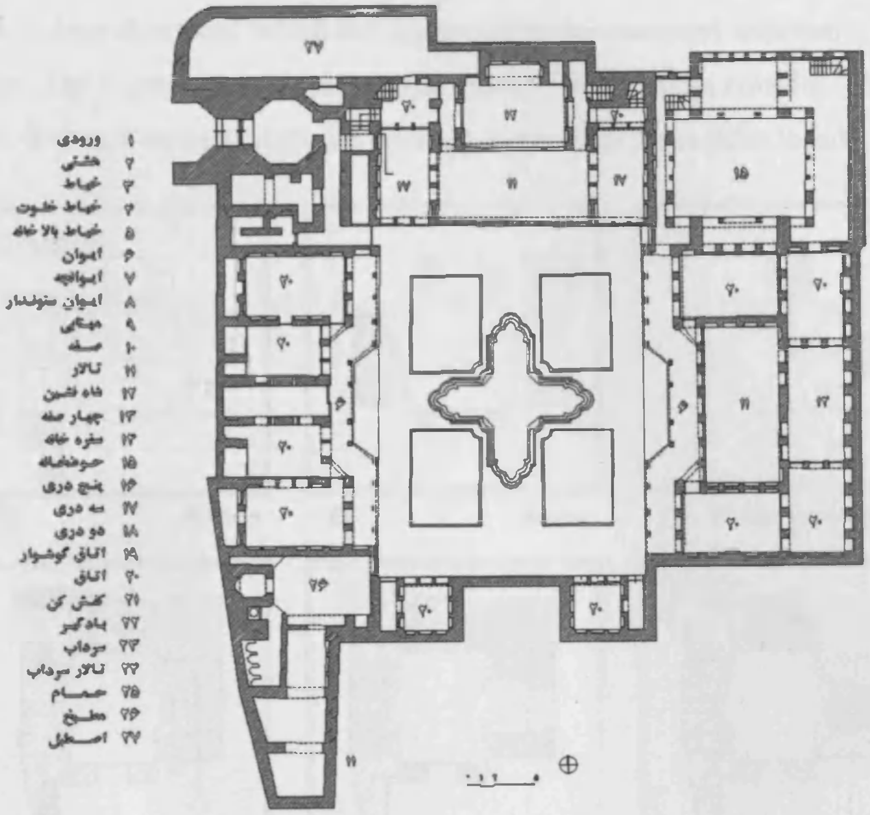

Figure 3-2: Charmi house
Source: (Khodadadi, 1999) (Edited and drawn by the author)

Charmi house (Figure 3-2 and Figure 3-3) is one the luxurious houses in Qajar period. The house is shaped around the central courtyard in four sides. It has three stories in the north, a hall is situated in the middle, and four 3-door chambers are located in two sides and in two floors. There is an aquarium in three floors, which is located in the northeastern corner, and a magnificent space was created with the last floor skylight. The eastern section is has a hall in the middle and two 3-door chambers in sides. “Shah Neshin”, which

4. Eyvan (patio): “Eyvan” is one of the most important components of the Iranian architecture, which can be found in most of the traditional houses. It has various shapes, sizes and positions in the house. It is the most important part of the traditional house for living and has different functions.
5. Hayat Markazi (central courtyard): Central courtyard is a roofless space located in the centre of the house. Central courtyard in different cities such as Isfahan, Yazd, Kerman and Shiraz is regarded as a small garden where rooms were built around it.
6. Otagh (room, chamber): In traditional Iranian houses, rooms were built with different names (such as Seh-dari, Panj-dari, Talar etc.) sizes and shapes. Each of the rooms had its own characteristic and function and the Iranian golden proportion (an encircled rectangle in a hexangular) was used in Sehdari (3-door chamber) and Panjdari (5-door chamber). Their common sizes were 3m x 4m, 3.5m x 5m, 3.5m x 2.5m or 3.4m and their depth was suitable to absorb enough sunlight during the winter.

is another kind of room, is connected to two rooms located behind 3-door chambers and a columned veranda, which connects eastern spaces to the central courtyard. Southern part has only two 3-door chambers, which are connected to the courtyard with two antechambers. The western part has an unusual plan, with its central corridor. The kitchen is located on the southwest and includes cooking and storage areas (Khodadadi, 1999).

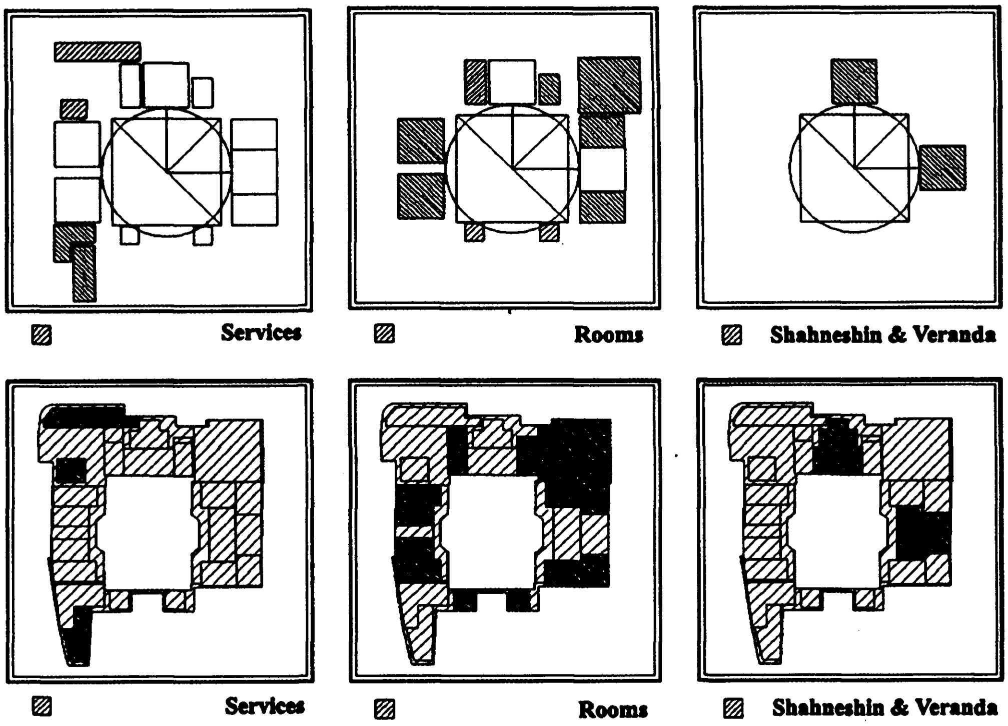

Figure 3-3: Location of different spaces in Charmi house
Source: (Khodadadi, 1999) (Edited and drawn by the author)

3.3 Iranian architecture and housing history

There are some turning points in the history of Iranian architecture during the previous century which are explained in this section.

3.3.1 Pahlavi period and social, cultural, economic and city structure

Constitutional revolution and distribution of new ideas and methods required new texture in social and cultural characteristic of the country. Appearance of Reza Shah and shifting the power were followed by a wide transition in Iran. Like many European countries after the First World War, new notions and innovations were privileged. Now, another duty was injected to Tehran by the expansion of the governmental duties. This was the end of tribe-based government. The society changed to a stratified society and different districts had different classes and categories (Shour, 1962).

Tehran developed in empty spaces of Naseri's city and this development continued to the north and west of the city. The extent of the city was about 46 square kilometres at this time. City development started with destruction of Naseri's fortifications and creation of new streets. Many new squares were built, mostly near the city's gate, and the traditional meaning of square changes. The city was influenced greatly by the Modern ideas and developed by international architects. City districts did not develop in an organic way along the city's skeleton. The city texture changed to checker with crossing streets and new districts were built based on the city planning plans. City at this time consisted of some squares and streets with their extension making the city centre (Figure 3-4) (Pakdaman, 1994).

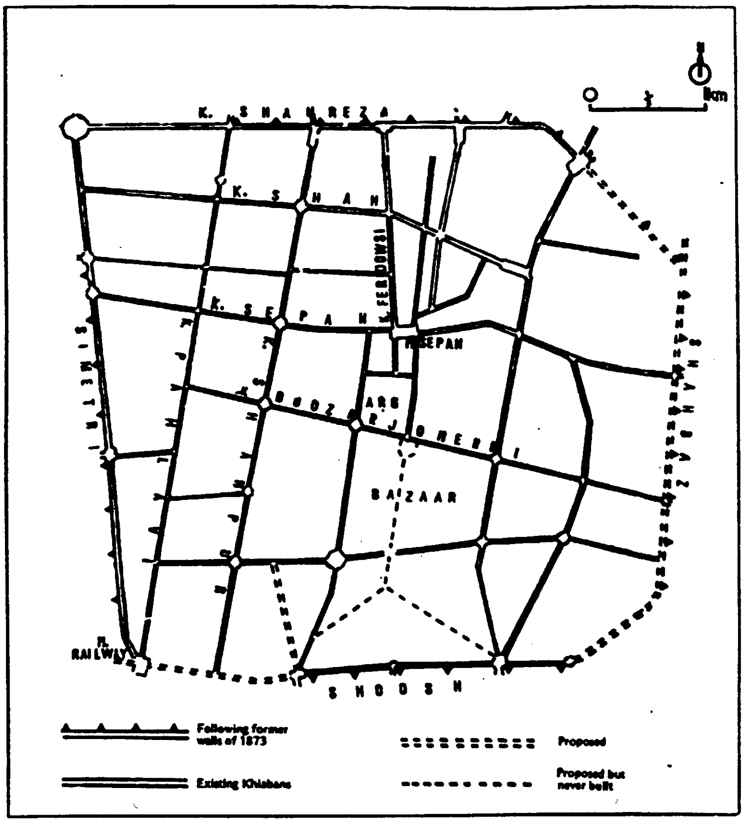

Fig. 2.25 Existing and proposed khiabans in 1937.

٤. شهر تهران در سال ۱۳۱٦ شمسی (۱۹۳۷)

تخریب حصار و دروازه‌های شهر در زمان رضاشاه و ایجاد مجموعه‌ای از شبکه خیابانها و میادین در ادامه

اصلاحات دوره قاجار

Figure 3-4: (Tehran in 1937) Removing gates and fortifications in Reza Shah's period and appearance of new streets and squares.
Source: (Pakdaman, 1994)

After the Second World War Tehran was the political centre of Iran and noticeable improvement in economy and technology in Tehran resulted in an obvious growth in the population. In 20 years, the population increased from half a million to two millions. The city suddenly developed and people were settled everywhere. Living conditions in the south were more critical due to the high density.

It was when the mass building was introduced with different names such as labour dwelling and bourgeois dwelling movement. The aims were to settle the increasing population, enhance the living standards, and increase the social justice.

In short, in this period, the city experienced the development along streets and international style was considered especially in the housing developments. Some projects were constructed in Yoosef Abad, Narmak, Nazi Abad and Manzarieh, which influenced the construction industry insofar as the private sector started to imitate (Shour, 1962).

3.3.2 The Islamic Revolution

Islamic Revolution in 1979 and the fake freedom resulted by not paying much attention to architecture and city planning resulted several problems.

Land and Housing Organization started to allocate free land to people and other organizations with very low prices and without paying any attention to the city planning and architectural considerations. The consequence was a fast rural migration and population increase which in turn resulted in an imbalanced texture of the city.

Moreover, the war between Iran and Iraq and encouraging people to have more children and unreliable investment in rural areas and small cities were serious issues that resulted in a dramatic increase in Tehran's population. However, later some plans were established for logical development of Tehran (Pakdaman, 1994).

3.3.3 Tehran's architects and architecture in Qajar and Pahlavi period

Tehran's architecture was mostly the Iranian and traditional architecture and was not affected by the western architecture until the midterm of its period as the capital city of Iran. The midterm of Qajar period with the start of a broad relation with the European countries was the beginning of Tehran's transition. Since then Iran's architecture was influenced by the western architecture and urbanism theories.

Some architectural methods such as the nineteen-century's eclecticism were imported and applied in the same order and style as the European ones. Many commercial and governmental buildings such as the old telegraph building around Topkhaneh square are examples of buildings with no signs of Iranian and traditional architecture (Pakdaman, 1994).

Meanwhile, besides European architects, Russian and Armenian architects gradually started to build European style buildings. At the beginning, Iranian architects did not pay attention to these styles and methods however, they gradually became more common.

Figure 3-5: Hasanabad Square
Source: (Sarami, 1991)

Applying the European decorations and ornaments such as Rococo and Empire Style, first became common in nobles' houses and were then introduced as the new art. Gradually these minor effects changed the whole architecture.

As an example, those houses with projecting columned main entrance and big ceremonial stairs in the middle and rooms located in two sides and in two floors can be mentioned (Figure 3-6). This style was completely different from the Iranian traditional architecture in which the stairs were usually situated in a corner of the house and were never disclosed openly.

In these cases, the plan is Western but verandas and other Iranian architectural elements have given an Iranian concept and image to the house creating a very desirable and pleasant space (Sarami, 1991).

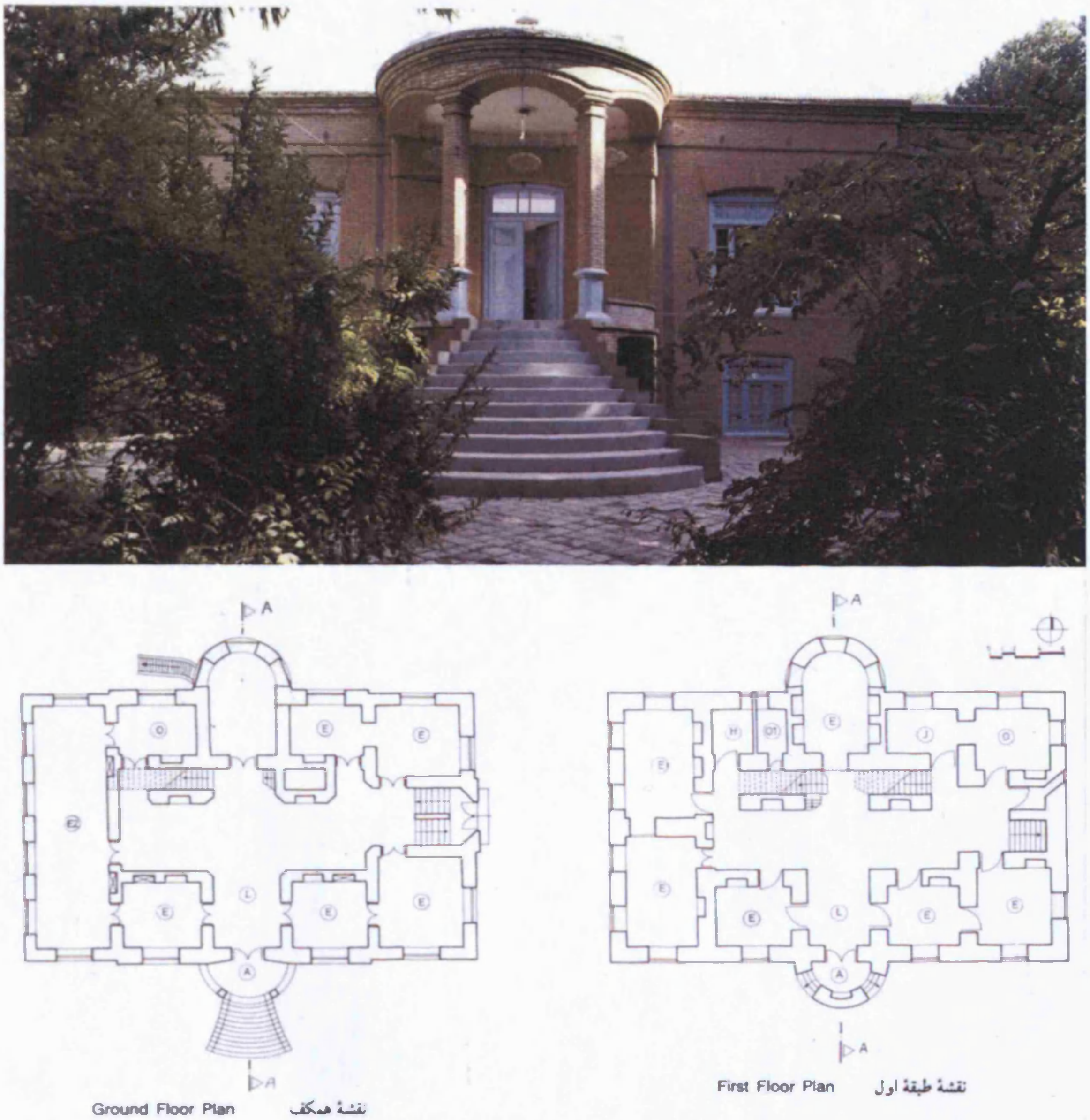

Figure 3-6: Amineslami house
Source: (Sarami, 1991)

During the first Pahlavi Period, Iranian architecture was influenced by Western neoclassic architecture. It became common to apply old architectural elements in buildings designed in western style. International architects had an important role in teaching young architects in Iran. Godar and Cyrus were of those who, besides building, were teaching architecture in Tehran. Godar was the first principal of the Faculty of Fine Arts of Tehran University and had an important role in architectural teaching for more than 20 years. He, with the help of Forooghi, established the architectural educational programmes based on the Beaux Arts of France.[8]

These architects at first had a very little impact on the residential architecture and their works were very little in housing sector. Most of their works were in governmental and important projects and houses were still built in their traditional methods and styles. However, as mentioned before, they had an important role in teaching young Iranian architects (Momeni, 1962).

After international architects, Iranian architects who had studied in Europe prepared the basis of changes from the Iranian traditional architecture to Modern architecture. These architects being influenced by some architects such as Gabriel Gourkian, Vartan Havansian, Mohsen Foroughi and Paul Abkar and Modern movement, which was swiftly spreading in whole Europe, USA and other countries, were trying to replace Modern Movement theories with the traditional ones.[9]

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[8] Maxim Cyrus during three decades was the most distinguished international architect in Iran. As an archaeologist, he was very interested in the Iranian traditional architecture but later started to build modern buildings applying the Iranian traditional elements (Marefat, 1962). So-called Godfather house type is an example of the housing types in this period, which was an introvert (inner-directed) house, with its rooms and other services located in four or three sides of the building. Its windows were directed to the courtyard and one side of the house was directed to the alley or the street where a door would connect the house to the outside world. Gradually some houses with the whole building located on one side and facing the entrance were built. These buildings were built in two storeys. The second floor was used for guests and the first floor was used for daily life because of its privacy and being protected from the sight of the pedestrians in the street.

In Reza Shah Period, because of the attention which was paid to the layout of the streets, buildings which were built alongside the streets, were built in three floors. The first floor was used for the shops, the second floor for offices, and the third floor was used for dwelling. The studies show that at first Armenians were settled in such houses and Muslims did not settle there since they did not want to live in apartments (Momeni, 1962).

[9] Mohsen Foroughi (the most distinguished architect in his period) was the first Iranian architect who participated in Reza Shah's programmes. He was the most influential person in architectural education and was one of the founders who established architecture profession in Iran. He was graduated from France in 1935 and was used to design buildings in Modern style. However, he would wisely apply his knowledge of Iranian traditional architecture in his works.

Foroughi also built many residential houses where new western styles, pattern and materias were applied. In these houses, instead of dividing the plan into "Andarooni" and "Anbirooni" it was divided into some rooms with specific functions. New bourgeois people, who had mostly studied in western methods, were interested in modern life style and some architects such as Foroughi would help and lead them to such western life style.

Gabriel Gourkanian was another architect who had a big role in spreading the Modern Movement theories in his short period of living in Iran. He is one of the very few Iranian architects who have worked in world-class level and have international reputation. In Werkbund residential complex in1930 in Vienna, which contains the selected collection designs of modern international architectures, the designed houses by Gourkanian were beside the houses designed by Adolf Loos, Josef Hoffmann, Andre Lurcat, Richard Neutra and Greit Rietneld.

Gourkanian would actively participate in CIAM congress, which had been held since 1928, and in the first CIAM congress was so active as the secretary of the conferences and his name was beside the name of Le Corbusier and Gideon. He did many works during his four years of stay in Iran and had a considerable

The result of their efforts was forgetting the traditional Iranian architecture and replacing an architectural order which was dispersed anywhere. From now, Modern architecture becomes the dominating architecture in Tehran and Iran. There is not any sign of traditional architecture and those complicated systemized regulations and arrangements in housing design. Form now on, all new houses become extroverted.

3.3.4 From continuity to discontinuity

To understand the current situation and changes which occurred in the modern Iranian architecture, it is necessary to have a brief review on external causes and factors.

Since the 19th century, many aspects of European life were transformed and a great revolution occurred in all fields. Increased progress in science and industry in European countries during this time expanded in an extraordinary way. Innovation of steam engine at this time became the symbol of industrial revolution. These progresses made several fundamental changes in science and industry in European countries. Increase in industrial production and consumption led to an expansion in relationship between Europe and other countries. Due to its particularly strategic situation, Iran was one of the attractive countries for the west and the relationship between Iran and Europe developed in all areas. However, despite previous periods, such as the Safavid period (1501-1722), when Iran appeared to be the dominant culture, at this time it was overwhelmed and lost its self-confidence due to extraordinary improvement of the western countries in science and technology.

At the beginning of the 19th century and during Fathali Shah of Qajar's reign, a loss of self-confidence surrounded Iranian people in such a way that they believed the whole progress of Western people is because they wear coats instead of long Iranian dress (Qaba) and shoes instead of "Giveh". This belief extended as so much as they forgot themselves as if there had never been a concept named "art" in Iran. This belief and its consequences harmed the Iranian arts and architecture more than any other phenomenon (Pirnia, 1977).

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influence on the Modern Movement in Tehran. His works were influenced by well-known Modernist architect Josef Hoffmann.

Vartan was another architect whom after finishing his studies and going back to Iran was employed by the government and worked in Tehran's municipality. He studied in Paris and worked there for a while. After 17 years staying in Europe and experiencing the European architecture and urbanism, he went back to Iran. He was a fan of modernity and believed that the glory and beauty of his buildings was in simplicity. His buildings had specific qualities, and signs, and in his buildings, he would use colours and contrast.

Pol Abkar was another young architect who had studied in Europe and after going back to Iran was one of the pioneers in Modern Movement in Iran. With his great talent, he would properly adapt his building with surrounding environment. His buildings were completely distinguishable from other buildings. Buildings with Bahmani Bricks and entrances with white surrounding stones and extended balconies on the elevations are some signs of his works (Pakdaman, 1991).

Iranian architecture has always been influential on the world architecture through creating a dominant art, filled with beauty and elegance. The architecture art of Ashkani and Sassani found its way to all parts of Europe and overseas, renamed as Islamic architecture art. Until the beginning of the 20th century Iranian architecture has always been manifested as an independent and professional architecture. During Reza Shah Period when construction activities were started, architecture was forced to receive and accept some elements and techniques of the western architecture (Rajabi, 1974).

When subordinate cultures face dominant cultures, they adopt many aspects of the dominant cultures in their deeds, conduct, behaviour, living style, clothes, foods and even in language and most importantly in architecture to decrease or even remove the gap. In particular, this happens when the subordinate culture is not prepared to put aside its traditions and symbols completely. This is when the artists of these periods start to create eclectic works (Jahanpour, 2000).[10]

When Qajar businesspersons and kings travelled to Europe, they were influenced by the Western culture and brought back many Western products and art works to Iran. This encouraged many Iranian artists to use artistic figures and elements of Western architecture.

Until Reza Shah's dynasty, the Iranian social life and culture were based on a traditional social life and the architecture would rely on traditional architecture with all elements which were created over many centuries. Meanwhile, there had never been a situation or requirement which affected the Iranian architecture fundamentally. However, with a revolution and immediately after that, the coup-dictate of Great Reza Shah in 1921, which was in fact another revolution, and also the technologic revolution of the 20th century, Iran was forced to adopt a revolutionary tone. The revolution was under its way and in this situation the architecture, which had so far kept itself balanced with the social and cultural movements, did not have any other choice but to accept an unprecedented revolutionary

[10] The root of Eclecticism in the west is very different from what occurred in Iran. Using western elements and combining them with traditional elements occurred in order to cover serious cultural differences between West and Iran. However, in western countries of 19th century the presence of two dominant architecture styles prepared the way for a new method and style. Benevolo in his "History of Iranian Architecture" has written: Challenges between Neoclassic and Neogothic which reached its peak in 1846 did not lead to follow any of them and since then, most architectures not only have been using Classic and Gothic styles, but also applied Roman, Henrans, Egyptian, Arabic and Renascence. A style, known as Eclecticism was developed with the roots hidden in the decadence of Neoclassicism and Romanticism...in practice. Eclecticism practically is performed in an undesirable style and intelligent and pioneer writers showed their serious protest from the beginning against it...."(Benevolo, 1998)

movement. On the other hand, by adopting and following a revolutionary movement, the Iranian society was forced to adopt several European socio-cultural behaviours and therefore the architecture could not remain away from the need for advanced patterns relying on the 20th century's technologies.

Apparently, since Reza Shah could not (or did not wish to) create a transforming substructure in the social, political and governmental structure, failed to modernise Iran as Modernism had done in Europe or even Japan. He made some reforms and changes in Iran in superficial rather than profound terms as an imitation of Modern Europe. Many modernization mottoes could not come to reality due to contradiction with the Shah's other interests.[11] For this reasons, only those aspects of modernism which did not contradict his dictatorship were applied in Iran. One of those elements, which involved no risk to Reza Shah's reign but could also manifest his power and authority, was the application of modern architecture.

Since then, Modernist trends and solutions governed Iranian architecture. Meanwhile, other symbols of the Western civilization entered Iran as requirements of new social conditions and needs. From now, the Iranian designers did their design works under the influence of Modernist journals and books to respond the tastes, trends, attitudes and motifs of their employers (Jahanpour, 2000).

Iranian architects and urban developers had some modern responses to address the new requirements resulted by migration and population increase. Residential complexes, apartments, and towers were all the answers to meet these needs. They were built in the same way as the West; however much weaker and less acceptable. Naziabad and Sizdah Aban residential complexes and Behjatabad, Saman and Ekbatan towers in Tehran are examples of those developments. Meanwhile, high rate of migration from rural areas to cities and uncontrolled development of these cities resulted in a new form of settlement known as informal settlement.

[11] When, in 1925, Reza Khan ascended to throne in full terms, more than two decades had passed from the Modern Movement in the West. The political systems were experiencing newborn democracy in the West while the Iranian political system was still relying on a traditional structure. Modernism was uttering "Globalization" motto while Reza Khan wanted to achieve a central stability and power during the post-shakes of lack of policies of Qajar. Thus, he wanted to centralize power in his own hands to enforce a dictatorship. Therefore, he did not tolerate democracy even in words. The fifth parliament post constitution movement uplifted Reza Shah to become a king and Reza Shah dissolved the very same parliament.

3.4 Conclusion

The history of the Iranian architecture and housing were discussed in this chapter. The Modern Movement changed the concept of Iranian architecture. The government and Iranian architects who had studied in European countries were the key players in this process. However, the problem was that the Modern theories were not applied completely and some basic and superficial theories were selected and applied. For this reason, the cultural concept and social meaning of the house in Iranian culture has more or less remained the same while the housing architecture has changed dramatically from traditional to modern.

Housing is a comprehensive subject which covers various issues including the culture, architecture, economy and planning. The background and current situation of the Iranian housing with regards to planning, economy and land are explained in the next chapter.

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Chapter 4: Iranian Housing (planning, economy and land issues)

4.1 Introduction

Housing is a complex issue which must be studied in the socio-economic context of a specific country. The Iranian housing industry is not an exception and it is therefore necessary to consider it in the social, economic and cultural context of Iran. The Iranian housing situation is the outcome of several issues including planning, land, economy and other internal and external factors which have direct or indirect effects on the housing market. Such factors can considerably increase or decrease the housing demand and prices.

Planning legislations can greatly influence the housing market and the government has been applying various planning strategies to control and evaluate the housing needs. Mass-building, small building, taxation policies and applying new technologies have been introduced to the housing industry during the last three decades to increase the housing output.

Land is another factor which can influence the housing market significantly. Land accounts for up to 50% of the housing costs in Iran. Therefore, the government has tried to control the housing market by intervening in the land market by introducing different land policies such as dispossession and supply, limitations in land possession, usage laws and regulations, taxation laws and regulations during the last five decades.

The government has also been trying to overcome the low-income housing crisis and the informal settlement by considering and enforcing different policies. However, such policies have been less successful mainly due to the lack of continuity and neglecting other countries' experiences. This chapter aims to evaluate the above issues to have a precise and comprehensive understanding of the current Iranian housing industry. Meanwhile, these issues have direct or indirect effect on the application of MMC in Iran.

4.2 Planning

There are several planning strategies in Iran such as short-term, mid-term and prediction.[12] These are to clarify the housing programmes, evaluate, and predict the housing situation

[12] There are several kinds of planning which the Ministry of Housing and Urban Design of Iran consider (Tofigh et al., 2003):

1. Short-term:

The intentions of short-term planning are firstly, the evaluation of the housing situation every year and if possible every month or season; and secondly, the short-term prediction of the housing situation based on the and the success or failure of such programmes. In this section, the background and current Iranian housing planning policies and objectives are briefly explained.

4.2.1 Housing Planning in Iran

According to Tofigh (2003), the policies of the Iranian government to overcome the housing problems are:

- increasing mass-building;
- applying new technologies;
- building more houses to sell;
- encouraging the society to save more;
- defining consumption model; and
- subsidising and taxation policies to encourage private sector to build based on the consumption model.

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current information. Therefore, the purpose of short-term planning is more to control the situation to prepare the supervisory tools for the application of programmes and correction of the process. Indeed, the purpose of short-term planning is to create a decision supporting system.

2. Mid-term:

The intention of mid-term planning is to clarify the mid-term principles and the ways to achieve these principles. This plan creates the ABC of the housing programmes during the five-year economic, social and cultural development plans of the country. In mid-term housing planning, evaluation of population and wages are the key issues.

3. Housing prediction:

To achieve a realistic horizon in housing, it is crucial to answer the following questions:

- Future housing pattern: are the appropriate future urban residential buildings in Iran apartments, towers, terraced, etc. or a combination of them?
- Future technology in housing: will the technology change in the housing industry? In what approach and aspects? Will it become industrial? What is the role of prefabrication system in housing market? What are the consequences and outcomes of the technology changes in machinery, human resources, constructional materials, production management etc? (my thesis is about this part)
- Future construction materials: is it necessary to apply a special building material? What materials and why?
- Future installations and services in residential buildings: is it necessary to use an especial installations and services (For example individual thermal- cooling units instead of central systems)? What installations and why?
- Future housing financial situation: what are the current housing economic and financial systems, budget and mortgage conditions? How should they improve if the current situation is not ideal? Should banks be governmental, private, commercial, or professional? How are the resources prepared?
- Future of housing subsidy: How the subsidy should be in the future? Should the subsidy be allocated to the supply or demand? Are the policies long-term or short-term policies?

Prediction is to answer one or a group of the mentioned questions. The main issue is that in all incidents, short-term and long-term consequences should be evaluated and the method to achieve the objectives should be defined. For example if it is aimed to change the composition of the residential buildings, consequences and needs such as installations, materials, security issues etc. should be defined. It is also crucial to define what should be done in short-term and mid-term. There are no statistics for the future and therefore there is not any other way but to use the mentioned methods and maybe other countries' experiences.

These kinds of policies have not been very successful in Iran. The statistics in Iran confirm the failure of national housing planning since despite five developing programs before the Islamic revolution and three programs after it, the housing shortage has increased. Statistics reveal the serious need for modification in the housing policies and programmes (Tofigh et al., 2003).

Experience has shown that when the housing effective demand increases, builders will naturally build and supply the demand. Also, to increase the production it is not necessary to encourage builders or to interfere in the process which is costly and ineffective. Some believe that governmental intervention worsens the situation.

Vahidi believes that direct or indirect governmental interference in the housing process and housing supply subsidises enter cheaper houses in the market and push the private sector out of the market being unable to compete with cheap houses. These in turn decrease the housing supply and worsen the situation. While the portion of governmental housing to the private housing is about 3% to 97%, this phenomenon in long-term will increase the prices and the government should supply more portion of the housing, which results in more financial and administrative costs for the government, and this erroneous loop continues (Vahidi, 1995).

4.2.2 Policies to achieve maximum physical output

The Iranian government has considered some general policies to maximize the construction output from the existing resources, which are as follows (National Land and Housing Organization, 2006):

- Small building
- Mass building
- Durability
- Optimized usage of land
- Renting
- Development of municipal organizations

Many of these policies have direct influence on industrialisation and application of advanced methods of construction. Some of these policies are explained in this section.

4.2.2.1 Small building

The harmony between the society's financial strength and young families' housing needs define the average area of new built houses to satisfy the minimum living requirements.

According to the planning policies, the average area of each residential building in big cities, such as Tehran, Mashhad, Isfahan, Shiraz and Tabriz, should be 75 square meters, 100 square meters in other cities and 80 square meters in rural areas. Statistics show that the government's plans to encourage small-building have not been very successful.

According to the Central Bank of Iran's reports on housing, the average area of new built houses has decreased from 127 to 122 square meters during 1995-2000. While about 95% of housing activities are by the private sector, such regulation are mostly encouraging, and as can be seen, there is still a huge gap between the reality and the objectives of the Third National Development Plan.

Figure 4-1 shows the average areas of residential units which have received building certificate in 2007. The figure indicates that the majority of housing units constructed in year 2007 are between 120 to 150 m².

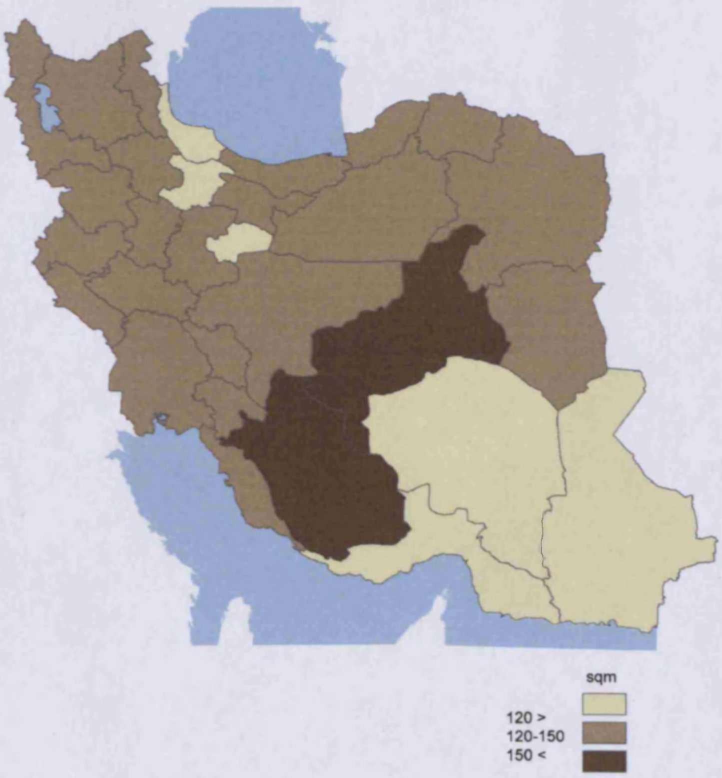

Figure 4-1: Average area of the residential units constructed in year 2007 (Edited by the author)
Source: (President Deputy Strategic Planning and Control, 2007)

4.2.2.2 Mass building

Iran requires more than one million houses to be built every year to satisfy the current demand.[13] It is obvious that it will be practically impossible to produce this number of

[13] Housing demand and supply will be explained in detail in Chapter 4

houses with limited resources and with the current Iranian construction characteristic, which is usually self and individual building.

Individual building increases the construction duration resulting in an inefficient use of resources, enormous waste, and unacceptable costs. Therefore, the best solution to overcome such problems is to encourage mass building, which is one of the major policies in housing policies in the Third National Development Plan. Mass building is one of the basic issues which should be considered when it comes to application of Modern Methods of Construction.

The main benefits of mass building are claimed to be (National Land and Housing Organization, 2006):

- Optimize usage of land
- Energy and materials savings
- Environmental advantages
- Improved technical factors and stability
- Efficiency in human resources
- Potential use of new methods of construction and management in housing

Therefore, in the Third National Development Plan special arrangements have been predicted to encourage mass building. In Article 138 of the Third National Development Plan, mass building has been defined as building three or more houses in rural areas and five or more units in cities with the population of less than 250,000, and ten or more units in other cities.[14] However, the effectiveness of these numbers should be questioned when it comes to the application of Modern Methods of Construction.

Some declared outcomes of this policy are: increased house building, decreased land consumption, increased quality, decreased housing area, increased number of units in residential blocks and tower buildings, increased application of machinery and technology, application of new methods of computer generated designs, application of new building materials and in the whole increased productivity (Motamedi, 2002).

[14] Some special facilities which have been considered for mass builders are:

1. Tax exemption for the first time of selling
2. Taxes to be based on each unit regardless of the total units built (it should be mentioned that in the past taxes for mass builders were based on the number of built houses)
3. Charges and costs of planning permission, gas, electricity and water supply to be similar to individual builders. (It should be mentioned that in the past such charges were based on the number of built units)
4. Some facilities for insuring the seasonal and permanent workers of mass builders

Currently the portion of mass builders in the housing industry is relatively small limiting the viability of applying Modern Methods of Construction (Table 4-1).

It has been argued that this phenomenon is one of the reasons that have increased house prices dramatically in Iran (Aftab.ir, 2007). One of the solutions, which may improve the situation, is to organize such small and medium size developers to make their projects feasible to apply advanced methods of construction.

Title	Beginning of the Islamic revolution (1997)	Beginning of the third development plan (1999)	End of the third development plan (2004)
Mass building portion of the whole construction in urban areas	5/9	25	50

Table 4-1: Mass building in urban areas (1977-2004)
Source: (ICIC, 2006a)

4.2.2.3 Durability

According to recent studies, the average lifetime of buildings in Iran is about 25 years, which is half or in many cases one fourth of the average lifetime of buildings in developed countries (ICIC, Sep 2004). The main reasons for the problem are substandard building materials and lack of accurate and suitable design and engineering, proper supervision, skilled labour, experienced contractors and also modern and advanced technology in the Iranian construction industry (Aftab.ir, 2006). Considerable personal and national savings will be achievable if building life-time is increased. This also helps to increase the effective housing output.

Alireza Shakeri, construction expert[15], believes that the short lifetime of buildings in Iran is the outcome of different shortcomings such as lack of stable building regulations and laws, lack of comprehensive policies in the construction, and traditional and old methods of construction (ICIC, Sep 2004).

The 1996 census, published by the Statistics Centre of Iran (SCI), indicates that only 65.9% of buildings in Iran were built from durable materials.[16] According to the Third National Plan, this figure increased to 66% in 1999 and to 77% by the end of the plan by 2002. Studies show that the number of buildings built with durable materials in rural areas is extremely low. For example in 1996 only 29.6% and in 1999, just 32% of buildings have been built from durable materials (Table 4-2). Many modern products

[15] The author was unable to clarify Mr. Shakeri's expertise.

[16] (Durable residential units are the houses which are built from steel frame or RC concrete or brick and steel or stone and steel)

are manufactured in the factory and benefit from quality control processes which decrease the risk of defects in the components.

Title	1986	1996	1999	2004 (objective)
Urban	69	78.4	84	94
Rural	16.6	29.6	32	43
Whole the country	46.3	60.9	66	77

Table 4-2: Percentage of durable materials used in houses
Source: (SCI, 1996, Management and Planning Organization, 2000)

Some believe that construction quality has tumbled due to the lack of executive supervision and administration as Adab Bahaoddin, construction expert, says that:

> *The Housing Ministry has failed to optimize potentials to manage and supervise construction processes through the Construction Engineering Council such as by appointing independent supervisors and, instead, has and continues to place full trust in contractors. The state has tampered with its executive by-law and made it into a kind of state auxiliary, instead of trying to turn the council into a non-government organization (Iran Daily, 2005b).*

4.2.3 New Cities

Building new satellite cities especially around the major cities, such as Tehran, is a new strategy that the government has considered to overcome the housing crisis. Therefore, the Ministry of Housing and Urban Development has started finding suitable locations to build 18 new cities in different parts of the country, amongst which the new city of Hashtgerd could be mentioned (Table 4-3). Building new cities, apart from several advantages such as decentralization and creating proper spaces in accordance to building regulations, increases the buying strength of the poor due to the low land prices, and enabling low-income people to live in a proper environment. It is planned to settle three million people in such cities by 2011.

Cities in studying phase	10 cities
Cities in building process	15 cities
Number of existing cities	18 cities

Table 4-3: 3 million people to be settled in new cities by year 2011
Source: (ICIC, 2006b)

According to Amir Farjami, deputy minister in the Ministry of Housing and Urban Development, 22 new cities have recently been approved to be built in Iran in addition to the above (Farjami, 2008). In many such cities application of advanced methods of construction is encouraged or required.

4.3 Housing Economy

Economic issues and misguiding policies are the source of many problems in the Iranian construction industry. In order to have a correct image of the housing situation in Iran, it is essential to understand the Iranian economy in addition to what was mentioned above. Moreover, economic issues would increase or decrease the associated risks with MMC if transferred from other countries to Iran.

As an economic good, a house has specific characteristics, which make it different from other goods and make its supply and demand complex.[17] Therefore a house is a unique and complex good and for these reasons there are various markets for ownership, renting/letting, high-rise, luxury, low-cost and affordable housing (Rafiee et al., 2003).

In this section, the influential factors on the housing demand and supply such as inflation, liquidity, housing and price fluctuations, and housing financial resources are briefly explained.

4.3.1 Effective factors on housing demand and supply

Several factors are involved in housing demand and supply. These can be divided into two groups of internal and external. Internal factors are the basis of changes in size and quality of demand or supply whereas external fetors are assigned in different sectors other than the housing itself such as governmental politics which influence the housing market.

There are many external elements which influence the housing market function. Also, the housing market function influences the national economy (investment, rate of unemployment, prices) and the industry in turn. Internal and external influence diagram is illustrated in Figure 4-2.

17

1. House is a fundamental good. After food and clothing, house is the most essential need of a family.
2. It is also a capital good. Buying a house is the biggest portion of a family's investment. Generally, because of the high risks of investment in the market and business, financial institutions invest some of their capital in properties.
3. It is a principal good which does not have any replacement, is permanent, immovable, and bound to its location.
4. It is a good the price of which relates to two groups of quantitative and qualitative factors. First, the physical and formal factors such as the area, density, material, lifetime, facilities etc. Second, the location and geographical situation such as the city, rural or urban, neighbourhood, access to streets, services, and shopping centres.

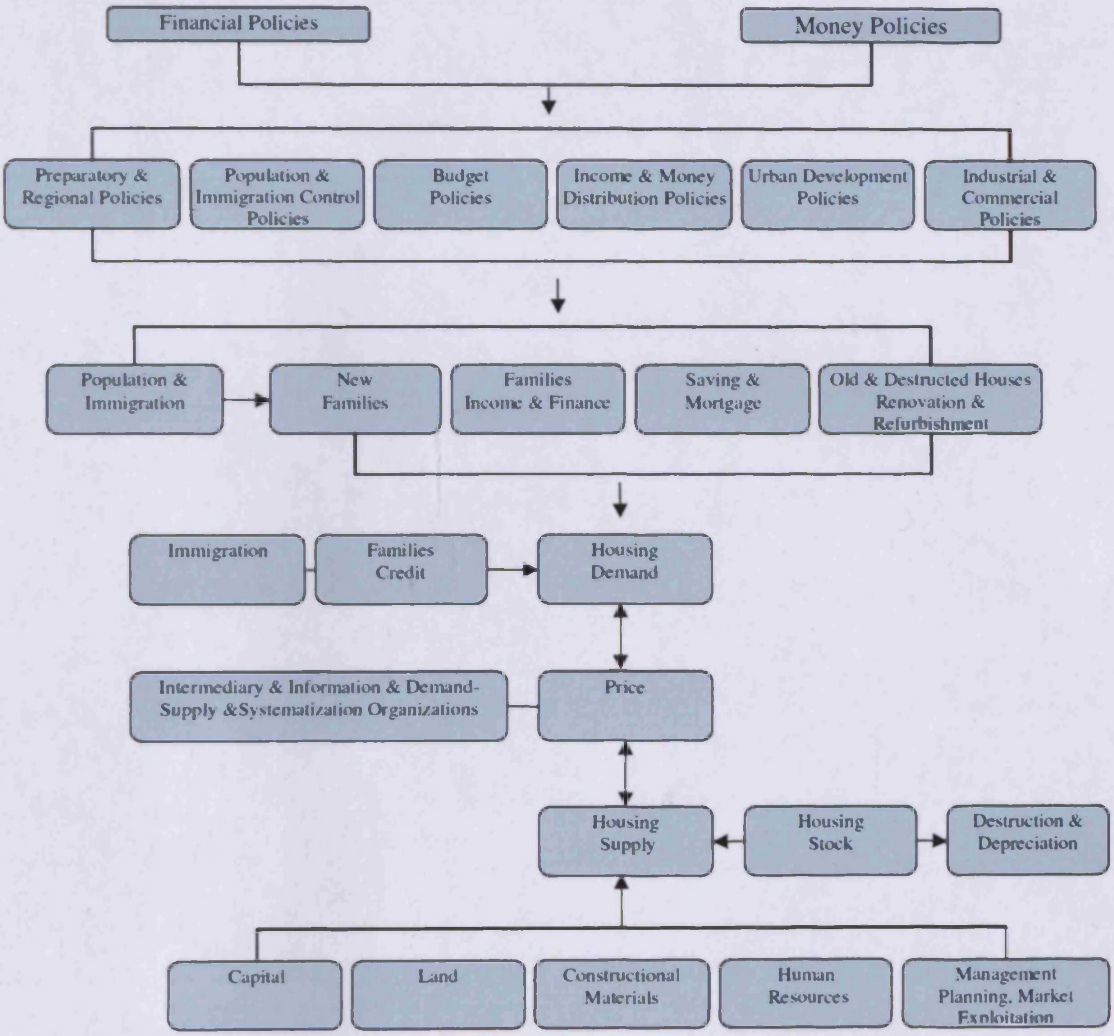

Figure 4-2: Housing demand and supply diagram (Edited and produced by the author)
Source: (Rafiee et al., 2003)

4.3.1.1 Effective factors on housing demand

Population increase and immigration are the principal criteria which increase the demand for new housing. On the other hand, existing old stock is demolished and replacement is required. Therefore, different demands for housing could be classified as follows:

1. New families
2. Immigration
3. Replacement of demolished houses
4. Present shortage

However, the effective demand in the housing market is the part which accompanies the ability to buy. Meanwhile the buying ability or financial strength are interrelated to family's income and saving and the ability to get a mortgage.

Conversely, the house is not only a capitalistic good. The housing demand as a capitalistic good is interrelated to the rate of return and interest compared with other types of investment, society's financial strength, and the interest rate on mortgages. Experience has shown that the house as a capitalistic good is safer and in long term more profitable than other investments such as shares and stocks in Iran.

In a recent survey, the shares of consumption demand and capitalistic demand from the whole demand were evaluated. During the last decade in urban areas, the share of whole housing demand has been about 60%, 40% of which has been capitalistic. Capitalistic demand for the house is an implicit phenomenon directly related to increased value of gold, foreign exchanges, and durable goods such as vehicle, the rate of return in other types of investment and the inflation (Rafiee et al., 2003).

Generally, housing demand increases with lower house prices and higher incomes. The amount of loans and mortgages increase the demand and the rate of interest influence the demand inversely.

4.3.1.2 Effective factors on housing supply

The rate of production in the housing industry is linked to land prices, building costs, the capital and the amount of profit. While the house price and profit is high the production increases. Table 4-4 shows the results of effective factors on demand and supply in urban parts of the country based on mathematical formula during last two decades. This table shows the tension rate of demand and supply based on internal and external factors. Comparing these factors, it can be deduced that:

- Housing demand of low-income people (consuming demand) is mainly influenced by the family income, ability to get mortgages, interest rate (APR), and the house cost.
- Housing demand of high-income people (capitalistic demand) is mainly affected by the increase of foreign exchange and the rate of inflation.
- The supply and production is more influenced by the cost of land and profitability than any other items.
- House price is mainly affected by increase or decrease in land prices.

	Price	Supply	High-income Demand	Low-income Demand
House Price	-	0.6	-0.3	-0.6
Family Income	-		0.3	0.7
Mortgages	-	-	0.35	0.7
Foreign Exchange Price Increase Expectancy	-	-	-0.8	-0.2
Economical Instability	-	-	-0.4	-0.01
Rate of Bank Interest	-	-	-0.24	-0.84
House Stock	-	-0.6	-	-
Land Price	1.4	-0.8	-	-
Building Cost	0.3	-0.7	-	-
Rate of Return	-	9.0	-	-
Supply Excess	-0.6	-	-	-

Table 4-4: Assessment of tension rate toward different factors
Source: (Yazdani, 2003)

4.3.2 House prices, liquidity and inflation

Some of the major problems of the Iranian construction industry are the liquidity and high inflation rate. Increased liquidity in the society can increase the prices considerably which in turn results in recession in the housing market.

Increased oil prices and liquidity lead capital to be invested in profitable activities. While the industrial activities are associated with several problems and are not profitable and while business activities are dealing with obstacles such as limitation in foreign exchanges and restrictions in export and import rules, and the value of foreign currencies and gold and durable goods are steady, the capital will be invested in the housing market. In short term a portion of this sum enters the housing market as capitalistic demand and increases the prices for a short time. Meanwhile, a portion of the sum entered in the housing market is used to build new houses. This is a phenomenon, which has been happening in Iran: Increased production accompanied with increase prices (Rafiee et al., 2003).

According to statistics published by the Central Bank of Iran, the rate of liquidity in the society has increased from 15.2% in 1997 to 29.3% by the end of 2000 and has reached 30% in 2001. The liquidity has risen from 70 thousand billion Rials (£4.4 billion) in year 2005 to 164 thousand billion Rials (£10.25 billion) in 2008 (Central Bank of Iran, 2008/2009).

In the absence of a perfect and active market and in a situation where the market of share and stock does not have the ability to absorb the liquidity, the capital will be invested in manufacturing industry or will be absorbed by hoarding activities. Considering the fixed value of foreign exchanges and the proportional and low increase in the value of gold and durable goods such as vehicle, which is less than increase in the value of the property, the excess liquidity has been absorbed by the housing market.

Investment in the urban housing market has increased from £1.11 billion in 1997 to £1.88 billion in 2000 and £2.4 billion in 2002. It should be mentioned that these numbers are without considering the value of land. Including the value of the land, the amount of circulated money would be more than £6.1 billion, which is 31% of the whole liquidity in the country in 2000 (Rafiee et al., 2003). Table 4-5 shows the amount of investment in housing during 1977-2002. The investment has increased from 2800 billion Tooman (£1.7 billion) to 7500 billion Tooman (£4.7 billion) in year 2004 (ICIC, Sep 2004).

Index		1997	1998	1999	2000	2001	2002
Investment in Housing	Urban	18715	18895	23231	30297	37969	52931
	Rural	2246	2286	5749	7103	7459	10586
	All	20961	21181	28980	37400	45428	63517
NGP		82035	96051	124201	153462	183322	239031
Housing Share %		25.6	22.1	23.3	24.4	24.8	26.6

Table 4-5: Investment in Housing in the year 1997-2002 (Billion Rials)
Source: (Central Bank of Iran, 2002/2003)

Adab Bahoddin, head of the board of managers of the Association of Construction, says that, "the government has failed to retain the huge volume of investments pouring into the housing sector. When profitability in gold, foreign exchange and car markets fell drastically a few years ago, the idle money began to flow into the housing market. Instead of controlling the liquidity, the Housing Ministry retracted and watched the situation which resulted in recklessly granted construction permits which in turn give rise to a great number of constructed houses in wealthy northern districts, enough to provide residence for the entire city dwellers"(Iran Daily, 2005b).

Indeed, the price raise in goods and services or in other words the 'inflation' is mainly allied with these factors:

- Demand pull
- Cost push
- Structural inflation (the liquidity increase in the society)

Increased demand and costs would increase the inflation directly while liquidity, as explained above, would increase the inflation since Iranian industry is not strong enough to absorb it properly.

The possibility of changes in any of the above elements could increase the prices. For example, the possibility of discontinued selling building density may result in increased land portion expenses which increase the house prices. Moreover, pay rises can increase the housing demand followed by an increase in prices in short term. Figure 4-3 shows that the material and the wages index has increased less than the inflation index and therefore the increase in manufacturing expenses has not been the major factor for high prices in recent years.

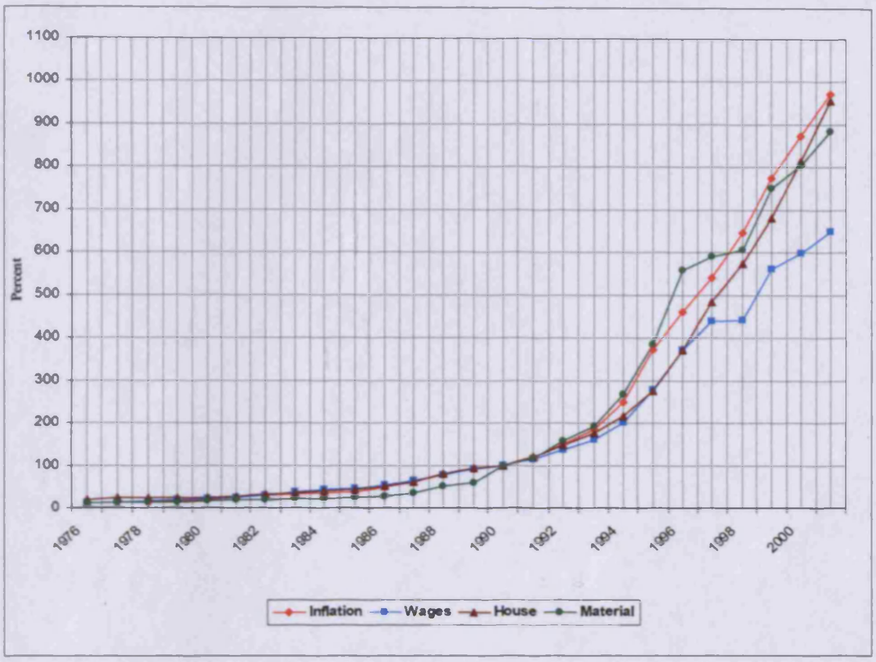

Figure 4-3: Assessment of inflation indicator, wages, house, and constructional materials during years 1976-2001 (Edited and produced by the author)
Source of table: (Central Bank of Iran, 2001)

Increased liquidity in 2001 resulted in people repeatedly buying and selling houses which increased the prices by more than 40% in urban parts of the country(Rafiee et al., 2003). It should be mentioned that the increase in house prices in 2001 was an international phenomenon. Increases in house prices in the United States and European countries (apart from Germany) all reached double figures. In fact, this phenomenon rescued the international economy from the expected recession in 2002. Indeed, the American and European economies have been mostly saved from the recession, which was predicted after September 11th and especially after the repeated price fallings in the main worldwide share and stock centres because of the increased house prices (Economist 8266, April 25th 2002).

However, what is not undesirable in the Western countries has been worrying in Iran. The outcome of rising house prices, while housing industry is facing a high rate of potential and not supplied demand, is more poverty since the housing demand of the majority of low-income families does not become effective.

4.3.3 Imbalanced housing market

Two fundamental characteristics of the Iranian housing market in recent decades are (Rafiee et al., 2003):

1. Short-term and severe fluctuations in housing market in investment, production and prices fluctuation.
2. Deficiency in housing market (inconformity of demand and supply patterns in urban areas)

Theses two features are explained in this section.

4.3.3.1 Housing fluctuation and trade periods

Housing industry instabilities and periodical changes in investment and housing production are international phenomena. The fluctuation in the Iranian housing industry influences the whole economy. This is while the housing is itself affected by the economy cycles and because of the transitory mass economy, the recession is more frequent. On the other hand, severe fluctuations in the housing market and unexpected entrance or exit of funds result in instability in this sector. Builders are mostly families who lose their financial strength to build their houses because of the country's economic instability, or are small builders who exit from or rush into this industry due to various reasons.

In countries with an organized housing market, housing fluctuations are anti-cyclical facing the NGP. This means that during standstill economic periods, the leftover production elements, such as capital, human resources and building materials, which have not been absorbed by other industries, are absorbed by the housing industry. This increases the production and rescues the national economy from recession, or at least prevents it from deepening. During the boom periods, the other sectors absorb the excess of the capital and resources.

In Iran, the evaluation of these relations shows that in some periods the process has been anti-cyclical and in some years a harmonious relation has been achieved between national production index and housing production. However, this phenomenon is to some extent different in different economy indicators.

The policies and programmes, which have been deployed despite being effective, have not been able to provide the necessary long-term balance in this sector. These political inefficiencies are mainly caused by profound effects of external policies and issues. Some of those issues are fluctuation in the oil income, fraction in the country's budget, liquidity and dramatic increase in urban population. Nevertheless, these fluctuations in the housing market are predictable since the models, which have been experienced and tested, show a frequency period of two to three years of falling and thriving in the market.

4.3.3.2 Price Fluctuations

To have a correct understanding of the price fluctuations, it is necessary to study the trend over an extended period of time since increase and decrease in prices are not gradual, and constant, and may not follow the same pattern of other goods. Moreover, economy booms and recessions have considerable effect on the prices.

According to information published by the Iranian Construction Information Centre (ICIC), which is illustrated in Figure 4-4, there has been a boom in 1995 when prices increased by 13% for houses and 23% for land. In 1997, there has been a fall of 28% in house and 16% in land prices.

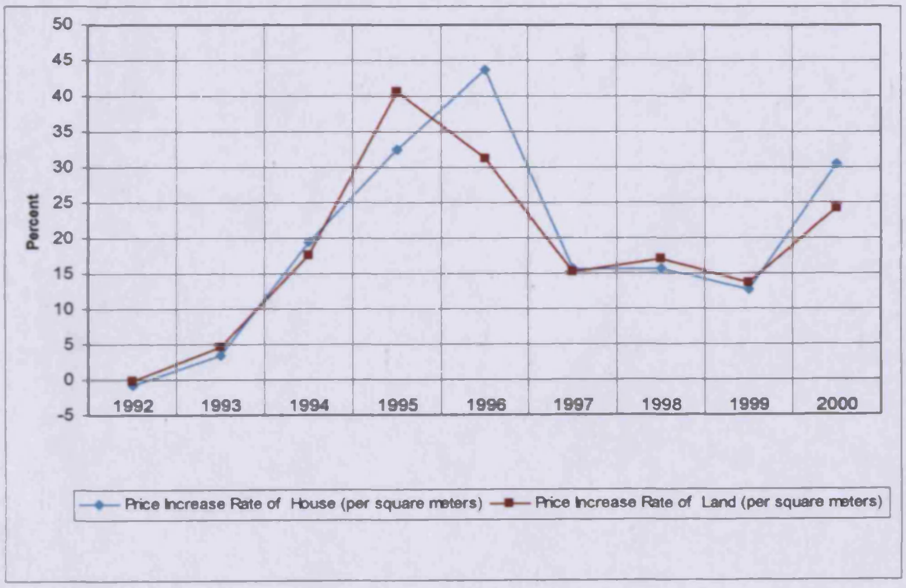

Figure 4-4: Land & House price increase rate in chosen cities (Edited and produced by the author)
Source of table: (ICIC, 2006c)

In 2006, house prices have increased by 30% to 40% for different reasons such as high demand and fewer building projects due to expensive construction materials (Iran Daily, 2006a). Construction industry has also experienced a rise of 50% to 100% in the first six months of 2006 (Iran Daily, 2006b).

Evaluation of fluctuations in the housing production and prices demonstrates that due to having too many small builders, traditional building methods and the lack of united information management, the housing market is facing an internal fluctuating behaviour and therefore its problems are more related to defective performance of the housing system itself than of other sectors.

Operation of too many builders has created the phenomenon of the so-called "prisoners' dilemma" in which despite the proper behaviour of individuals, the behaviour of the whole system is irrational. Moreover, as the capital of these builders is limited and because of the application of traditional construction methods, the possibility of economies of scale is so little (Abasi, 2002).

Besides, the lack of united information management worsens the situation. Due to lack of communication between developers, information interchange is almost impossible and for this reason, none of the builders has accurate and complete information about the housing market in the beginning of their projects. Even if the information was available, it would be out of date and such delayed information with other delays in building process will result in fluctuating behaviour in the housing market.

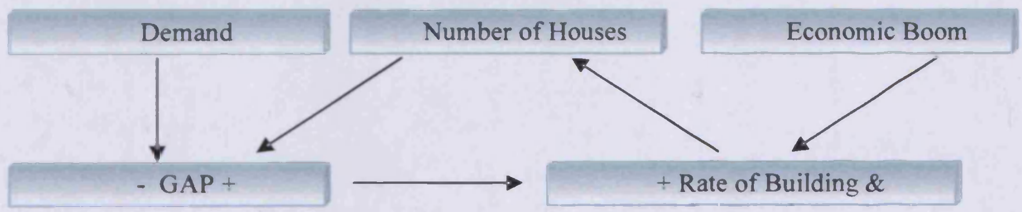

Figure 4-5: Housing fluctuation (Edited and produced by the author)
Source: (Abasi, 2002)

Figure 4-5 demonstrates that the gap between demand and supply results in an increase in the rate of building and construction. Increase in the rate of construction results an increase in the number of built houses which in turn decreases the gap. Decrease in the demand and supply gap, results a decrease in the rate of construction and this loop fluctuates until there is a balance in the loop.

Builders in Iran believe that, even in the worst situations, any house built will be sold since there are always some homeless families. It seems that the only encouraging factor for them to enter the housing market is the economic boom. On the other hand, builders do not have any organization which can predict and evaluate the housing demand, supply and other related information to inform the members. Moreover, it is almost impossible to establish R&D organizations since there are too many small builders with limited capital. As a result, there is never an accurate image of when the economic boom starts, how long it lasts for and when it finishes. Furthermore, there is not a correct understanding of the consumer behaviour and the amount of savings etc.

In this situation, if the expected financial profit is more than the other sectors, several new builders enter the housing market. Experience has shown that they do not have any awareness of the housing situation and the houses which have been started in the past and are not completed yet. While the economic boom in Iran is for a limited time, because of unavoidable delays in understanding the housing market and delays in buying and preparing building sites, it is possible that the beginning of a project falls in the last months of the economic boom.

As soon as the economic depression starts, builders may be forced to decrease the prices because of their financial commitments. The price decrease is an alarm for the others not to enter the housing market and investments are taken out of the housing market, which in turn worsens the economic depression. The consequences of continuous economic slump are cancellation of many contracts and housing shortage. Housing shortage increases the prices and encourages the builders to enter the housing market, and this loop continues (Abasi, 2002).

In this situation industrialization and application of information management systems, to eliminate delays and shorten the building process, are necessary. Industrialization and application of new technologies encourages developers to consider bigger projects and shorten the building process. Meanwhile, eliminating of the information delays in the system helps to reduce the fluctuations. This becomes possible by introducing a united information management system in which the housing market is evaluated and the entry and exit of the builders are systemized.

4.3.4 Financial Recourses

Financial resources in the Iranian housing industry are as follows (National Land and Housing Organization, 2006):

- Bank facilities: these have been allocated in different areas to individuals and mass builders including: individuals (subsidy to government employees) by Maskan Bank, mass builders, social housing, development and mass building in rural areas.
- Saving: saving in housing sector is divided into two parts of general housing saving accounts and youth housing saving accounts.
- Subsidies: Housing subsidy started in 1993 to achieve national plan objectives such as small building and increasing the financial strength of applicants.

One of the main issues in Iran is that there is not any harmony between the rising house prices and mortgages. According to the available statistics, governmental mortgages cover about 10% to 20% of the building or buying costs whereas, this figure is about 80% to 90% in the developed countries. This is while inappropriate conditions and limitations such as high interest rates and need for assurances has restricted the chance for low-income people to uses such facilities (ICIC, Sep 2004).

Mostafa Khosravi, a manager of Estate Consultants Union of Tehran, says that, the increase in mortgages is not comparable with 70% to 80% increase in the house prices and the governmental mortgages cover only a very tiny portion of the prices. He believes that mortgages will not be effective unless they cover 70% to 80% of the prices (ICIC, Sep 2004).

4.4 Land

Management of the land market is a major factor in controlling the housing market and prices. The importance of land policies in housing is more obvious when we realise that the cost of land stands for up to 50% of the housing costs in Iran (Iran Daily, 2005a, Rafiee et al., 2003). The reason for housing problems should firstly be sought in land area since the housing problems are not economic or the consequence of lack of enough land but more related to obligatory situations of the land market, lack of comprehensive urban planning regulations and, as a result, artificial increase in the land prices (Goederitz et al., 1957).

Indeed, access to land will probably solve 50% of the problems since housing, despite mass-production theory, is a slow process which could be finished in long term based on people's abilities while the government could accelerate the process with allocating loans in different ways even if they were very little (Dadvar, 1996).

Land price is mainly stated by the buyers and the applicants and the proposed land price is related to several factors.[18]

Figure 4-6 shows the average price of land for residential buildings in different provinces of Iran during 2000-2003. Figure 4-7 also illustrates the average price of floor

18

1. What will be built in the land (the usage).
2. What the building value is after it is finished (the supplementary value).
3. What the land's development costs are (the costs).
4. What the least expected benefit for the buyer is (the profit).

Proposed land price is evaluated based on the mentioned factors. Density and the taxations tariffs influence the prices too.

area for residential buildings during 2000-2003. Prices have increased steadily during this period and, as is obvious, there is a direct relation between the land and housing prices.

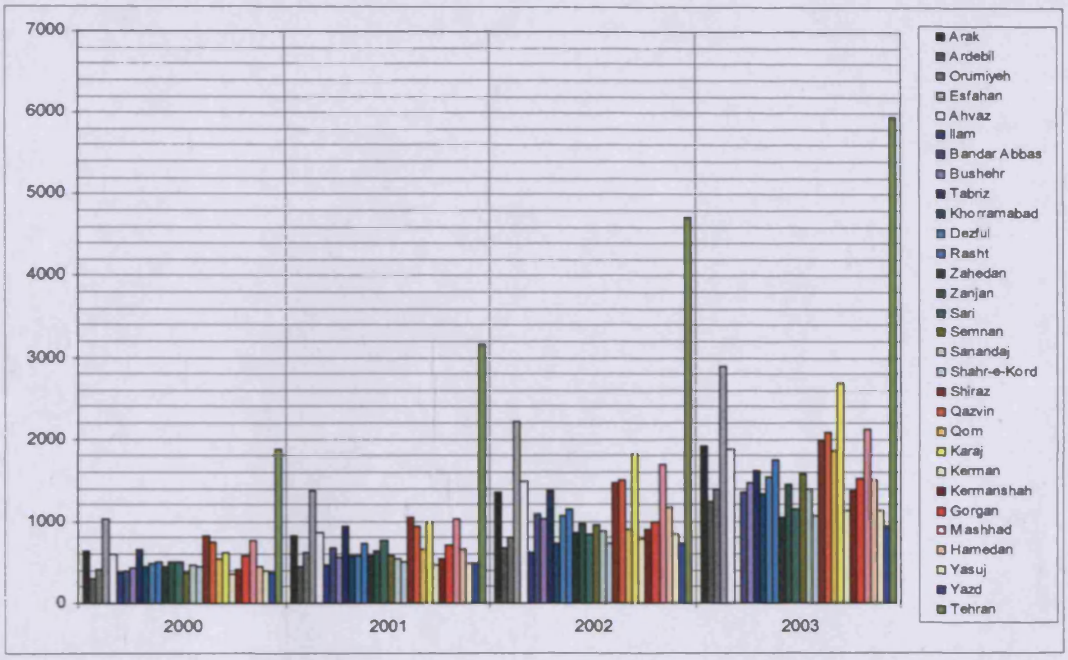

Figure 4-6: Average price of land per square meter for dilapidated residential buildings transacted in real estate agencies by selected cities (1000 Rials) (Edited and produced by the author)
Source of table: (SCI, 2007)

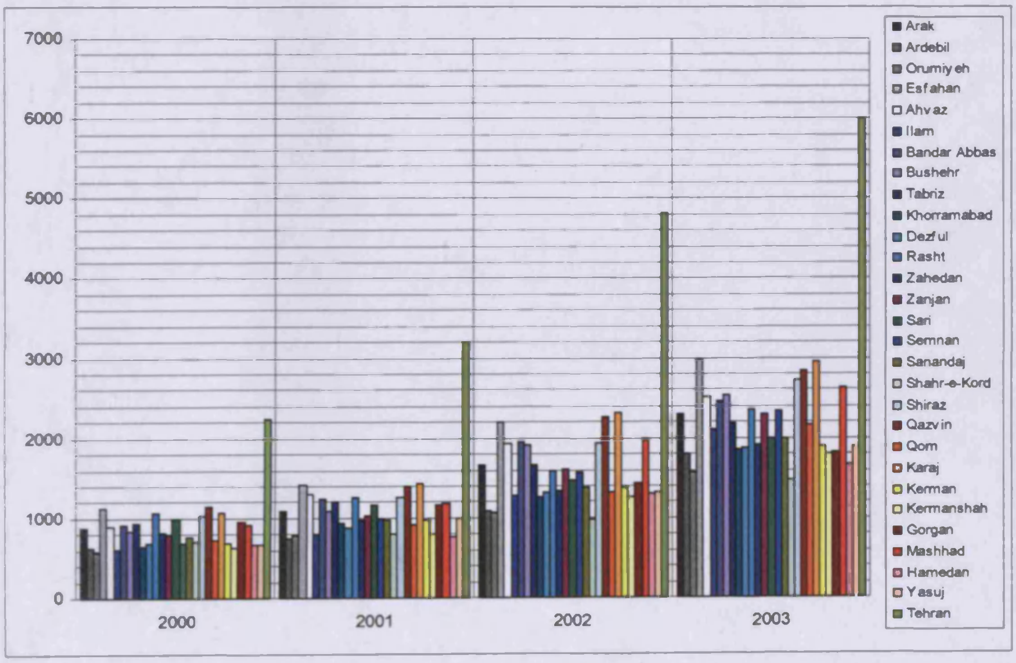

Figure 4-7: Average price of floor area per square meter of housing units transacted in real estate agencies by selected cities (1000 Rials) (Edited and produced by the author)
Source of table: (SCI, 2007)

Governmental policies are also crucial in land and house prices. Open market mechanisms cannot lead the society to economic efficiency under all circumstances. There have been several cases in which the market has failed and government intervention has been necessary. Right now in year 2009, many governments including the UK, have been forced to intervene in the financial and other markets to prevent a global disaster.

External effects, desire to increase the financial ranking in the society, lack of clear information and last but not least the capitalistic demand for the land are the issues which lead the market to failure. As an example, while there is a capitalistic demand and while there is not any effective policy such as taxation in the market, a lot of land plots remain barren and undeveloped. In many cases, this phenomenon could increase the land and house prices. For these reasons, governmental intervention has been acceptable in all countries. In general, the governments apply these methods to intervene in the land market (Rafiee et al., 2003):

1. Dispossession and supply
2. Limitations in land possession
3. Usage laws and regulations
4. Taxation laws and regulations

It seems that to achieve the best result, a group of different policies should be applied.

During the last two decades, the governmental actions included vast marketing of the urban lands with very low prices and several supporting housing policies. These policies, during the first decade, resulted in a considerable increase in housing production. However, these policies had also several unwanted consequences such as shifting the consumers to producers in the shape of individual builders. The outcomes of this were low-rise buildings with massive areas and horizontal development of the cities, which in turn resulted in costly infrastructural costs for the government (Rafiee et al., 2003).

Conversely, Motamedi believes that an effective policy is to allocate free land by the government or municipalities and other authorities to build houses. He continues that this policy will decrease the house prices up to half or more and will create a low-cost housing market for low-income people (Motamedi, 1995).

In 2007, the government's new policy is to allocate land in the form of leasehold for 99 years to applicants who are houseless and have not used governmental facilities before. The objective is to eliminate the land cost from the finished price. The success or failure of this policy should be studied in the future.

4.5 Deficiency in low-income housing

During the recent years the uncontrolled development of big cities' informal settlements, and even their transmission to smaller cities, have been the symptoms of inaccurate prediction and performance of low-income housing policies. This is the consequence of high-rate migration[19] and slow housing supply which resulted in fast development of informal settlement with poor infrastructure in city centres where now one-fourth of the urban population live (Iran Daily, 2005b). This is because of neglecting the low-income housing due to different issues and shortcomings.

In the Iranian Constitution Law, it is a right for any Iranian family to have a proper house based on the family's needs. In another clause, it has been emphasised to eliminate any food, housing, job and sanitation poverty and to generalize social insurance. However, it seems that the government has not been very successful in this approach since the informal settlement has been increasing. As an example in Tehran, the informal settlement was 5% in 1976, 11% in 1986 and 19% in 1996 (UARC, 2001). Also about 30% of citizens of some major cities such as Mashhad, Zahedan and Bandarabbas have built their houses unofficially. Moreover, non-standard housing in smaller cities such as Natanz, Bookan, Pars Abad, Khalkhal, Dezfoul and Jahrom has been increasing (Ministry of Interior's, 2001).

Apparently, poverty is not the reason for informal housing.[20] In fact the problem has roots in present situation and lack of proper planning in the low-income housing.

Meanwhile, other sources and information suggest low-income people in Iran are in a very critical situation. According to the Iranian Construction Information Centre (ICIC), working-class people have to spend more than 70% of their income to rent a house. This is while, according to international standards, a family should not spend more than 30% of its income to rent a house however in Iran, especially in big cities, this figure reaches to up to 100% of the family's income (ICIC, Sep 2004). Also, the average house price in urban

[19] since mid 70s when the urban population increased from 46% to 62% in mid 90s

[20] In year 1995, the average residential land area per capita has been 6.1 square meters in low-income countries and 15.1 square meters in under average income countries while the average area in low-income parts of Tehran in year 1996 has been 16 square meters. This means that the average residential area in informal settlements in Tehran has been more than under average income countries. In other words, the Iranian low-income people have had more financial strength than the average income people of such countries. The majority of building materials (about 90%) in the Iranian informal settlement are from common materials such as block and steel, whereas, for example in Latin America the majority of building materials in slums are uncommon materials such as cans and tin. As another example, there are one million homeless people in Cairo and six hundred thousand homeless people in Calcutta. This means that the majority of what is called informal housing in Iran is the dream of many low-income people in other developing countries (Athari and Javaheripour, 1995).

areas in Iran is 10 to 12 times more than the average income of families. (Hosein Zadeh Dalir, 1996, Rafiee, 1997)

Since the First Developing Programme (1948-1955), the low cost housing has been privileged but there have not been any specific activities in favour of low-income people. In the Third Developing Programme (1963-1967), elimination of what is nowadays known as informal settlement, became the objective of low-cost housing programmes. The goal was to build residential estates to settle the poor and to remove the slums. Sizdah Aban and Nazi Abad estates in Tehran and some other estates in Mashhad were the results of these actions.

In the Fourth Developing Programme (1968-1972), the low-income housing policies were more developed and the private sector entered the low-income housing in addition to the government.[21] During the Fifth Developing Programme (1973-1977), some signs of low-income contribution in their own building process were observed. In addition, some policies were established which are still followed in the housing programmes.[22]

After the Islamic revolution of 1979 the low-income housing programmes shifted from building and allocating houses to allocating land and mortgages (Rafiee et al., 2003).[23]

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[21] The objectives were as follows:

- manufacturers became responsible to prepare the housing requirements for their labours
- the priority of the governmental investment was defined to be in the low cost housing and removing the slums

However, the first objective remained on the paper and did not come to reality due to its financial overload for the manufacturers.

[22] The objectives were as follows:

- construction of 57 thousand affordable apartments and allocating them, with long-term mortgages, to low-income people
- construction of 16 thousand affordable residential units for suburbanites
- banks became responsible to supply the cooperative housing organizations with their required sums
- construction of 30 thousand rural houses by allocating mortgages and cooperation of people
- construction of satellite cities and labour residential estates outside the big cities

The first objective is now being followed in the form of building and allocating apartments with the name of so-called "hire-purchase", but the third to the fifth objectives have not been followed as strictly as stated. In other words, the cooperative housing is not supported and the governmental housing is the only objective which is continued.

[23] The problem with the recent modification was that in major cities only the housing cooperative organizations, which were formed in companies with the minimum of seven members, were allowed to use the mentioned facilities. In this situation, only big workshops and companies could establish a housing cooperative organization within themselves and as a result, about 60% of employed people did not have the opportunity to benefit from these facilities. Thus, the majority of urban low-income people were outside the housing programmes.

Other complementary programmes would also intensify the problem since in these programmes the urban and building regulations were of higher standard of what low-income people could afford. The outcome of this was that despite allocation of land and low-interest mortgages, the informal settlement increased (Athari and Javaheripour, 1995).

From 1989, with the beginning of modification policies in the First National Development Plan, low-interest mortgages were stopped and from 1995, with the start of the Second National Development Plan, allocating of low-cost land was decreased to minimum. In addition, governmental housing was considered for the second time as the only way to avoid the market failure for the low-income housing. The social housing in the Third Development Plan, in year 2000, was even more emphasised and resulted in even more informal settlements, with its distribution to all cities in the country.

The second consideration of low-income settlement by the government, in which people would possess their houses by paying rent in long term, has been considered despite the failure of all developing countries and Iran in social housing and also partial failure in land preparation and allocation programmes (so called Site & Service). Yet, the theory of exploitation and cooperation of low-income people with financially enabling them, has been successfully considered in other countries (Rafiee et al., 2003).

The latest low-income housing programme has been launched by the government with the name of Maskan Mehr (Mehr Housing) in different provinces of the country. The aim is to decrease house prices by omitting the land costs from housing by considering the 99 years leasehold policy (Saidi Kia, 2008b). According to Saidi Kia, the minister of Housing and Urban Developmet, there have been about 4 million applicants for Mehr Maskan (Saidi Kia, 2008a). The success or failure of this programme should be studies in the future.

4.6 Conclusion

Many of the current housing problems in Iran are the result of poor planning policies. Various short-term and mid-term planning strategies have been considered by the Iranian government during the last decades to address these and to encourage developers to follow it's the government's land and housing programmes. The current policies of the government are: small building, mass building, durability, optimized usage of land, renting, development of municipal organizations. For various reasons, the Iranian government has not been very successful in achieving all its objectives; however, the government claims to be extremely successful in many areas, according to published documents.

Two principal characteristics of the Iranian housing market in recent decades are short-term and severe fluctuations in housing market and deficiency in housing market (inconformity of demand and supply patterns in urban areas).

Housing demand in Iran is massive however due to different problems such as high inflation and rapid increase in the house and land prices, which are not in accordance with increases in wages, houses are not affordable and the demand does not become effective. Therefore, many houses remain empty being not affordable for the majority of the Iranian families.

Meanwhile, due to the lack of proper information management systems, inaccuracies and information delays, small developers rush in or exiting the housing market. It is argued that introduction of industrialised building systems and application of information management systems can eliminate or reduce housing fluctuations.

Land has also a considerable portion in the housing costs. The government has tried to control the land market by considering various policies such as dispossession and supply, limitations in the land possession, usage laws, and taxation. Such policies have in some cases increased the land and house prices.

Nevertheless, governmental intervention can improve the situation of the land market and prices by supporting and leading the market in the correct direction. One of the latest policies of the government is to decrease house prices by omitting the land from housing costs by considering the 99 years leasehold policy.

Informal settlements and slums are also common problems of major cities in many developing countries. Iran is not an exception and the Iranian government has been trying to overcome this problem since the First Developing Programme in 1948.

The government has considered various methods such as building residential estates to settle the poor and remove the slums, involving the private sector and the poor in the building process, allocating low-interest mortgages and cheap land, and recently the rental housing (hire-purchase) project. It seems that the government should consider other methods, which have been applied successfully in other countries, to resolve the low-income housing problems.

The current situation of Iranian housing was discussed with regards to planning, economy and land issues in this chapter. As mentioned above, these have direct or indirect effects on the application of MMC in Iran. There are some other issues such as the industry and climate which should be considered when transferring MMC to Iran. These are explained in the next chapter.

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Chapter 5: Iranian Industry, Climate and Current Housing Situation

5.1 Introduction

In addition to the background and governmental policies which were discussed in the previous chapter, there are some other issues which should be considered to understand the Iranian construction industry and economy correctly. Iranian construction industry takes just a small portion of the whole economy but it is very influential on the whole industry being interrelated to several other sectors. Indeed, as many other countries, Iranian construction industry in general and housing industry particularly, is one of the most important and influential industries on the social, economic and political aspects of the country.

Therefore, it is vital to have an understanding of the Iranian economy as well as the construction and housing industry in order to introduce new methods of construction to Iran correctly.

This chapter intends to introduce the Iranian industry and to evaluate the current situation of construction and housing industries in more depth. For this reason, housing demand and supply have been evaluated in two different categories of quantitative (such as the number of required and supplied housing units) and qualitative (such as the type, area and location of required housing) aspects. The climate is also explained briefly since it has a great impact on housing types and construction methods in Iran.

5.2 Iranian industry

The Iranian economy can be divided into twelve key sectors of oil, agriculture, mining, manufacturing, water, electricity & gas, construction, trade, restaurant & hotel, transport, storage, communication, finance services, professional services, public services and social services. Figure 5-1 shows the share of GDP for each section.

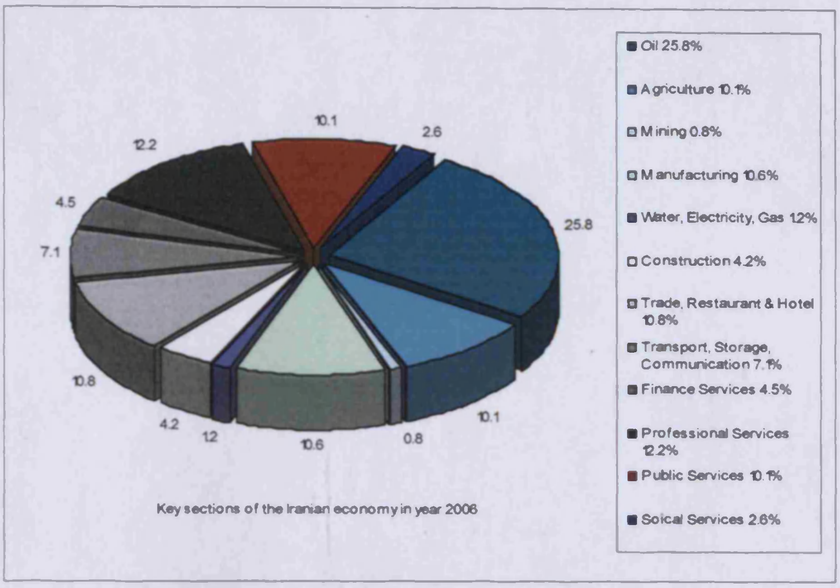


Figure 5-1: Iranian Industry (Edited and produced by the author)
Source of table: (Central Bank of Iran, 2006a)

Generally, construction industry could be divided into three sections of: residential, non-residential and infrastructure. The proportion for each category in Iran is as follows (Ghanbari, 1989):[24]

- 40% Residential
- 22% Non-residential
- 38% Infrastructure

Iran's construction market is now the largest in the Middle East(Austrade, 2006). Meanwhile the portion of construction is only 4.2% of the Iranian economy. This is mainly because of the oil industry which takes a big portion of GDP. In year 2005, the construction industry's financial output has been 300-350 trillion Rials (Iran Daily, 2006a) (£23 billion). Meanwhile, housing accounts for about 40% (Sarabandi, 1995, Ghanbari, 1989) of the construction output in Iran. Therefore, housing stands for 1.6% of the Iranian economy with about £8.4 billion turnover.

There are different figures for the current UK construction output however it seems that it accounts for about 8-10% of GDP. According to the Department for Business Enterprise & Regulatory Reform UK construction industry the second largest in EU with an annual turnover of more than £80 billion (Ormerod, 2008) which accounts for about 8.7% of the country's GDP (BERR, 2009).

[24] The author was not able to find updated figures for this section

According to governmental reports, 88% of building permissions in 2007 have been issued for residential buildings. Another 6% have been issued for residential buildings mixed with workshops. Therefore, 95% of all building certificates have been directly related to residential projects. The rest of building types including industrial, educational, commercial and health care accounted for only 5% of all construction projects in year 2007. Figure 5-2 shows the percentage of building certificates issued by municipalities for different building types in 2007. It should be mentioned that the number of building permits does not necessarily show the actual percentage of total building area and value of each construction type.

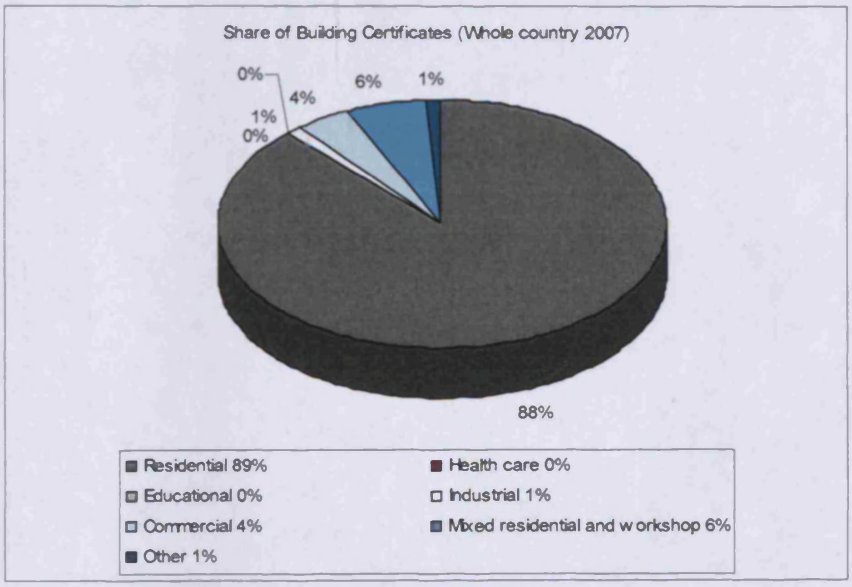


Figure 5-2: Share of building permits based on construction types (edited and created by the author)
Source: (President Deputy Strategic Planning and Control, 2007)

5.2.1 Labour Force

With about 28.7 million labourers, Iran is the 20th country in the world's labour force ranking; however, Iran suffers from scarcity of skilled labour (International Market Research Reports (IMRR), 2008). According to the recent documents published by the Statistical Centre of Iran, 21.5% of the Iranian labour force is employed in agriculture, 32.7% in industry (including mining, industry, construction and energy) and 45.8% in services. 81% of the labour force is employed in the private and 18.5% in the public sectors. The rate of unemployment has been about 11.6% in 2006 (SCI, 2006d).

There is sufficient number of architects, engineers and non-skilled labour in the construction industry but the industry suffers from lack of semi-skilled and skilled labour. For instance, according to Mr. Motaghi, chief director of architecture and construction of Tehran municipality, 98% of building labourers in Tehran are not skilled (Motaghi, 2009).

According to Alireza Shakeri, housing expert, 600 jobs are, directly or indirectly, linked to the construction industry in the country. Also statistics suggest that housing sector stands for about 16% of the whole employment in developed countries, 6% to 8% percent in developing countries, and about 10% in Iran (Shakeri, 2004)..

A report published by the office for human resources of the Planning and Budget Organization (PBO) shows that a huge percentage of time capital and material is wasted in the construction industry due to the lack of skilled labour. This report indicates that 4-5 man-days is required for construction of each square meter in public sector compared with 2-3 man-days in ideal conditions. This figure is 1-2 man-days in developed countries. In this respect, the Iranian government has tried to improve the building quality by training skilled construction labourers; however this has not been very successful due to different problems. The above figures indicate the urgency of training skilled labour for to increase the productivity and output of the construction industry. It is claimed that skilled labour shortage can be addressed by applying Modern Methods of Construction.

5.2.2 Building materials production and imports

Iran is a main producer of steel and cement products which are used extensively in the construction industry. Main constructional productions of Iran are: cement, copper, aluminium, steel, glass and tiles (Table 5-1).

Title	Units (thousand tons)
Cement	40046.7
Copper	203.0
Aluminium	202.8
Steel (raw)	10298.2
Steel product	14343.2
Flat Glass	841.6
Tiles, Ceramics	2671.2
Artificial Fibres	63.8

Table 5-1: Building material production in Iran in year 2007
Source: (SCI, 2007)

Iranian construction also relies on importing construction materials to meet local demand. According to the statistics published by Customs office of Iran, the major imported items are:

- iron and steel (iron slabs and steel, iron and steel bars, rolled iron and steel wares)
- pre-fabricated buildings
- elevator wares
- block and tackle

- road-building machinery
- digging and excavation machinery
- cranes
- hygienic products made of plastic and china
- stoneware
- plaster and cement

"Other imported items are: glass, timber flooring, lighting, paint, electrical and electronic fittings and accessories, lock, key hardware and aluminium for façade design" (Austrade, 2006). When introducing new methods of construction, it will be more rational to use locally available materials to decrease the costs.

5.3 Climate of Iran

Climate can be very influential on the architecture, construction methods and applied materials. Harsh weather conditions can increase the construction time and costs. Therefore, it is important to have a general idea about the climate conditions of Iran while the climate of Iran is totally different from many other part of the world. Too much rainfall is unwanted in the UK while in Iran extreme heat in many parts of the country is one of the major problems for the construction on site.

Iran is situated in a region of the world with variety of climates. In fact Iran is has the real four seasons. A large portion of the country suffers from intense cold and heat between winter and summer. Rainfall is mostly limited to two seasons of winter and spring. However, a small strip along the Caspian coast has subtropical climate and the heaviest rainfall is from late summer to mid winter.

Iran's geographical coordination is 32 00 N, 53 00 E. Iran's climate consists of four major categories as follows (Figure 5-3) (Kasmai, 1993):

- Subtropical climate (along Caspian coast)
- Cold mountainous climate (western mountains)
- Hot and arid (central parts)
- Hot and humid (southern coast along Persian gulf)

About 73% of the country has hot and arid climate, 24.4% is temperate and 2.4% has a cold mountainous climate (Fallah, 2001).

Figure 5-3: Iran's climate
Source: Kasmai, Morteza, "Climate and Architecture", (Edited by the author)

Here, Tehran's climate is explained briefly as an example. Tehran's geographical coordinates are 35 40 N, 51 26 E, Elevation 1200m (3900ft). Three factors are important in Tehran's climate: Alborz Mountains, the latitude and the western currents. In fact because of Alborz Mountains the weather is moderate in Tehran. Average annual rainfall is about 220 millimetres. The cold season usually starts in December and ends by mid-March and it gets rather hot by mid-May. In a period of 43 years since 1951, the maximum and minimum temperatures in Tehran have been +43C and -15C degrees. The average wind speed in Tehran is 5.5m/s(Tehran Municipality, 2008). Figure 5-4 summarizes the climate conditions in Tehran

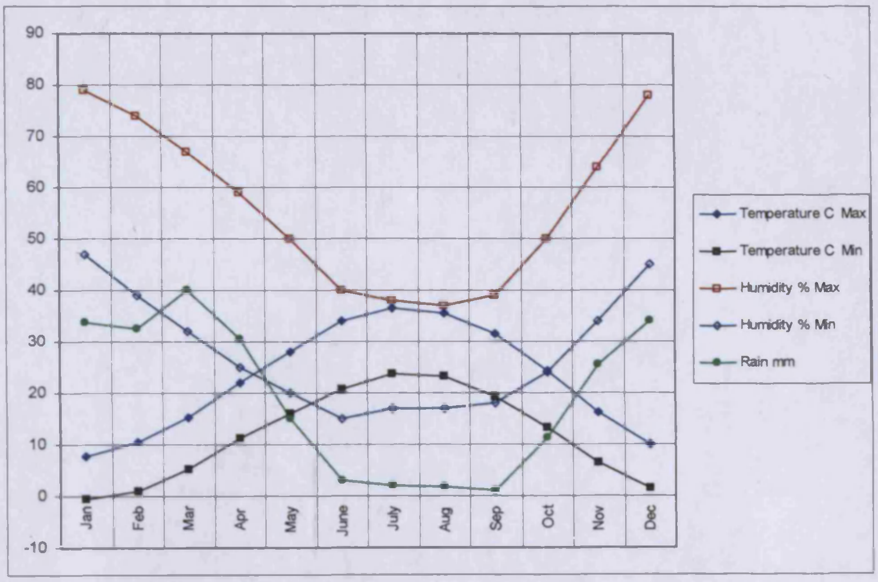


Figure 5-4: Climate of Tehran (Edited and created by the author)
Source of tables: (I.R. of Iran Meteorological Org., 2003)

5.4 Housing demand and supply in Iran (Quantitative aspects)

In this section, quantitative aspects of housing demand and supply, and the reasons for such high demand in Iran will be discussed. Available data suggest different views with regards to the current Iranian housing situation. It is aimed to refer to most available data however, in some cases the information may be contradictory.

5.4.1 Housing demand and population in Iran

Population growth, loss of old stock due to rising living standard, shortcomings and inadequacies in the building industry, and destructions caused by natural disasters, such as earthquakes, have caused high demand for new housing. "Iran will need 25 million new houses in the next 20 years. An average one million houses have to be constructed each year to keep up with the growing demand" (Iran Daily, 2006a).

Iranian construction industry and especially the private sector have been engaged to answer to the high demand in the last four decades(Ahmadian, 1996). Unfortunately governmental mass building plans have been less successful. According to the World Bank reports, the number of houses in Iran for 1,000 people is 198 units which show that Iran is far behind the world standards(Saadati, 2006).

The housing shortage in year 1996 was about 1.6 million units, according to 1996 census. About 450,000 families are added to Iranian households each year and 700,000 new houses are needed to keep up with the demand (SCI, 1996).

Iran's population is about 70 million with the median age of 24.8 which means that the majority of people are young. According to published documents by Statistical Centre of Iran total number of the Iranian families has increased from 16,420,861 in 2004 (SCI, 2006b) to 16,667,929 in 2005 (SCI, 2006c). However, published documents by Iran Construction Information Centre (ICIC) show that there have been 15.6 million families in Iran in 2004.

Figure 5-5 shows the change of housing indicators during 1976_2004. In 2004 the number of families has been 15.6 million which have been living in 13.9 houses. This means that there has been a shortage of 1.7 million houses in 2004. However if the first figure of 16.7 million existing families is considered the shortage will rise to 2.8 million units. This information shows that the housing demand in Iran is increasing dramatically.

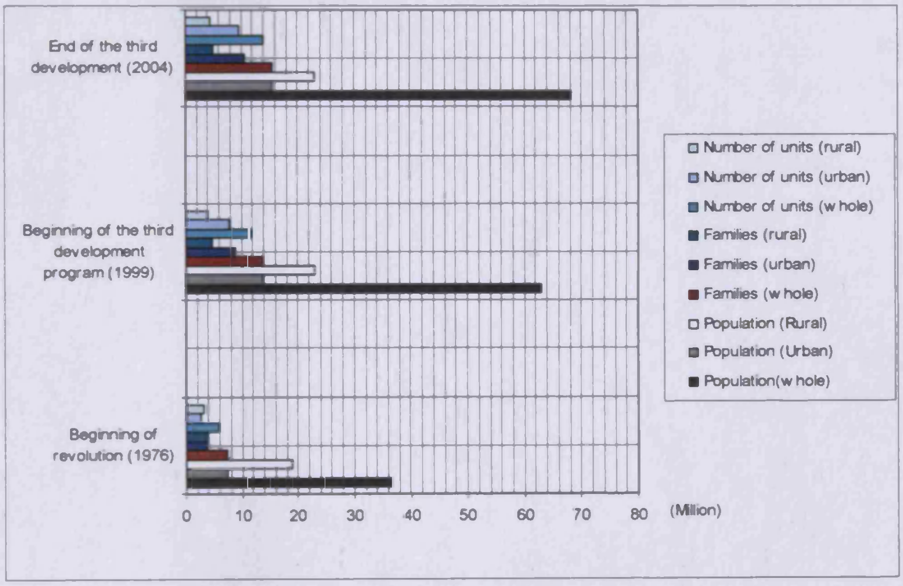


Figure 5-5: Housing indicators (1976-2004) (Edited by the author)
Source of table: (ICIC, 2006c)

This contradicts with some documents published by the government which suggest that the household density is decreasing. According to NHLO the number of families in each household has decreased from 1.15 in 1996 to 1.13 in 2000 (NHLO, 2006a). Table 5-2 also indicates that the number of families in each household has decreased from 1.15 in 1999 to 1.12 in 2004. This information is also supported by ICIC (Darvishzadeh, 2004). Also, according to Mr. Saidi Kia, the minister of Housing and Urban Development, the current household density has decreased to 1.09 (Saidi Kia, 2008b).

Title	Beginning of revolution (1976)		Beginning of the third development program (1999)		End of the third development Program (2004)	
	Change	size	Change	size	Change	size
Density of each household Urban rural	- - -	1.26 1.37 1.18	- - -	1.15 1.15 1.14	- - -	1.12 1.12 1.13

Table 5-2: Household density
Source: (ICIC, 2006c)

The latest census in year 2006 indicates that there are 17.5 million families in the country living in 16 million residential units which means a shortage of 1.5 million housing units. Also 800,000 new families are added every year to the population (SCI, 2006e).

One of the latest studies on housing in 2004 indicates that there is a demand for 1.2 to 1.5 million houses per year to be constructed in Iran (Iran Daily, 2004):

> *Housing market calls for 1.2 to 1.5 million housing units annually as the number of cities in Iran has increased considerably from 442 in 1979 to 936 in 2004. Every year 800,000 new families are formed in Iran but capacity for building houses stands around 450,000 units. Iran's need for an annual investment of 200 billion Rials in the housing sector is out of the capacity of domestic investors. The government has announced readiness to prepare the ground for foreign investments in the sector given that Iran needs to build over one million housing units annually. The trend should continue through at least 2010-11. The housing market has an annual pent-up demand for 150,000 housing units and another 650,000 units of new demand.*

This figure has been confirmed by the minister of Housing and Urban Development of Iran (Saidi Kia, 2008a). Other sources suggest that every day 2000 residential units are constructed which should be increased to 2740 due to the current need (Austrade, 2006, Darvishzadeh, 2004) . There are huge differences in available data published by different Iranian bodies for the current housing demand. Since the housing production has always been less than the housing demand, the demand has been increasing year by year.

5.4.2 Housing supply

Table 5-3 shows the area of housing production in Iran during 1996-2000. Housing production has increased from 39.3 m^2 million in 1996 to 42 m^2 million in 2000 and 48 m^2 million in 2001. Also published information by Central Bank of Iran and the Third National Development Plan documents indicates that the number of built residential units in urban areas after the recession of 1997 and 1998, have increased to 350,000 units built by the private sector in different cities of the country in 2000 (NHLO, 2006a).

Year	1996	1997	1998	1999	2000
Residential area	39.3	34.8	36.9	36.9	42.0
Non-residential area	3	2.5	2.7	2.7	2.9
Whole	42.3	37.3	39.6	39.6	44.9

Table 5-3: Residential and None-residential produced area in urban areas (million square meters)
Source: (ICIC, 2000)

During the first six mounts of 2001, 217,055 residential building permissions have been issued. Thus, with such trend, it could be estimated that 434,000 houses have been built in the urban areas. Table 5-4 indicates 520,000 houses have been built in 2000 which demonstrates 102% success compared to the objective of the plan and 12/1% growth compared to the previous year.

	1996			1997			1998		
	Programme Objective	function	Success percentage	Programme Objective	function	Success percentage	Programme Objective	function	Success percentage
Urban	310	314	101	330	283	85.5	352	286	81.3
Rural	175	150	86	200	142	71	237	143	60.3
Whole country	485	464	95.7	530	425	80	589	429	72.8

	1999			2000			2001		
	Programme Objective	function	Success percentage	Programme Objective	function	Success percentage	Programme Objective	function	Success percentage
Urban	376	304	81	340	350	103	380	434	114
Rural	270	160	56.2	170	170	100	180	-	-
Whole country	646	464	72	510	520	102	560	-	-

Table 5-4: Number of issued building permissions (1996-2001)
Source: (ICIC, 2000)

Figure 5-6 also shows the housing production during the Third National Development Plan (2000-2004). The government's objective was to produce 3.114 million houses by 2004. The aim was to increase the housing production from 510,000 to 744,000 units which means an average growth of 9.1% per annum. About 200,000 of the 744,000 units are replacement of the existing stock in the urban areas.

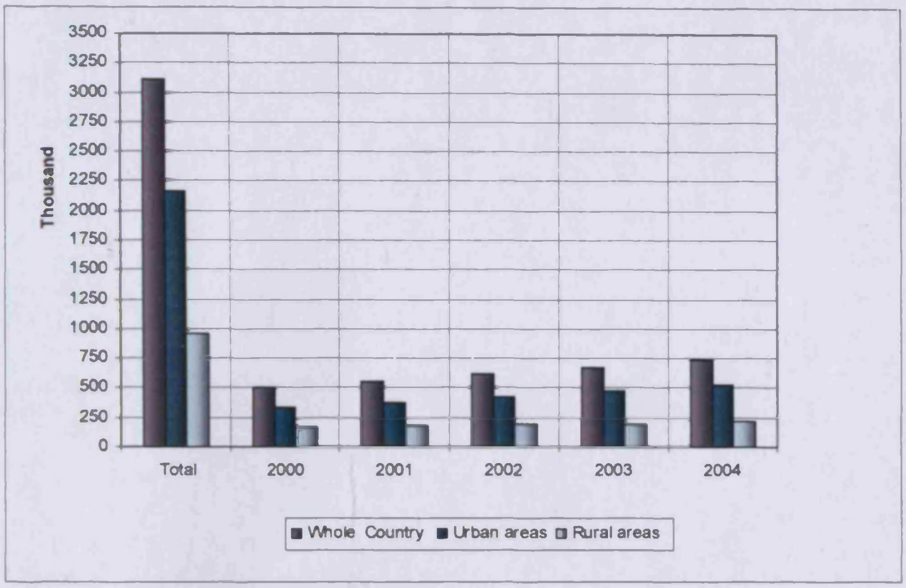


Figure 5-6: Number of Houses Built Between 2000-2004 (Edited by the author)
Source of table: (ICIC, 2006b)

Year 2005 was the beginning of the Fourth National Development Plan. Now, after increasing the country's housing output to 750,000 units per annum (if achieved), the government's plan is to increase the annual output to 1,000,000 units by the end of this programme. This is while an annual renovation of 500,000 units should be added to this figure (Saadati, 2006). However it seems to be too optimistic to achieve these figures as housing production has always been facing difficulties and the government has rarely achieved its objectives.

5.4.3 The Iranian Housing Characteristics

The characteristics of the Iranian housing are defined by the very high home ownership (69.29 %) and self-built housing where people build their houses based on their needs, and domination of the housing industry by the private sector (SCI, 2006a).

The construction industry consists of public and private sectors where housing as the largest proportion plays an important role. The private sector is responsible for the majority of the built houses. According to two national development plans since 1979, more than 95% of houses have been built by the private sector. During the period of five years of the Second National Development Plan, according to the Housing Foundation of Islamic Revolution, 1,842,000 houses were constructed which means an average of 368,400 units per annum. During this period only 5% of houses (130,000) were constructed by the government and the remaining 2.46 million (95%) were constructed by the private sector (Sarabandi, 1995, Tofigh et al., 2003).

The private sector housing in Iran can be classified to the following sections (Memarzia, 1995):

1. Free market housing: there is no governmental support in this section and houses are usually built with higher standards and are mainly self-built.
2. Protected type of housing: national building specifications applied to these houses to restrict the floor area to control the costs. The government's supports include reducing the tax and service charges and low interest rate mortgages.
3. Social housing: low-cost housing with minimum facilities suitable for young families. The idea is to address the housing shortage to help the families who could not afford bigger houses.

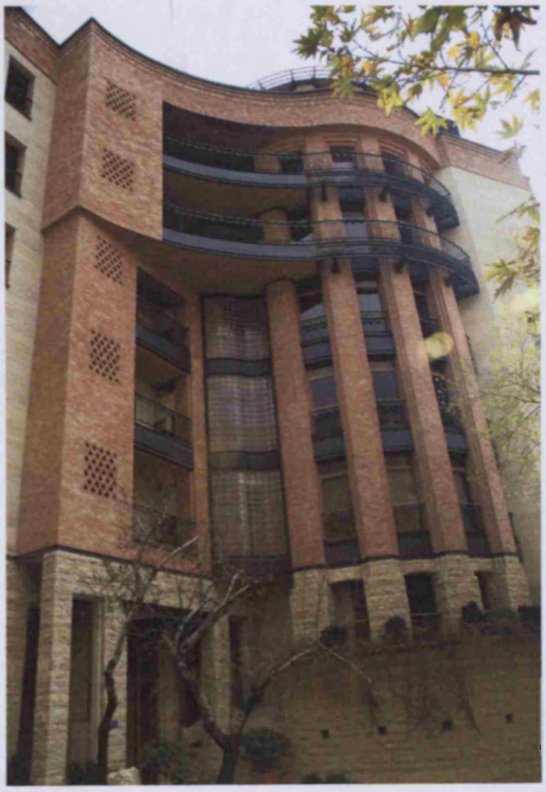


Figure 5-7: Example of free market flats in north Tehran
Source: the author

5.5 Housing Demand and supply in Iran (Qualitative aspects)

In this section the qualitative aspects of housing demand in Iran are explained. The intention is to clarify the common types of housing, the actual required and supplied floor area and the location of housing demand.

5.5.1 Housing types

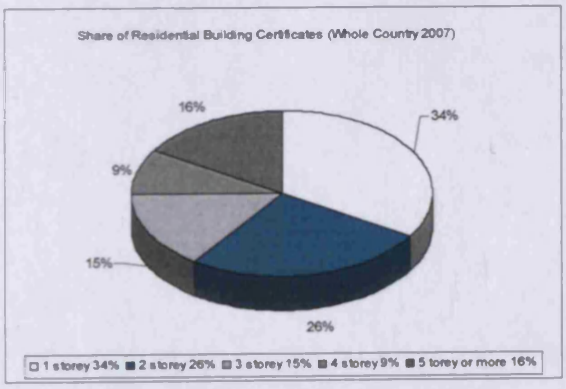
According to a report by Central Bank of Iran, the number of buildings with six or more units has increased from 25.8% in 1997 to 33% in 2000 and the number of buildings with three or more storeys has increased from 19.5 % to 27.8%. This means the portion of flats is gradually increasing and the industry is going toward building three or more storey buildings (Table 5-5).

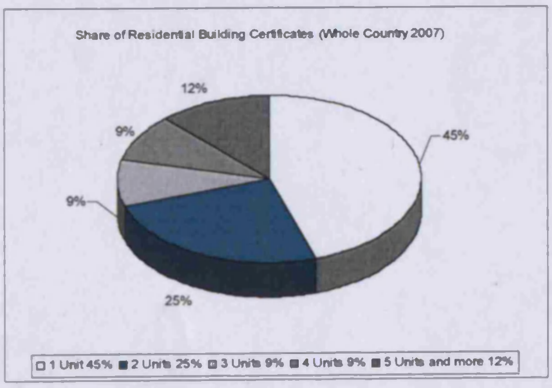
YEAR	1997	1998	1999	2000
The portion of buildings with six or more units	25.8%	27%	32%	33%
The portion of building with three or more storeys	19.5%	19.6%	21.6%	27.8%

Table 5-5: Portion of flats in the construction industry (1997-2000)
Source: (Central Bank of Iran, 2006b)

Figure 5-8 shows the Share of residential building permissions based on the number of storeys and units in Tehran and the whole country in 2007. The majority of building permits (86%) in Tehran are for buildings with five or more storeys. About 99% of residential units are with three or more storeys and only 1% are single storey houses which shows the popularity of flats in Tehran.

The situation is completely different when considering the whole country since 34% of the building permissions have been issued for single storey houses and 45% for single unit houses. 40% of the building permissions have been issues for residential buildings with three or more storeys. Although not comparable with Tehran, it is still, a considerable portion of the whole residential buildings which shows the popularity of flats in the country. It should also be mentioned that about 23% of all building permits in year 2007 have been issued in Tehran which shows the weight of this province in the Iranian housing market.





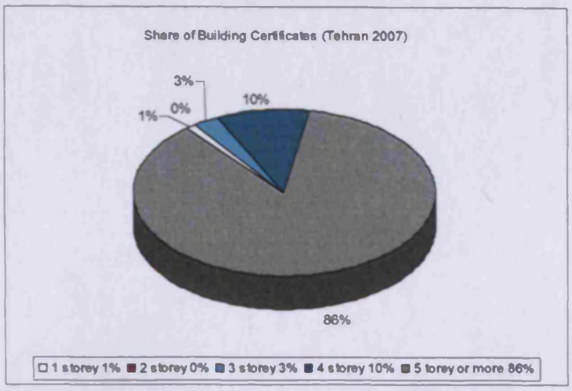


Figure 5-8: Share of residential building permissions based on the number of storeys and number of units in year 2007 (Edited by the author)
Source: (President Deputy Strategic Planning and Control, 2007)

5.5.2 Housing floor area and actual demand

The Iranian government has recommended a limitation of 75m² floor area for residential buildings in some major cities such as Tehran, Tabriz, Mashhad, Shiraz and Isfahan, 100m² in other cities, and 80m² in rural areas. Such residential buildings are entitled to some special facilities and subsidies from the government(Rafiee et al., 2003). According to Table 5-6 the average area of houses in Iran in 2004 has been 100m² in urban areas and 80m² in rural areas (ICIC, 2006a).

Title	title	unit	Year					Annual increase rate %
			2000	2001	2002	2003	2004	
Average area of houses	Urban Rural whole	m²	110 72 96.5	108 74 97	105 76 96	103 78 95	100 80 93	110 70 96

Table 5-6: Housing area in urban and rural areas (2000-2004)
Source: (ICIC, 2006a)

In 2007 the majority of the residential buildings which have received building permission are within the area of 120 to 150 m². Figure 5-9 illustrates the averages area of residential units which have received building permissions in 2007. It seems that the country has gone backward since the average area of the residential buildings has increased despite the government's recommendations. This shows the inefficiency and ineffectiveness of the governmental policies towards small building.

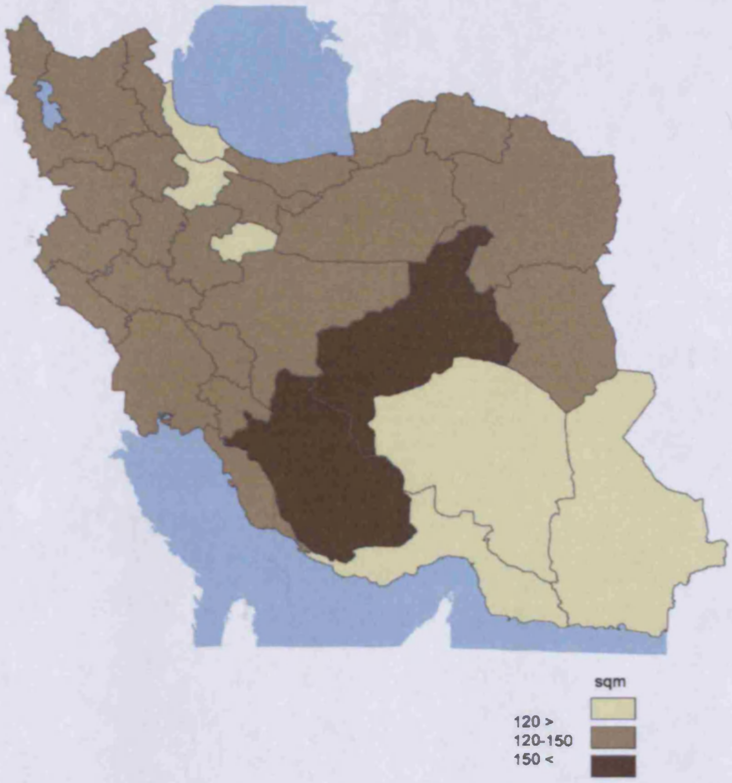


Figure 5-9: Average area of the residential units constructed in year 2007 (Edited by the author)
Source: (President Deputy Strategic Planning and Control, 2007)

This is while, more than 53% of the urban houseless families are under the housing financial strength line and need the governmental assistance to buy their houses. The financial strength of 43% of those 53% is lower than the average price of houses, which means they are under the housing poverty line and will not be able to buy their own house without an extensive support of the government or other sources (Rafiee, 1997, Rafiee et al., 2003).

The comparison between the financial strength of different income categories with the average area of constructed houses reveals that there is a fundamental difference between the demand and supplied housing area. Table 5-7 shows that the demand for houses with the area of less than $50m^2$ is about 43% of the total housing demand; however, the housing industry answers only 20% of this demand. The demand and supply for houses with an area of less than $70m^2$ is almost balanced and the supply for houses with the area of more than $100m^2$ is about 26% more than the demand.

Percentage of the supply	Percentage of the whole Demand	Area Demanded	Income Group
20	43.3	50<	1 to 4
30	32.8	70<	5 to 7
50	23.9	100	8 to 10

Table 5-7: Demanded and supplied housing area
Source: (Housing Economy, 2003)

Such differences between demand and supply have caused a big portion of demands in the housing market to remain unsupplied while many houses are empty. Currently, in Tehran alone, 5000 billion Toomans (about £3.3 billion) has been stagnated in empty houses. According to Eshrat Shaghayegh, member of the Iranian Parliament, more than 100,000 houses, which are less than 10 years old, have remained unsold in Tehran as they are not affordable for most families. She adds that, considering the current stagnation in the housing market, rents have dramatically increased and buying strength of low-income people has decreased due to uncontrolled increase in house prices in recent years (NHLO, 2006b).

These figures show that low-income people are neglected in the Iranian housing industry however there is a huge housing market for this part of the society. Therefore, developers should be informed and encouraged in an effective way to build smaller houses to cover unanswered part of the housing demand. Moreover, any attempts to introduce new methods of construction to Iran should consider the above issues to have long-term demand for the products.

5.5.3 Location of demand

Like many other countries, housing demand in Iran is concentrated around the major cities. Figure 5-10 show that the housing production in major cities has increased from 50.3% in 1996 to 65.1% in 2000. This is while the portion of housing in Tehran has increased dramatically from 15.6 to 36.1 which mean a sharp rise of 231% in a period of four years.

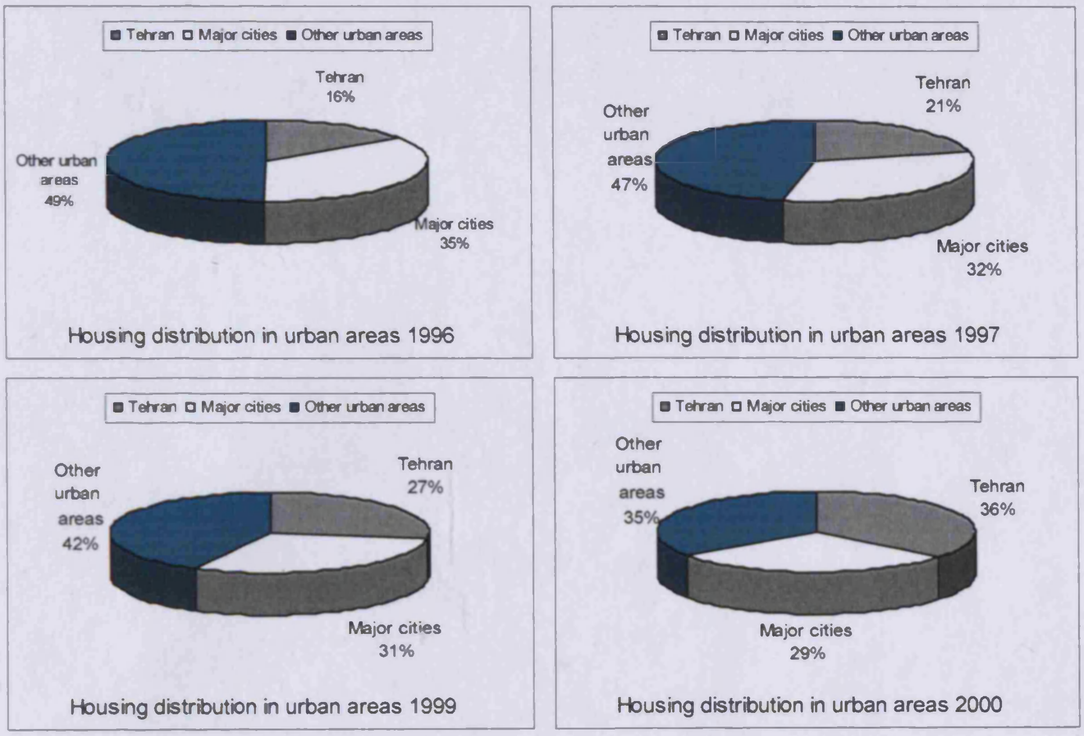


Figure 5-10: Housing production in urban areas (1997-2000) (%) (Edited and created by the author)
Source of tables: (ICIC, 2006a)

Meanwhile, the family density, and housing demand, have changed dramatically since 1986. Figure 5-11 shows the population density in Iran. The density is much more in the North, Northwest and West of Iran since two huge deserts (Kavir Markazi, Kavir Loot) are located in central Iran. However, there are some cities, such as Mashhad, Shiraz and Esfahan, with the population of more than one million which are outside these areas. Some of these major cities are about 1000km far from the central Iran. The location of such major cities makes the prediction of future housing demand more complex.

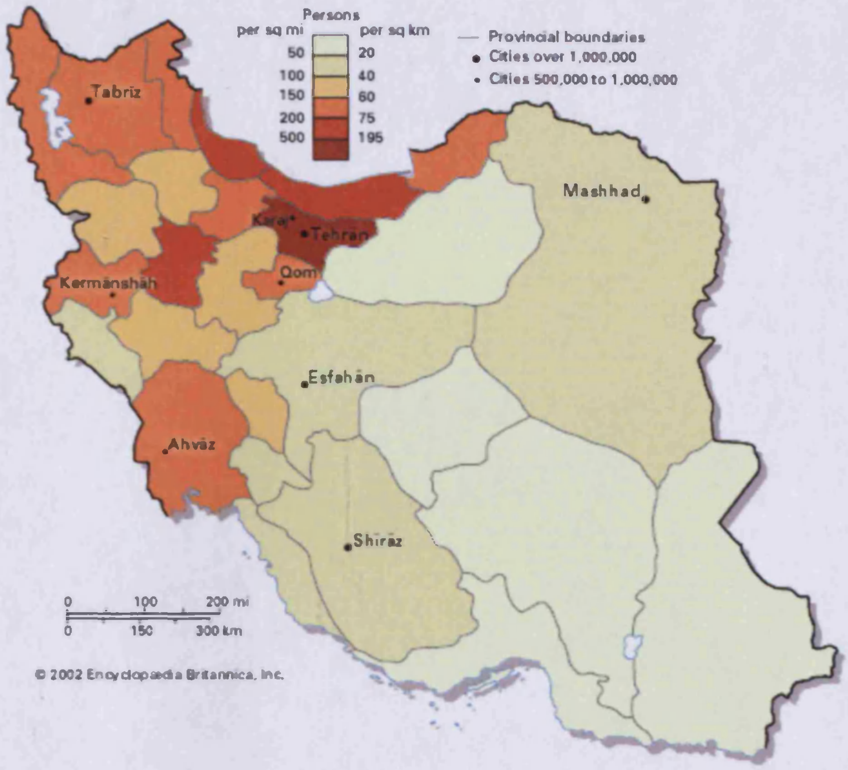


Figure 5-11: Population Density of Iran
Source: (Encyclopædia Britannica)

Figure 5-12 illustrates the share of predicted constructed houses in 2007 based on the issued building permissions by municipalities in different provinces of the country. Figure 5-13 also illustrates the approved density for residential buildings by the municipalities in 2007. Considering these three figures, it seems that there are some differences between the population density, which can be assumed as the location of housing demand, the approved housing density and the share of constructed houses in different areas of the country. Currently the housing projects are very diverse; however it seems that housing projects are concentrated around major cities such as Esfahan, Tehran, Tabriz, Mashhad and Ahvaz.

To have a clear understanding of the future demand and to avoid mistakes and possible failures, comprehensive and up to date research is required based on which the housing and raw material factories (if any) should be located and established. This is crucial to decrease the costs and negative environmental effects of transport and to have guaranteed long-term, and steady, demand for the products.

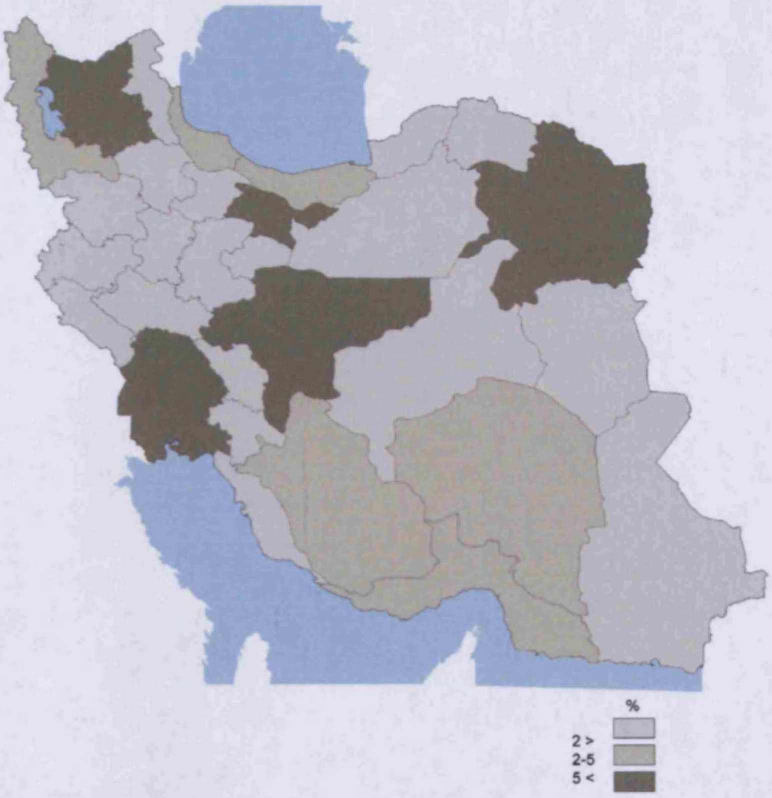


Figure 5-12: The share of constructed residential units in different provinces in year 2007 (Edited by the author)
Source: (President Deputy Strategic Planning and Control, 2007)

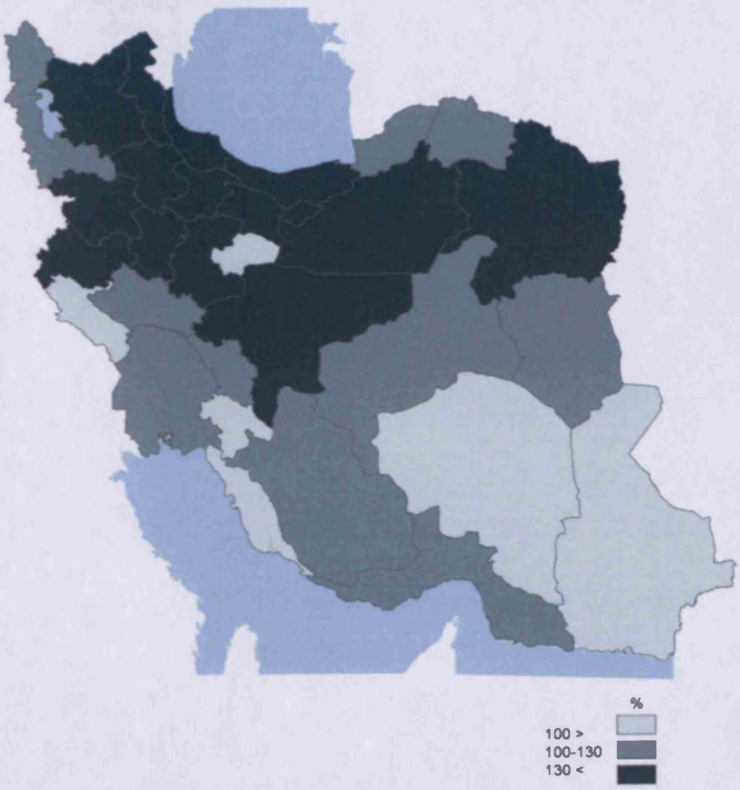


Figure 5-13: Approved density of residential buildings constructed in year 2007 (Edited by the author)
Source: (President Deputy Strategic Planning and Control, 2007)

5.6 Conclusion

The current situation of the Iranian industry in general and construction industry particularly, the climate and the high demand for new housing were reviewed in this chapter.

Iranian industry consists of several sections including oil, agriculture, mining, manufacturing, water, electricity & gas, construction, trade, restaurant & hotel, transport, storage, communication, finance services, professional services, public services and social services. Construction industry accounts for only 4% of the whole economy however, due to its strong relation to the other sectors it has a great influence on other parts of the industry. Housing with the share of 40%, is the largest sector in the Iranian construction industry. Meanwhile, the Iranian construction industry is suffering from lack of enough skilled labour.

Iran is a major producer of cement and steel products but many building products and heavy machinery are imported from other countries.

The Iranian climate condition is totally different from many other part of the world. Iran's climate is mostly hot and arid with considerable difference between summer and winter temperatures. This influences the construction methods and building types considerably.

Housing demand and supply was also discussed in this chapter. Population growth, high migration rate from countries to cities, new young families, high rate of destruction due to natural disasters etc, have caused a very high demand for new housing in Iran. There are different and sometimes contradictory information about the current housing demand and supply however; according to available information, Iran needs about 1.2 million new residential units to be constructed annually to cope with the current housing demand. Meanwhile, the construction industry's output is about 750,000 units per annum since the construction methods are mostly traditional. In this situation, it seems impossible to produce 450,000 more houses, unless the speed and output of the construction industry are increased. Meanwhile considerable investment on production of raw materials is required.

All the above issues should be considered seriously when introducing a new method of construction to Iran. Moreover, comprehensive studies on required skills, resources, infrastructure and cost issues are required to prepare the base for introduction of new methods of construction.

Part 1 of the thesis intended to explain the history and current situation of the Iranian architecture and housing industry. Several subjects such as the housing history, planning, economy, industry, climate and housing demand and supply were discussed in this part. In Part 2, various Iranian and UK issues with regards to Modern Methods of Construction are explained.

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Part 2 (Modern Methods of Construction)

Chapter 6: UK Housing History (with regards to construction technology)

6.1 Introduction

Generally, industrialized building systems in the UK have not been very successful persistently due to various reasons including inconsistent governmental policies. The industrialization of construction industry was criticized by the society because the quantity was considered more than quality. In many occasion designers were not very successful in considering technical matters in conjunction with aesthetic matters. In many cases the society has criticized the local authority housing for losing the identity of its tenants which has caused many social problems such as depression, vandalism and other crimes (Osbourn, 1989).

In fact, the history of UK housing and introduction of new methods of construction in the 20th century are linked to several factors such as the World Wars, Modern Movement, Welfare State policies which influenced the construction industry considerably.

Huge destruction after the world wars, which resulted in massive and urgent need for new housing, encouraged the government to enter the housing market. Consequently, the massive size of housing programmes outside the capacity of existing traditional building resources, including materials and skilled labour, gave rise to the idea of applying alternative methods of construction capable of using new materials and non-skilled labourers outside the construction industry. The main reasons for this were shortages of skilled labour and traditional building materials (Finnimore, 1989, White, 1965).

The general belief was that by applying advanced technologies, housing would change from an expensive capital investment to an easily available product. It was hoped that like other goods, houses could be mass manufactured from main components (Finnimore, 1989, Harvey and Ashworth, 1997).

In fact, after the beginning of Modern Movement in architecture, building industrialization has always been studied and supported. The most idealistic outcome of these efforts to move the building process and production from site to the factory was the prefabrication of entire buildings including all their details (McEvoy, 1994).

The unique post-war conditions and reconstruction programmes after the Second World War offered a great opportunity for Modernist architects to enter the government for the first time and to apply their theories, including prefabrication, mass building and high-rise blocks, in practice.

This situation, where new technologies were greatly welcomed and supported by the central government, created a proper environment in which new national and international building technologies were introduced and developed greatly. Most of these new methods of construction were based on removing the expensive, and time consuming, building skills such as bricklaying from the building process. Among these new systems, large concrete panels proved to be cost saving compared to other systems which were used largely in construction projects during the 1960s.

The 1960s was the era of high rise flats applying prefabricated building methods. However at the same time, arguments against such types of buildings and methods of construction were becoming more apparent among politicians and architects. The Ronan Point disaster, when a high rise tower was completely collapsed by a gas explosion, almost terminated the construction of such buildings.

During the 20th century about one million prefabricated homes were built which led to a negative public attitude toward prefabrication due to the low quality of design (Harvey and Ashworth, 1997), materials and building skills (Parliamentary office of science and technology, 2003).

This chapter intends to explore the history of the UK housing with regards to new methods of construction. It is also aimed to discuss the reasons for the failure of such methods. The current situation of the UK has roots in this period. Also, the current situation of Iran is more or less comparable with the UK after the World Wars in many areas including the housing demand and supply, governmental, environmental and technological issues. The author believes that the history of UK housing is important since firstly, Iran needs to learn from other countries' experiences and secondly, this thesis aims to investigate the applicability of UK Modern Methods of Construction in Iran.

6.2 Housing demand and supply and economy situation

During the 20th century housing demand and supply have been fluctuating showing the cycling nature of the UK house building. There have been several booms and recessions in the housing market; however the general trend of housing has been downward during the last 50 years. The rate of new house building in England has decreased from over 250,000 in mid 1970s to 200,000 in 1989 and 150,000 in 2004. This has been because of two main reasons: first, the governmental investment in new social housing has decreased dramatically; second, the rate of private sector house building has also declined. The low level of house building has caused house prices to increase harshly while interest rates have dropped and the economy has developed (Wilcox, 2005).

After an increase in housing production in 1950s, the private sector reached its period of recession. There have been however some peaks in 1967, 1972, 1983 and 1988 followed by recessions in 1970, 1974, 1980 and 1992. Social housing also decreased dramatically during 1950 to 1960 due to lack of enough support by the Conservative government. After this period there have been some peaks in social housing in 1967 and 1975 and depressions in 1973, 1981 and 1991. The number of built houses by the government reached 26,500 units in 1991, the lowest since the First World War. The social housing has reached to almost zero in recent years. In general, the number of houses built in the UK has been fluctuating after 1965 but the general trend of house building has been downward since 1967 (Balchin and Rhoden, 2002).

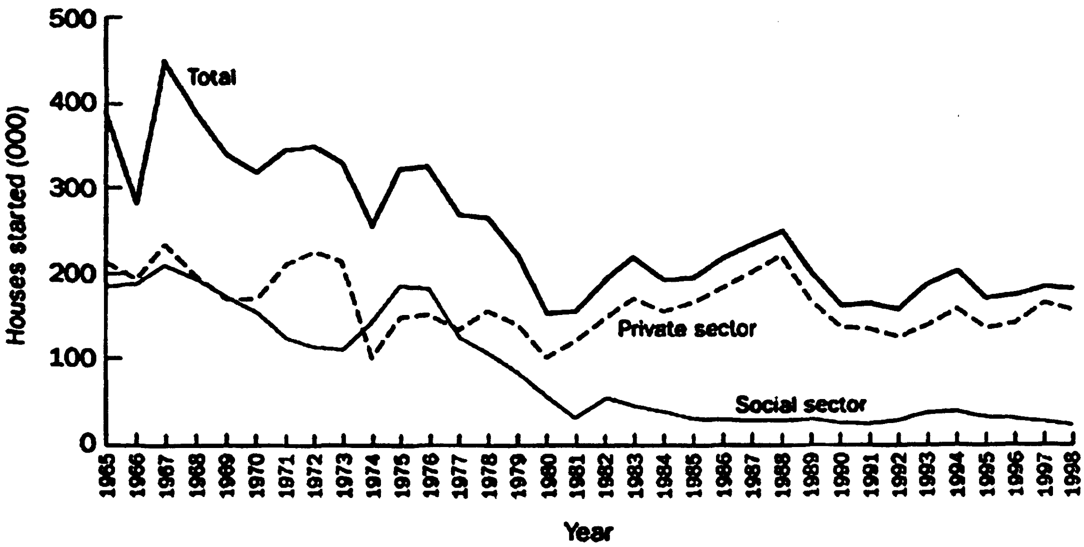

Figure 6-1: UK housebuilding cycle, 1965-98
Source: (Balchin and Rhoden, 2002)

Housing shortage was almost over by 1970s and by 1981 there was a surplus of about 910,000 houses which decreased to 480,000 houses in 1998. The 1998 housing surplus did not however show the real situation in terms of demand and supply since there were more than a million houses in poor condition. The relationship between demand and supply also differed greatly in different parts of the country since there were plenty of cheap houses in the North and Midlands while there was a housing shortage in the South and London (Balchin and Rhoden, 2002).

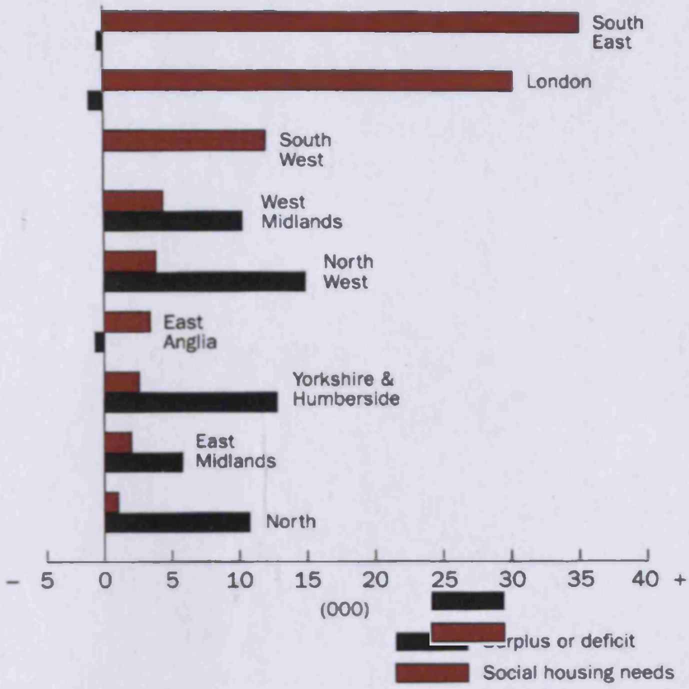

Figure 6-2: housing surplus and deficit in England, 1998
Source: (Burnett, 1993) (edited by the author)

During the 1990s, there were many signs indicating the end of economic recession. Inflation fell from 20% in 1980 to 2-3% in 1996, interest rates decreased from 15% to less than 5%, unemployment decreased from 12% in mid 1980s to less than 6% by 1990s. In spite of these positive signs, houses were neither built nor sold enough due to the lack of confidence in the future (Harvey and Ashworth, 1997).

Despite very low interest rates on mortgages, making houses affordable, the memory of very high interests of 1980s and the possibility of increasing interest in the future would stop people from applying for mortgages (Balchin and Rhoden, 2002).

Currently (year 2009) UK housing is facing another recession due to the global economic problems caused by international 'credit crunch'. This may also have a huge effect on the rate of house building during the coming years.

6.3 The government's involvement in housing

There have been some issues in the UK's recent history including housing shortage caused by World Wars, slum clearance and the high rate of new forming families which encouraged the government to enter the housing market.

Housing shortage after the First World War in England and Wales in 1919 was about 600,000 which increased to 805,000 by 1921(Bowley, 1945). In 1945 after 6 years of war, 475,000 houses were destroyed or uninhabitable (Cleeve Barr, 1958). Only 200,000 houses were built in this period (White, 1965).

In addition to the destruction caused by the war, the population of England and Wales increased by 8 million (from 38 million in 1921 to 46 million in 1961) while the number of households increased from 8.7 million to 14.9 million. This means that the number of households almost doubled (Halsey, 1972). Also during 1961 to 1981 the population increased by about 7% while the number of households increased by about 20% (Burnett, 1993). In this situation government intervention was inevitable due to such huge housing demand.

In 1945 the government did not have any hesitation to act as a major player in housing as a result of the national need. By 1957, 2.5 million new houses and flats were built, three quarters of them by local authorities (Burnett, 1993). The new government set itself an ambitious objective of 500,000 new houses a year by 1970 which was not achieved due to economy crisis in 1967. However, the rate of house building remained high, with a peak in 1968. Between 1965 and 1969, about 1.8 million new houses and flats were built which were almost equally divided between the government and the private sector (Burnett, 1993).

In general, the government's involvement in housing differed from time to time mostly depending on the Labour or Conservative party in power. Figure 6-3 summarizes the UK housing policies between 1945 and 1997. During 1945-1955 the government's policy has been mainly on building new houses due to huge housing shortage. After 1955 the emphasis has been more on the housing quality divided into two main categories of A (between 1955 and 1968) and B (between 1968 and 1997).

Between 1955 and 1968 the emphasis of the government has been more on slum clearance and building new houses whereas during 1968-1997 the policy has been to maintain the existing stock. The other phenomenon of this period (1970-1977) was decline in the council housing by leaving the housing market to the private sector. However after 1985 housing quality issues caused the government to intervene in the housing market once more.

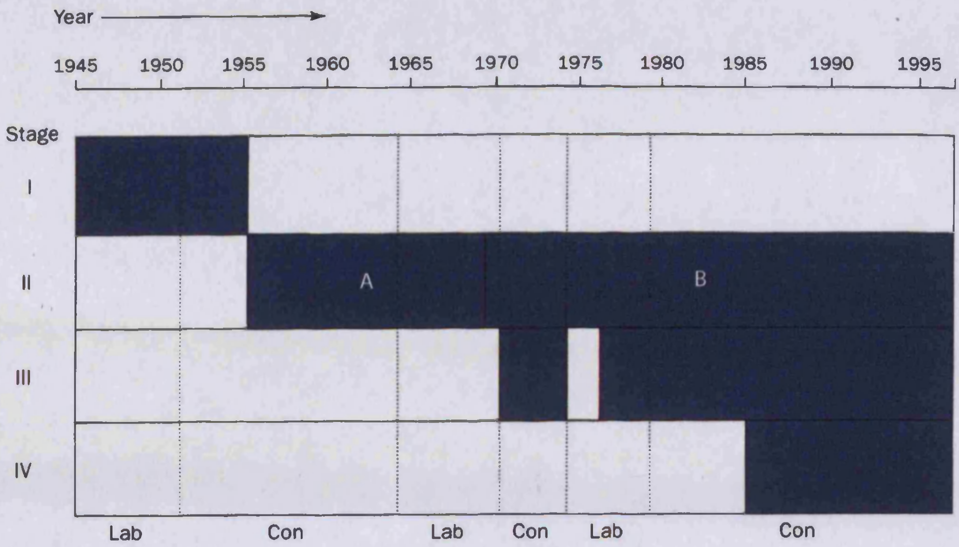

Figure 6-3: UK housing Policy
Source: (Burnett, 1993) (edited by the author)

6.4 The "emergency" period

In February 1944, Winston Churchill declared his objective of producing 500,000 temporary houses from steel "as a military operation handled by Government, with private industry harnessed to its service" (Finnimore, 1989). The government's aim was to supply a huge number of houses without increasing demand on conventional building resources and skilled labour. For these reasons, the government supported prefabrication and helped the sponsors and local authorities by offering subsidies to offset the higher costs resulting from new technologies.

However, the objective of producing 500,000 temporary houses failed since it was reported that only 150,000 bungalows could be constructed without increasing demand on conventional resources for permanent dwelling (Finnimore, 1989).

There were four prototype Bungalows which were produced sufficiently to be called mass-produced. Other prototypes were never produced enough to be considered. 156,623 prefabricated bungalows were produced under the Churchill's programme (Figure 6-4).

Four types of prefabs which were mass produced are as follows:

- Arcon (38,859 units)
- Uni-seco (28,999 units)
- Tarran (19,041 units)
- Aluminium (54,500 units)

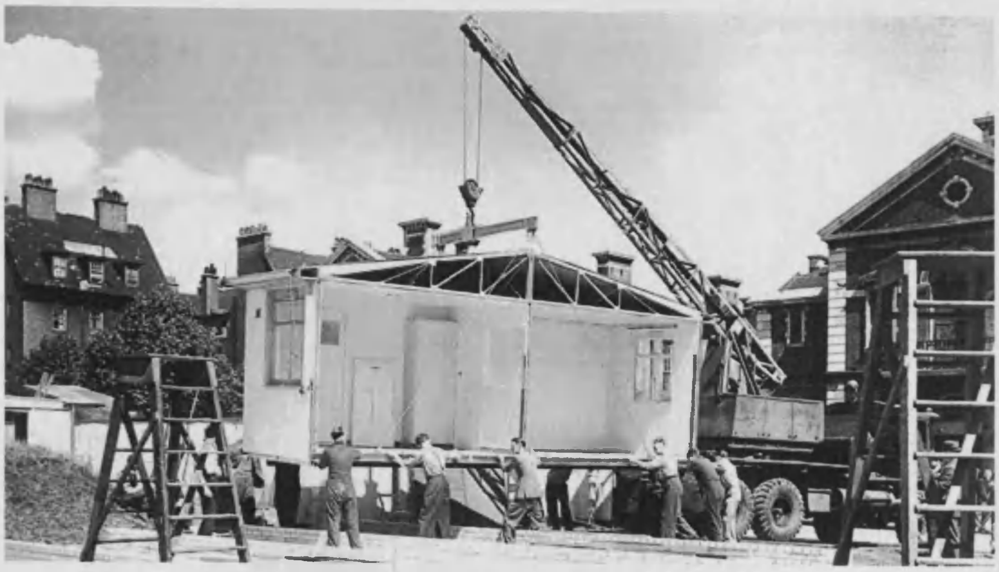

Figure 6-4: Aluminium Prefab
Source: (Amgueddfa Cymru, 2008)

These prefabs were designed to last between 10 to 15 years however there are still more than 67,000 in use in England and Wales. While Churchill's objective of building temporary houses for homeless was a short-term programme, the long-term government objective has always been to provide permanent houses for people (Vale, 1995, White, 1965).

6.5 Flats: a new type of housing

Until after the World Wars, flats were not a common type of housing in the UK. Mass destruction caused by World Wars and slum clearance associated with introduction of new methods of construction, which suited high rise block towers, created a situation in which flats became very common in the following years.

With regards to slum clearance, flats were considered by the local authorities and the central government as an answer to the problem. The idea was that the original occupants of the demolished slum could be resettled on the same site. In addition, the council believed that there would be some saving on infrastructure since the existing water and electricity supplies could be used for new buildings instead of moving dwellers to other areas which required new infrastructure. Also it was assumed that the flats themselves would be cheaper in total since the cost of land would be shared between the dwellings (Vale, 1995).

Although very little (only 5% of all subsidized buildings), 1930s saw an increased number of flats as an alternative to traditional two story cottages. This was not certainly because of being cheaper than the traditional houses since soon it was proved that five story flats were one to two third more expensive than houses. It was proved that for the same floor area the cost of flats was almost doubled (Bowley, 1945) (50% more as mentioned in another source) (Finnimore, 1989). The additional cost was because of the lack of enough research in design and constructions methods of flats to make them efficient for saving purposes at the time (Finnimore, 1989).

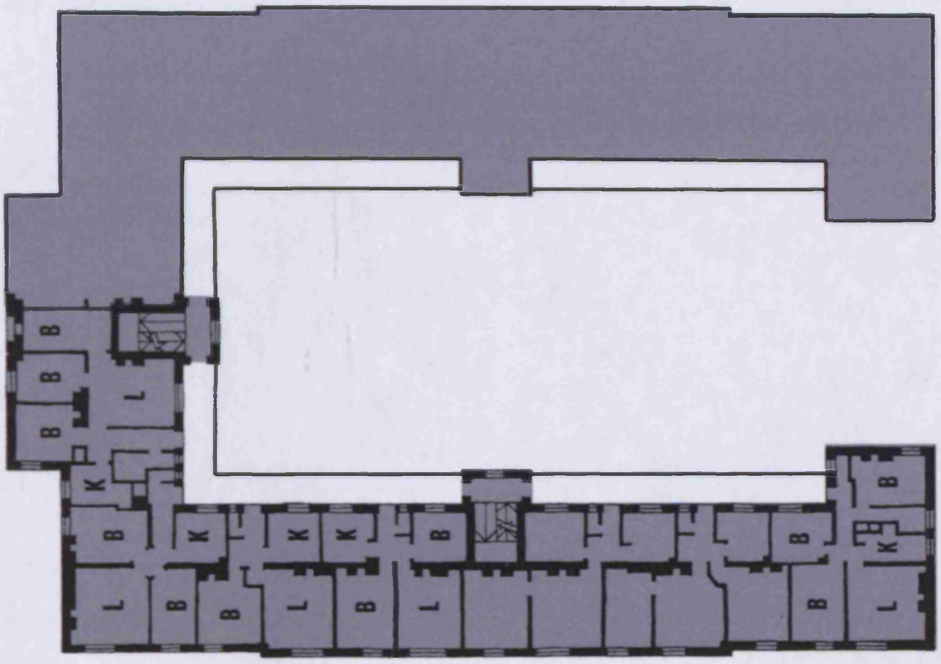

Figure 6-5: An example of flat blocks in 1936
Source: (Burnett, 1993) (edited by the author)

It was not until 1964 when it was demonstrated that flats built with large prefabricated concrete panels could be cheaper than other types of buildings. Governmental statistics in 1964 indicated that flats with over four storeys were more than 2% cheaper than conventional systems if large-panel prefabricated systems were applied. Small concrete panels proved to be uneconomical. The application of large panels was influenced by various factors: first, government interest in tower blocks and second, improved jointing systems and third by introduction of towercranes to the construction industry which were developed in the Europe after the wars (Finnimore, 1989).

Dr E. W. Cooney has also argued that high-rise flats were built under an architectural ideal influenced by Modern Movement and pioneers such as Le Corbusier and Gropius who introduced the theory of vertical garden city. On the other hand it was believed that applying industrial methods of construction in tall blocks was more economical (Bowley, 1945, Vale, 1995).

There have been some arguments which challenge the theory of flat and prefabricated methods being cheaper than conventional methods of construction. According to some research on different methods of construction, it was suggested that the efficiency and cost saving of new methods of construction have not in fact been much related to the technical issues and methods of construction themselves. Apparently, the efficiency and cost saving have had more to do with proper management and cost-effective design. It has been argued that new methods of construction have attracted well organised contractors which could have achieved the same efficiency by applying traditional methods of construction too. Therefore such houses and flats could have been cheaper regardless of the method of construction (Finnimore, 1989).

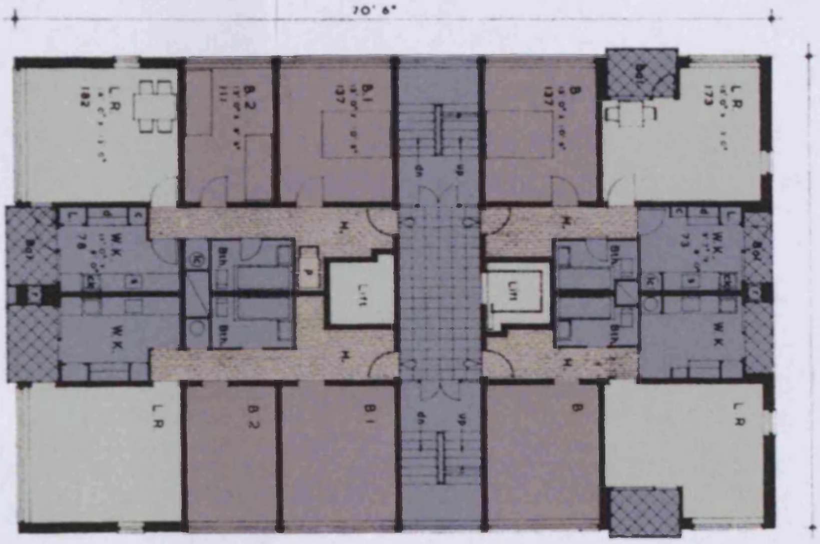

Figure 6-6: an example of flat blocks in 1958
Source: (Burnett, 1993) (edited by the author)

The portion of flats increased significantly and reached 55% by 1964. High rise flats with five or more storeys accounted for 26% of constructed buildings by 1966. There was however a fast decline in flat building to 10% by 1970 (Bowley, 1945, Vale, 1995).

The 1960s was the era of housing blocks when prefabricated elements were applied greatly in buildings. 30% of the local authorities' housing during 1966-1972 was completed by system building with a peak of 41% in 1970 (Finnimore, 1989).

A disaster ended the golden age of flats. The objection against high rise flats is usually linked to the Ronan Point disaster in 1968 when a gas explosion caused structural failure of a 23 storey prefabricated block (Figure 6-7). However, this was not the only reason for rejection of the flats. In fact, the Ronan Point accident supported the opinions already discussed widely to introduce high-rise tower blocks as an unacceptable type of building in the future (Bowley, 1945, Harvey and Ashworth, 1997, Finnimore, 1989).

Later, it was discovered that the reason of failure in Ronan blocks was insufficient design joints. The blocks were demolished in 1991. During demolition more construction faults were discovered such as mixed mortar with tin cans, and newspapers, and critical areas mortared with only half of the specified depth. Such poor design, supervision and management caused industrialized housing to be reduced from 43% in 1960s to only 2% in 1990 (Harvey and Ashworth, 1997).

Figure 6-7: The Ronan Point disaster, 1968
Source: (Harvey and Ashworth, 1997)

6.6 Fundamentals of the System Building

After the First World War, what was later known as system building was introduced to the governmental housing programmes.

System building was more than just a new method of construction since it changed the role of all key bodies involved in the construction industry including clients, architects, manufacturers, contractors and labours. System building was introduced as a theoretical idea by the Modern Movement and considered something more than just an affluent economy (Finnimore, 1989).

Modern Movement raised the argument that mass production was needed to cope with the massive social demand. After the Second World War, mass production became the objective of housing policies (Finnimore, 1989). The Modern Movement also argued that architects should familiarise themselves with new building science and technology to take the responsibility of this project. Such a social role for architects was defined by being employed in the government. This created some opportunities for the local and central government's architects to be pioneers in applying new building methods in their projects.

The reality is that after the wars in a strange situation which was created by social policy, architects were able to create a new role in the building economy for themselves by the support of the system building which led to their success (Finnimore, 1989). The professional skills of the Modernist architects were much appreciated by the politicians and therefore they used their power in the government to plan the state's research programmes and to design and promote their own systems (Burnett, 1993).

During the 1960s the acronym IB or Industrial Building, was widely used for describing fast and advanced methods of construction. It became evident that mass production was more complicated and broader than just prefabrication. IB was a series of different issues linked to industrialised manufacturing methods which was explained by the government in 1965 as (Finnimore, 1989): "All measure needed to enable the industry to work more like a factory industry. For the industry this means not only new materials and construction techniques, the use of dry processes, and the manufacture of large components under factory conditions of production and quality control; but improved management techniques, the correlation of design and production, improved control of selection and delivery of materials, and better organisation of operations on site. Not least, IB entails training teams to work in an organised fashion on long runs of repetitive work, whether the men are using new skills or old."

The other issue that should not be neglected in the development process of system building is the relation of Welfare State policies with the system building. Welfare State created an extraordinary demand for the housing for about thirty years (Finnimore, 1989). Huge difference between demand and supply for social housing was one of the main reasons for developing system building. Massive housing programmes when building resources were limited created an environment in which alternative methods of construction were considered seriously. System building supported the traditional building resources in two ways: first, by employing unskilled labourers from other industries than housing by manufacturing components offsite and second, by introducing new resources to the industry (Finnimore, 1989).

The Welfare State has been the main client and investor in the economy generally and housing specifically after the Second World War. It has been suggested that the extraordinary rapid growth rate of Europe after the world war was mainly the consequence of huge demand and investment of the welfare. This situation stimulated the housing market too. In 1968 Welfare State purchased half of the new work in the housing market (Finnimore, 1989). The welfare policy according to B. Ward, was probably "a more important stabiliser of demand and stimulator of growth than monetary fiscal policy"(Cippolla, 1976).

6.7 Post-war methods of construction

The post-war construction methods could generally be divided into two main categories of:

- Traditional methods
- Industrialised methods

Traditional methods are mainly referred to brick and mortar and industrialised methods are essentially referred to pre-cast concrete and timber frame methods. Theses methods are explained in this section.

6.7.1 Bricks and mortar

Since its appearance, system building has always been a challenge for traditional methods of construction, including brick and mortar, but has never been capable of replacing traditional methods. Although in 1970 the portion of system building increased to 40%, the social housing has always been grateful for the volume of housing done by traditional methods. Not only the traditional methods allowed for better building design but until the 1960s they were statistically cheaper than industrialised methods. Brick and mortar offered the most efficient houses despite several efforts of the government, sponsors and the Modern Movement. Moreover, traditional methods exploited many of the new technologies and components used by the system building which made traditional methods increasingly efficient and modern after the wars (Finnimore, 1989).

It should be also borne in mind that bricklaying has historically been an expensive trade in the UK construction industry. The result of a research by the government in 1917 revealed that including the cost of material and labour, out of eleven businesses involved in house construction, bricklaying with 31% and carpentry and joinery with 26% were the most expensive trades. But, although carpentry and joinery moved toward prefabrication, brickworks remained the same. Bricklaying traditionally remained the major cost in house building and therefore the future desire of system building was to find an alternative for it (Finnimore, 1989).

In 1948 another research by the government revealed that the costs of construction had increased three and a half times compared to pre-war. It was found out that the situation was mostly as a result of 45% higher labour requirement which meant 31% less output. The reasons for lower productivity were firstly the effects of war causing deskilling of the construction industry and secondly the "lack of individual effort" caused by the labour market and in an environment of full employment when the construction was in desperate need for labour (Finnimore, 1989). The high cost of skilled labourers was one of the main reasons for finding some labour saving methods to replace traditional methods.

6.7.2 Industrialised system

By 1939, more than 23 new methods of construction such as pre-cast concrete panels and some timber based methods were developed which created the basis of the post Second World War construction methods. The theory behind such methods was the replacement of bricklaying with some substitute factory made systems which were carried out by unskilled labourers (Finnimore, 1989). Generally, there were four main categories of (a) concrete slabs or blocks which would form a cavity wall (b) concrete cavity blocks which were the full thickness of the wall (c) in-situ concrete walls (d) various kinds of reinforced concrete construction. Ten advantages were claimed by the supporters of prefabricated methods. Cost efficiency, time efficiency, quality improvement, design improvement, improvement in equipment, efficient use of available labour, removal and reassemble and improvement in working conditions (White, 1965). Most of these are still claimed by the supporters as the advantages of prefabrication methods.

6.7.2.1 Pre-cast reinforced concrete systems

Application of reinforced concrete goes back to the 19th century when it became a major common material in construction because of many advantages compared to other building materials: its key components including sand, water and gravel were cheap and available almost everywhere; its production was not very complicated; was easily shaped; was durable, strong and usable as exterior façade with little treatment. These advantages made reinforced concrete comparable with stone, timber, brick and steel in different buildings (Warszawski, 1996).

After the Second World War with developing transportation and assembly methods, the full potential of precast concrete was discovered. Prefabricated concrete was now a real alternative to the conventional methods of construction which soon became the main building method. However it was not able to compete with conventional construction methods in small projects (Warszawski, 1996).

During the 1950s, construction methods for multi storey dwelling towers were mostly in-situ concrete systems. However such methods were quickly outdated in 1960s by introduction of pre-cast concrete panels which were bought from France and Scandinavia and became very popular due to their production advantages (Finnimore, 1989).

Foreign systems were adopted greatly in the UK construction industry during late 1950s. This was when housing programmes, grew considerably and investors became confident about local authorities and the government's commitment to the system building. Subsequently, this caused a phenomenon in which foreign and UK building systems flooded into the housing market and local authorities. Since the number of systems was far beyond the housing capacity, it soon became obvious that only some of the systems would become successful (Finnimore, 1989).

There were several pre-cast concrete systems applied in the construction projects from which the following could be mentioned:

- Bison's Wallframe (Vale, 1995)[25]
- Wimpey No-Fines (Finnimore, 1989)[26]

[25] "Aflexible system of large panel construction using load bearing walls and precast flooring slabs was developed by Bison, i.e. the Bison wall frame system. It proved economical to use when as few as 24 units were being erected. Blocks of flats with four to eight flats per floor and from 8 to 20 storeys could be constructed using standard units. Each flat used a number of specialized units, for example single unit bathroom, staircase castings, liftshaft and staircase housing. The standard two bedroom flat uses a total of 21.5 prefabricated units. The windows are cast into the walls in the factory and can be painted and glazed in the factory. Building services are incorporated in the construction and ducts into the floor and wall slabs to carry services. Under floor heating is incorporated in the flooring screed. A tower crane is needed on site for erection of the block of flats but no scaffolding is required except when a brickwork outer leaf is used. The Bison factories produced prefabricated units for 8 to 20 dwellings per day. Each flat could be erected by 10 men and it is reported that the saving in erection time over the construction of a traditional building is approximately two-third. Hence, a traditional building which takes some 18months to erect takes only 6 months using the Bison system. Saving claimed in the cost of construction can be as much as 20% in comparison with equivalent traditional methods."

[26] "There were many systems which used concrete poured into reusable shutters but none which used proved as popular as George Wimpey's No-Fines. By June 1968 Wimpey were able to claim that three quarters of a million people were living in No-Fines houses they had built. (*IBSAC* 2 (Jun 1968), p.51)

No-Fines was first developed in The Netherlands which, like Britain, was affected by shortages in skilled building labour and traditional materials immediately following the first world war. The system was imported to Britain in the early 1920s and used by a number of firms including Laing. (MOW, PWBS No.25, pp. 63-73). In contrast to its later success, only small numbers of No-Fines houses were built between the wars due, according to the Ministry of Health, to a shortage of the plasterers needed to complete the roughly cast walls.

- Easiform (Finnimore, 1989) [27]
- Reema (Diamant, 1968)[28]
- Wates system (Vale, 1995)[29]
- Larsen / Neilson (Vale, 1995)[30]

(MOH, *Second Interim Report of the Committee on New Methods of House Construction (1925), pp 4)* No-Fines was based on a concrete mix which omitted sand (hence "no-fines2) poured into reusable shutters to form external and internal walls. According to the Ministry of Housing and Local Government, No-Fines was not a particularly labour saving system, requiring on average 1,700 labour hours per house. (PRO HLG 101/371, MHLG u.d.c. 1952.) However, Berand Gosschalk points out that the unskilled labour used afforded a considerable cost saving and suited the system to post-war skilled labour shortages. (Gosschalk, thesis, pp.121.) Furthermore, the completion of No-Fines shells at the rate of one a day speeded the remaining building work. The omission of sand, as well as lightening and cheapening the mix, lightened the shuttering which could be manhandled into position without craneage. Shuttering was the main form of investment in the system and its application was not limited by the available of craneage or proximity to casting plants. The lightweight shuttering and absence of plant made the system highly mobile. The omission of sand also resulted in a cellular composition which provided thermal insulation and prevented the capillary attraction of water through the wall. Due to No-Fine's lack of tensile strength, window openings were limited to modest sizes and evenly distributed throughout the walls _ very much in the manner of brickwork. This, together with the rendered external finish, determined the appearance of the finished dwellings which were indistinguishable from rendered brick construction. Floors and roofs were constructed in timber."

27 "Like No-Fines, Easiform was a poured concrete system, although it incorporated a cavity and used dense concrete for the inner leaf. This in turn required heavy shutters and, therefore, craneage, making the system more complex to operate and, significantly, putting it at a disadvantage to No-Fines."

28 "Reema construction system used storey-height hollow concrete wall panels for the construction of small houses and blocks of flats up to four storeys in height. External walls of cavity construction and some 200 mm thick, largely unreinforced apart from areas adjacent to openings were cast from dense concrete. The internal walls incorporated steel reinforcement and were used as load bearing units. The wall units were cast the factory and ready for transportation on the day after casting. Windows were cast into the wall units and were ready-glazed in the factory. Transportation was by road or rail and even in 10 or 15 tonne loads it was economic to transport the units up to 100 miles from the factory. Floor panels could be of hollow construction or constructed from precast concrete beams and timber boards. Standard components weighted approximately 2 tonnes but special components up to 3.5 tonnes could be used. Mobile cranes were required to assemble the buildings. The roofs were conventional pitched roof or, alternatively, were designed as horizontal and constructed from prefabricated concrete units. The advantages of the Reema system lay in the erection time for the structures when compared with conventional techniques. For example, a pair of semi_detache houses could be erected by a labour force of five men in only 19 days. Not only is a saving of 40% in man-hours claimed but the composition of the labour force is such that a smaller proportion of skilled men is required, i.e. from three skilled men and two unskilled men to one skilled man and two unskilled men."

29 "The Wates system of construction is a panel prefabrication technique used in low and high-rise blocks of flats; block in excess of 20 storeys have been constructed. Steam-heated mould plates for the panel units achieve accelerated curing of the concrete panels. The production cycle for the units is 24 hours. Most units are of 3_4 tonnes maximum weight to match conventional foundations. Structural concrete is poured around steel reinforcing bars between the panels. Vertical joints between the panels are made by placing a concrete mix into the facing castellated grooves. It is claimed that the total man-hours are reduced by 50% and the tradesmens' hours by 60% when compared to conventional construction."

30 "A well known Danish system of prefabrication is that of Larsen and Neilsen. It was adopted by Taylor-Woodrow Anglian Ltd for use in Britain. The building units, which are factory produced, can be used for the erection of small houses, blocks of flats and factories. The wall panels and flooring slabs are cast as large as possible often being of whole room dimensions. The average weight of the units is between 3.5 and 4.5 tonnes. The largest prefabricated components are the bathroom units which weigh approximately 8 tonnes. The panels and slabs are cast in horizontal moulds, the production of each unit taking 24 hours. The units are stored in the open air for at least two weeks before transportation to the site. The cross-walls of the completed building carry the vertical loads down to the conventionally constructed foundation whilst proving, with the longitudinal walls, stability against horizontal wind forces. Mobile cranes erect between

Later on, extreme use of prefabricated systems gave rise to the argument among architects as to if they should accept the simplicity and uniformity of such materials or to mask them with some claddings with traditional materials. In general covering fans, won the argument and many new towns and houses were covered by claddings of tiles, bricks, etc. These could be seen as hopeless attempts to recover some identity and to give character to the houses since UK housing identity such as pitched roofs and chimney stacks were virtually disappeared from houses (Burnett, 1993).

6.7.2.2 Timber frame

Although timber is very suitable for prefabrication purposes, the use of timber frame systems became common only after the use of system building reached its peak during the 1960s. Yet, timber frame was developed and broadly applied in Britain by as far as in 1976 more than half of the system building was timber frame. Moreover, timber frame was the only system building which was broadly applied by speculative house builders (Finnimore, 1989).

Timber was an imported material and therefore its use was strictly restricted during the early years after the wars. However, it developed considerably in prefabricated methods during the 1930s, by introduction of plywood which was light, strong and manufactured industrially (Finnimore, 1989).

Timber frame was attractive to sponsors for its manufacturing qualities and to architects and clients for its flexibility in design. Moreover, since buildings built with timber frame were identical to those with traditional methods, it was broadly accepted by speculative developers.

There are some other advantages for prefabricated timber frame houses compared with concrete and brick methods. Their erection is quicker; their foundation is lighter and therefore cheaper. Also, they have lower u-value and therefore the heat loss is decreased in timber frame buildings. Time wise, building a small brick house may take about 3000 man-hours whereas a timber frame house takes about 1200 man-hours in total from which about 200 man-hours are used for the manufacturing of the components (Vale, 1995).

two and three flats per eight-hours working day and only half the labour force is required compared with that of traditional construction. For small houses, the actual shell of the houses can be erected in a single working day. Even large industrial buildings can be erected quickly."

According to the Timber Research and Development Association, when timber frame was used properly would need one third to half of the labour compared to when traditional methods were applied. It was also claimed that there could be a saving of 5 to 10% in total.

The system which was mainly used for the timber frame buildings was "Platform frame"[31] (Finnimore, 1989) which conquered the timber industry since it needed less investment compared with concrete and steel methods.

Figure 6-8 illustrates the simple concept of Platform system. The concept is to build a platform and then the load bearing walls upon it. Next stage is to build the roof and attic upon another set of load bearing walls (Allen and Iano, 2004).

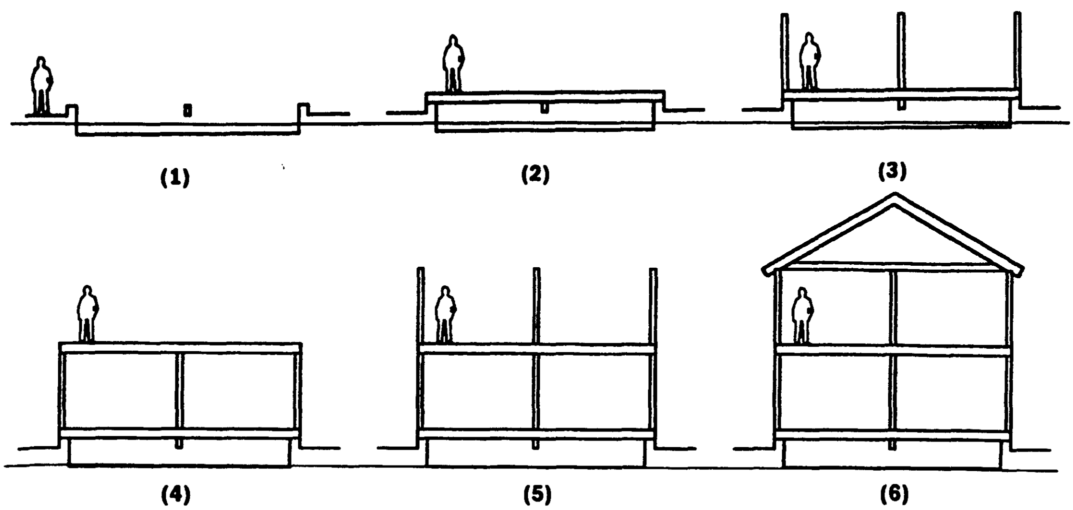

Figure 6-8: Platform system
Source: (Allen and Iano, 2004)

After downfall of pre-cast concrete in 1960s, timber frame and conventional methods of construction which had improved in terms of productivity were the main players in the UK construction industry (Finnimore, 1989).

6.8 System building theory, architects and building labourers

Architects and building labourers were predicted to be considerably affected by mass production and building technology. While construction labourers found it difficult to adapt themselves to system building, architects adapted themselves more successfully.

[31] "Originally developed in America and Canada after the war, platform frame was a considerable departure from the traditional timber house, eliminating most of its skilled labour content. Rather than using a skeletal frame constructed *in situ*, prefabricated wall panels were brought to site and, in conjunction with floor and roof units, rapidly nailed together to form a rigid box-like, weather-tight structure. Like steel frames this allowed the simultaneous working of subsequent finishing trades throughout the house. Wall panels were made up in workshops using large table jigs on which the timber studs, ply sheathing, windows and door frames, vapour barriers and insulation were assembled by unskilled labour".

Skilled labourers were very afraid of system building since it was assumed that system building could remove their skills from their job which would consequently result in them receiving basic rate wages and destroying their trade union in turn.

Architects, like building labours, were afraid of new technologies. Architects were particularly worried about increased machinery since it was assumed that standardisation would result in building uniformity and would certainly decrease the need for design which was the architects' main skill (Finnimore, 1989, Osbourn, 1989) .

6.9 Conclusion

Huge housing programmes associated with post-war high costs and limited building recourses forced the UK government to consider new recourses and methods of construction. The aim was to change the house from an expensive to a cheap and easily available product by applying new technologies. This situation created a proper environment for Modernist architects to enter the government and try their theories such as the mass production and industrialisation. What happened in this period had a phenomenal effect on the future development of new building technologies.

Several new methods and technologies were invented and developed during this period such as prefabricated concrete systems. Meanwhile, traditional methods were still so common. Traditional methods of construction were also developing and becoming more efficient by applying new theories and technologies.

Flats and tall buildings were developed as new types of housing for various reasons including a theory which would suggest that such buildings were more cost effective when applying prefabricated concrete panels.

Later, the process of industrialisation was criticised increasingly by the society and some architects since the quality was neglected in the favour of quantity. Ronan Point disaster put an end to the accelerated use of prefabricated components.

In the next chapter the current situation, various building methods, advantages, constraints, risks, sustainability and costs of MMC in the UK are explained.

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Chapter 7: Current Situation of MMC in UK Housing

7.1 Introduction

The history and fundamental principles of system buildings were discussed in the previous chapters. This chapter aims to concentrate on the current situation of Modern Methods of Construction in the UK.

Applying Modern Methods of Construction to affordable housing has been considered by the UK government at various times during the 20th century for different reasons, such as high demand, skilled labour shortage, high building cost, etc (Parliamentary office of science and technology, 2003)[32]. It seems that the same criteria are being considered by the government to encourage developers and architects to apply MMC in their projects in the 21st century. Different factors are involved in considering MMC as a potential solution to the UK housing scarcity among which cost, as a historical challenge, can be mentioned. Other concerns such as environmental and planning issues have been added to the 20th century's concerns.

During 1996-2004 more than one million new families were added to the existing households which means the number of households has increased by 5% compared with 2% increase in population (National Audit Office, 2005c). This has occurred while, the new housing supply has sunk to its lowest rate since 1945. Currently housing supply in the UK is 175,000 units per year. It is estimated that 3 million new houses will be needed by 2016, which means 230,000 houses per year. This is mainly due to the changing lifestyle, as more people live on their own. There are currently about 30 house building factories in the UK, which can produce 30,000 MMC houses per year. This stands for 17% of the current need (Parliamentary office of science and technology, 2003).

UK housing is dominated by the private sector with about 90% of houses built by it. Although the governmental housing portion and influence on the private sector is limited, the UK government is encouraging the industry to apply MMC since it is believed that MMC offers social, economic and environmental advantages(Parliamentary office of science and technology, 2003).[33]

Housing demand will increase to 3.8 million by 2021. The government's housing bureau is encouraging use of MMC by insisting that 25% of its budget for social housing

[32] These issues were also explained in chapter 5

[33] This situation is comparable with Iran with 95% of residential buildings built by the private sector

(one million units over the next 25 years) must be in developments which apply some kind of MMC (Bågenholm et al., 2001, Burwood and Poul, 2005, Parliamentary office of science and technology, 2003, National Audit Office, 2005c).

Application of MMC is currently limited in the UK because of cost issues. The reason is that the industry is not sufficiently mature to be as economical as other methods of construction. Meanwhile, there are many associated advantages when applying MMC. Such advantages should be publicised using different tools including marketing and media to increase the demand for MMC(Burwood and Poul, 2005).

Estimates by National house Building Council indicate that about 10% of the UK new housing are applying timber frame, 5% other methods of MMC and the rest are using traditional methods. This means about 25,000 of UK new houses are applying MMC (National Audit Office, 2005c).

The use of MMC seems to be much less than in many other countries. For example in Japan 40% of new houses are built applying MMC. Also, many other European countries, particularly Scandinavians, use MMC much more than the UK. Some European housing companies such as Polish ones are exporting their products to UK. The reasons for less use of MMC in the UK are not very clear yet but there are four theories (Parliamentary office of science and technology, 2003):

- Construction season of other countries is shorter than the UK because of bad weather which makes the application of MMC more common since they make the construction process faster.
- MMC products are more accessible in such countries
- Since self building is more common in such countries and MMC offers faster construction and therefore earlier occupancy and less disruption to neighbours, such methods have become more common and accepted in such countries.
- Some methods of construction which are classified as MMC are culturally more preferred in Scandinavian countries.

If current housing demand could not be met using traditional methods of construction and traditional methods were not capable of producing zero carbon houses, the application of offsite methods would increase in the UK, says Darren Richards, offsite manufacturing consultant (Woudhuysen and Abley, 2004).

Figure 7-1 shows the UK offsite output in 2005. In 2005 OSC (Off Site Construction) accounted for £2-3 billion out of £106 billion of the construction industry as a whole. It is aimed to increase the figure by 100% by 2010, and a further increase of tenfold by 2020 which means £40-60 billion by 2020 (OSC, 2006).

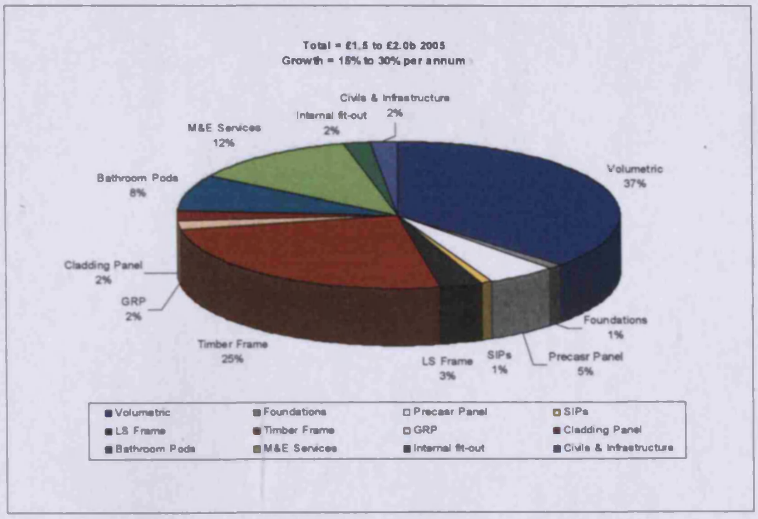

Figure 7-1 : UK Offsite Output 2005 (edited by the author)
Source: (Goss, 2005)

This chapter intends to explain briefly the current situation of the UK construction industry and to answer three key questions:

1. What are MMC building methods?
2. How should MMC be applied in construction projects to achieve the best result?
3. Can MMC be respected as a potential answer to the current UK housing shortage?

To answer the first question, definition of MMC and some common MMC building methods will be explained briefly; and to answer the second and third questions, the context, influential factors on MMC and some advantages and disadvantages of MMC will be discussed. Answers to these questions are essential to evaluate the current situation of the UK construction industry and the applicability, and transferability, of the UK's Modern Methods of Construction to Iran.

7.2 MMC building methods

MMC can be divided into five main building methods (Ross, 2005, CABE, 2004, National Audit Office, 2005c, Burwood and Poul, 2005, Goodier et al., 2005, Ely, 2005, BRE, 2004):

- Volumetric system
- Panel system (open & closed)
- Hybrid system (semi-volumetric)
- Sub-assemblies and components

- Site-based methods

7.2.1 Volumetric system

This system is also known as Modular Construction. In the volumetric system, three-dimensional units are completed in the factory and then the units are transported to site to be assembled (Ross, 2005, National Audit Office, 2005c). In this system about 85-90% of the process is completed in the factory (Burwood and Poul, 2005). There are some advantages and disadvantages associated with application of volumetric systems. Since they are almost finished in the factory, they benefit from controlled environment of factory and on site construction period is extremely reduced. Meanwhile, volumetric systems have some disadvantages including transportation cost especially if they are imported. Also storage costs should be considered (Ely, 2005).

Figures 7-2: Volumetric Building Method
Source: (Diesis Group, 2007a)

7.2.2 Panel system

Panel systems include walls, floors and roofs, which are made from flat, pre-engineered panels and are assembled on site. Panel systems can be divided into two main categories, of Open and Closed systems. In an Open system, structural components are taken to site, where the rest of work is done, and in a Closed system, which is more complex, different components such as windows, doors, internal finishes, external cladding, insulation etc can be fitted in factory (National Audit Office, 2005c, Ely, 2005, Ross, 2005, Burwood and Poul, 2005).

One advantage of panel systems is more efficient transportation (when compared with volumetric systems) whereas the need for onsite finishing may be considered as a disadvantage for panel systems (Ely, 2005).

Figure 7-3: Panel system (timber frame)
Source: (Hague, 2006)

Figure 7-4: Closed panel system
Source: (Kingspan Offsite, 2007)

7.2.3 Hybrid system

This system is also known as the semi-volumetric system where panelised and volumetric systems are combined. The volumetric system is frequently used in kitchens, bathrooms and other highly serviced places which are known as Pods (Ross, 2005, National Audit Office, 2005c, Ely, 2005).

Some construction components such as lavatories involve about 25 different trades in their construction process. Such components have been manufactured offsite as Pods which can be installed on site quickly by only connecting them to building services.

Considering transportation, hybrid systems appear to be more efficient when compared with volumetric systems. The reason is that the walls are panels and only those components which need to be finished in high quality such as kitchens and bathrooms are volumetric. Another advantage of hybrid systems is that pods can be built in the factory while the construction is carried on site. Meanwhile, fair transportation costs and need for skilled labour on site could be mentioned as disadvantages of hybrid systems (Ely, 2005).

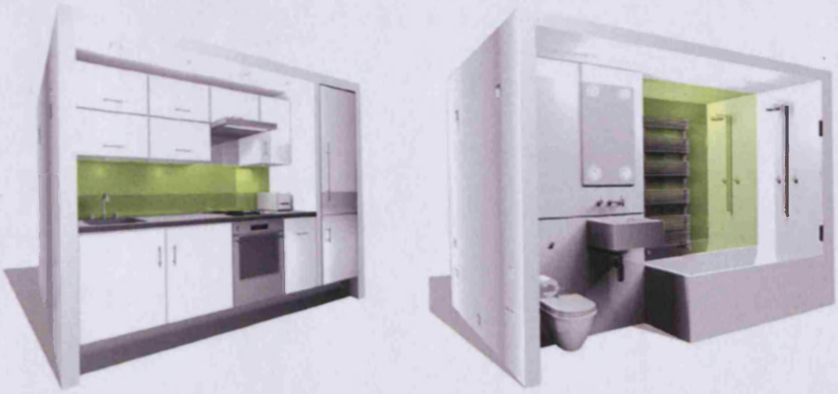

Figure 7-5: Pods
Source: (MoCo Loco: co-pod, 2006)

7.2.4 Sub-assemblies and components

Many times, prefabricated components and conventional framing systems of concrete or steel are mixed together. Such components include modular hollow core slabs, tee beams, thin membrane plates, stairs, external walls, and truss rafters. Such systems combine the flexibility of conventional methods with savings of prefabricated components (Warszawski, 1996).

Sub-assemblies and components mainly include floor or roof cassettes and pre-cast foundations, which are made in the factory (National Audit Office, 2005c, Ross, 2005, Burwood and Poul, 2005).

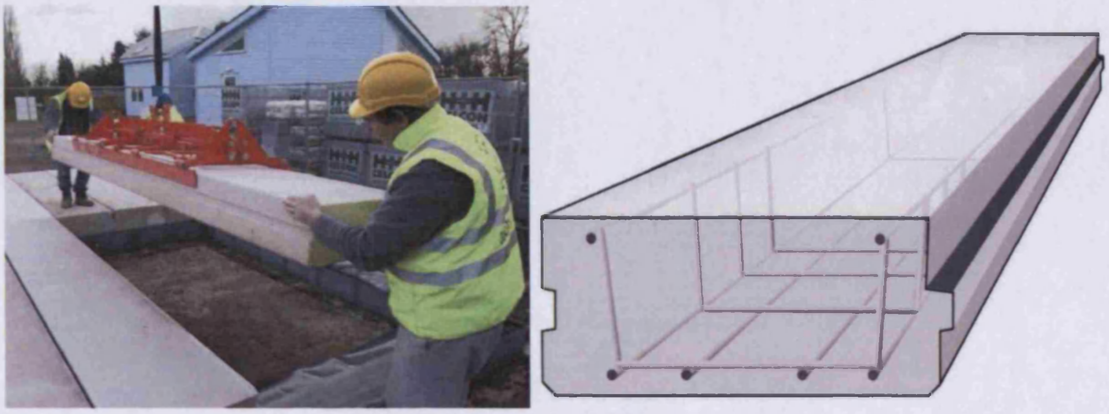

Figure 7-6: Sub-assemblies and components
Source: (Celcon Flooring System, 2006)

7.2.5 Site-based methods

As is obvious from their name, these methods are site-based, and apply traditional building methods and components in an innovative way. They are also known as "industrialisation onsite". Examples of such methods are: Tunnel-form (cast in-situ concrete where heated steel modules are applied) and thin joint masonry (National Audit Office, 2005c, Ross, 2005, Burwood and Poul, 2005, Warszawski, 1996).

Tunnel form method has good sound and fire resistance and is currently applied broadly in Belgium and Netherlands. It is also possible to build buildings of up to 40 storeys using this method. There are also some disadvantages associated with tunnel form such as sustainability and environmental issues and high installation costs (Ely, 2005).

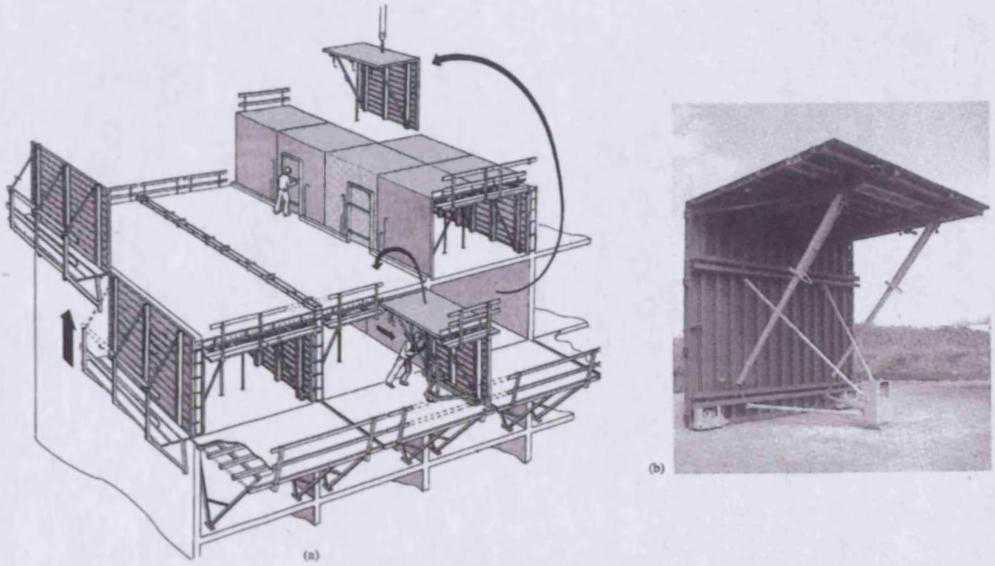

Figure 7-7: Tunnel-form system
Source: (Warszawski, 1996)

7.3 Examples

In this section some recent examples of the UK buildings and competitions, which have considered MMC as the method of construction, will be explained.

7.3.1 DFM competition

The UK government has been trying to encourage architects and developers to apply MMC in their projects through participation in different competitions and the implementation of best practice since the early 20th century and specially during World War reconstruction (Vale, 1995).

Design for Manufacture is one of the latest competition, announced in 2005 to prove the feasibility of building a house with the budget of £60,000. It is not the intention to speak about this competition; however, there are some lessons learnt from it which are relevant to the aim of this chapter and are listed below (English partnerships, 2006):

- Applying MMC does not necessarily mean higher costs.
- Costs have been cut without making houses smaller, which means greater value for money.
- MMC can provide many different styles when the basic structure is right.

Figure 7-8 shows an example of the ideas which were built as prototypes in the competition.

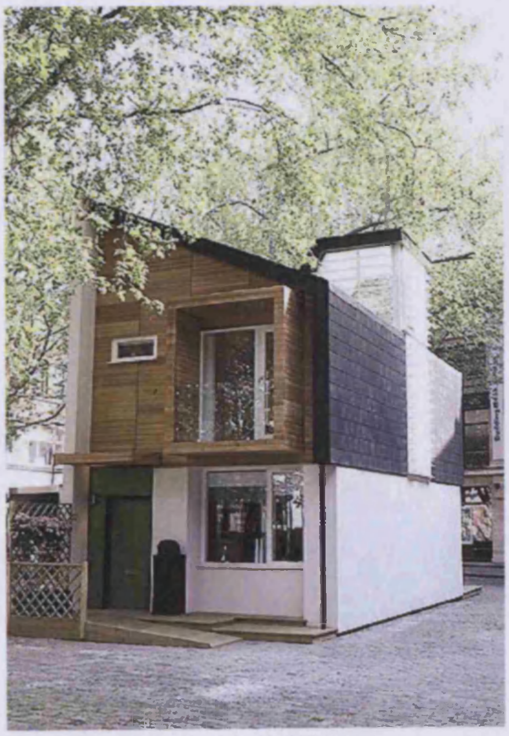

Figure 7-8: 60K House
Source: (MoCo Loco: co-pod, 2007)

Figure 7-9 shows the distribution of proposed building technologies in the competition. As is obvious, about 90% of projects have applied different methods of MMC to achieve the best cost effective and environmentally friendly option in the project. Only 10% had used traditional methods of construction in their buildings.

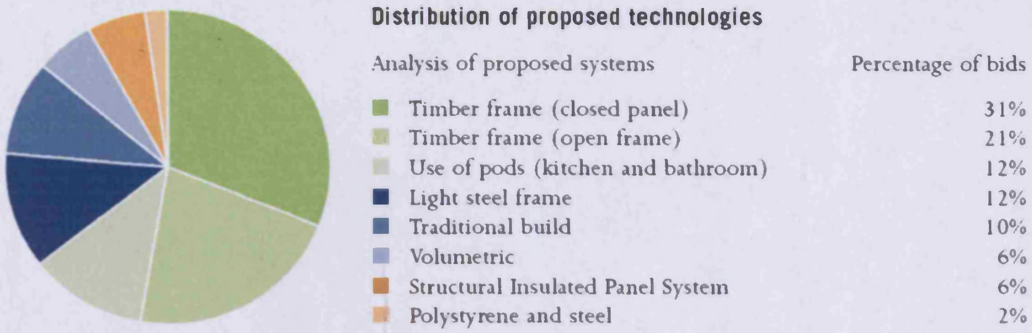

Figure 7-9: Distribution of proposed technologies in DFM competition
Source: (English partnerships, 2006)

7.3.2 BRE Innovation Park

Building Research Establishment (BRE) has established a permanent exhibition since 2005 know as BRE Innovation Park with the purpose of introducing Modern Methods of Construction, zero carbon homes and other innovative technologies (BRE, 2006).

Kingspan Offsite has constructed its innovative 93 m², two and a half storey, two-bedroom Light House which is extremely environmentally friendly and is designed according to the government's code for sustainable home level 6 to which all new UK houses should be designed and built by year 2016. The annual heating cost for the house (including water and space) is only £30 which means about 94% saving on fuel costs. In Light House, Kingspan's TEK Building System has been applied which is an SIP (Structural Insulated Panel) system (Kingspan Offsite, 2008). Kingspan Lighthouse net-zero carbon can prove that MMC can be very environmentally friendly.

Figure 7-10: Kingspan light house
Source: (Kingspan Offsite, 2008)

7.3.3 Greenwich Millennium Village

Greenwich Millennium Village, situated in southeast London, is another example of applying MMC. Two key issues of this £250 million project are sustainability and innovation. The project started in 1999 and will provide 1,377 homes; 1,079 apartments and 298 houses.(Barker, 2001) In this project waste has been reduced by 56% and energy will be saved by 65% over its lifetime however; this is not only because of applying MMC, as waste has been reduced mostly by modifying on-site operations and energy saving has been mostly achieved by applying an "efficient local combined heat and power (CHP) generator" (Parliamentary office of science and technology, 2003). Below are some pictures of the project.

Figure 7-11: Some views of Greenwich Millennium Village
Source: The Author

7.4 MMC advantages & barriers

Almost all reviewed sources state more or less similar advantages and barriers for MMC. Claimed advantages for MMC are as follows: (National Audit Office, 2005c, Parliamentary office of science and technology, 2003, Bågenholm et al., 2001, Burwood and Poul, 2005, BRE, 2004, Goss, 2005, Harris, 2006, Pan et al., 2006).

- Improved speed
- Improved quality
- Improved health and safety
- Improved control conditions
- Addressing skilled labour shortage
- Not weather dependant
- Minimized waste & energy consumption
- Enhanced value for money
- Cost predictability

Only 63% of the UK construction projects are finished on time and only 49% are completed on the planed budget. Appling MMC will improve the predictability of time and cost (Yorkon, 2006).

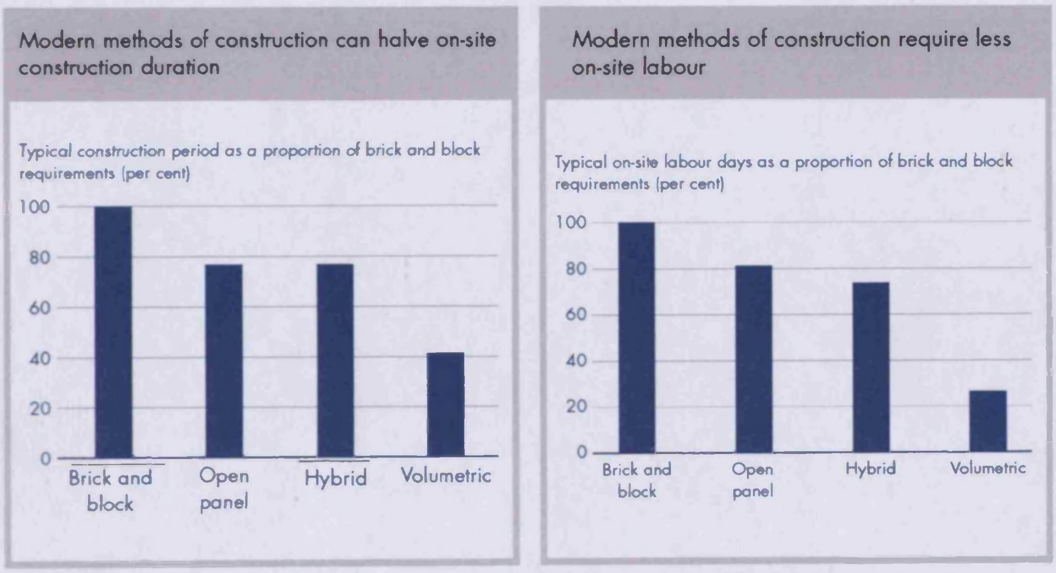

Figure 7-12: Construction duration and on-site labour
Source: (National Audit Office, 2005c)

Figure 7-12 shows that applying MMC has some advantages over traditional methods. Figure 7-12 illustrates that MMC can be considerably faster than traditional techniques. Volumetric systems can be 2.5 times quicker than brick and block systems. Moreover, panel and hybrid systems can save more than 20% of construction time comparing with brick and block. Figure 7-12 also indicates that on-site labour can be reduced to 25% by using volumetric compared with brick and block methods. In other words with the same number of on-site labourers, it is possible to build four times more than with the traditional methods. There is also about 20% on-site labour saved on hybrid and open panel systems comparing with brick and block.

Figure 7-13: Using MMC does not mean lower quality
Source: (Diesis Group, 2007b)

MMC has also some claimed barriers:

- Extra immediate costs (8-15% (CABE, 2004) or 7-10% (Harris, 2006) or 5-20% (BRE, 2004)
- Greater fixed costs (less flexible and less responsive to demand fluctuation)
- Negative public attitude
- Transportation (depending on the distance between site and factory)
- Limited industry capacity (Shortage of skills, factory manufacturing capacity)
- Restrictive planning issues
- Insurance and mortgage problems (doubts re. long term viability)

One of the barriers toward applying more MMC in housing is its higher immediate costs meanwhile there are some financial benefits when MMC is applied. Figure 7-14 shows some of these benefits such as earlier rent and shorter borrowing periods thanks to the less construction periods when applying MMC. Snagging and need for inspection are also decreased due to high quality control in the factory.

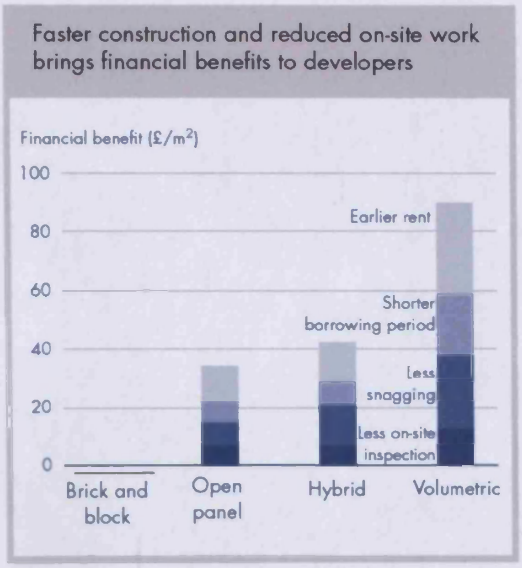

Figure 7-14: MMC has some financial benefits
Source: (National Audit Office, 2005c)

Negative public attitude is another problem facing MMC which has roots in the 20th century when low quality design and materials associated with lack of required skills were used to build prefabricated houses (Harvey and Ashworth, 1997, Parliamentary office of science and technology, 2003).

Another challenge facing more application of MMC in the UK, which again has roots in the 20th century, is that insurers and lenders are not very sure about the quality of houses built with new methods of construction. The reason for this is that the lenders and insurers do not have enough information on long term performance of such methods and materials and therefore are not sure about the risks involved in MMC houses. There has been, however, some research undertaken by different bodies to overcome this problem. LPS 2020 is a performance requirement scheme published by BRE to ensure lenders and public about the quality of MMC products. Other research by Smartlife has been done on different methods of construction to assess the quality and performance of such methods in different construction projects (Burwood and Poul, 2005).

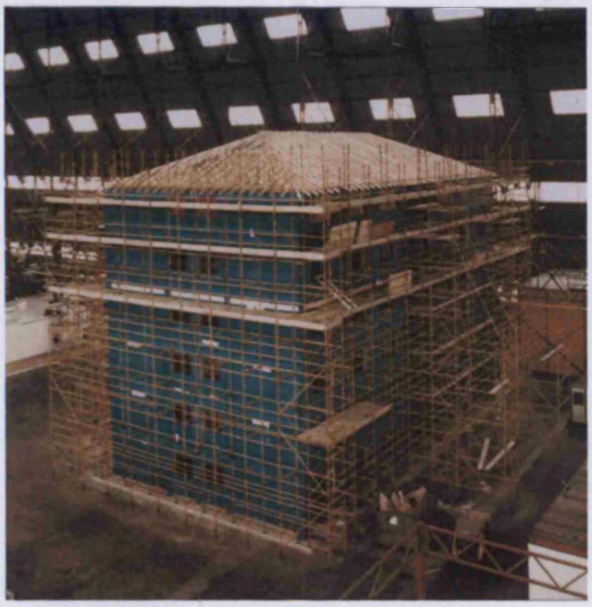

Figure 7-15: Timber frame construction tests
Source: (Palmer and Heriot, 1999)

One of the other issues which should be considered when using offsite methods is the availability of required skilled labour. About 80% of the UK developers have had difficulties to find the required skilled labour for their projects. Applying MMC, fewer skilled labourers are required on site however the requirements for skilled labour to assemble the components is not clear yet (Parliamentary office of science and technology, 2003, Burwood and Poul, 2005).

Improved health and safety is another issue which can be improved when applying MMC. Construction industry is one of the most hazardous industries in the UK with 72 deaths in 2004. Health and safety can be improved when applying MMC since the majority of construction process can be done in the controlled environment of the factory (Burwood and Poul, 2005).

7.5 Cost issues

Designers should be aware of all limitations which may be resulted by resources (human resources, financial resources, machinery etc.) from very early stages of construction. A construction system may be preferred to another because of its less immediate cost or life cost (Allen and Iano, 2004). Whenever possible, available materials and building systems should be considered instead of choosing methods of construction which may not be financially efficient. There are two different costs which should be considered when looking at a building: immediate building costs and life costs. Immediate building costs are about construction costs including material, plants and labour whereas life costs are about running costs of a building including energy consumption and maintenance (Osbourn, 1997).

Buildings are usually expected to work properly for at least 50 years however their real lifetime is generally much more. The most important factor for a building to work properly in such long lifetime is obviously the quality (Warszawski, 1996).

7.5.1 Influential factors on MMC (immediate cost)

Cost has great influence on MMC growth. MMC may not be very successful if its cost is not comparable with other methods of construction even if all other issues such as planning, supply, environmental and labour are resolved. Many developers who acknowledge MMC benefits are currently avoiding MMC because of cost issues (BRE, 2004) .

Research by BCIC indicates the average cost for different methods of construction as illustrated in Figure 7-16. It shows that Volumetric and Hybrid systems are usually more expensive than traditional methods; however, open panel systems can be as cost-effective as traditional systems. The larger overlap between different methods shows that in certain conditions MMC can be as cost effective as Brick and block.

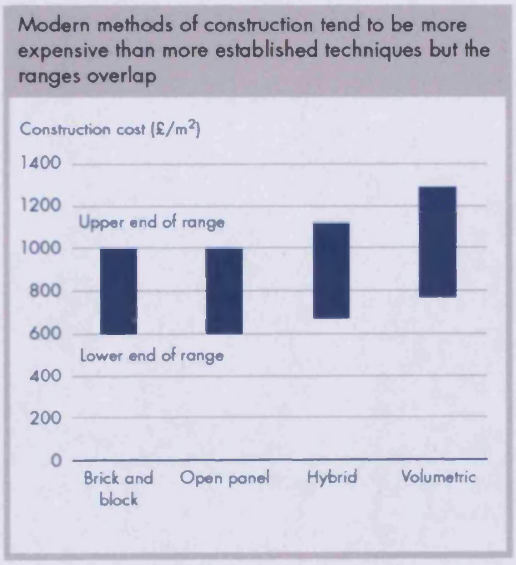

Figure 7-16: MMC can be more expensive
Source: (National Audit Office, 2005c)

Table 7-1 also indicates the percentage of off-site manufacturing over and above the brick and block method.

Construction Method	Percentage of offsite manufacture (including supplier erection)*
Timber framed	16%
Advanced panel	25%
Hybrid	30%
Volumetric	65%

* In addition to brick and block specification.

Table 7-1: percentage of offsite manufacturing in different construction methods
Source: (National Audit Office, 2005b)

Transportation is currently an issue with regards to environmental and cost issues(Bågenholm et al., 2001). Other issues such as design, fixed costs, supply capacity etc. may influence the final cost of MMC. According to NAO, when applying MMC design team should be very well organised to avoid any late design changes since late design changes influence the cost of MMC considerably. Figure 7-17 illustrates the outcomes of different issues such as no standard layouts in design, late appointment with contractors, late design changes and using inexperienced contractors with regards to time and cost.

	Brick/Block		Timber frame		Advance panel		Volumetric	
	Cost	Time	Cost	Time	Cost	Time	Cost	Time
Standard Layouts and designs								
Agreed with contractor/manufacturers								
No standard layouts	££	tt	££	tt	£££	tt	£££	tt
Early Contractor appointment								
Project appraisal								
Later than outline design	£	0	£	t	££	t	££	tt
Design changes								
None after design fix								
Changes after design fix	£	t	£	t	££	tt	£££	tt
Experienced contractor								
Appropriate to method								
No previous experience	N/A	N/A	££	tt	££	tt	£	t

£	=<£100 per unit
££	= £100-£1000 per unit
£££	= >£1000
t	=<week in overall programme
tt	= week-month in overall programme
ttt	= >month in overall programme

Figure 7-17: Impact of project management in terms of time and cost
Source: (National Audit Office, 2005c)

The figure shows that non standard layouts are so costly in advanced panels and volumetric systems. Late design changes are also too costly in volumetric systems.

Mass building is also one of the key issues in viability of offsite methods of construction. It should be borne in mind that mass building can reduce the costs (Burwood and Poul, 2005). Mass production dose not affect manufacturing, assembly and transportation however design and operating costs are greatly affected by mass building (National Audit Office, 2005c).

NAO has also studied the effects of various design options such as mixed development of houses and flats, number of storeys on cost and time of different methods of construction. The results are as follows (National Audit Office, 2005c):

- The overall cost and time of different methods of construction are not affected by mixture of flats and houses
- With regards to number of storeys, apparently cost increases per unit for all methods of construction. The reason is that the need for communal areas, staircases and lifts increases with the number of storeys. Meanwhile, it seems that the cost rises faster in traditional methods when building above three storeys.
- Using some cladding materials may decrease the costs however costumers and planners may prefer other materials.
- Using panel systems in habitable rooms in roofs may not be very cost effective however they are used more and more due to planning issues. Applying flat roofs in volumetric systems may be cost and time effective but costumers and planners do not have a positive attitude toward them.
- There are other roof systems which are more cost effective however the problem is that they are not the favour of costumers and planners.
- With regards to energy efficiency, some panel and volumetric systems currently achieve higher standards than what is required however all methods may be affected if higher requirements are put in force.
- Regarding the sound insulation issues, all methods of construction are facing similar issues however brick and block systems will achieve better results when mass is the concern.

Although currently the figures are suggesting higher costs for offsite products some research by NAO suggests that there is potential cost reduction of up to 15% if the industry is matured and if there is an available market for such methods. This saving of 15% will be enough to encourage developers to increase the application of Modern Methods of Construction in their projects (National Audit Office, 2005c).

7.5.2 Life-cost, durability and quality

Different issues are involved in durability and life cost of a building which are listed below:

- Quality of applied components

- Climate and environment
- Construction Skills
- Design
- Use
- Maintenance

All the mentioned issues are the same for all buildings except the design and construction skills. According to a report by NAO, based on a 60 year durability research, all construction methods in the report had the same or similar durability. Thus, construction systems only differ in their structure (steel, concrete, timber etc.), construction process and insulation materials. Therefore, the whole life cost is influenced by the mentioned issues as well as operational performance with regards to the following issues: "structure, insulation, construction process, building quality, on site assembly and adaptability and tolerance to use" (National Audit Office, 2005d). Energy consumption costs should also be added to the mentioned issues (Allen and Iano, 2004).

It seems that there is considerable number of defects in houses which have been built with traditional methods in the UK. Developers need to spend up to £2000 to resolve the problems such as damp proofing etc. Applying Modern Methods of Construction can decrease such faults since MMC use factory manufactured components which enhances the quality and decreases the risk of damages caused by the site situation and weather. Yet, applying MMC increases the risk of hidden faults which may be repeated several times in many houses (Parliamentary office of science and technology, 2003).

Snagging as a percentage of build costs			
Brick/Block	Timber Frame	Advance Panel	Volumetric
35%	2%	1.5%	0.5%

Table 7-2: Snagging as a percentage of build costs
Source: (National Audit Office, 2005d)

7.6 MMC & Sustainability

Modern Methods of Construction can be an answer to current environmental concerns. Some environmental issues which can be addressed by using MMC as an alternative to the conventional methods of construction include:

- Waste: Applying MMC can reduce material waste. 25% of UK waste is caused by construction and demolition (Parliamentary office of science and technology, 2003). It has been argued that about 11% of prime material is wasted on site which can be reduced to 1.8% in the factory (Goss, 2005).

- Transport: Factory-made components can reduce the number of trips to the construction site. This is more important when houses are built in inner city areas. Transport benefits mainly depend on the distance between the factory and construction site (Parliamentary office of science and technology, 2003). However, in the UK, well established factories are situated in the north of England whereas the demand is in the south (Bågenholm et al., 2001).

Figure 7-18: The number of trips to site can be reduced
Source: (Roberts and Gwalia, 2006)

- Energy saving: Due to their increased fitted insulation, houses built with MMC need less heating energy (Parliamentary office of science and technology, 2003).
- Pollution: As a large portion of the building is constructed away from the construction site, MMC causes less disturbance and is cleaner for the local areas in terms of dust, noise and pollution. Also, congestion will be reduced and limited to the period of delivering products from factory to construction site (Bågenholm et al., 2001).
- Local, renewable materials: It is essential to use regionally sourced and renewable materials to make MMC more sustainable (Harris, 2006).

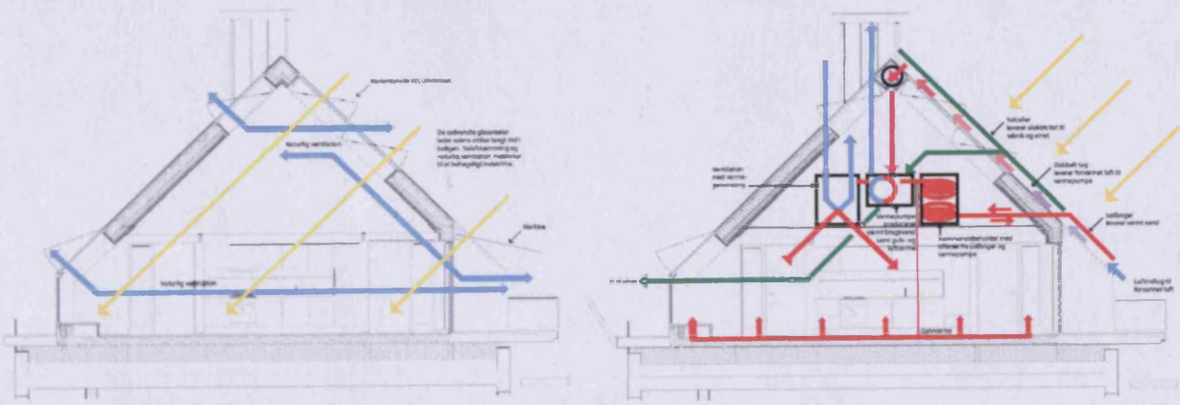

Figure 7-19: MMC is Sustainable
Source: (Soltag, 2006)

7.7 MMC risks

There are different sets of risks for MMC suppliers and consumers. There is always significant risk for early adopters of modern methods of construction. This will reduce the potential for progress and development of new building methods (CABE, 2004). Moreover, as mentioned before, it costs about £10 million to build an MMC factory and train staff. Therefore, investors need to make sure that there is long-term demand for their products (Parliamentary office of science and technology, 2003).

Compared with traditional methods, MMC enforce different kinds of risks. According to NAO most of such risks of MMC are actually before the construction process starts (National Audit Office, 2006).

NAO classifies MMC risk for consumers as (National Audit Office, 2005c): “Late design changes; Loss of factory production slot/production capacity; Inaccurate or unsuitable foundations; Suppliers failing to deliver on time; Manufacturer insolvency”. NAO also adds planning decisions to the mentioned risks. Applying MMC decreases risk in some areas such as price fluctuation during construction process and delays relating to bad weather (National Audit Office, 2005c). Table 7-4 summarise the main development risks and required action in traditional and Modern Methods of Construction.

Process stage	Risk description	Brick and block	open plan	Hybrid	volumetric
planning	**Undertaking planning decision**	■ (green)	■ (green)	■ (red)	■ (red)
Mitigating action:					
Early and extensive consultation with planning authorities					
Education of design team and planners in capabilities of different build methods					
Design coding					
Pre-construction	**Losing factory production slot/production capacity**	■ (green)	■ (amber)	■ (red)	■ (red)
Mitigating action:					
Effective supply chain management stabilises workflow to factory					
Manufacturer sets up overtime working or starts additional shift					
Pre-construction	**Late appointment of contractor/manufacturer**	■ (green)	■ (amber)	■ (red)	■ (red)
Mitigating action:					
Efficient developer procurement processes					
Long-term working relationship with contractors or clients					
Pre-construction	**Design not suited to construction method**	■ (green)	■ (green)	■ (red)	■ (red)
Mitigating action:					
Accessible component and experienced team in process					
Effective communication across supply chain					
Pre-construction	**Lack of standardization**	■ (green)	■ (green)	■ (red)	■ (red)
Mitigating action:					
Use standard dimensions or shells					
Effective communication across supply chain					
Detail design and production information	**Design changes after order placement/product information stage**	■ (green)	■ (green)	■ (red)	■ (red)
Mitigating action:					
Early involvement of manufacturer in design					
Effective communication across supply chain					
construction	**Foundations inaccurate/unsuitable**	■ (green)	■ (amber)	■ (amber)	■ (red)
Mitigating action:					
Pre-inspection by system manufacturer					
Education of groundworker and main contractor					
Better site management					
construction	**Suppliers fail to deliver on time**	■ (green)	■ (green)	■ (red)	■ (red)
Mitigating action:					
Effective communication across supply chain					
Identify long lead items early					
Good processes in place to manage, e.g. ISO 9000					
construction	**Suppliers fail to deliver correct components**	■ (green)	■ (green)	■ (red)	■ (red)
Mitigating action:					
Effective communication across supply chain					
Good processes in place to manage, e.g. ISO 9000					
Standardisation					
construction	**Manufacturer insolvency**	■ (green)	■ (amber)	■ (red)	■ (red)
Mitigating action:					
Standardisation					
Effective communication across supply chain					
Select quality and experienced manufacturers					
Effective developer procurement processes					

Table 7-3: Summary of the main development risks and their management (edited by the author)
Source: (National Audit Office, 2005c)

Process stage	Risk description	Brick and block	open plan	Hybrid	volumetric
construction Mitigating action: Good route planning and experienced haulage contractors Educated site management teams Site security Avoid storage on site if possible	Damage to key pre- assemblies or critical components	Low	Medium	High	High
construction Mitigating action: Educated design team Experienced manufacturers with good design resources Effective communication across supply chain Standardisation	Modern methods of construction and traditional components incompatible	Low	Low	High	High
construction Mitigating action: Select quality and experienced manufacturers Check manufacturer' Quality Management system status (ISO 9001 or 9002) Third party factory inspection Bespoke quality specifications for the project	Quality problem with product	Medium	Low	Low	Low
construction Mitigating action: Partnering and open book approach Effective communication across supply chain	Price fluctuations during the construction phase	High	Medium	Low	Low
construction Mitigating action: Education and awareness of site teams Contingency plan cover windy days Alternative on-site storage arrangements	Delays due to bad weather	High	Medium	Low	Low
construction Mitigating action: Skills training programmes with contractors Long term relationships with approved suppliers Process and specification changes to reduce reliance on scarce trade skills	Lack of key trade skills	High	Medium	Low	Low
construction Mitigating action: Clear communication of business need and build strategy during planning stage Training of work force or use of manufacturer's installation Quality control review during site assembly	Service installation faults	High	Medium	Low	Low
construction Mitigating action: Good site management and operative education and training Continuity of supplier partnerships Training and awareness programmes of change in working practices	Health and safety hazards	High	Medium	Low	Low
Occupation and review Mitigating action: Good design and integration Effective communication across supply chain Training and awareness programmes of change in working practices	Complete construction does not match specification	High	Medium	Low	Low
Occupation and review Mitigating action: Good site management and project KPI benchmarking Continuity of supplier relationships Training and awareness programmes of changes in working practices Consider only those systems that have a BBA or BRE certification	Defects at handover/during liability period	High	Medium	Low	Low

Low Risk	■ (green)
Medium Risk	■ (yellow)
High Risk	■ (red)

Table 7-4: Summary of the main development risks and their management (edited by the author)
Source: (National Audit Office, 2005c)

7.8 Design

Design process is one of the fundamental issues which should be considered seriously and correctly when MMC is considered as the method of construction. Planning permission is one of the issues in the design process. To avoid future problems, it is useful to choose the construction method prior to planning application. This will considerably decrease the risk of amendments, redesign or maybe resubmission for the planning permission (CABE, 2004).

One of the common approaches in construction projects which has undesirable effects such as higher costs and delays, is the late detailed design. In traditional design approach, architectural and engineering ideas are combined for all components. In many cases designing and detailing tasks are left to contractors or subcontractors and such second or third hand designs usually try to work alongside the main designers and catch up with their concepts. This consequently may result in ignoring the available details in the market and leaving the detailed design to the last minute. However, considering available details in the market in early stages of design will improve the project delivery and process. This approach is repeated in many construction projects although the unwanted effects of it are very well known in the construction industry (Pasquire and Connolly, 2003). Figure 7-20 illustrates the flow of detailed design information under traditional procurement

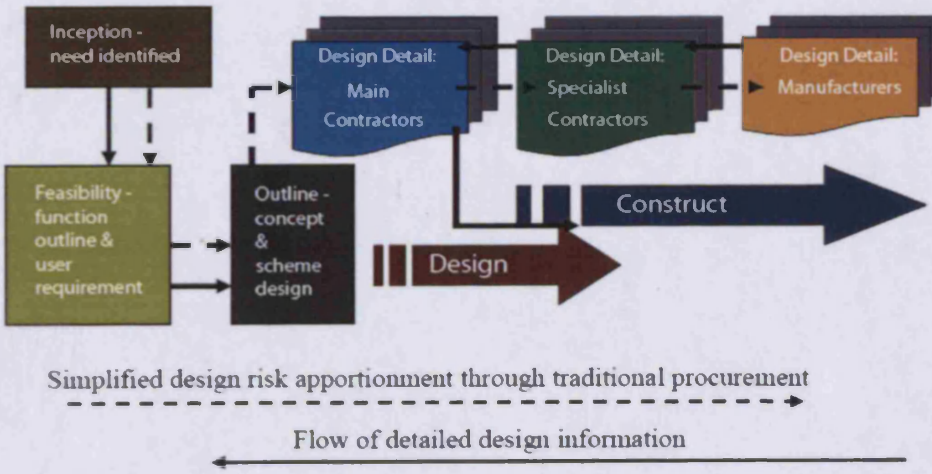

Figure 7-20: Flow of detailed design information under traditional procurement (edited by the author)
Source: (Pasquire and Connolly, 2003)

To enhance the design process both sides of the construction industry including designers, contractors and manufacturers should change their traditional attitude toward the design process. There are two fundamental changes that should take place:

a) "That designers leave detailed design to manufacturers and become expert in component specification and defining client/user experience."
b) "That manufacturers (including contractors) provide better product specification and take more care to understand client need and building design constraints." (Pasquire and Connolly, 2003)

To improve the design quality there should also be more communication between designers and manufacturers to help designers in choosing the proper system and apply the manufacturers components better than traditional systems (CABE, 2004, Burwood and Poul, 2005, Pasquire and Connolly, 2003). Figure 7-21 illustrates the enhanced design process when offsite methods of construction are considered.

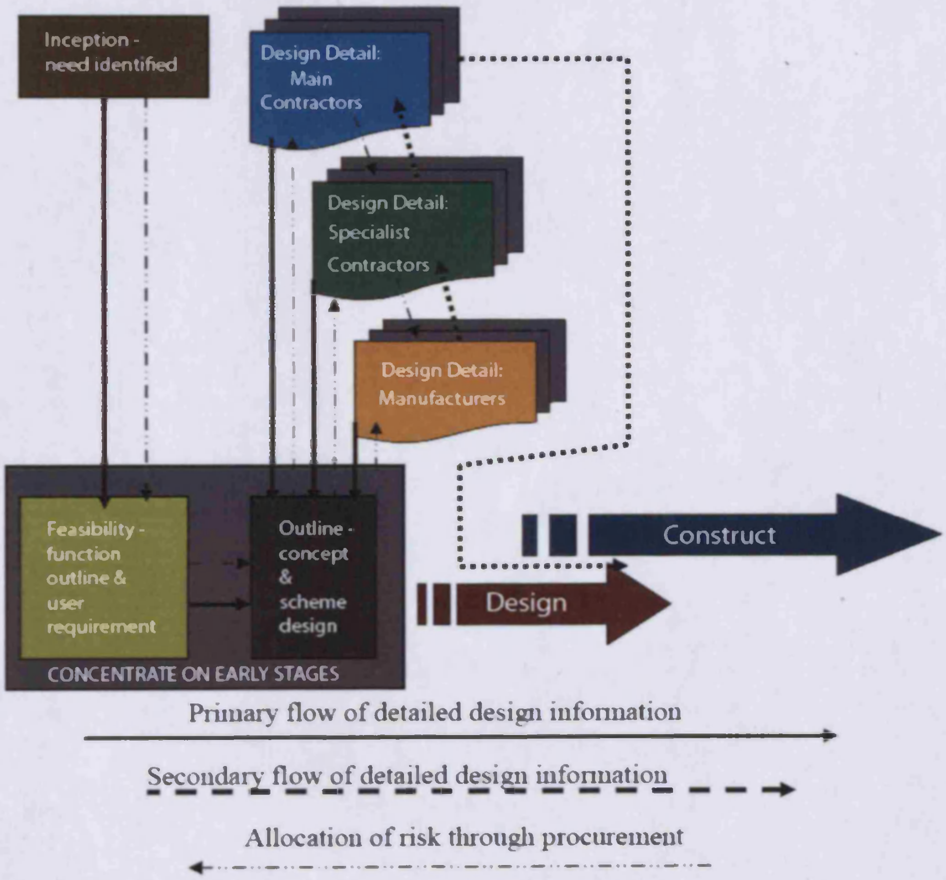

Figure 7-21: Using Existing Design Expertise in Early Stages (edited by the author)
Source: (Pasquire and Connolly, 2003)

When considering MMC, Designers have a major role compared with traditional methods of construction. More time and concentration are required in early stages of construction when the project is still at risk. Comprehensive research is needed to study "suppliers' credentials, investigate mortgage and insurance issues, visit previous sites, talk to system suppliers, obtain technical performance guidelines, understand junctions and interfaces, coordinate other consultants, obtain building control input and so on" meaning that additional time and financial support are required. It is vital to use experienced and qualified staff when applying MMC. Moreover, management is a crucial issue and traditional construction management may not be the best approach to manage contractors and sub-contractors when it comes to MMC (CABE, 2004, Bågenholm et al., 2001).

The quality of design is one of the other concerns when using Modern Methods of Construction since standardization is introduced to the projects to control the costs. Standardization should be encouraged in structural components however it should not cause uniformity and dullness. Applying MMC should offer the opportunity to design and build affordable modern houses in a proper way. According to a recent study by the Commission for Architecture and Built Environment (CABE) on some projects, design quality does not change considerably when applying MMC (Burwood and Poul, 2005).

According to another study by CABE speed of construction has been the main reason for considering MMC as the method of construction not the quality of design. The study also shows that designers have not had any involvement in decision making for considering MMC as the method of construction. The main decision makers were the clients and contractors however, this result is not unexpected since designers' role is usually consulting not decision making (CABE, 2004).

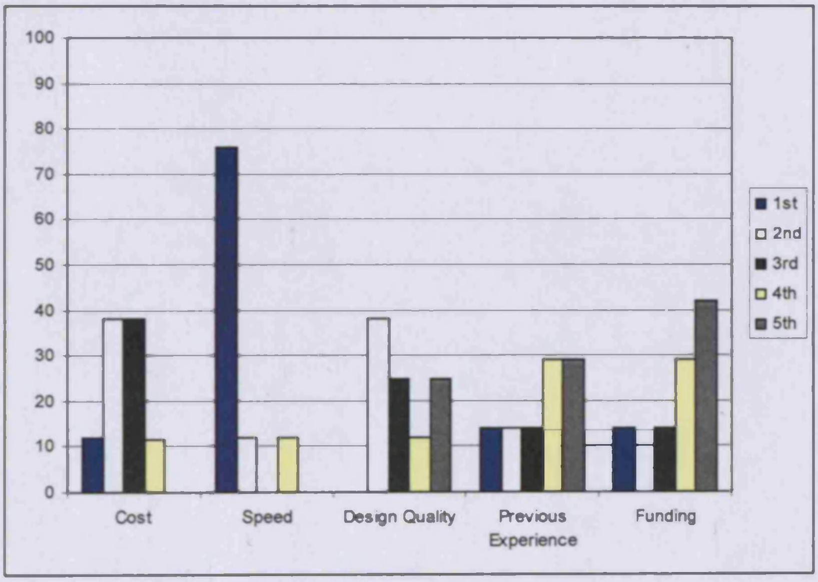

Figure 7-22: The main reasons why MMC was chosen (1st = most important) (edited by the author)
Source: (CABE, 2004)

7.9 Some recommendations

Barker 33 Cross-Industry Group has made some comprehensive recommendations addressing the barriers and encouraging use of MMC in the UK construction industry. The recommendations are as follows (Baker33 Cross-Industry Group, 2006).

"Communication, education and training:

- Establish an industry-wide understanding of MMC
- Encourage the professional institutions to recognise and promote understanding of MMC through an appropriate syllabus
- Identify and establish training for specific site skills required for full implementation of MMC
- Certification bodies, etc. to provide best practice
- HBF to facilitate and support stakeholders in the guidance to support education and training provision of education and training for innovation and new technologies

Culture change:

- Create more favourable climate in the City for development of MMC through exemplifying benefits and showing willingness to address key city concerns
- Develop a more pro-active strategy towards regulatory environment emphasising the partnership between regulators and suppliers necessary to release best value from MMC
- Strengthen supply chains through developing partnerships with appropriately skilled suppliers
- Initiate objective assessment of the business case for MMC relevant to housebuilders
- Engage media more actively
- Invest in training and education of professional and traditional craft operatives

Whole project costing:

- Recognise that MMC can be cost competitive (See National Audit Office report – Using modern methods of construction to build homes more quickly and efficiently November 2005)
- Understand that savings in process efficiency can put MMC costs on a par with traditional construction approaches
- Appreciate that process and product improvement are the core mechanisms for cost reduction

Regulation:

- Encourage stronger discipline and structure in the regulatory processes
- Establish structured process for regulatory decision making
- Ensure dialogue between regulators and regulated
- Develop increased flexibility of design within structured process
- Seek consistency through planning guidance to structure the local planning process

Warranty and certification:

- Develop appropriate standards and accompanying certification schemes that command stakeholder and industry confidence addressing the issues of resilience, reparability, adaptability, whole life costs and on-site quality
- Establish mechanisms to assess and quantify risks
- Develop the use of quality assurance and audit schemes to minimise the risk of MMC failure due to poor design specification and/or poor practices on site"

7.10 Conclusion

Applying Modern Methods of Construction in the UK has been considered by the government for addressing housing shortages after both World Wars and for slum clearance (Parliamentary office of science and technology, 2003), since the early 20th century. It seems the history is repeating for the second time as the drivers behind applying MMC are still the same: the need for faster construction, shortage of skilled labour, high demand, high building costs etc.

The current UK housing supply is about 175,000 units (Parliamentary office of science and technology, 2003) and it is estimated that 3.8 million new houses will be required by 2021 which means about 271,000 units per year (Bågenholm et al., 2001). Due to this and many other factors, the UK government is encouraging the construction industry to increase the portion of MMC by 20 times by 2020 (OSC, 2006).[34]

MMC has different types including volumetric system, panel system (open & closed), hybrid system (semi-volumetric), sub-assemblies and components and site-based methods.

MMC has several claimed advantages over traditional methods; however there are some barriers towards increasing the rate of application of MMC in the UK housing industry. The main barrier is its higher immediate cost (CABE, 2004) compared with traditional

[34] These objectives should be questioned considering the current global recession.

methods. Meanwhile, MMC has some financial advantages, thanks to the faster construction process, which should be considered in the whole life cost.

Application of MMC involves some risks which are very different to traditional methods in terms of the nature and construction stages. Considering such risks are crucial toward successful application of MMC.

Considering MMC advantages, barriers and risks, MMC could be a potential answer to the current and the future UK housing scarcity. However, to increase use of MMC, some work is required to familiarise public and experts alike with MMC advantages. Also some modification in the construction industry, design process, regulations, insurance and certifications are required to have a successful application of MMC in the future.

The current situation of MMC in the UK was discussed in this chapter. Similar criteria to those which were discussed in this chapter should be considered when transferring MMC to Iran. The history and current situation of MMC, prevailing methods of construction, building process and regulations, material and energy wastes are discussed in the next chapter.

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Chapter 8: Methods of Construction and Building Process in Iran

8.1 Introduction

Iran is one of several developing countries which are trying to become industrialised. The Iranian construction industry is suffering from various problems such as low productivity, waste, low quality, skilled labour shortage, poor administration and communication and lack of proper legislations, some of which were discussed in previous chapters. These issues have direct or indirect effects on the applicability of Modern Methods of Construction in Iran. Evaluation of the current situation of the Iranian construction industry with regards to different applied methods of construction is also vital in addition to the above issues. This is to find out the compatibility and applicability of new methods of construction in Iran.

There have been several attempts made by the government and different individuals since the 1950s towards application of advanced methods of construction in Iran. However, many such attempts have failed due to lack of understanding of the Iranian market potentials and limitations. This section aims to study the background and prevailing methods of construction to evaluate the problems, constraints and potentials of the Iranian housing market in more depth. It also intends to explain the reasons of failure of previous attempts and some of the key issues which should be considered when applying Modern Methods of Construction in Iran. There are also some interviews with construction experts and governmental bodies which show the opinion of experienced architects and engineers towards the application of new methods of construction in Iran.

8.2 Current methods of construction in Iran

Currently steel frame and reinforced concrete systems are more common than any other methods of construction in Iran however traditional methods of construction are also used especially in low-rise buildings. Figure 8-1 and Figure 8-2 illustrate the number of permits issued for the whole construction and residential buildings by types of construction methods during 1991-2004. The majority of buildings in this period have been constructed using conventional steel and brick, steel frame and reinforced concrete systems. The figures also indicate that during 1991-2004 the trend of using steel and brick methods has been downward compared to steel frame and reinforced concrete systems. However, they are still taking a considerable portion of constructed buildings. Other methods of construction, including brick and wood and concrete block, have very small portion of the whole construction industry.

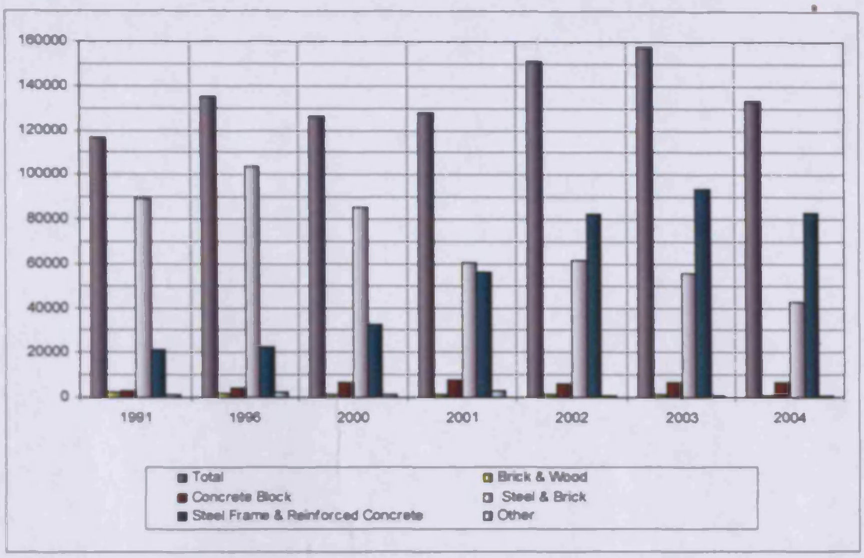

Figure 8-1: permits issued for construction in urban areas by types of main construction materials (excluding Tehran city) (1991-2004)
Source of tables: (SCI, 2006)

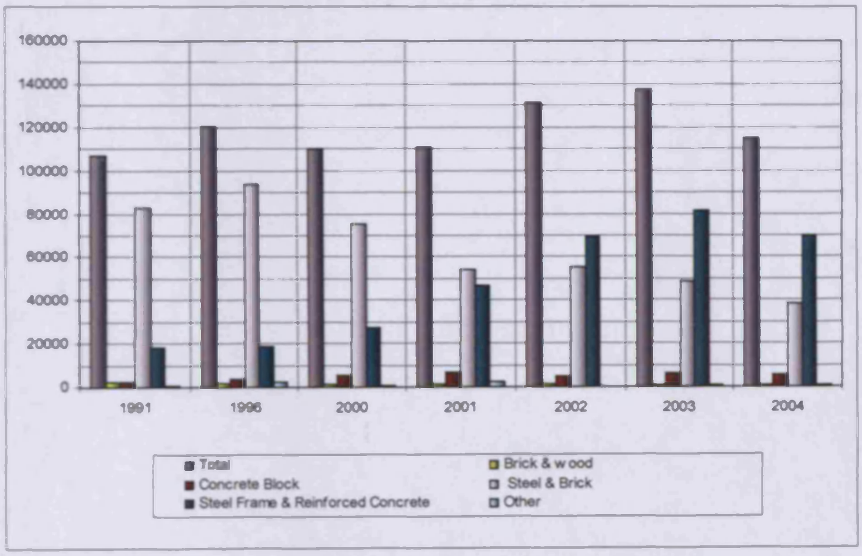

Figure 8-2: permits issued for construction of residential buildings in urban areas by types of main construction materials (excluding Tehran city) (1991-2004)
Source of tables: (SCI, 2006)

According to published data in 2005, 41.1% of the issued building permits have been for construction of steel frame, 27.8% for reinforced concrete, 27.4% for steel & brick and 3.8% for other methods of construction (SCI, 2007). Also, the latest information published by the government in 2007 shows that three types of construction methods including steel and brick, RC concrete and steel are the most common building systems in Iran. RC concrete with 39% and steel frame with 36% are the leading construction methods in Iran (Figure 8-3). Meanwhile the trend of using these two methods has been upward.

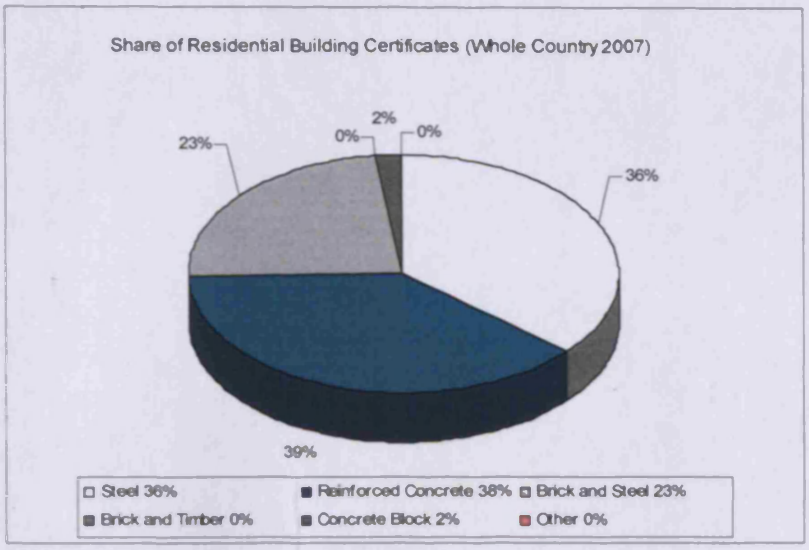

Figure 8-3: Share of residential building permits based on building materials and the structure in year 2007 (Edited by the author)
Source: (President Deputy Strategic Planning and Control, 2007)

Such information demonstrates that new methods of construction which are compatible with steel frame systems, reinforced concrete system and also conventional methods of construction may have more opportunities to be accepted and adopted by the Iranian construction industry. Figure 8-5 also shows the share of residential building in different provinces by types of construction materials during 1991-2004.

Figure 8-4: Construction methods in north of Iran (RC frame)
Source: the author

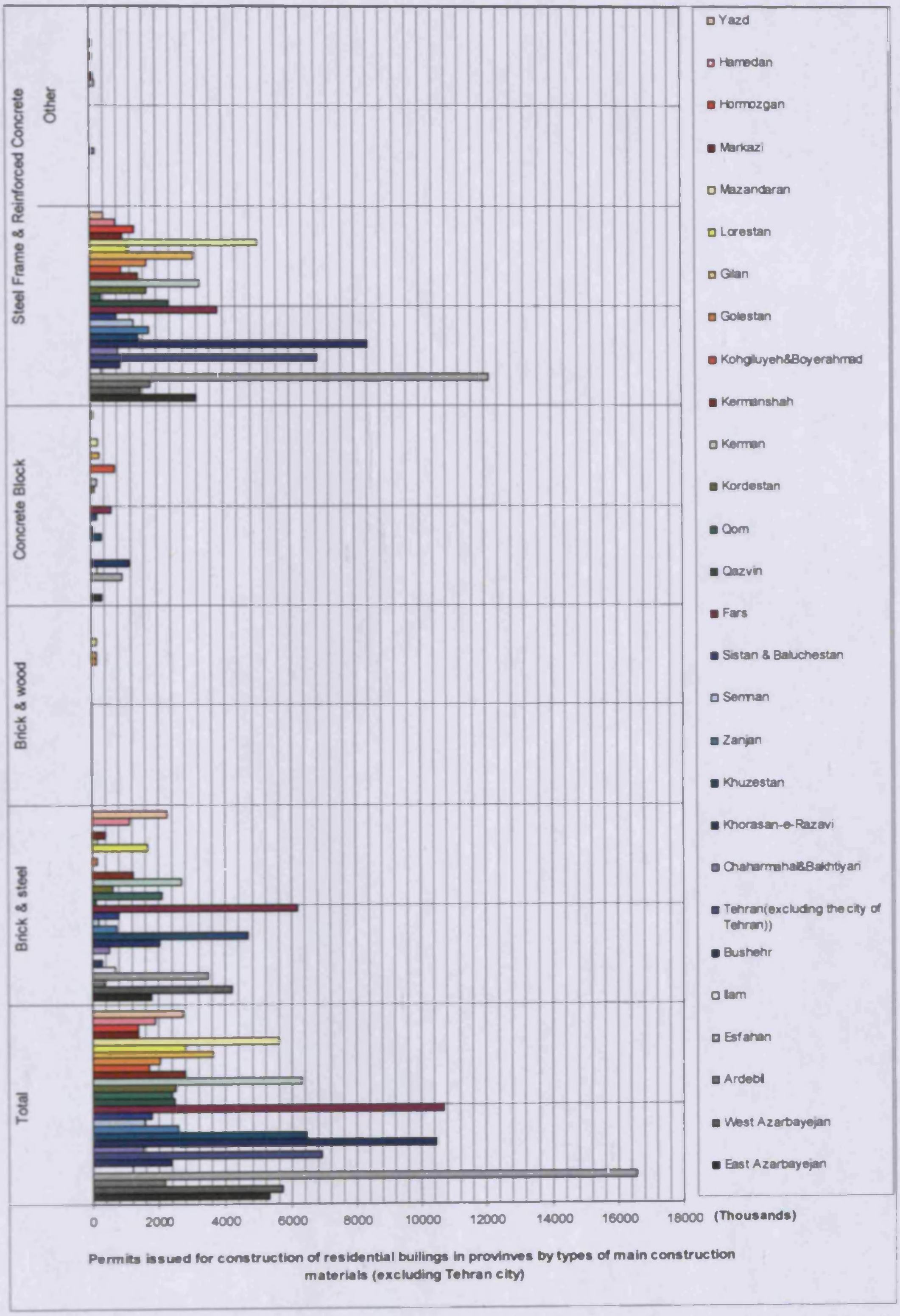

Figure 8-5: permits issued for construction of residential buildings in provinces by types of main construction materials during 1991-2004 (excluding Tehran city) (edited and created by the author)
Source of table: (SCI, 2006)

Figure 8-6: Construction methods in Tehran (RC frame)
Source: the author

Table 8-1 shows the share of cost for material, labour and plant for three different methods of construction in 100 square meters in Iran in 1991.[35] According to the table, material and labour take the largest share of costs in the building process. Costs of machinery take only a small portion of total costs. These figures would change considerably if offsite methods of construction were applied.

Method			Cost (Rial/100 sq. m)	%
1	RC Frame	Material	3,500,000	57.00
		Labour	2,509,171	38.50
		Plant/ Machinery	290,000	4.50
2	Steel Frame	Material	3,180,300	54.60
		Labour	2,265,800	36.50
		Plant/ Machinery	344,300	8.90
3	Masonry	Material	2,482,400	54.80
		Labour	2,008,200	44.07
		Plant/ Machinery	116,350	1.13
4	Total	RC Frame	6,299,171	
		Steel Frame	5,790,400	
		Masonry	4,606,950	

Table 8-1: Share of material, labour and plant costs for three major methods of construction in Iran in year 1991
Source: (Arbabian, 1997)

[35] Unfortunately the author was not able to find the up to date data from available sources

8.3 Building Regulations in Iran

There are several regulations relating to land usage and building process in Iran. It is helpful to discuss and clarify such regulations to understand the current situation and limitations. There are some issues regarding the land usage and building process, which should be considered when constructing a building. These include land separation rules (minimum land area, dimensions and suitability, access) and building conditions (building's footprint and density, land occupation by building, building height, courtyard size (occupancy), disposition of building in land and neighbourhood, parking numbers and areas, other open spaces (such as skylights and patios), lighting and ventilation rules, building openings to the courtyard and patios, spaces and installations on the roof, façade in urban design etc. (Committee of urban planning and architecture of Iran, 2000).

There are also several rules and standards regarding the energy efficiency (part 19 of building regulation) fire (part 3 of building regulation) and especially earthquake regulations (standard no. 2800) which are of great importance in Iran. Such regulations influence the shape and height of the building considerably.[36] It is not aimed to explain all above issues however, earthquake, building process and density will be briefly discussed in the following sections since they have great influence on the construction industry and construction methods in Iran. More information about the Iranian building regulations is also included in the following chapter.

8.3.1 Earthquake

Iran is situated on a Himalaya-Alps seismic belt where earthquake must be a concern in the construction process. Every year there are two to three major earthquakes in Iran, which cause a massive destruction, and many people -especially in small towns and rural areas- are unfortunately killed. Based on the available statistics every year there is an earthquake of six on the Richter scale and every few years a deadly earthquake that is more than seven on the Richter scale. In Tehran region alone, every month there are about 50 earthquakes of 2 to 4 on the Richter scale (Mokhtari, 2004).

The reasons for such disastrous destructions in recent earthquakes are the use of low quality materials and that the majority of residential buildings are not earthquake proof.

[36] Complementary building regulation can be found in building regulations published by Ministry of Housing and Urban Development of Iran and also Building and Housing Research Centre of Iran.

For these reasons, experts and the government are trying hard to encourage builders to apply high quality construction materials in all building types.

In 2002 the government statement was issued asking municipalities and local authorities to follow the earthquake standards. However, applying such standards increases the construction costs by about ten to fifteen percent, which is one of the reasons that such standards are neglected despite the government's efforts to inform people about their importance (Iran Daily, 2006b).

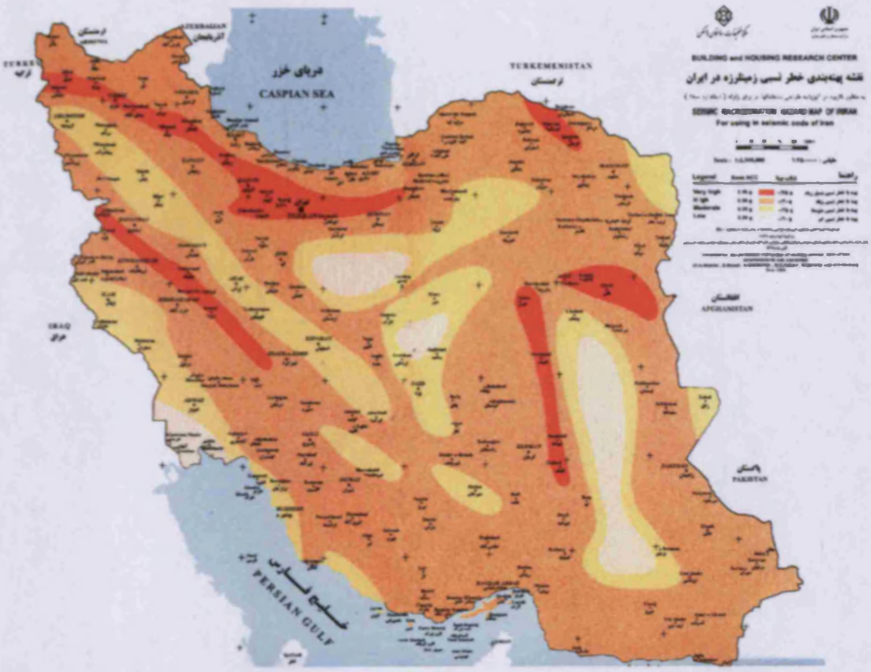

Figure 8-7: Seismic macrozonation hazard map of Iran
Source: Iranian Code of Practice for Resistant Design of Building (standard No. 2800)

Mr. Shakib, the head of Tehran City Council Safety Committee, says that: "At least 100 unsafe buildings are constructed in Tehran per day nearly one and a half years after the law under which new constructions should obtain Building Technical Certificates (This certificate shows the technical features of a building and gives information on how resistant a building would be in an anticipated earthquake in Tehran) was ratified but never enforced in the over-crowded metropolis." (Iran Daily, 2006a)

A strong earthquake in Tehran would cause a national disaster. An earthquake of 7 Richter would destroy 640,000 houses (half of the whole buildings) and 1.5 million people would be killed, says development deputy governor of Tehran province (ISNA, 2006).

It seems that the conventional methods of construction are not very reliable to build earthquake-proof high-rise buildings. Even if all earthquake rules were considered in design and structural calculations, applying conventional methods along with human interference in installation of structural elements such as welding and concrete works, would make it almost impossible to have a reliable structure. Even if a building has a tiny structural problem, it will be damaged from that specific area in the event of the earthquake (Figure 8-8).

Figure 8-8: Human mistakes could be fatal in the event of the earthquake
Source: the author

New technologies are trying to decrease human interference in the building process to the minimum to build a reliable and homogenous building with industrializing and automation of the process. Meanwhile, advanced technologies are often too expensive relative to the local income and industrial infrastructures are required which may take decades to build up.

Meanwhile, it should be borne in mind that the application of industrialised methods of construction is not the only solution. Traditional and conventional methods of construction should also be improved to achieve high standard buildings which are resistant against the earthquakes. In this respect, quality control during the construction process plays an important role (Figure 8-9).

Figure 8-9: Conventional methods do not necessarily result in lower quality (North Iran)
Source: the author

8.3.2 Building process, density and planning issues in Tehran

Building permission is required for construction in Iran. Assessing plans and issuing building permission for either residential or commercial buildings is one of the major roles of municipalities where the drawings are checked for compliance with building regulations. Building control is the responsibility of a private engineer who reports the construction progress to the municipality at five different stages of: foundation, skeleton, floors, services, and finishes. Building controller has also the responsibility of controlling the quality of building materials and ensuring that the building process is in accordance with the regulations and the approved drawings.[37]

Excess density selling is one of the policies which have been followed by the municipalities however; it does not exist in any part of the developing programmes. During recent years, this policy has been an effective factor in the housing boom especially in the mass-building phenomenon. However, there are objections about its conflicts with the urban planning and citizenship rights. Decisions in this area are based on the urban planning where high-density city zones are defined. Vagueness in this area is due to trivialization of the comprehensive urban planning, lack of public contribution in local planning and generally inefficiencies in management of municipalities.

The background of Tehran Comprehensive Plan in the recent two decades demonstrates that, according to the available documents before 1979, each zone of Tehran's comprehensive plan had its stated density. The densities would start from low (50-100 %) in the first and some other zones to high (400-600%) and finally mixed densities. During 1980-1982, Tehran 's municipality announced that the building density of all parts of Tehran is , for various reasons, 100% and building permission will not be issued for three-

[37] For more information about the regulation, refer to the national building regulations published by the Ministry of Housing and Urban Development of Iran

storey and higher buildings and thus Tehran's comprehensive plan was completely dissolved.

During 1990-1991 and after that, based on the theory of financial independency of Tehran's municipality, selling excess density was announced as the new policy. From then, people were allowed to build as much as they proposed if their applications were approved. The destructive consequences of these unplanned decisions, which were not based on any urban standards and principles, were gradually revealed insofar as in 2002 the policy of selling density was stopped. Building process in Tehran in the recent two decades means disregarding all the pre-planned programmes, policies of Tehran's comprehensive plan and the Third Development Plan (Motamedi, 2002).

Tehran needs about 1.2 million new residential units and for this reason, a huge number of construction permits has been sold to the public. Experts believe that this is one of the main challenges for Tehran as selling construction permits has been one of the major sources of income for Tehran's municipality. The other major source of income for Tehran's municipality is trough so-called Article 100 Commission that deals with construction offences after completion of the building. The point is that the municipality has been asked to secure the major portion of its budget through these two sources while council tax does not exist in Tehran. This method of income for the local authorities does not exist in any part of the world. Recent agreement of Tehran City Council has helped to cut down building permissions but has forced the municipality to increase building permission prices by 100% and in certain areas 300%, which means increase in housing prices. Moreover, Article 100 Commission reveals the fact that the municipality tolerates the offences in order to fine the builders to increase its income (Iran Daily, 2005).

8.4 Building Dead Load

Applying new technologies in the construction industry may help to have more and stronger buildings with longer lifetime and defined financial recourses. Moreover, using new materials and new building methods, which are simpler and faster, can help to increase housing production and resolve the current problems including massive building dead load in Iran.

Massive and permanent production, optimum use of materials and resources, faster production and elimination of time wasting conditions and elements are the most important advantages of applying such methods. On the other hand creating proper working environment for production is another advantage of such methods.

Although industrial production has been a proper method for many countries, applying these methods in other countries requires accurate studies and consideration of special technical and economic conditions of those countries. Not having earthquake in many countries, speed, ease of performance and costs are the major concerns of the construction industry. Meanwhile considering these rules can decrease the destructions caused by earthquakes (More, translated by Golabchi, M. (2002)):

- Locating heavy loads and installation on lower levels (To decrease structural elements sizes.)
- Using high resistant (strong) structural materials (To decrease building dead load)
- Using light materials in construction

Less dead load decreases the size of foundation, columns, beams and other structural elements saving a considerable amount of structural materials. On the other hand, it decreases earthquake forces on the building(Berger, 1966). As a result, building costs decrease considerably. Meanwhile less material consumption means protecting the environment and decreasing the energy consumption. Minimizing building weight means decreasing dead loads in all parts of the building including structural, internal and external walls (Salvadore, translated by Golabchi, M. (2000))

Currently, building dead load in many cases is about 400 to 500 kilogram (800-900 Kg according to other sources) (ICC, 2005) per square meter, which is more than 5 to 10 times more than the dead load in many countries where common building methods are applied (Mossavi Khalkhali, 2002). Some believe that the situation is even worse. Mojtaba Bigdeli, a member of directors of mass builders says that, the construction dead load in Iran could be more than 1500 kilograms per square meter (Bigdeli, 2004). In this situation great amount of material and cost can be saved by applying new methods of construction. Considerable consumption of building materials, massive weight, and long building time reveal the necessity of reconsidering the current construction methods and materials in Iran.

Figure 8-10: Building dead load should decrease
Source: the author

8.5 Material waste and energy consumption crisis

One of the current problems of the Iranian construction industry is the waste of building materials. According to Alireza Shakeri, construction expert, 20% of building materials are wasted in Iran compared with 5% waste in developed countries. He continues that, with this amount of wasted material, 60 million square meters equal to 120,000 houses could be constructed in the country (Shakeri, 2004). Other sources confirm this figure (Mola, 1995).

Figure 8-11: Construction material waste (Iran)
Source: the author

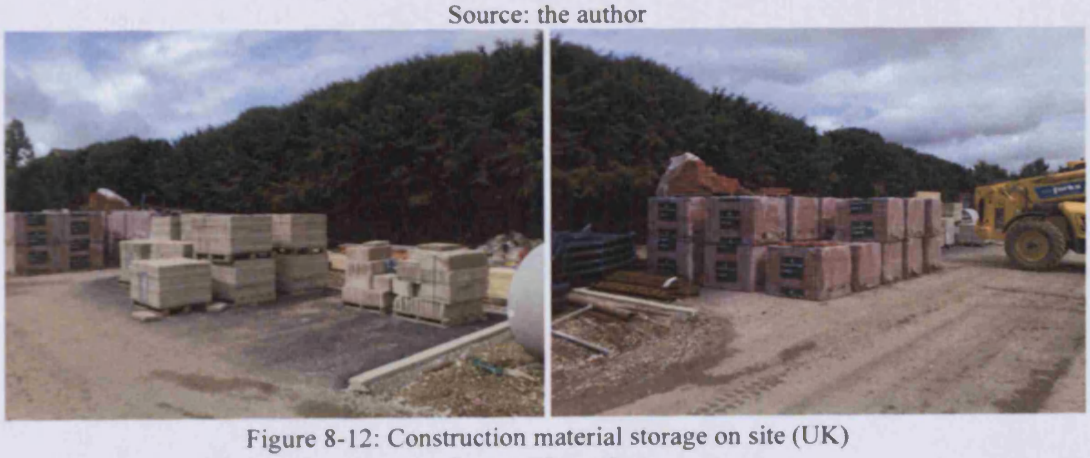

Figure 8-12: Construction material storage on site (UK)
Source: the author

Energy efficiency is a further concern in the Iranian construction. About 40% of consumed energy in Iran is related to construction industry (Heydari, 2002). Currently energy efficiency regulations are not mandatory in all building types and builders are only encouraged to apply such regulations. Due to cheap energy prices, builders and people do not feel the importance of such regulations. Mousa Khalili, deputy manager of construction section of the Iranian Fuel Consumption Optimization Organization says that energy efficiency regulations would become compulsory in all buildings from 2011. He adds that, "the average energy consumption in housing sector, with regards to the country's climate, is about 2.6 times more than international standards" (Khalili, 2004).

The necessity of applying such regulations to avoid unwanted environmental consequences becomes more evident when we know that energy consumption in Iran with the population of 70 million can be compared with China with more than one billion population (Bigdeli, 2004). This is while the building costs in Iran increase by less than 5% if energy efficiency requirements are applied correctly. The cost of proper insulation is about 5% (IFCO, 2009) of the construction costs which comes back in at most three years.[38]

The other major problem of the Iranian construction industry is the waste of energy during the construction period. Gharazi, head of Iranian Construction Engineers Organization, says that, 70% of consumed energy, such as gas, electricity, and water, is wasted in construction process in Iran and only 30% is used efficiently (Gharazi, 2004).

These figures show the importance of application of comprehensive regulations and guidelines for the construction industry in accordance with the sustainable development to avoid any further damages to the environment. Application of advanced methods of construction will potentially decrease the construction material waste.

8.6 Modern Methods of Construction in Iran

During the last four decades the Iranian government has tried to encourage industrialised construction methods by introducing different policies which have failed for various reasons. Despite such failures, some studies and many scholars believe that industrialization is the only way out of the current housing crisis. It is obvious that with such experiences the compatibility and transferability of Modern Methods of Construction should be studied carefully to avoid failures in the future.

[38] Iranian TV, Khabar Channel, 08/05/2007, 10:15 pm

Modern methods have been increasingly applied in the Iranian construction industry not only because of governmental policies but also several individual decisions by the private sector but without any comprehensive study of requirements, potential and ability of adoption to the country's conditions. Many such attempts have been condemned to failure due to several shortcomings and neglects.

Unfortunately, there is not enough information on MMC in Iran. One of the reasons for lack of studies in this field is that the Iranian universities rarely have any relation with the industry particularly in construction area. Moreover, the published data are often unrealistic and unreliable. There are, however, some recent academic studies relating to the Iranian building industry in which some advanced construction methods and housing crisis are addressed. This section intends to explore the current situation of the Iranian construction industry with regards to Modern Methods of Construction in more depth. Since the available information and data are extremely limited, it was decided to refer to any available data and ideas stated by individuals, experts and governmental bodies.

8.6.1 Introduction of industrial building systems and the reasons of failure

Several attempts have been made towards industrialization of the Iranian construction industry since 1951. Studies show that in all attempts the local building industry and its potentials were neglected (Memarzia, 1995, Hosein-Nia, 1995, Ghanbari, 1989). The attempts were first begun by professionals and supported by the government and academics. Such attempts have always been based on some facts such as low productivity of traditional construction process (Memarzia, 1995). Some argue that the introduction of such methods during the 1950s was due to increasing population of Tehran and need for new housing particularly high rise buildings. Also, steel frame and reinforced concrete systems were not common in the country and traditional methods of construction were not able to answer the high demand. Dr Fallah classifies the main reasons for importing prefabricated systems as follows (Fallah, 2001):

- Faster construction and less weather dependent
- Good earthquake resistance
- Improved quality due to better control in factory environment
- Faster production which could answer the high demand especially the housing

According to Ali Abdolalizadeh, former minister of Ministry of Housing and Urban Development of Iran, 25 years ago ten factories with a common characteristic of producing and assembling heavy components in the factory were imported to introduce industrialization to the construction industry. However, they were unsuccessful due to the heavy load and inflexibility of their products (Abdolalizadeh, 2004).

An Italian company (Chidonio) was the first established prefabrication factory in Tehran in 1955 and the second was a French company (Kalad). Both were shut very quickly. An English company (Reema) was the third one, and did not operate successfully either. Main reasons for the failure were shortage of: heavy construction machinery such as cranes, transportation facilities and infrastructure, skilled labour and experienced engineers, architects and managers (Salehi, 1986).

Tehran's international building material exhibition in 1969 was an opportunity for foreign companies to know more about the Iranian housing market and to enter into joint ventures with Iranian companies to establish prefabrication factories. However, number of problems arose due to too rapid process. Some would argue that the ability of such factories to meet the country's particular need due to the lack of skilled labour, regulation, standards and experience (Amiri, 2001).

In 1977 there were nine active prefabrication factories and some plans for establishing seven new factories. However such factories were not successful in Iran. The reasons for the failure of some of the factories according to the Ministry of Housing and Urban Development of Iran were: (Amiri, 2001).

- scarcity of building heavy equipments;
- transportation and infrastructure problems; and
- higher prices of prefabricated houses due to lack of proper management and higher labour wages compared with traditional methods;

However, the main reason for the failure was in fact low demand for mass-produced houses, which were monotonous and boring, due to sufficient output of the traditional methods.

After the Islamic Revolution in 1979 in Iran, some factories finished their activity as a result of the nature of the revolution. Some of the governmental factories reactivated after a while but the private factories did not return to production. According to an official report by the Ministry of Housing and Urban Development in 1982 there were 17 factories two of which were active, six semi active, three inactive and six in the setting-up stage (Salehi, 1986). However it seems that this report has not been very accurate. The first comprehensive report was by Building and Housing Research Centre in 1991. According to this report there were 67 factories which were manufacturing some kind of industrial building components. However, most of the 18 factories designed to produce a complete building, were inactive (Shafaiee and Ghasemzadeh, 1991).

Different interpretations have been made for the failure of such factories. Dr Hanachi, former deputy minister of Ministry of Housing and Urban Development of Iran, classifies the reasons of failure as follows.[39] Products were:

- very heavy and massive
- not flexible in architectural plans; and
- not easily transported

Dr Fallah has also classified the reasons of failure as follows:

- high costs
- not being flexible to be used in conjunction with other methods
- being dull and monotonous
- need for special skills and skilled labour which were not available in Iran

The majority of the factories failed to achieve their objectives mainly due to unsuitable roads and infrastructure, absence of experienced staff, lack of necessary machinery and higher prices comparing with the traditional methods. Moreover, the aesthetic reasons should not be neglected. However it seems that flexibility and adoptability of such methods to the Iranian situation were the most important reasons for their failure. Therefore, comprehensive studies with regards to the mentioned issues are essential to avoid future failures when transferring a method of construction to Iran.

8.6.2 Current situation of MMC in Iran

Many experts believe that the only solution for the current Iranian housing crisis is industrialization. Mehdi Moazen, the head of society of Construction Technicians of Tehran, believes that the low-income housing crisis could be addressed by stopping the traditional production and introducing industrialized construction methods. He also believes that mass-housing using current advanced methods of construction should be considered to overcome the housing crisis (Moazen, 2004).

According to Mr Farzin Fardanesh, the level of technology and the performance in developing countries is low. Although, the technology itself is not a low technology but it is not comparable with developed countries. Construction technologies in such countries are either imported from developed countries which are proper for short periods or are

[39] Interview with Dr Hanachi, July 2005 by the author.

local and traditional technologies. Therefore the construction industry is not able to answer the demand. He believes that several criteria including the society, economic, industry, legislation, building process and planning should be considered to improve the construction technology (Fardanesh, 1997).

Urgent need of the country to substructure is about 45 million square meters however the conventional methods and all private and governmental resources are capable of production of only 17 million square meters a year. In fact, supplying the demand for residential, educational, sanitary, social and industrial buildings in short-term and long-term and achieving acceptable standards may only be possible by application of industrial constructional systems and specially prefabrication and mass-building. In the evaluation of the Iranian industrial housing phenomenon, some elements should be considered (Kheiri, 2002):

- paying attention to the importance of research in industrial constructional production;
- systematization of the ABC and necessary standards of industrial constructional production;
- establishment of technical schools for industrial constructional production;
- advertisement and publicity to introduce industrial constructional production to the society;
- importing and establishing new and advanced constructional factories;
- implementation of eligible management in industrial constructional production; and
- governmental support of industrial constructional production.

Dr Fallah says that, "for the successful application of any new method the first step is to understand the particular features of the traditional construction industry and skills and materials, taking into account the geographical conditions of the country, including earthquake" (Fallah, 2001). Other studies indicate that it may be necessary to alter the legislations and required skills to introduce changes to the building industry (Arbabian, 1997, Ghanbari, 1989).

It is broadly believed that rationalisation of the design and building process is an appropriate method to increase productivity. Many support the theory of offsite construction to remove the effects of adverse weather conditions and reduce the waste (Kheiri, 2002, Memarzia, 1995, Sarabandi, 1995). Memarzia believes that improved productivity is a complex process relating to many factors including education, technology, management, production facilities, labour and manufacturing organisations (Memarzia, 1995).

Sarabandy also believes that mass production of building materials will enable producer to control the quality and also costs since the production is faster and is in the controlled environment of the factory. Mass production requires industrialization and industrialization is not possible unless there is a harmony and standard in design and execution (Sarabandi, 1995). Some scholars believe that both modern and traditional sections in the construction industry should develop more (Hosein-Nia, 1995, Razani, 1997, Sadeghi Golroudbari, 1995).

Waste is another serious problem in the Iranian construction industry where a great improvement could be achieved. However, due to the geographical diversity of Iran and economic, cultural, and technical issues, heavy industrialisation and building mass production are far from appropriate. Some studies support this view (Jahani, 1992, Mehrim, 1998, Razani, 1997, Abdolalizadeh, 2004). Others disagree as Amiri says that, "the large scale introduction of IBS (Industrialized Building System) could significantly increase the rate of housing provision in Iran and other countries with similar geographic and economic systems" (Amiri, 2001). Theses issues will be discussed in the next chapter.

Hassani has suggested that the Iranian government should ban non-professionals from building (Hassani et al., 1994). Also the government should establish an organizations to train skilled labour. Many support this idea (Arbabian, 1997, Ghanbari, 1989, Memarzia, 1995, Mossavi Khalkhali, 1996). Dr Fallah has suggested lightweight steel framing for various reasons as an alternative for residential building construction in Iran (Fallah, 2001).

Some studies show that construction management is another serious problem in Iran (Hassani et al., 1994, Rafiee and Kamal, 2003, Jahani, 1992, Rafiee et al., 2003). Many scholars believe that the construction management should improve since many construction problems are directly or indirectly related to the management. Hafizi believes that planning and legislation is another issue which should be addressed in the Iranian housing industry. She seeks the solution in structural changes in production process and offers some short-term and long-term solution to reform the housing provision (Hafizi, 1990). Salamti has also studied the housing planning situation and concludes that, "housing design guideline on a national level are required that can help the decision making process as well as helping relevant professionals in their work." (Salamati, 2001)

Figure 8-13: Use of MMC in Iran (Tehran Borj)
Source: the author

8.6.3 Government's and society's attitudes towards MMC

As mentioned previously, the Iranian government is actively encouraging the construction industry to apply advanced technologies in construction. There have recently been some plans to allocate land with special discounts to mass developers who apply some kinds of approved MMC in their construction projects. There are other plans to allocate land with special facilities to private manufacturers of modern materials and equipments. It is also the duty of the Central Bank of Iran to provide up to 80% of required investment. There will be some low interest loans and mortgages for the builders and buyers of such houses which are in accordance with the consumption pattern if MMC is applied (aftab.ir, 2007a, Khajeh Daloui, 2008).

This is while manufacturers express their dissatisfaction from being neglected by the government, investors and mass builders. They believe that the government and other stakeholders do not do anything in practice despite the government's insistence on the importance of application of MMC. Mass builders also continue using traditional methods of construction.

During the past 10 years, some producers have introduced advanced technologies to the construction industry but they have remained very little known. Statistics show that the share of new technology is only 10 million square meters from 100 million square meters of constructed roofs in Iran (Saadati, 2006).

The situation is even less favourable in housing sector. Dr Heydarinejad, former head of Building and Housing Research of Iran says that, "Every year there are only 2000 houses which apply new technologies". He said that the government could encourage the private sector to apply such methods by applying new technologies and materials in only half of its buildings (about 50,000 houses or 5 million square meters) (Heydariannejad, 2005). The government is trying to increase the share of advanced methods of contraction by urging developers to use such methods in new planned cities and Mehr housing projects.

According to Dr. Fatemi, the president of Building and Housing Research Centre (BHRC), "less than 3% of constructed buildings in Iran are built using industrial methods of construction. The rest of buildings are applying traditional or semi-industrial methods of construction" (Fatemi, 2008). Mr. Saidikia, the minister of Housing and Urban Development of Iran also says that, "the aim is to increase the share of industrialisation to 20% by the end of the Fifth National Development Plan in 2013" (Khajeh Daloui, 2008, Saidi Kia, 2008).

Now the question is that why developers do not apply such methods of construction. Different bodies have different ideas with respect to new technologies. Mass builders' and developers' answer is the higher prices of MMC compared to the traditional methods. Bigdeli, a member of board of directors of Housing Mass Builders believes that, "the producers of modern materials sell their products up to four times more expensively than similar products in Dubai. The modern materials are produced very little in the country and do not have any approved standards." He believes that applying such methods of constructions would increase the construction speed and decrease the costs by 25% to 30% if mass building was applied.[40]

According to Dr Mansouri, housing expert, the production of modern materials in Iran is limited to luxury materials. The factories should apply new technologies to produce windows, doors, walls, roofs and prefabricated facades. Unlike other countries, industrial production was more expensive than traditional production in Iran. He believed that

[40] This is while, as mentioned in chapter 7, despite mass production of such products in the UK, they are still more expensive than traditional methods of construction. Such methods have historically been more expensive that traditional methods in the UK. According to a UK committee which was formed after the Second World War, mass produced products could be cheaper provided there was considerable and continuous demand for the products without any change in products (White, 1965).

industrial building accelerated the construction process and reduced the house prices by 10% (ICC, 2005).

One of the main issues for limited application of MMC is its cost efficiency for the government, producers and developers. This is while some experts believe that the problems have roots in other areas than the costs. Many major developers in main cities are currently considering MMC in their projects while traditional methods of construction are still very common. They believe that the reasons for interest in traditional methods are possession issues, small scale of projects, market fluctuations, and economic relationships with the material dealers and use of un-skilled labour, which encourage the developers to consider traditional methods. The lack of proper culture and knowledge of MMC amongst developers and buyers are also important. Mehrabadi, one of MMC producers, believed that the reasons for such ignorance were the lack of knowledge amongst involved bodies, people and developers and also lack of confidence in reliability of such methods of construction (Saadati, 2006).

The cultural issues are also so important in the Iranian society. Many are afraid of losing their good reputation by introducing new things to the society. Ghahvehi, architect and university lecturer, believed that encouraging people to accept new forms and materials was very difficult. He says that, "if you build an ordinary house there will not be any problem however, if you use red brick instead of yellow, you have ruffled the balance and harmony. There is another danger of losing your honour and credit by using new innovations (Ghahvehi, 2005)."

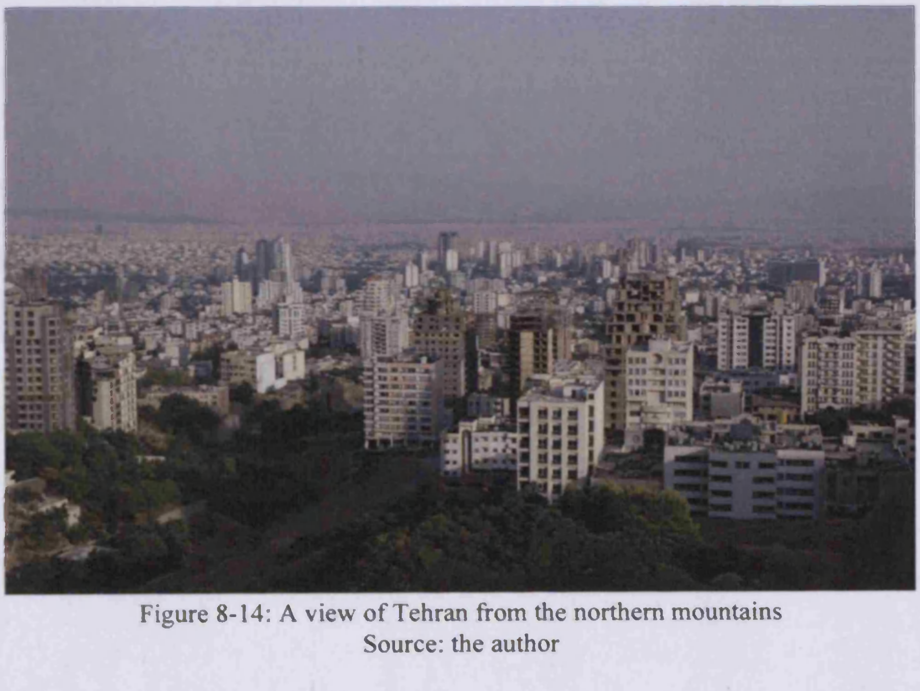

Figure 8-14: A view of Tehran from the northern mountains
Source: the author

8.7 Some Interviews (experts' opinions toward construction problems and barriers in Iran)

In this section problems of the Iranian construction industry have been discussed with some Iranian experienced architects and engineers who are well known university lecturers and have some governmental responsibilities too. The interviews are general discussions and the questions have been designed in a way to give the interviewee the opportunity to express his opinion on various issues and concerns of the Iranian construction industry. However, it has been tried to lead the conversation to the cultural and technological aspects of the construction which are the focus of the interview. Unfortunately due to the short time of the interviewees it was not possible to complete some interviews. The key question is about the problems of the Iranian construction industry with regards to transferring and applying Modern Methods of Construction in Iran. The interviews have been summarised and the full version of discussions are included in Appendix 1.

8.7.1 Interview with Dr Isa Hojjat (Lecturer of Architecture, Tehran University), June 2005

Dr Hojjat disagreed with the theory of transferring technology from European countries to Iran. He believed that the technology needed to be produced in the country. He said that even the technology which was currently used in Iran had been imported from European countries and were applied after being localized.

He continued that, "the other problem is that the buildings are in fact built by non-skilled labourers and the engineers are not involved as much as needed. In this situation there will not be any progress in work unless the workers understand how to apply the new material and technology. One of the serious problems of housing and construction is that the majority of housing projects are small and not organized. There are a lot of none experts in the construction industry who experience the building from the scratch."

He said that the problem of the Iranian construction industry was that old technologies which were applied in low-rise buildings were also used in high-rise buildings. "For example masonry walls which are used in one or two storey buildings are also used in ten storey blocks."

Dr Hojjat had a strong opinion on changing the culture of the society. He believed that many problems were related to cultural issues. He indicated that in this situation only a part of technology which was accepted by people would be applied in the construction. He also said that legislations were not enough alone to change the situation and even if the regulations were mandatory they would not be applied unless they were accepted and believed by people. He continued, "the legislation process should also be gradual to be digested by people. The standards are too high for Iran to be accepted by developers and there should be a compromise between the legislators and developers. There are also some shortcomings regarding the controlling and supervision however, what is more important is again the acceptance of the society."

He also believes that the Iranian construction industry was suffering from lack of proper construction management.

8.7.2 Dr Pirooz Hanachi (Lecturer of Architecture, Tehran University; Former Deputy Minister of Ministry of Housing and Urban Development), July 2005

Dr Hanachi believed that the cost and quality of technology were the two most important issues when applying Modern Methods of Construction. He also mentioned that one of the problems of the Iranian construction industry was the involvement of non-experts. He said that the clients were too important in decision makings process and this was while engineers and architects should in fact be responsible for making decisions.

He also believed that we had problems with regards to availability and recognition of the skilled labour. He said skilled labourers should have a certificate which is the responsibility of the Ministry of Work and Social Affairs.

Meanwhile, he believed, "high risk of investment because of the political problems has stopped big international companies from investing in Iran. The government should also use its tools such as application of MMC in social housing, informing the society and considering financial facilities for MMC buildings to promote advanced methods of construction in Iran."

8.7.3 Dr Mahmoud Golabchi (Lecturer of Architecture, Tehran University), July 2005

Dr Golabchi believed that building technology in Iran had not improved enough in methods and material compared with calculation and engineering sciences; however, there was hope for change. He said there were two key reasons for this: first, the scientific facilities and bases were not prepared and second, the buildings were mainly constructed by non experts and they were still built with traditional and old methods.

Dr Golabchi said that the government tended to be a controller and supervisor than an executer. The government should help and supervise investors in new technologies and building methods from a higher position and should lead them in the correct path.

He believed that the MMC application was a gradual, long term process and started from more visual parts of the building such as the envelope and continues to non-visual such as the structural parts. He said that this movement would gradually shift all parts of the construction industry.

He said "with regards to technology transfer, there are two theories. The first theory is to assume that the technology is separated from culture and is transferred from a place to another without any unwanted outcomes. The second vision is that the technology is not separated from cultural issues and influences the culture and behaviour of the society and may have some unwanted consequences. However, if technology is modified and adapted to the society's requirements, it will not be in contrast with architectural, cultural and traditional values of that society and would be successfully transferred and applied in our country. When these technologies and materials are transferred, at the beginning, they would be evaluated and judged based on their economic and performance aspects. If such methods and materials are cost effective, they will be used without any recommendations or encouragements."

With regard to cultural issues, Dr Golabchi believed that Iran had open minded people and we should not be worried about acceptance of people while technology was applied correctly.

8.7.4 Mr Ali Abdoalizadeh, (Structural Engineer, Former Minister of Ministry of Housing and Urban Development (1977-2005)), November 2007

Being the Minister of Housing and Urban Development of Iran for eight years, Mr Abdolalizadeh mentioned several important issues with regard to offsite methods of construction.

Mr Abdoalizadeh believed that offsite construction was superior to onsite construction since the accuracy and quality in offsite products were improved; however there were some restrictions and shortcomings which made it difficult to introduce such methods to the Iranian construction industry. He said that volumetric systems, for instance, did not have a long background in Iran and they were mainly used in rural schools where access to site and skilled labour was restricted. He believed that these schools were possibly of the best ways to advertise such methods.

He believed that construction was a matter of culture as well as other issues which made it more complex. He said, "we should consider such cultural issues in construction methods and applied materials. Also offsite methods show their advantages in mass building which unfortunately has not been much developed in Iran. Our mass builders are not big and strong enough to import and advertise new technologies themselves. There are 4,000 registered mass builders in Iran who produce between 50 to 200 units per annum. There are only six main developers in Iran and only two of them produce more than 1000 housing units per annum."

He continued that during the Third National Development Plan we had started to clarify the definition, advantages and laws of mass building, and begun registering and organising mass builders across the country. In the Fourth National Development Plan it had been predicted to use the mass building organization to go towards new technologies. It was almost impossible to urge small builders to apply new technologies in their projects. It was true that the mass building society had been dominated by small builders but if we organized them, there would be about 120,000 houses/flats. The plan had been to introduce new technologies and methods to all that 120,000 housing units or at least to those houses which had been constructed by major developers which had meant decreasing the costs. The new government however did not believe in mass building and therefore such programmes had stopped when the government had changed. Their new policy was to allocate land to housing co-operations who might not be expert in construction.[41]

He also mentioned that the lack of enough research in the construction industry was another issue which should be addressed. He said, the problem went back to lack of major developers who could not afford to do research in this sector. There had been some plans which had stopped when the government changed.[42]

He continued that offsite manufacturing had mostly been used in façade systems which were more common and accepted than other systems in Iran. However, façade systems had their own problems around the world as the applied materials were changing too frequently for aesthetic and regulation reasons. Meanwhile, since the speed of construction was a key issue, in some of our residential towers they were using some kinds of prefabricated systems.

[41] This situation may be compared to Lib-Lab policies in the UK when for 4-5 years Labours had the power with their own programmes and during the next 4-5 years when conservatives were in power they would change the housing policies completely!

[42] A solution to this problem may be establishing some organisations that can continue research independently regardless of governmental changes.

He said the other main issues which the Iranian construction industry was suffering from, was the accuracy and tolerance which were the outcome of lack of skilled labour. Finally, he believed that to have successful application of offsite methods in the Iranian construction industry they should promote mass building, support mass builders, train engineers and skilled labourers and activate the financial system to allocate loans of at least 80% of the costs.

8.7.5 Mr Mehdi Tafazoli (29 years of experience mostly in executive management, Civil Engineer), November 2007

Former deputy minister of Ministry of Housing and Urban Development; Former deputy minister of Ministry of Road and Transportation; Former technical deputy manager of Management & Planning Organization of Iran and other governmental responsibilities

Mr Tafazoli believed that the Iranian construction industry was not developed; however, they had exceptional human resources. He said that he thought they did have the capability but not the right management which went back to the government's involvement and policies. He said he thought the government had not been successful in its responsibilities and technology issues had been neglected for years. Only recently in the Forth National Development Plan, technology issues had been discussed quite well but the programme had not been followed perfectly since the government changed.

Mr Tafazoli continued that the experience had proved that it was impossible to satisfy the current housing demand by applying traditional methods of construction alone. The current governmental policies such as allocating land to building co-operations to produce 1,500,000 houses had been, in his idea, a big mistake. "How is it possible to build 1,000,000 houses with building co-operations and without any plans and capital? How can building co-operations import new technologies without any capital?" He said, they needed to concentrate on absorbing investments in the housing industry. "Indeed, if we can absorb international investments, technology will automatically be imported."

Mr Tafazoli believed that housing problems were more financial than technological. "I have always believed that the housing problems should not be searched in engineering and building performance. The roots of housing problems should be searched in the in the economy since housing is an economic good."

He continued that they had not been very successful in industrialization and introducing new technologies to the construction industry. He mentioned that the lack of long-term planning was another issue. "Culturally, we escape form any planning and we cannot follow programmes. Meanwhile introducing new methods of construction to Iran cannot be the answer of all problems and shortcomings. Housing is a package especially in financial and investment issues. New technologies are also necessary in this package. All governments after the Islamic Revolution have been unsuccessful in housing policies."

He said with regards to building regulations, they had high standard regulations. The problem was that the regulations were neglected in practice. He said there were some other problems such as controlling systems and cultural issues which should be addressed. "The government's responsibility is not only to spend money and to invest in the construction industry. The government's view should change from hardware to software which means that the government should change this situation by using its tools such as the media."

8.8 Conclusion

Many scholars and experts believe that industrialization and application of advanced methods of construction should be considered to overcome the current housing crisis in Iran. Meanwhile, very few studies have been undertaken to investigate the consequences of industrialisation in Iran. However, between those little academic researches many believe that applying advanced methods of construction will resolve several problems of the Iranian construction industry such as waste, energy efficiency, unacceptable construction dead load, time, and skilled labour issues.

Industrialization is a complex process in which many factors such as management, planning, resources etc. should be considered. Moreover, Iran is situated on Himalaya-Alps seismic belt where earthquake is a concern for builders and developers when applying any method of construction.

Studies show that some previous attempts to import prefabrication factories have failed due to complexity and inflexibility of their products and also lack of proper infrastructure of Iran. Therefore, any new attempts to introduce new methods of construction to Iran should consider such limitations to avoid repeating the previous mistakes. It seems that the higher cost of new methods and materials is one of the major barriers towards broader application of new methods of construction in Iran.

The results of some interviews with Iranian construction experts also confirm the above issues. Cost, quality of products, cultural issues, legislations and involvement of non-experts are the key criteria which should be considered to have a successful application of MMC in Iran.

The background and current situation of the Iranian and UK construction industries in general and MMC particularly were discussed in this and previous chapters. The UK and Iranian construction industries have some similarities and several dissimilarities. These should be seriously considered when introducing UK's Modern methods of Construction to Iran. The UK and Iranian construction industries have been compared in more detail in Chapter 9.

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Chapter 9: Feasibility of application of UK Modern Methods of Construction in the Iranian construction industry

9.1 Introduction

The Iranian and UK construction industries differ in various respects such as the building and planning regulations, building methods and materials, and the industry performance. The UK construction industry is more advanced and efficient than the Iranian one and for this and other reasons any construction methods transferred to Iran may face problems if they are not selected on the basis of comprehensive research. This chapter intends to evaluate and compare different aspects of the Iranian and UK construction industries with regards to transferability of UK's Modern Methods of Construction to Iran.

When considering the transferability of different methods of construction, various criteria are involved; some are desirable, some absolute; some controllable, some uncontrollable; some measurable and some unmeasurable. With regards to MMC transferability from the UK to Iran, these may be divided into nine key areas as follows:

- Demand
- Building Regulations & Standards
- Practicality
- Cost
- Cultural issues and public attitudes
- Sustainability
- Policy and planning issues
- Early adaptors and stakeholders
- Construction industry, design and flexibility issues

In this chapter, these criteria are examined in more detail and key differences between the Iranian and UK conditions, potentials, and limitations are compared and discussed. A questionnaire has also been designed and distributed amongst Iranian architects to evaluate the current situation (such as the attitude, risks, knowledge etc.) of the Iranian architectural profession with regards to Modern Methods of Construction.

This chapter intends to summarise and discuss the findings of the previous chapters to evaluate the opportunities and difficulties facing a Modern Method of Construction if transferred from the UK to Iran. To emphasise the interaction between the identified criteria, all factors involved in a particular topic are included even though this necessitates some repetitions.

9.2 Demand

One of the first issues which should be considered when transferring a method of construction is the current, future and continuing demand for it.[43] The cost of an MMC factory including staff training is over £10 million in the UK (Parliamentary office of science and technology, 2003). Therefore, it is vital, to ensure the potential investors about the future long-term demand for MMC products.

According to the latest census published by the Statistical Centre of Iran (SCI) in 2006 there have been 17.5 million families living in 16 million residential units, which means a shortage of 1.5 million housing units. In addition, 800,000 new families are added every year to the population (SCI, 2006). According to the Third National Development Plan (2000-2004) the housing production has reached 744,000 units per annum. About 200,000 of these are replacements for the existing stock in the urban areas (ICIC, 2006). Therefore, to answer the current need in a period of ten years, there should be 1,150,000 units per annum.[44] The government has been trying constantly to increase the housing supply, however as the current housing output is not capable of dealing with such huge demand, housing demand in Iran has been increasing inexorably year by year.

The UK situation is very different in terms of housing demand and supply. Supply has sunk to 175,000 units per annum, its lowest rate since 1945. It is estimated that three million new houses will be needed during 2003-2016, which means 230,000 houses per year. This is mainly due to changing lifestyles, as more people live on their own (Parliamentary office of science and technology, 2003). Housing demand will increase to 3.8 million by the year 2021 (Bågenholm et al., 2001). Currently (year 2009) because of the global financial crisis the housing market in the UK is in recession. Therefore, previous figures will definitely be affected by the current situation resulting in even less housing production and, in the short term at least, less demand for MMC products.

The comparison between the UK and Iran reveals that the housing demand in Iran is considerably more than the UK (about 5 times more) which can ensure potential investors about the current and future demand for MMC. As discussed in Chapters 5 and 8, currently applied methods of construction are not capable of answering the housing demand in Iran.

[43] The Iranian and UK housing demand and supply were discussed in detail in chapters 5, 6 and 7.
[44] 800,000+200,000+1,500,000/10=1,150,000

MMC can enhance the situation considering their advantages over traditional methods of construction such as: improved speed, improved quality, improved health and safety, improved control conditions, addressing skilled labour shortage, not weather dependant, minimizing waste and energy consumption, enhancing value for money and cost predictability (Parliamentary office of science and technology, 2003, Bågenholm et al., 2001, NAO, 2005a, Burwood and Poul, 2005, BRE, 2004, Goss, 2005, Harris, 2006).

Meanwhile, as discussed in Chapter 4, new cities are of new policies which have been considered by the Iranian government to address the housing shortage. In many such cities application of advanced methods of construction is encouraged and required. This is a good policy which can increase the demand and promote the use of MMC in the country.

9.3 Building Regulations and Standards

One of the main issues regarding transferability of MMC is their compliance with the building regulations of the destination country. Given the UK's building traditions they are more concerned about the conventional (brick and block) methods of construction and there are still some gaps regarding the Modern Methods of Construction which should be addressed. In general UK building regulations and standards[45] are more detailed, precise and comprehensive than the Iranian ones.[46] Many of the Iranian regulations are more or less a copy of European countries' standards. Therefore in general, it can be argued that if an MMC is transferred to Iran, it will comply with many of the Iranian building regulations with great certainty. The obvious exception is being earthquake-proof design. Therefore, applied details and materials may need to be reviewed and modified to adapt to the Iranian conditions.

[45] UK building regulations: Part A: Structure, Part B: Fire safety, Part C: Site preparation and resistance to contaminates and moisture, Part D: Toxic substances, Part E: Resistance to the passage of sound, Part F: Ventilation, Part G: Hygiene, Part H: Drainage and waste disposal, Part J: Combustion appliances and fuel storage systems, Part K: Protection from falling collision and impact, Part L: Conservation of fuel and power, Part M: Access to and use of building, Part N: Glazing, Part P: Electrical safety, Regulation 7: Material and workmanship. (Planning Portal, 2009)

[46] Iranian building regulations: Part1: Definitions, Part2: Administration & Enforcement, Part 3: Fire Protection, Part 4: General Building Requirements, Part 5: Building Materials & Products, Part 6: Loads, Part 7: Foundation, Part 8: Masonry Buildings, Part 9: Concrete Structures, Part 10: Steel Structures, Part 11: Prefabricated Construction, Part 12: Precautions During Building Operations, Part 13: Electrical Installations, Part 14: Air-Conditioning and Heating Installations, Part 15: Lifts and Escalators, Part 16: Sanitary Installations, Part 17: Gas Supply Plumbing, Part 18: Acoustics and sound Control, Part 19: Energy Conservation, Part 20: Signs, Standard No. 2800: Iranian Code of Practice for Seismic Resistant Design of Buildings. (MHUD, 2007)

Seismic requirements are covered by so-called Standard No. 2800 (Iranian Code of Practice for Seismic Resistant Design of Buildings). As Iran is situated on the Himalaya-Alps seismic belt, earthquake is a serious concern throughout the country and almost every year many people are killed by several earthquakes. Any potential MMC must therefore comply with earthquake regulations and, for structural reasons, it is recommended to use lightweight materials and products which decrease the building dead-load and therefore earthquake forces on the building.

Applying such standards may make transferred MMC too expensive when compared to the currently applied methods of construction. One solution is to start with some methods and products which do not need fundamental modifications such as non-loadbearing parts of the building or other components which are relatively easily modified. Different cladding systems, separating and internal walls, some roof systems, etc. may be suitable options. Meanwhile, since the Iranian building regulations are not as restrictive as the UK ones, especially in fire and energy efficiency, huge savings can be made in these areas which will probably make such products comparable with the Iranian construction methods and products in terms of costs.

9.4 Practicality

Practicality is one of the most important issues to be considered as the risks of failure will increase considerably if practicality requirements are not met. There are several criteria involved in MMC practicality in Iran:

- machinery and plant
- workmanship and labour
- industry capacity
- transportation and infrastructure
- ease of performance
- raw materials
- climate and environmental issues; and
- earthquake issues

As discussed in Chapter 5 and Chapter 8, many of these are not prepared in Iran and therefore such issues should be considered carefully. For instance, Iran suffers from a lack of skilled labour (International Market Research Reports (IMRR), 2008). Although efforts have been made to address this issue, they have been less successful due to several shortcomings including the lack of cooperation between governmental bodies and discontinuous plans and policies. For this reason, training the required labour or transferring some methods of construction which are less complex and do not require highly skilled labourers may be a proper way of addressing this issue.

Heavy machinery is also mainly imported from other countries. As discussed in the previous chapter, one of the reasons that previous industrialisation attempts in Iran were not successful was the shortage of heavy machinery (Salehi, 1986). Therefore, some MMC that require heavy machinery may face the danger of limited availability of such equipment. Hence, there should be plans to cover these gaps. For instance, required machinery could be imported at the same time when transferring an MMC; however this will increase the associated costs of the products. Another option is to transfer some light and simple MMC which do not require heavy machinery.

Infrastructure and transportation issues should also be of concerns when transferring heavy MMC as Iran does not have very efficient infrastructure and transportation systems. It is important to mention that the lack of these contributed to the failure of some previous attempts to introduce prefabricated methods of construction to Iran (Amiri, 2001). In this regard, some MMC that are easily assembled and do not require heavy transportation machinery may be more successful and adaptable. For instance, light cladding systems are likely to be more successful than heavy prefabricated concrete panels.

Availability of raw materials is also a fundamental issue. For instance, whereas timber frame construction is common in the UK, timber is not produced in Iran and is therefore uneconomical. Light concrete and steel frame systems, by contrast, may be more successful since Iran is a major producer of steel and cement.

The majority of Iranian buildings are of steel or concrete frame construction [about 75% in total (President Deputy Strategic Planning and Control, 2007)][47] and therefore such methods are well known to Iranian architects, engineers and builders. Therefore, there may be more opportunities for those methods of construction which are compatible with steel and concrete frame systems to be accepted and adopted by the Iranian construction industry.

Industry capacity not only deals with the availability of raw materials, labour and machinery, but also the capacity to answer the demand. If there is a huge demand for the products and suppliers are not capable of increasing the supply, there will be a risk of

[47] Refer to Chapter 8.

demand exceeding supply which pushes the prices up. Meanwhile, low demand means bankruptcy for the producers. Therefore, there should be a balance between demand and supply to avoid this. Investment in the production of raw materials to increase the industry capacity to deal with the additional demand resulting from the application of new methods of construction is also vital.

When transferring UK's MMC to Iran, adaptability to the climate should also be a concern since Iran's climate, as mentioned in Chapter 5, is mostly hot and arid. Therefore, materials and MMC which are resistant to such climate should be considered. The result will otherwise be some undesired consequences such as lower quality, shorter building lifespan and negative public attitude. For instance timber or Plexiglas and some other materials may not be very resistant in such climate. Expansion details of some MMC such as claddings should also be reviewed as the temperature differences between summer and winter is considerable in some regions of the country.

9.5 Cost and economic issues

Cost is almost the first issue to be considered when applying a method of construction. If not cheaper, transferred MMC should at least be comparable with the prevailing methods of construction. Higher costs of MMC products are of major barriers to broader application of MMC in both Iran and the UK. The cost of MMC in the UK , as discussed in Chapter 7, is currently 8-15% more than traditional methods (OSC, 2006) and it has been estimated that such materials and products could be up to four times more expensive in Iran than in other countries (ICC, 2005). Indeed, one of the reasons for the failure of previous attempts to apply prefabricated methods in Iran was the higher costs compared with traditional methods of construction (Amiri, 2001, Fallah, 2001).

Cost can be divided into two main categories of immediate and life costs. Immediate costs are those involved in the building process whereas life-costs mean building running costs in the long term such as energy requirements and maintenance. When transferring MMC both should be considered, however in practice many people are usually more concerned about the immediate than the life costs. Key factors involved in finished prices of MMC are:

- transportation
- fixed running costs of the factory (labour, storage, energy, etc)
- design
- material

- labour
- maintenance
- machinery
- economy stability, price fluctuation and inflation
- quality
- waste
- speed & time
- building type, area and number of storeys
- volume (mass production)
- characteristics of the construction industry

All of the factors mentioned under practicality above, have direct or indirect effects on the finished price of MMC. Regarding the industry capacity, there need to be sufficient producers to create a competitive environment and to have the capacity to answer the demand and stop prices from being pushed up.

Transportation is especially important as Iran is a big country and it will not be cost-effective to transport products from one side to the other of the country. Therefore, the location of the factories becomes crucial. For this reason MMC factories should be located around the areas where the current and future demand is concentrated.[48] This is vital to avoid unnecessarily long travel distances which increase the costs as well as haveing undesired effects on the environment.

With regard to material and labour costs, there will be greater opportunities for MMC in Iran as these are much less than in the UK. However, the availability of skilled labour is a concern in Iran and therefore training will become critical when transferring an MMC. Also as mentioned in Chapter 4, the inflation is much higher (23.3% July 2007 (Central Bank of Iran, 2008/2009)) and the economy is less stable than the UK which can influence the prices considerably. However, the same situation applies to other products and industries.[49]

Other issues such as lower quality and much more material waste (about 20% in Iran (Mola, 1995) compared with 11% in the UK (Goss, 2005)) and much higher construction dead-load (ICC, 2005, Mossavi Khalkhali, 2002) in traditional construction industry compared to the UK, make the Iranian traditional construction methods rather more

[48] The location of housing demand has been discussed in section 4 of Chapter 5.
[49] Refer to Chapter 8.

expensive than those in the UK. Therefore, whilst MMC is about 8-15% more expensive than the traditional methods of construction in the UK (CABE, 2004), the finished price of MMC may be well below the traditional methods in Iran as the material waste is much higher. Moreover, due to low quality of materials and lack of proper workmanship, Iranian buildings do not last very long. The building lifespan in Iran is about 20-30 years (Mir Mohammad Sadeghi, 2006) which is much less than the expected lifetime in the UK which is more that 60 years (NAO, 2005b, Mayer, 2005). Therefore, people should be informed about the benefits of MMC as higher quality, less waste and energy saving of MMC should mean longer lifespan, less maintenance, and personal and national savings. Meanwhile higher construction speed of MMC means enhanced value for money as investors' money will not be bound up in one project for a long time.

Statistics suggest that 40% of the total of residential buildings in Iran have three or more storeys and 30% have three or more units (President Deputy Strategic Planning and Control, 2007).[50] Therefore, considering the UK experience, which suggests the cost of traditional methods increases faster for higher buildings and flats (NAO, 2005a), applying MMC in such buildings will be more cost effective. Moreover, the majority of effective demand for housing falls for residential units with 50 to 70 square meters (about 43% for 50 and about 33% for 70 square meters (Housing Economy, 2003)). This means that in order to have sufficient long-term demand, transferred MMC should be capable of producing flats with the area of 50 to 70 square meters.

On the other hand, a characteristic of the Iranian construction industry is that there are many self and small builders which is in conflict with the nature of MMC which requires mass production to reduce costs. Therefore, if an MMC is capable of supporting small buildings or there is a system to manage such small developers, the chance of success will be much higher. It should also be mentioned that in some parts of the country, especially around big cities, mass building appears to be much more prevalent than in the other parts of the country. For instance, in 2007, 86% of the building permissions for residential units in Tehran have been for buildings with five or more storeys (President Deputy Strategic Planning and Control, 2007). Therefore, the chance of success in these areas will probably be more than in other parts of the country.

About 95% of housing projects in Iran are built by the private sector (Sarabandi, 1995, Tofigh et al., 2003) which is comparable with the UK where 90% of residential buildings

[50] Refer to Chapter 5.

are built by the private sector (Parliamentary office of science and technology, 2003). The housing sector is one of the rare Iranian industries where the government's share is much less than the private sector, giving the private sector the opportunity to follow its own plans in applying MMC.

9.6 Cultural issues and public attitude

A major barrier to broader application of MMC in the UK, as discussed in Chapter 7, is the negative public attitude towards such methods because of bad memories of prefabrication systems applied in the UK after the World Wars to overcome the massive housing demand caused by bombing and slum clearance (Parliamentary office of science and technology, 2003).

One of the positive points about the Iranian society compared to the UK is that the Iranian people have almost a fresh mind towards MMC and especially prefabricated methods of construction. The majority of buildings have been built using conventional methods of construction[51] and there are only few residential complexes such as Ekbatan and Saman which have been built using prefabricated methods of construction. This can be a great opportunity for MMC to be applied successfully; however, it also gives a serious responsibility to the would-be users to learn from the UK's and other countries' experiences to avoid repeating similar mistakes.

Meanwhile, it is necessary to be aware of different cultural and religious beliefs of the society since they may have fundamental influence on design and applied materials of the components. For instance, whereas in the UK it is acceptable to use carpet for internal finishes of the bathrooms, it may not be acceptable in Iran for hygiene and religious reasons. This and other issues can significantly influence the design and materials of some MMC such as Pods.

9.7 Sustainability

Sustainability is a recent issue in Iran which is becoming more and more important especially in the field of energy conservation. Different issues are involved in MMC sustainability from which four may be of particular importance in Iran:

- energy
- transportation

[51] Refer to section 2 of Chapter 8.

- waste
- material

Barriers toward applying energy saving methods are the very low prices of energy and the regulations where insulation is only recommended and not mandatory in all buildings. However, due to the huge costs of energy subsidies and global environmental concerns, energy efficiency is becoming increasingly important and there are plans to make energy regulations mandatory for all buildings by 2013 (IFCO, 2009). There are also plans to eliminate energy subsidises which increase the prices considerably and reveal the importance of energy efficiency regulations to the society.

According to the Iranian Fuel Conservation Organisation (IFCO), building costs in Iran increase by less than 5% if energy efficiency requirements are applied correctly. This may still make it uneconomical for the builders to follow such regulations, however the extra immediate costs come back in about three years (IFCO, 2009). Meanwhile, UK building regulations are of higher standards than the Iranian ones which make UK MMC products even more expensive if transferred to Iran. Therefore, transferred MMC should be modified to comply with the Iranian standards and requirements. People should also be informed about the advantages of such construction methods which are energy and cost efficient in long-term.

With regards to waste, MMC applications can make the Iranian construction industry more environmentally friendly as huge amounts of energy and materials are wasted on site. As mentioned under the material waste in Chapter 8, 70% of consumed energy, such as gas, electricity, and water, is wasted during the construction process in Iran (Gharazi, 2004). Also, as mentioned before, 20% of building materials are wasted on site (Mola, 1995). These figures show how dangerous the current Iranian methods of construction are for the environment. It is argued that material waste can be reduced to 1.8% in the factory (Goss, 2005). Therefore introducing some MMC, which benefit from controlled factory environment, will have great advantages for the environment.[52]

Transportation is also important regarding environmental issues as Iran is a vast country with an inefficient transportation infrastructure. Therefore, it will not be environmentally friendly to transport products to far distances. But in dense cities like Tehran that suffer from air and sound pollution and heavy congestion, it may be more environmentally friendly to use offsite methods of construction to decrease the number of travels to site and

[52] Refer to Chapter 7.

to make the construction process as fast as possible. Also, as mentioned before, the required factories should be located carefully based on the current and future demands to avoid unnecessary transportation.

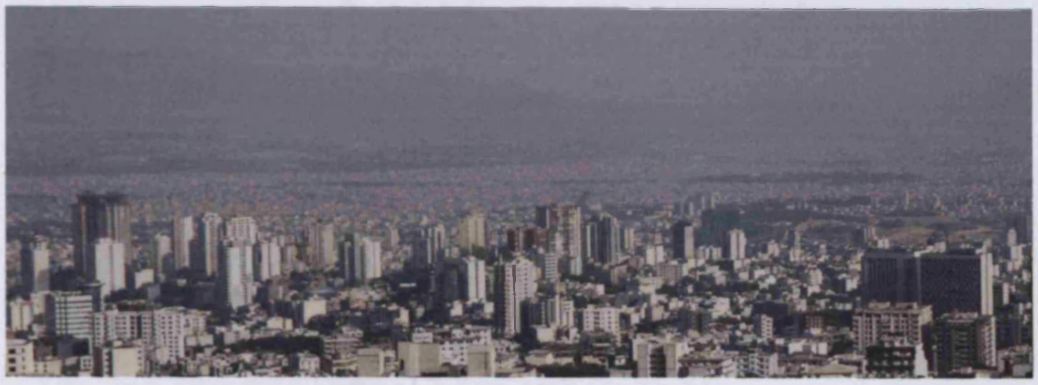

Figure 9-1: Air pollution in Tehran
Source: the author

9.8 Policy and planning

Governmental policies are of great importance to both countries and can influence the construction industry greatly. Basic procedures are more or less alike as there is a central government (Ministry of Housing and Urban Development of Iran) and local governments (Municipalities in Iran). As noted above, official figures are unreliable in Iran. It is clear from the housing shortage that centrally set targets are not being met. This appears to be due to several shortcomings including the relationship between the central and local governments in Iran. Therefore, reviews and reformations in governmental policies are required in order to have a more efficient construction industry.

A major issue in Iran is that the housing industry is one of the first sectors to be influenced by governmental policies. In many cases such policies, especially financial policies, [53] create big shocks in the housing market which is followed by massive rises in the house and building material prices in a very short period. Rising house prices is not necessarily a bad phenomenon if it happens in a logical way since it can stimulate production, but this is not the case in Iran. Prices in Iran may rise up to 100% or more in a very short period as happened recently in many parts of the country. According to Mr. Abdolalizadeh, former minister of Housing and Urban Development of Iran, house prices have increased by 800% in some areas during the last four years (Abdolalizadeh, 2009).

[53] As happened recently during the last four years when increase in mortgages, and wages, and other financial policies of the government resulted in a sharp rise in liquidity and consequently massive increase in house prices (Refer to Chapter 4, section 3).

For this and several other reasons, which were discussed in Chapter 4 and 5, there are frequent housing booms and recessions in Iran which can influence the demand and prices of raw materials and consequently MMC products. These fluctuations in the housing market are predictable since the models, which have been experienced and tested, show a frequency period of two to three years of falling and thriving in the market (Rafiee et al., 2003). Economic instability, however, may have some benefits for MMC too. This situation may encourage builders to use offsite methods of construction since the contract for such products is set at the beginning of the project when prices are fixed. Therefore developers do not need to be concerned about such price fluctuations while the project is in progress on site. This may increase the demand for MMC products. Meanwhile, MMC manufacturers should be cautious about such fluctuations and should have clear plans to avoid potential financial losses.

It is becoming more and more important to the Iranian government to introduce new technologies to the construction industry as there is huge demand for new construction and housing which cannot be satisfied by traditional methods. The Iranian government is constantly promoting and supporting some subjects such as mass-building which are essential for MMC. However, according to the Third National Development Plan (2000-2004), mass building has been defined as building three or more houses in rural areas and five or more units in cities with a population of less than 250,000, and ten or more units in other cities.[54] The effectiveness of these figures should be questioned when it comes to application of Modern Methods of Construction. There are other plans to support MMC manufacturers by allocating land and up to 80% of the needed investment which decreases the investment risks compared to the UK. To benefit from such facilities, construction methods must be certified by a governmental committee (Building and Housing Research Centre) (Golabchi, Jul 2005). This is while the lack of cooperation between different governmental organisations has made such plans and policies less viable.[55]

Another negative point towards broader application of MMC in Iran is that not only are high tariffs for imported materials normal, but their level is extremely volatile giving importers little certainty about costs. These issues increase the associated risks making

[54] Refer to Chapter 4.

[55] For instance, the above facilities have been approved by the Ministry of Housing and Urban Development but when it comes to land allocation, investors have to refer to the Ministry of Industries and Mines which has its own policies and does not necessarily accept what has been announced by the other ministries. In this respect, the government need to ease the process by decreasing the bureaucracy and increasing the intergovernmental collaboration.

MMC less comparable with traditional methods which generally use local materials. In this respect, the government should provide facilities for new methods of construction to make them more feasible. Meanwhile, to avoid such problems, it would be more rational to localise transferred MMC by using imported materials as less as possible, with a corresponding decrease in the finished prices. It should also be mentioned that many materials used in MMC, such as steel, cement, brick, block, insulation, etc., are supplied in Iran,[56] however there may be some differences between the UK and the Iranian standards and specifications. Meanwhile, sanctions and financial limitations have made it even more difficult and risky for investors in this sector.

As mentioned in Chapter 7, restrictive planning policies are major barriers towards broader application of MMC in the UK (Parliamentary office of science and technology, 2003, Bågenholm et al., 2001, NAO, 2005a, Burwood and Poul, 2005, BRE, 2004, Goss, 2005, Harris, 2006). Many such limitations do not exist in Iran which is a great opportunity for successful application of MMC. Although this is a crisis considering urban planning and design, fewer restrictive planning regulations are encouraging phenomena which decreases the associated risks.

9.9 Early adopters and stakeholders

Identifying early adopters is a key factor in successful adoption of an innovation. Early adaptors are the most influential group in any system since potential adaptors look to them for advice and information (Rogers, 1995). Likely early adopters and stakeholders of such methods of construction are not readily apparent in Iran. There are two key questions which should be answered:

- Who would be the pioneers to invest in MMC?
- Who would be the pioneers to adapt MMC changes and its innovatory approach to design, manufacturing and management in the construction industry?

Comprehensive research needs to be undertaken amongst different stakeholders including the architects, consultants, engineers, developers, contractors, manufacturers, society and also the government itself to answer these two fundamental questions.

The UK government is encouraging and promoting MMC through different activities such as research grants, best practice strategies and national and international competitions. The government is also applying MMC in its social housing and other governmental

[56] Refer to section 4 of Chapter 5.

projects. The Iranian government can also encourage the construction industry to apply new methods of construction in their projects by following such policies. This may also make it possible to identify early adaptors and stakeholders of MMC.

9.10 Construction industry, design, and flexibility

In order to have successful application of MMC, fundamental changes in the role of designers and manufacturers are essential (Pasquire and Connolly, 2003). These were discussed under the design section of Chapter 7. There are four main questions to be asked when transferring new construction technologies to Iran:

- How ready are the designers and manufacturers to change their traditional roles and attitudes toward new methods of construction?
- How does the construction industry work in Iran and the UK?
- Is the industry prepared to invest more time in early design stages?
- To what extent are the stakeholders (clients, architects, engineers, contractors etc.) aware of MMC and its advantages and risks?

As MMC is a relatively new subject in Iran, compared to the UK, more effort may be required to change the traditional role and behaviour of the clients, designers, engineers, and manufacturers in the construction industry. Moreover, they do not know much about such methods of construction.[57] In the UK, MMC is becoming more and more popular and accepted by the construction industry as it is also promoted by the government (Burwood and Poul, 2005). The number of Continuing Professional Development (CPD) and other seminars held in the UK is far greater than in Iran. There are also specialist organisations such as Mtech Group, Buildoffsite, and the Building Research Establishment which are constantly working on different technological and environmental issues of MMC whereas in Iran there is no organisation to consider such issues in detail. Therefore, the government's responsibility is to establish some specialist organisations and create an environment where more seminars and courses are held to introduce and promote such methods of construction in the Iranian construction industry.

The UK construction industry differs from the Iranian one in many other aspects. The UK construction industry works as an open system, meaning that many products from different manufacturers are compatible with each other. UK companies and manufacturers co-operate with each other and refer to or recommend other companies' products that are

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[57] This issue will be discussed later in this section.

compatible with theirs. For example, to build a party wall that complies with Part E of the UK building regulations, Metsec products can be used in conjunction with British Gypsum products where Robust Details are applied. This means that many products can be easily applied in different projects without concerns about their compatibility. A good example may be a computer system for which different components such as the main-board, graphic card, sound card, CPU etc, are produced by different manufacturers but are compatible with each other. Many manufacturers also recommend some approved contractors who work under their licence. This will guarantee the quality of finished products. Published literature and technical help lines also assist architects and engineers to choose the right products and materials. Many seminars are also organised by manufacturers to introduce and promote their products in the market.

The situation is completely different in Iran since most of manufacturing systems, such as concrete panel systems, are usually closed and different products do not necessarily match each other. Manufacturers collaborate very rarely and there are not many relevant seminars held in Iran. For various reasons many manufacturers are not ready to publish their technical information and very few companies assist architects and engineers during the design process. Therefore, architects are responsible for almost all detailed drawings without any assistance from the industry, resulting in some fatal errors if MMC is applied. Moreover, unfortunately there is a culture which does not take the design stage very seriously. Sometimes, based on the author's experience, the idea is to leave problems to be resolved on site which is extremely dangerous when it comes to off-site methods of construction. These issues decrease the productivity of the whole construction industry. This situation needs to change to create a proper environment where the design stage is taken more seriously and designers have access to all details and specification in order to increase the productivity and decrease the associated risks of MMC.

Flexibility in design and application is another issue to be considered in any kind of MMC. As previously noted, the use of heavy and inflexible products was a major factor in the failure of previous attempts of industrialisation in Iran (Amiri, 2001, Fallah, 2001, Abdolalizadeh, 2004). Key factors involved in flexibility are listed below:

- variety in design
- variety in projects
- future development
- adaptability to different climates of Iran

It is vital not to repeat the UK mistakes during the1960s when monotonous and ugly prefabricated buildings are widely considered to have caused some serious social and environmental problems, leading to the premature demolition of many such buildings. Variety in products and components can help to avoid having monotonous buildings and cities with their attendant problems.

The chance of successful application of MMC will increase considerably if the products are flexible enough to be used in different projects including residential, educational, industrial etc. Housing projects in Iran are only 40% of the whole construction output (Ghanbari, 1989). Flexibility is also essential in addressing the country's different climatic regions (Subtropical, Cold mountainous, Hot and arid, Hot and humid). Adaptability to such climates may increase the demand and therefore the chance of success.

In this situation, three options for transferring MMC to Iran appear to be viable:

- first, to transfer a closed system where every single component is manufactured in the system itself;
- second, to localise transferred MMC; and
- third, to start with some methods and products which are not complex

In the first scenario, transferred MMC may become far too expensive compared with prevailing methods of construction in Iran. On the other hand, such systems may not be flexible enough for future developments which may result in their failure. The second option means to use regional materials and possibly modify the details and components to produce an MMC which is suitable for the Iranian conditions. This will increase the chance of success for such MMC. The third option, which has already been started by some individuals, may be more successful since such methods are simple, easily performed, do not require highly skilled labour or heavy machinery and are easily combined with the currently applied methods of construction. Examples are some internal wall systems and roof systems such as light gauge steel frame, and polystyrene block and beams in flat roofs.

9.10.1 Professional awareness and experience

Some general issues with regards to technology transfer were discussed above. Understanding the construction industry to observe the criteria which are important to architects and other stakeholders is a vital stage towards successful application of a method of construction. The construction industry can be divided into several subdivisions including the government, architectural and engineering professions, contractors, manufacturers, clients etc. One of these is the architectural profession which require more in depth research. It was decided to concentrate on this area since it was more relevant to the author's expertise as an architect. Yet, it is necessary to mention that all the criteria in the previous sections are interrelated and influential on each other and therefore it is almost impossible to study one issue without considering the others. Thus, many of the above subjects are considered in this section; however it has been tried to focus on the design and construction issues as much as possible.

Unfortunately the author was unable to find any comprehensive research documents which cover these issues. Therefore, to complete the study, it seemed necessary to design a questionnaire to evaluate the current situation of the architectural profession to find out how ready the architects would be if such methods of construction were to be introduced to Iran. In other words, the questionnaire has been designed to undertake a risk assessment, evaluate the architectural profession and to find out what should be done in order to have successful application of MMC (offsite methods of construction in this section) in Iran.

The results reveal several important issues which should be considered prior to any attempts to introducing offsite method of construction to Iran. It should be mentioned that to achieve the best result, it is necessary to study different stakeholders including contractors, engineers and clients too. This is a massive job which requires extensive amount of time and resources and should be undertaken by a team of researchers as a possible research area in the future.

The results of the questionnaire will be evaluated in conjunction with the findings of the previous chapters to conclude with some guidelines and recommendations which will be discussed in the next chapter as the conclusion of this thesis.

9.10.2 Questionnaire objectives and design

Several criteria are involved in the design and construction process when considering a modern method of construction. Thirty one criteria were defined as the most important factors when considering a method of construction. These were based on the findings of the previous chapters, available literature, similar questionnaires undertaken in the UK including a survey by the Commission for Architecture and Built Environment (CABE,

2004) and also some discussions with the Iranian and British architects.[58] The criteria were as follows:

Cost issues:

- Speed of construction
- Total costs
- Quality of products
- Size of projects
- Ease of future selling
- Management of design / construction changes

Practicality issues:

- Previous experience
- Skilled labour requirement
- Machinery availability
- Availability of details/ information
- Availability of experienced contractors
- Availability of products in the market
- Climate / weather dependency
- Ease of construction (e.g. less complicated details)

Design issues:

- Design quality
- Flexibility
- Being fashionable & modern
- Cultural issues / social acceptance
- Client /costumer preferences
- Aesthetic matters

Technical issues:

[58] As a part of the piloting work, such issues were discussed with Professor Richard Weston, two experienced Iranian architects and three experienced British architects for several days. Based on the received comments, some questions and words were modified, added or eliminated from the questionnaire. There were, however, some issues which were not included unintentionally, from which the accuracy and weight of products could be mentioned.

- Sound resistance
- U-Value
- Contract type
- Resistance in natural disasters (e.g. Earthquake)

Governmental issues:

- Ease of Planning/building approval
- Governmental support
- Insurance
- Mortgage

Sustainability issues:

- Environmental
- Location of projects
- Health and Safety

The above categories are not fixed and many of the subdivisions are related and interchangeable. For instance previous experience can also be classified under the cost category since lack of experience may increase the mistakes resulting in higher costs. As another example, location of project is relevant to travel and transportation which may be regarded as CO2 emission and sustainability issues. It could also be classified under the costs issues since long and repetitive travel or transportation may increase the costs. The above categories were not revealed in the questionnaire to avoid any pre-judgement by the respondents.

A serious problem, which was discovered during the piloting process (Oppenheim, 1992, Bryman, 2004), was to explain the meaning of Modern Methods of Construction to the research group. Since MMC is not only a method of construction but also a process and covers a broad area, it was complicated to explain MMC to architects. Therefore, it was decided to make MMC more understandable for the research group by translating it to "Offsite Methods of Construction" as most Modern Methods of Construction are manufactured offsite. Even doing this, it was difficult for architects to define the word "offsite". This was also realised during the process of the questionnaire's test where some of the questionnaires were distributed amongst architects to be filled in for their detailed comments. The situation was even more critical in Iran since offsite methods were not very well-known. Therefore, a short description of offsite methods was included in the beginning of the questionnaire to give an overall idea to the research group about the offsite methods of construction.

The questionnaire structure was formed according to questionnaire design books and recommendations from researchers experienced in questionnaire design. For the purpose of attitude scaling, Likert scales were considered (Bryman, 2004, de Vaus, 2002). Also, since the questionnaire was rather long, some filter questions (Oppenheim, 1992) were considered to split the respondents into two main groups of those who were and were not experienced in using offsite methods of construction. The majority of the questions were in multiple choice and closed format (Bryman, 2004, Oppenheim, 1992, de Vaus, 2002).

The questionnaire was divided into eight main sections and aimed to investigate two main subjects as follows:

1. The current situation of the Iranian architectural profession with regards knowledge of and experience with offsite methods of construction.
2. The real and perceived risks if MMC were to be introduced to Iran

Sections A, B and C of the questionnaire deal with the current situation of the Iranian construction industry and evaluate the weight of the criteria mentioned for the Iranian architects. Sections D, E and F examine the feasibility of applying offsite methods of construction in Iran by studying the attitude of architects towards various matters. And finally sections G and H study the personal ideas of the Iranian architects toward some issues related to different methods of construction. The final objectives are to find out the most influential issues, barriers and risks when transferring a method of construction to Iran, as perceived by Iranian architects.

To minimise the mistakes and to achieve reliable results, some questions were repeated in different ways. For instance questions 1, 3 and 11 were designed to investigate the main reasons for choosing or rejecting a method of construction and questions 2, 5 and 12 were designed to certify the results which were fortunately proven in almost all cases. It would normally take about 20 minutes to answer the questionnaire. A copy of the questionnaire can be found in Appendix 2

9.10.3 Questionnaire Distribution

The questionnaire was distributed amongst Iranian architects and for the purpose of distribution, consulting companies were searched and selected randomly from the TBCEO website[59]. Thirty two companies were visited (between 192 registered companies at the time) and three hundred questionnaires were distributed from which about one hundred returned and eighty eight were reliable. Some questionnaires were not reliable for being incomplete or filled by some other experts than architects who were outside the research group. Such questionnaires were eliminated from the analysis process.

There were several problems in distributing the questionnaire among which, time limitation and arranging meetings with company directors could be mentioned. For instance, a company was visited, telephoned and corresponded officially for several times without any positive results. The rest of the companies were visited at least three times and wherever possible, the questionnaires were filled in the presence of the author to achieve accurate results. However, without the help of some staff who took the responsibility of distributing, explaining and collecting the questionnaires in their companies, it was almost impossible to achieve the required number of questionnaires.

9.10.4 Analysis

The results of the questionnaire were analysed using SPSS and Excel software programmes. Since the data were nominal and categorical, descriptive data analysis was applied using frequency and percentage. The questionnaire has been tested to examine the significance and reliability of the results by applying the "Chi Square" test. In almost all cases the results were statistically significant to $P<0.05$ which is a recognised scale in social sciences (Sheppard, 2004, Bryman, 2004). Also, graphs have been produced in Excel. A copy of the results can be found in Appendix 3 (Questionnaire results).

9.10.5 Results

9.10.5.1 Section A: Considering a method of construction

The study shows that the most important criterion for Iranian architects when considering a method of construction, regardless of being experienced in offsite methods, is the quality of products. The architects were asked to choose their first five most important criteria when considering a method of construction. The result was as follows Figure 9-2):

- Quality of products
- Speed of construction
- Total costs

[59] http://www.tehran-nezam.com

- Resistance in natural disasters (e.g. Earthquake)
- Aesthetic matters

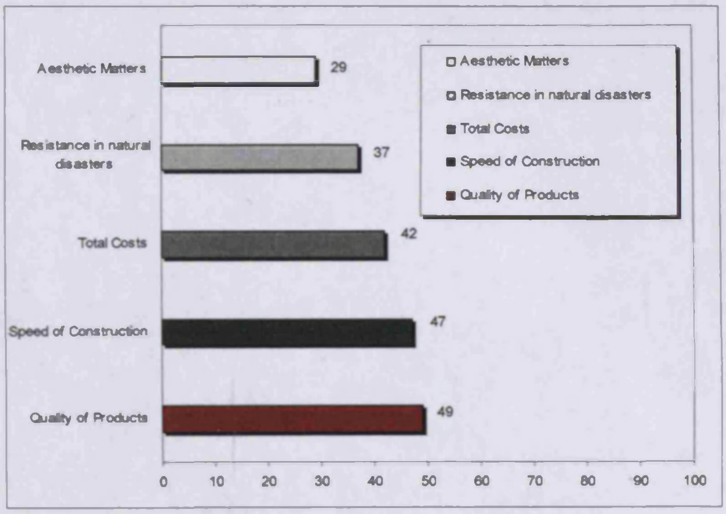


Figure 9-2: The reasons for choosing a method of construction

Also the study reveals that the least important issues for Iranian architects when considering a method of construction are in descending order:

- Ease of planning/building approval
- Governmental support
- Mortgage matters

Therefore, from the above information, it may be concluded that since the first five mentioned criteria are of significantly higher priority to the Iranian architects, it may be more ideal to focus more on these to achieve better results when promoting a method of construction in Iran. Three of the five most important criteria fall into the first category (cost issues) which was mentioned in the questionnaire design section. This shows the importance of cost issues for the architects. It seems that the technical issues are of less importance to architects when considering a method of construction. It may also be deduced that the Iranian government has not been very successful in encouraging architects to use offsite methods since governmental issues are not important to the architects.

9.10.5.2 Section B: Why offsite?

When it comes to offsite methods, it is obvious from the results that "speed of construction" is the most important issue for Iranian architects. The information gained from question five, which asks about the first five reasons for choosing offsite methods, supports this idea too. Architects have chosen the following criteria as their first five most important issues when considering offsite methods of construction (Figure 9-3):

- Higher speed of construction
- Higher quality of products
- Reduced total costs
- Enhanced design quality
- Being modern and fashionable

However, the fifth issue with 28.3% is so close to “size of project” with 25.4%.

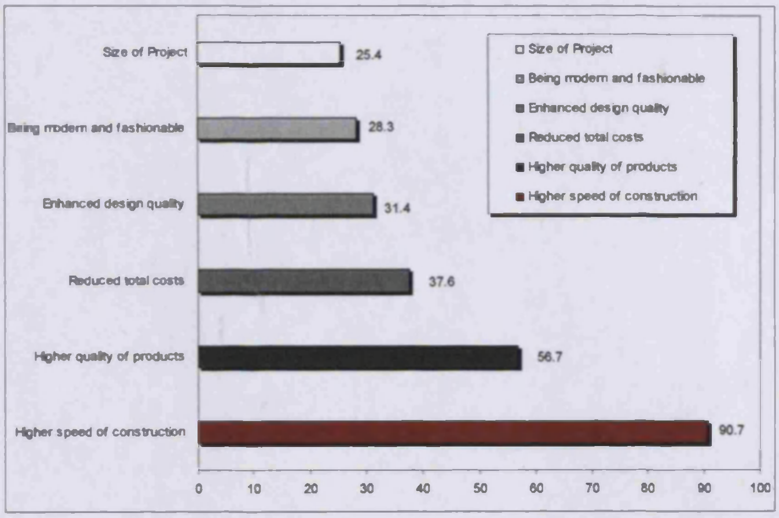


Figure 9-3 : The reasons for choosing offsite methods

Meanwhile, another issues, which Iranian architects are concerned about and was not included in the questionnaire, is the weight of offsite products. It seems that the available prefabricated concrete panels in the market are too heavy, decreasing the building’s resistance against earthquake. More weight requires stronger structure, which results in using more material, and more costs and waste of materials in turn. Therefore the total weight of the products should be a concern when introducing offsite methods of construction to Iran.

The least important issues for the Iranian architects when considering offsite methods of construction are:

- Less climate / Weather dependent
- Mortgage matters
- Governmental supports; and
- Cultural issues

Once more, this supports the result of the first question which means governmental support does not play an important role in choosing a method of construction. Meanwhile, it is interesting to know that one of the most important advantages of offsite methods which is "not being weather dependant" is one of the least important issues for Iranian architects. This may be because of differences between Iran's and UK's climates. On the other hand, the questionnaire was distributed in Tehran where the climate is tolerable compared with many other parts of the country. The results may have changed if the questionnaire had been distributed in other regions of the country that suffer from too hot summers or too cold winters. Besides, based on the results, it seems that Iranian architects do not have strong belief in the relationship between construction methods and cultural issues.

The study also reveals that most of the Iranian architects (about 56%) are familiar with offsite methods. Almost 100% of those who were experienced in offsite methods had used panel systems and about 75% had not used any other systems but panel systems (Figure 9-4).

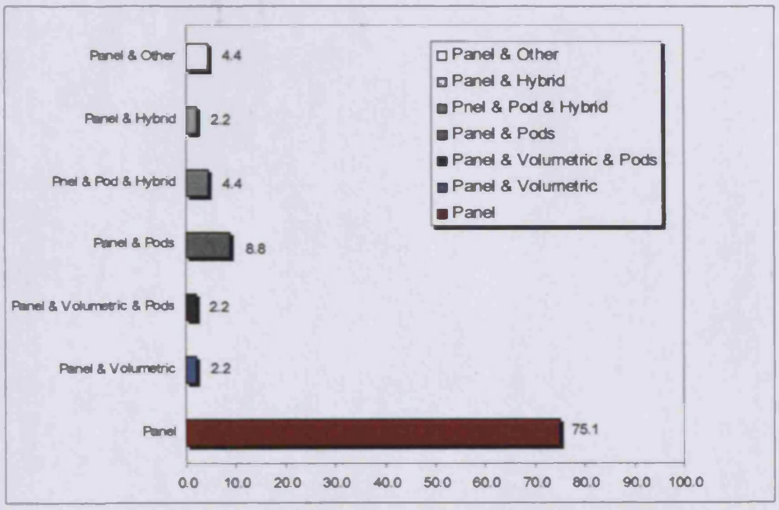


Figure 9-4: percentage of different offsite methods

This means that, apart from those who have never used offsite methods (about 44%), about 75% of the rest are not experienced in any other offsite methods. It becomes more obvious when some architects were interviewed since many did not know much about other systems however almost all had used or at least heard about panel systems. Therefore, apart from panel systems, in total about 86% of Iranian architects are not experienced in any other offsite methods. Moreover, architects are not even very experienced in panel systems since about 91% have applied offsite methods in only 1 to 5 projects from which more than 64% are housing.[60]

Also about 67% of those who were experienced in offsite methods indicated that the approximate proportion of offsite products in their housing projects was less than 25% in terms of volume. About 95% of the offsite manufactured components used in housing projects were wall systems, 68.5% floor and roof systems, 13% pods and 0% volumetric.

From the above information, two facts may be deduced: First, Iranian architects need to be educated to know more about offsite methods of construction. Second, if adapted to the Iranian needs, advanced panel and floor & roof systems may be more successful in Iran since almost all architects have used or are at least aware of them and therefore less effort may be required to encourage them to use such methods. Also, comparing question one and four (the criteria that architects think about when considering a method of construction and offsite method of construction) indicates that there is a correlation between these two questions and they share many facts. The findings show that the four most important criteria for all Iranian architects regardless of method of construction are as follows:

- Quality of products
- Speed of construction
- Total costs; and
- Aesthetic matters

Therefore, going back to the categories which were defined in questionnaire design section, it could be argued that cost and design issues are the most important issues for Iranian architects when considering any method of construction.

9.10.5.3 Section C: Why not offsite?

Section C mainly aimed to study the barriers towards applying offsite methods in Iran. The information gained from question 11, which asks about the main reasons for avoiding offsite methods, reveals that the first reason for those who have never used offsite methods is the "lack of experienced contractors". Next question almost confirms this with 51% of respondents selecting this issue between their first five most important barriers for not applying offsite methods. In general it could be concluded that the first five reasons for avoiding offsite methods are in order (Figure 9-5):

[60] It seems that there is a misunderstanding or lack of enough knowledge about offsite methods in this figure since, however explained in the beginning of the questionnaire, some architects have chosen panel systems with hybrid or pod. However it is ignorable due to its low percentage.

- Lack of previous experience
- Lack of experienced contractors
- Lack of offsite products in the market
- Reduced design flexibility
- More skilled labour requirement

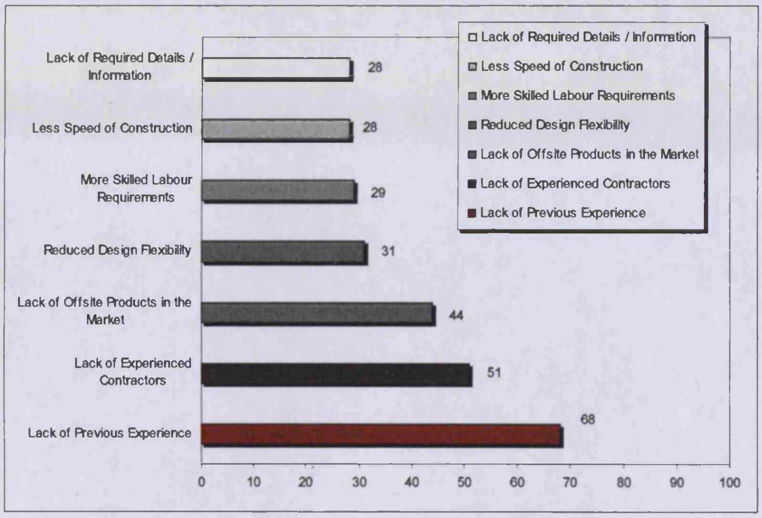


Figure 9-5: Main reasons for not using offsite

Four of the above issues are related to practicality requirements. Therefore, practicality issues should be addressed to encourage architects to consider offsite products in their projects. There are other issues which are rather important for Iranian architects for not applying offsite methods of construction. The study shows that the next most important issues which can not be neglected are:

- Less speed of construction
- Lack of required details / information
- Cultural issues / social acceptance
- Less resistance in natural disasters

This shows that those architects who have not used offsite methods have contradictory ideas to those who have. For instance according to the previous section, "higher speed of construction" is the most important driver for those who are experienced in offsite methods of construction. This is in conflict with the idea of those who are not. If it is assumed that experienced people know more about such methods than inexperienced ones, the need for educating inexperienced architects becomes even more evident since they have some incorrect ideas about offsite methods.

Meanwhile, among those who had never used offsite methods, 100% indicated that they liked to apply such methods in their projects. This information reveals that many Iranian architects are so positive towards applying offsite methods which would be a great opportunity if such methods were to be introduced to Iran.

9.10.5.4 Section D: Construction methods and industry relationships

The aim of this section was to study the professional relationship between Iranian architects and other stakeholders. It was also aimed to study the procedure as to when architects would think about or ask for advice when considering a construction method.

The information gained from question 13, which asks about the stage of a project when architects think about a construction method, reveals that 57.7% of Iranian architects think about the construction method during outline proposal and planning stage. Also 23% think about the construction method in very early stages of design (Figure 9-6). All architects consider the construction method prior to the tender stage.

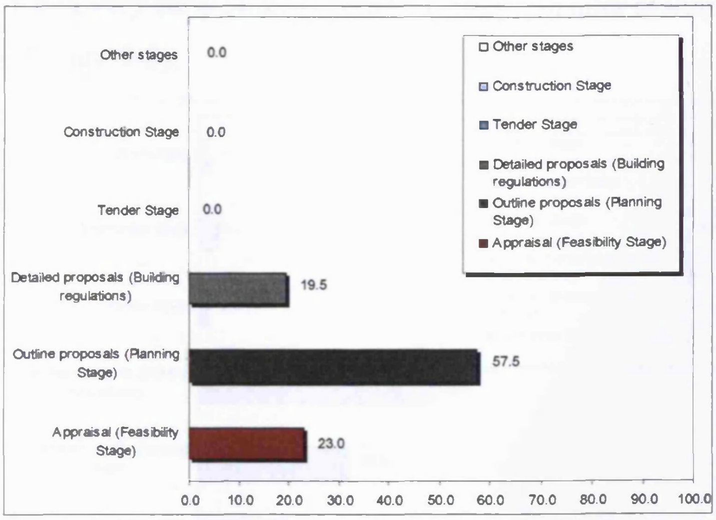


Figure 9-6: The stage when architects think about construction method

The figures are not very promising when it comes to fixing the construction method since about 53% of the respondents have chosen the third stage of construction process which is detailed proposals. The situation is even more unstable in some cases as 18.4% of the respondents have answered that construction methods change even during construction on site. Only 1.1% mentioned that the method of construction is fixed in feasibility stage (Figure 9-7). This means that the risk of using offsite methods is considerably high.

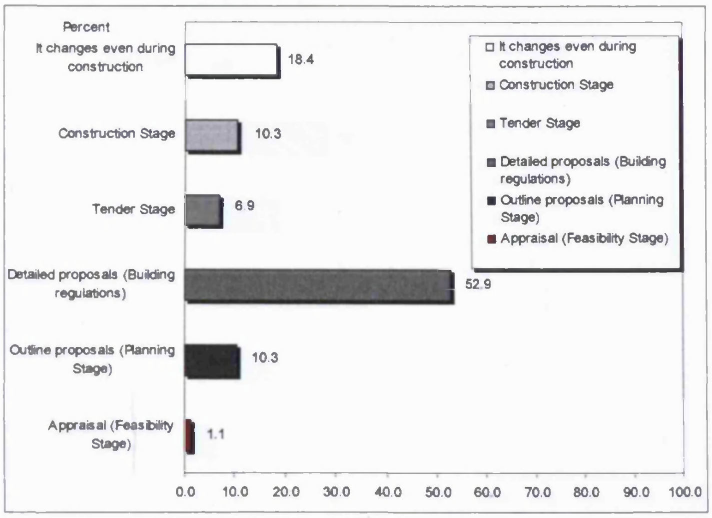


Figure 9-7: The stage when construction method is fixed

The situation improves a little when architects were asked about the stages when they would ask for advice from manufacturers. The results indicate that 18.4% ask for manufacturers' advice in very early stages and about 94% consider manufacturer's advice before tender stage (Figure 9-8).

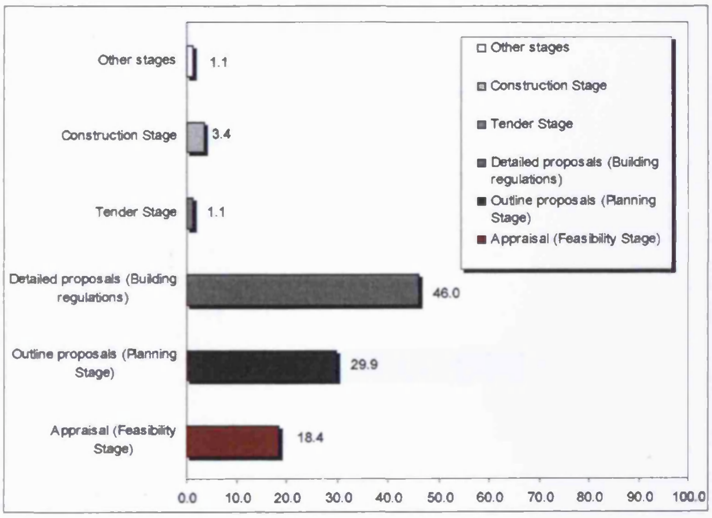


Figure 9-8: The stage when architects ask for advice from manufacturers

The results fluctuated when architects were asked about the time when they would ask for advice from contractors. The figures indicate that 26.7% ask for contractors' advice in very late stages which is during construction and only 4.7% consider contractors advice in feasibility stage (Figure 9-9).

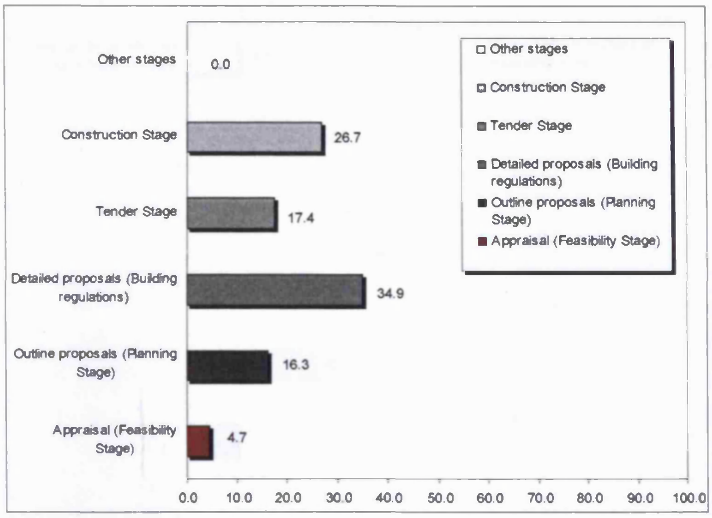


Figure 9-9: The stage when architects ask for advice from contactors

When it comes to advice from structural engineers, the results show that most of the architects (66.3%) consider the structural engineers' advice in planning stage which is more promising. However, only 7% of them ask for advice during the feasibility stage (Figure 9-10).

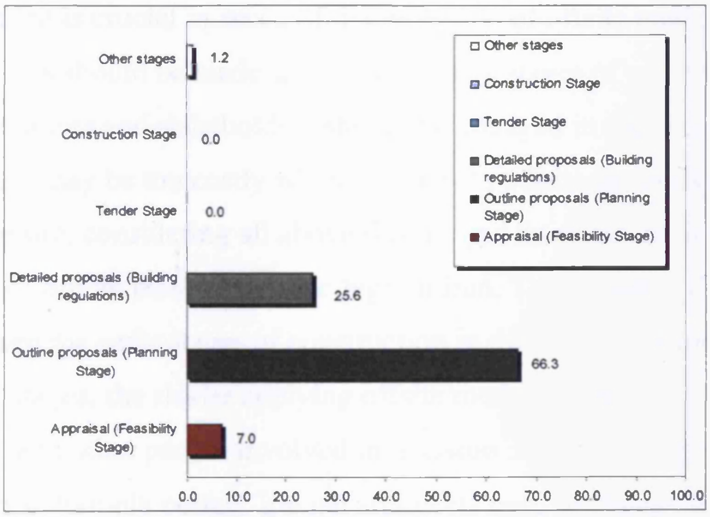


Figure 9-10: The stage when architects ask for advice from engineers

The results fluctuate again when architects were asked about the professional relationship between all the bodies involved in the construction process. Only 9.5% of the respondents said that all or most of the people involved in the construction process (client, designer, engineer, contractor and manufacturer) would meet up during the feasibility stage (Figure 9-11).

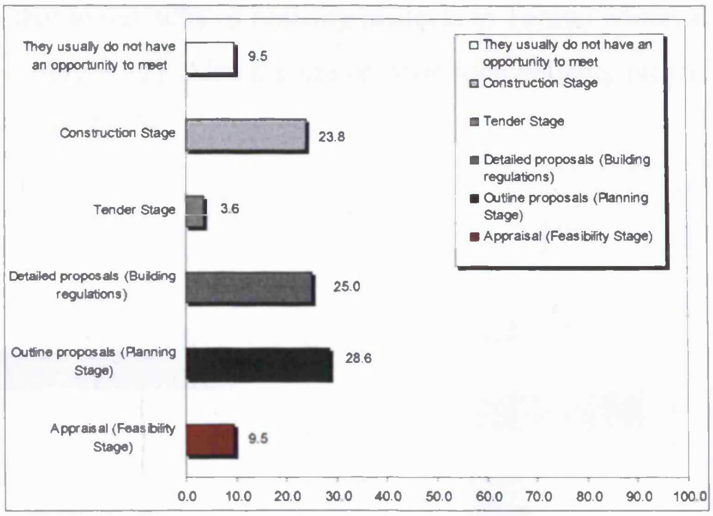


Figure 9-11: The stage when all or most of the involved people in construction meet

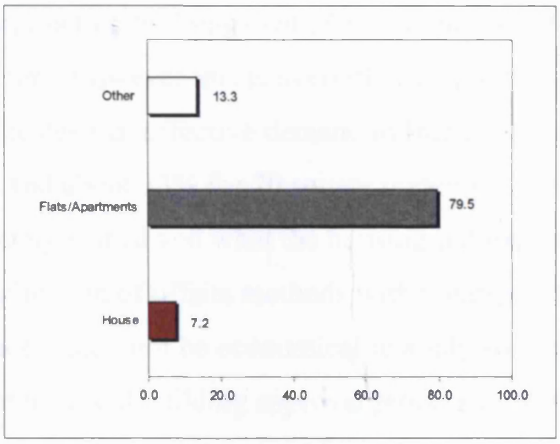
Moreover, according to the information gained from question 20, which asks about the influential bodies in considering a method of construction, 64% of the respondents believed that architects were the most influential people with regards to decision making on construction method. About 25% believed that clients were the most influential people.

Project management is crucial in successful application of offsite methods of construction. Decisions should be made and fixed in early stages of construction and manufacturers, contractors and stakeholders should be engaged in the process of decision making. Late changes may be too costly when it comes to offsite methods of construction (NAO, 2005). Therefore, considering all above figures and information, it seems that the risks of application of offsite methods are too high in Iran. The reason is that very few architects have chosen the early stages of construction in different questions. The closer the answers are to final stages, the riskier applying offsite methods become. Consequently, educating architects and other people involved in decision making process to become more aware of the risks, is extremely curtail. Iranian architects need to change their traditional role in the construction process in order to have a successful application of offsite methods in Iran.

9.10.5.5 Section E: Housing Projects

Section E of the questionnaire intends to study the current situation of housing projects in Tehran. It is aimed to investigate the suitability of sizes, types and number of housing units with regards to offsite methods.

The study shows that about 80% of housing projects in Tehran which are designed by architects are flats (Figure 9-12). Also the majority of such housing projects (about 43%) have 6 to 10 units (Figure 9-13).



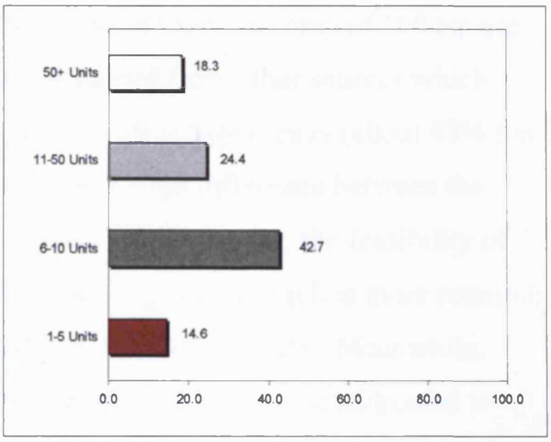
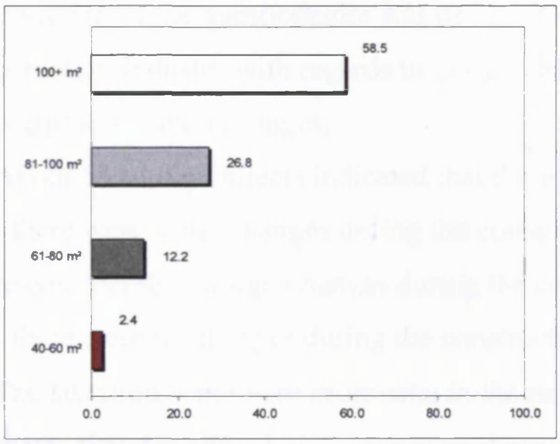


Figure 9-12: Type of housing projects (left)
Figure 9-13: Number of units (right)

In addition, the area of 58.5% of such residential units is more than 100 square meters (Figure 9-14) and about 57% have 5-10 storeys (Figure 9-15).



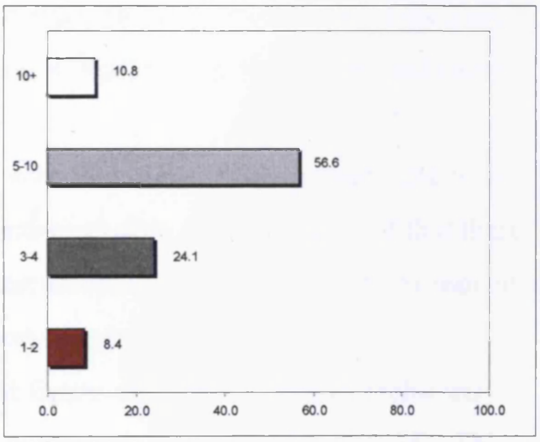


Figure 9-14: Housing areas (left)
Figure 9-15: Number of storeys (right)

Regarding planning and building permission, it seems that the process is very time consuming since 45.6% said that planning permission process would take between 2 to 4 months for the majority of projects. 27.9% said that the process took even longer. This process needs to be cut and clarified since planning permission is one of the major risks facing applying offsite methods of construction (NAO, 2005, CABE, 2004). When applying offsite methods it is recommended to invest in early stages of design to develop the design as much as possible. This would considerably increases the associated risks and costs if planning application was not approved or the building permission is not granted.

In short, it seems that transferred MMC to Iran (especially Tehran) should be capable of constructing buildings with 6 to 10 units and 5 to 10 storeys with the area of 100 square meters. However this is in conflict with information gained from other sources which indicates that effective demand in Iran is between 50 to 70 square meters (about 43% for 50 and about 33% for 70 square meters).[61] This shows a huge difference between the society's need and what the housing industry is producing. Moreover, the feasibility of application of offsite methods with regards to the scale of projects requires more research since it may not be economical to apply such methods in small projects. Meanwhile, planning and building approval process is another issue which should be addressed to decrease the risks involved in applying offsite methods of construction.

9.10.5.6 Section F: Design changes

One of the major criteria, which increase or decrease the risks of introducing offsite methods of construction, is design changes during the design and construction process. This section of the questionnaire was designed to study the current situation of the Iranian construction industry with regards to design changes, reasons and people who are more responsible for such changes.

About 55% of architects indicated that there were few design changes and 32% believed that there were some changes during the construction process. 12.6% indicated that there were considerable design changes during the construction process and only 1.1% indicated that there were no changes during the construction process.

The situation is not very promising in the next figure since about 70% of architects indicated that design would change even during construction on site (Figure 9-16). This significantly increases the risks of applying offsite methods (NAO, 2005). However, according to the previous figures most of architects believed that these changes were minor.

[61] Housing Economy Periodical No. 34 autumn 2003

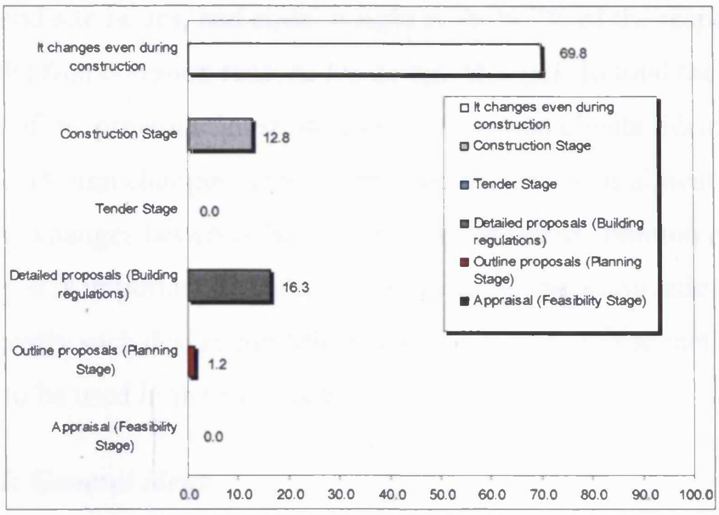


Figure 9-16: Construction stage when design is fixed

It seems that most of changes occur during outline proposals and after planning stage in detailed proposals (Figure 9-17).

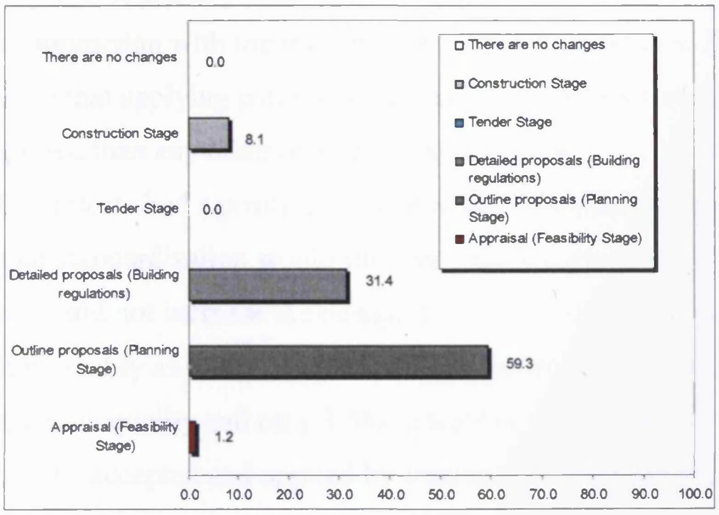


Figure 9-17: Construction stage when changes are most common

Meanwhile, the study demonstrates that about 49% of the respondents believed that clients and about 33% said that architects were the most responsible people for design changes. Structural engineers take the second place with about 35% of respondents selecting them as the second most responsible person for design changes. This shows the importance of the relationship and cooperation between these three main bodies in early stages of construction to minimize the changes. Again, educating clients, architects and structural engineers to work collaboratively seems essential.

Also information gained from question 30, which asks about main reasons for changes, reveals that architects believed that different issues influenced the design equally. Cost, client preferences and site issues, had equal weight with 26.7% of the respondents choosing them as the first common reasons for design changes. In total the information confirms the result of the previous question which means that clients' ideas were the most important reason for design changes since "client preferences" was almost always chosen as the top reason for changes between the 1st, 2nd and 3rd most common reasons of changes. Therefore, it is important to make clients aware of the implications of such changes and how costly such design modifications would be if offsite methods of construction were to be used in their projects.

9.10.5.7 Section G: General ideas

Section G aimed to study architects' ideas about the current construction methods and situation of the Iranian construction industry. According to question 31, which asks about different methods of construction, it can be deduced that most of Iranian architects (65.5%) prefer to apply a well known method of construction all aspects of which have been examined. This, in conjunction with the information gained from section B of the questionnaire, indicate that applying panel systems may be more successful since they are more known and applied than any other offsite methods in Iran.

The majority of architects had a positive attitude towards standardization since about 63% of them said that standardization would increases the design quality. Only 17.4% said that standardization would not increase the design quality. The result enhances when it comes to construction quality as 88.5% of the architects believed that standardization increased the construction quality and only 3.4% disagreed. This creates a good potential for offsite methods to be accepted and applied by Iranian architects since one of the major stages toward offsite construction is standardization.

Regarding applying Iranian or international materials and products, it seems that it does not matter much to architects whether the products are Iranian or not. However, 36.5% of respondents preferred non-Iranian products and 43.5% said that it did not matter to them where the products were from and 20% preferred Iranian products. This again shows that there is a great opportunity for international systems to be applied easily by Iranian architects.

Once more, Iranian architects seem to have positive ideas about new methods of construction since about 53% indicated that they believed that such methods were more stylish and only 5.7% disagreed. It also seems that the majority of Iranian people prefer modern looking buildings since about 64% of respondents indicated that people would prefer modern looking buildings in which new materials were applied.

In total, it seems that the Iranian society and architects are very positive towards offsite methods of construction. Also it seems that panel systems may be more successful in Iran since they are better known than any other offsite methods and architects may therefore accept them more than any other offsite methods of construction.

9.10.5.8 Section H: General ideas about offsite methods

This section intends to evaluate the architects' views specifically towards offsite methods of construction in more detail. To achieve more precise results, those respondents who were not experienced in offsite methods have been filtered. Many of the issues covered in this section are a repetition of subjects covered in section B however, since the questions are in complete sentences, the risk of misunderstanding is lower.

Regarding the total costs of offsite methods, about 38% believed that they were more expensive than conventional methods of construction and about 28% said that they were not. 51% of the respondents indicated that lifespan of offsite products were longer whereas only 13.3% disagreed. Meanwhile 60% said that offsite products had higher quality than onsite products.

Almost all architects (91.3%) believed that offsite methods were faster than onsite methods which confirms the findings of section B of the questionnaire. 55.6% said that they would improve the design quality however 50% indicated that they were more complicated and about 67% said that more time was required in design stage when applying offsite methods which is a correct idea according to Commission for Architecture and Built Environment and other sources(CABE, 2004, NAO, 2005).

About 73% mentioned that the society was showing more interest in offsite methods and 86% stated that such methods were becoming more common in construction industry. 48.9% said that there was not huge demand for such methods however; about 40% mentioned that the current supply could not answer the demand. These results seems to be confusing since the first sentence indicates that such methods are becoming more common and the other says that there is not huge demand for offsite products. The authors' understanding from the results is that although such methods are becoming more common in the industry, many of the developers are still using traditional methods of construction and therefore there is not huge demand for such products. Therefore, some work should be done to encourage builders to apply such methods of constructing since one of the main issues for successful application of such methods is enough and continues demand (Parliamentary office of science and technology, 2003).

Almost all of the respondents (93.3%) indicated that architects needed to know more about offsite methods. Respondents did not have strong ideas about building insurance and financial matters involved in applying offsite methods of construction.

9.10.5.9 Section I: Classification

This section is only for classification purposes to give an idea about the research group who were all employed Iranian architects in consultant companies. Figure 9-18 shows the number of staff employed in companies. Most of the companies were fairly large companies with 100 or more staff.

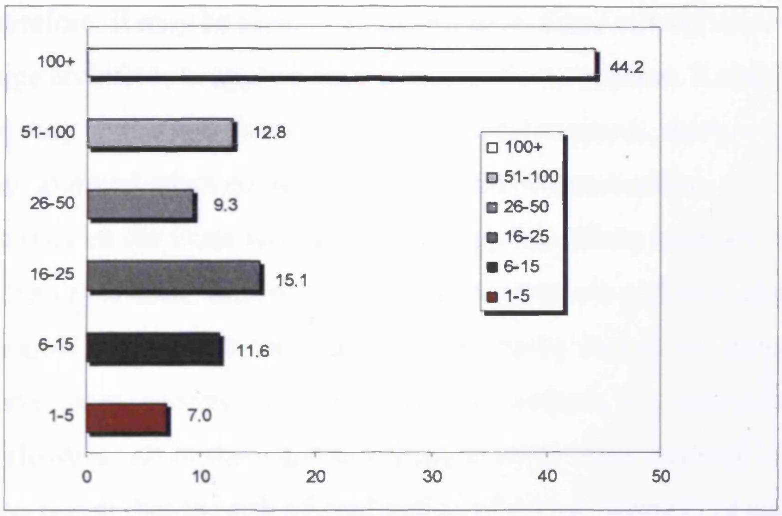


Figure 9-18: Number of staff

40.2% were very experienced architects with more than 10 years in practice while some 32% had three to five years (Figure 9-19).

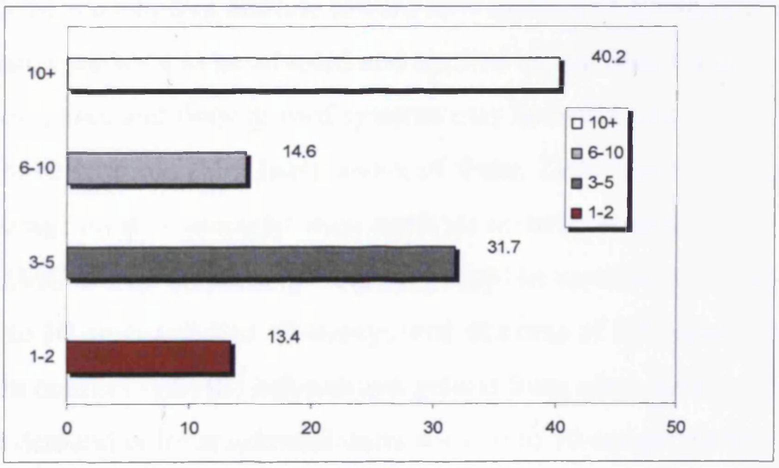


Figure 9-19: Experience

Regarding the age of the architects, respondents were fairly distributed with almost all ages from 20-25 to 50+. Finally the respondents were almost equally distributed regarding the gender with 47% females and 53% males.

9.10.6 Questionnaire summery of findings

The results of the questionnaire reveal several important issues which should be considered when transferring a method of construction to Iran. When considering any method of construction, regardless of being offsite or onsite, the quality of products, speed of construction, total costs and aesthetic matters are more important for Iranian architects than other issues. Resistance against natural disasters such as earthquake should be added to the above issues. Therefore, it may be ideal to concentrate on these criteria more than other issues to encourage architects to apply a new method of construction. It also seems that architects are not very concerned about the governmental supports, mortgage, and planning/building approval when considering a method of construction.

The first three reasons for those who have never applied offsite methods of construction are lack of previous experience, lack of experienced contractors and lack of offsite products in the market all of which are related to practicality issues. Moreover, the results show that they have some incorrect ideas about offsite methods of construction which need to be addressed. However all of them are so willing to apply such methods in their projects.

The results also reveal that the risk of application of offsite methods of construction in Iran is considerable since not many architects are aware of associated risks and the correct process of applying such methods. In this situation, educating architects and other stakeholders to inform them about potential advantages and risks of MMC is vital.

Meanwhile, there is a positive attitude toward new method of construction which is an opportunity for such methods to be adapted and applied by the construction industry. In addition, advanced panel and floor & roof systems may be more successful in Iran, since many architects have used or are, at least, aware of them. Therefore, less effort may be required to encourage them to consider such methods in their projects.

Transferred MMC to Iran (especially Tehran) should be capable of constructing buildings with 6 to 10 units and 5 to 10 storeys with the area of 100 square meters. However this is in conflict with the information gained from other sources which indicate that the effective demand is for residential units with 50 to 70 square meters. The scale of projects should be questioned since it may not be economically feasible to apply offsite methods in such small projects. Meanwhile, although planning regulations in Iran are not as restrictive as the UK, the approval process is very time consuming. Therefore the planning process should be clarified and reduced as much as possible to decrease the risks of application of offsite methods of construction in Iran.

9.11 Conclusion

Several criteria should be considered when transferring Modern Methods of Constructions to Iran. These can be classified according to the following criteria: demand, building regulations and standards, practicality, costs, culture and public attitude, design, sustainability, flexibility, policy and planning, early adopters and stakeholders. To judge whether an MMC is transferable or not and to avoid future failures, a comprehensive research should be considered and all above issues should be studied. Even after considering all above issues, the appropriateness or inappropriateness of an MMC will not be definite unless it is transferred and examined in real context of that country. Meanwhile, other countries' experiences, previous attempts, research and studies may enable us to predict the adaptability of a method of construction.

Studies suggest that the current demand for housing in Iran is about five times more than the UK, which could be assumed as long-term demand for MMC products. Thus, investment in MMC may be less risky than the UK. However, in view of the uncertainties surrounding official figures, comprehensive study is required to evaluate the current interests and requirements of the Iranian construction industry and also the location of current and future demand.

Since British standards are higher, and building regulations are more detailed and comprehensive than the Iranian ones, it can be argued that transferred MMC should not face any major problems in this respect. There are, however, concerns about the earthquake regulations which must be considered although applying such standards may increase the costs.

Finished prices of MMC products are not clear since several criteria which have the potential to save costs (such as less waste, cheaper materials and labour) or increase them (such as less industry capacity, transportation, economic instability) should be evaluated in more detail.

One of the positive points about the Iranian society compared with the UK is that the Iranian people do not have any negative attitude towards MMC which increases the chance of successful application of such methods. Meanwhile, there are some cultural and religious issues which should be considered in some MMC such as pods.

Having regards to sustainability, MMC offer some advantages as in theory greater energy saving and less material waste would be achievable if MMC were applied correctly. Meanwhile, there are concerns about transportation as Iran is a vast country which suffers from inefficient transportation systems.

The implications of governmental policies on MMC are not completely defined yet. The Iranian government has announced some plans to support investors in MMC however, they are neither enough nor effective in practice. Some restrictive policies on import and export, high tariffs on some materials, sanctions and financial issues may limit the applicability of MMC in Iran. Meanwhile, comparing to the UK, there are less restrictive planning policies in Iran which is an opportunity for MMC. Also stakeholders and early adaptors of MMC should be clarified in Iran.

The Iranian construction industry is immature in terms of performance compared with the UK. Several modifications are required in order to decrease the risks of application of MMC in Iran. Also the chance of success will increase for those MMC which are not complex, do not require highly skilled labour or heavy machinery and are compatible and easily combined with the prevaling methods of construction in Iran. Transferred MMC should also be flexible in terms of design, usage and future developments. It should also be adaptable to different climates of Iran.

The results of the questionnaire also reveal several important issues which should be addressed. Some criteria such as the quality of products, speed of construction and cost issues are of greater importance than others for Iranian architects. It is evident that Iranian architects need to know more about Modern Methods of Construction and their potential advantages and risks. Meanwhile there is a positive attitude towards such methods of construction which is a great opportunity for MMC.

Finally, much more research is required on all above issues with regards to transferability of new methods of construction to Iran. The reason that the government is promoting advanced methods of construction is to increase the productivity of the construction industry. There are however several gaps and shortcomings which should be addressed. MMC is very different from traditional methods of construction in terms of the risks and construction process. Without considering such issues, not only MMC fails to achieve its potential advantages over traditional methods, but the situation may even get worse. It should also be mentioned that after about a century of experiencing new methods of construction, the UK is still suffering from several social, environmental and economic problems some of which have been the outcomes of mistakes made during the last century. Iran should learn from the experience of such countries to avoid repeating their mistakes. Yet, there would be great opportunities for some MMC if the mentioned issues were considered and such MMC are modified to adapt the Iranian needs and situation. It is the government's responsibility to prepare the base for successful application of MMC in Iran.

Chapter 9 intended to compare the Iranian and UK construction industries in detail. Several potential opportunities and constraints facing transferred MMC to Iran were explained in this chapter. As the conclusion of this thesis, the summary of findings and some recommendations for successful application of MMC in Iran are given in Chapter 10.

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Chapter 10: Conclusion

10.1 The outcomes

Various issues in Iranian and UK relevant to the application of MMC, including the housing background, economy, planning, and technology have been discussed in this thesis. The aim was to have a clear understanding of the historic and current situations in both countries as a basis upon which to reach conclusions about whether or not UK construction methods would be suitable for Iran.

Further research about issues that were beyond the scopes of this thesis is still required to evaluate the viability of MMC in Iran. These include the demand, building regulations and standards, practicality, costs, culture, design, sustainability, policy and planning, pioneers, education and management. These issues need to be studied in more detail to identify the requirements and limitations as the likely success or failure of MMC is directly related to the above criteria. Despite these limitations, on the basis of the work undertaken in this thesis the following outcomes can be reported and recommendations made.

10.1.1 MMC and housing demand

Housing demand in Iran is massive, and due to various problems the current supply is not capable of meeting it. As discussed in Chapter 4, this is the outcome of several issues including the planning, land, economy and other internal and external factors which have direct or indirect effects on the housing market. Such factors can considerably increase or decrease the housing demand, supply and prices. During recent decades, the government has been trying to overcome the housing problems by considering various policies. One of these has been the introduction of advanced methods of construction to increase the housing output and productivity. It is broadly believed that housing problems would be resolved if more advanced methods of construction were introduced to Iran. However, Iran is making similar mistakes to those made by the UK during the 20th century since meeting quantitative demands has become more important than the quality of the housing. Therefore, it is recommended that housing quality should be considered as well as housing output to avoid potential social and economic problems in the future.

10.1.2 Which MMC?

Different types of MMC were discussed in Chapter 7. MMC has several advantages which could theoretically resolve some of the current problems of the construction industry;

however, several other criteria should be considered prior to introducing Modern Methods of Construction, particularly offsite methods of construction, to Iran. Indeed, based on the findings of Chapter 9, the current situation would remain the same or even deteriorate if such methods were transferred without undertaking comprehensive research and preparation. The Iranian construction industry is not fully ready yet to adopt complex methods of construction successfully.

Some MMC such as light cladding systems, are simple and do not require heavy machinery, and will be more suitable for Iran. This does not mean that more advanced and complex methods of construction would definitely fail in Iran. Indeed, like the rest of the world, Iran needs to move towards adoption of such innovations; however, this should be a gradual long-term process.

10.1.3 Prevailing methods of construction

While considering the merits of MMC, the potential for improving prevailing methods of construction should be studied and changes implemented. As discussed in previous chapters, it is not true to assume that MMC can be a wholesale replacement for traditional methods of construction. Great results are achievable if currently applied methods are optimised in terms of materials and construction waste. The same process has been happening during the last century in the UK. Even now, as mentioned in Chapter 7, conventional construction methods remain more efficient than many Modern Methods of Construction in several aspects, including costs.

10.1.4 Education

A major issues to be addressed when considering the introduction of MMC to Iran is the lack of understanding of the risks and constraints they involve. This was particularly evident in the results of the questionnaire discussed in Chapter 9, and significantly increases the associated risks of MMC in Iran. In this respect the following actions are recommended:

- Increase the level of awareness in the society using different tools including the media.
- Educate architects, engineers, clients and other stakeholders to increase their knowledge about the advantages and risks of such methods. In this respect increasing CPD seminars and including MMC in the formal university educational systems are recommended.

10.1.5 Research

The amount of relevant research undertaken in Iran is not comparable with the UK. The only available data on the subject is in disparate research by individuals and some unreliable information in non-academic publications which are neither sufficient in equality or scope, nor well enough organised to act as a useful body of knowledge. As discussed in Chapter 9, unlike the UK, there is no professional research organisation comparable to the UK's Building Research Establishment, devoted to the subject. It is therefore recommended to establish one or more organisations to undertake professional research on construction technologies and to publicize the results.

A major source of information generation in the UK is the collaboration between research organisations/universities and the industry. The amount of such collaborations in Iran is not comparable with the UK. Therefore, it is also important to increase the integration and collaboration between the industry and universities.

10.1.6 Industry

Arguably, the construction industry is the most important sector which requires urgent consideration. There are several fundamental issues such as the information delays, skilled labour shortages, regulations and standards, small and unprofessional developers, infrastructure and industry capacity which need to be addressed.

As mentioned in Chapters 4 and 5, available information on housing is not sufficient, reliable or up-to-date. This is one of the causes of the frequent booms and recessions in the market. Establishing a central information management system for up-to-date and correct information on the housing market will improve this situation.

Also as discussed in Chapters 4, 8 and 9, there are too many small, unprofessional developers in the housing market, making housing planning very complicated. It is recommended to create a professional construction industry and re-organise small builders to create major cooperative partnering developers which makes the application of MMC more feasible.

It is also important to create a competitive environment in which innovations are welcomed and the industry is encouraged to apply innovative methods of construction. A similar strategy, as explained in Chapter 6, was considered in the UK after both World Wars and resulted in the occurrence of several innovations in the construction industry. In this respect, considering national and international competitions, exhibitions, seminars, best practice implementation throughout the construction industry and application of MMC in governmental projects would be constructive.

Moreover, as discussed in Chapter 2, mass production and mass building are basic requirements for industrialisation, and the accepted definition of mass building in Iran,[62] needs to be reconsidered to achieve the economy of volume when MMC is applied. To this end the following are recommended:

- Increase the industry capacity to avoid imbalances in demand and supply for the raw materials, energy and components.
- Improve the transportation systems and infrastructure. This is essential since, as discussed in Chapters 8 and 9, poor infrastructure and transportation systems were of the major reasons for the failure of previous industrialisation attempts.
- Introduce training programmes to create the poll of skilled labour needed to apply MMC effectively.

10.1.7 Government

The government should have a supervisory supporting role and use its potential to lead the market in the correct direction by providing information and incentives to industry. As discussed in Chapter 6, constant long-term supporting policies in the UK housing policies, particularly in innovative methods of constructions made the investors confident about the future demand for such methods. This was one of the key factors for the increasing use of innovative methods of construction in the UK. By contrast, in Iran frequent changes in governmental policies increase the associated risks which are discouraging for the potential investors and adopters. It is therefore recommended that the government should:

- Implement long-term plans for housing to give potential invstors confidence about the future of capital-intensive methods of construction.
- Accept more responsibilities to accelerate and ease the process for investors and manufactures of MMC.
- Promote greater integration of, and collaboration between the various governmental organisations involved in housing supply and management.
- Ensure the plans, policies, and facilities are clarified in detail to avoid potential conflicts.

[62] Refer to Chapter 4, section 4.2.2.2.

- Create a stable economy, since the lack of stability and frequent uncontrolled fluctuations in the economy indicators such as liquidity and inflation are discouraging for potential investors.

10.2 Future research

This study has explored the feasibility of applying UK Modern Methods of Construction in the Iranian construction industry, but further research is required to provide the comprehensive knowledge base needed. My recommendations for further work are:

- Explore systematically and in greater detail the various factors and recommendations identified above in this concluding chapter.
- Evaluate other countries' experiences regarding the construction technology. For several reasons, the UK has not been very successful in the application of MMC in the construction industry compared with other countries such as Japan and the Scandinavians. The successful experience of such countries should be evaluated and compared with the UK and Iran for a more comprehensive understanding.
- Examine the knowledge and attitude of other stakeholders such as engineers, contractors etc. regarding Modern Methods of Construction.
- Assess the risks and adaptability of the various methods of MMC - such as panel systems, cladding systems, pods, hybrid systems etc.- based on the criteria which were discussed in this thesis.

10.3 Closing statement

Based on this research, the author believes that more advanced construction technology, although necessary, is not the only way out of the current Iranian construction crisis. Several other criteria such as the economy, education, infrastructure, regulations and standards, etc. must also be considered. The process is long-term and evolutionary, and there is need for continuous close integration and collaboration between the stakeholders including the government, industry and universities to identify the requirements and constraints.

Modern Methods of Construction is a process in which hardware (such as the components, materials etc.) and software (such as the management, human resources, education etc.) technologies need to be considered together. In Iran the hardware technologies have currently become much more important than the equally vital software, and in this situation Iran cannot fully benefit from application of advanced methods of construction. *Although so optimistic and willing, the Iranian construction industry is not sufficiently mature to digest and adopt complex methods of construction successfully.*

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Appendices

Appendix 1

Interview with Dr Isa Hojjat, June 2005

Dr Hojjat disagreed with the theory of transferring technology from European countries to Iran. He believed that the technology needed to be produced in the country. He said, “even the technology which is currently used in Iran is imported from European countries which are applied after being localized. The problem is that the buildings are in fact built by non-skilled workers and the engineers are not involved as much as needed. In this situation there will not be any progress in work unless the workers understand how to apply the new material and technology. One of the problems of the Iranian construction industry is that old technologies which are applied in low-rise buildings are also used in high-rise buildings. For example masonry walls which are used in one or two storey buildings are also used in ten storey flats.

The core of many problems is cultural. The problem is so complicated since there are several involved factors. In this situation only a part of technology which is accepted by people would be applied in the construction. One of the serious problems of housing and construction is that the majority of housing projects are small and not organized. There are a lot of none experts in the construction industry who experience the building from the scratch. We should have large and organised companies (with enough experience and knowledge) who know how to build a building. In our culture people trust unauthorized mechanics more than official ones. It is the same in the construction industry since people trust uneducated but experienced people more than educated engineers.

Legislations are not enough alone to change the situation and even if the regulations are mandatory they would not be applied unless they are accepted and believed by people. The legislation process should be gradual to be digested by people. Also, standards are too high for Iran to be accepted by developers and there should be a compromise between the policy-makers and developers. On one hand, the Ministry of Housing and Urban Development declares high standard laws and on the other hand the market, because of different problems (such as financial, cultural, facilities), do not obey such rules and regulations. Therefore, there should be a sort of balance between the government and private sector. For instance the government should make the building regulations of lower standard and offer builders some facilities to encourage them to apply them. Developers and private sector should also accept such regulations. It is only in this situation that we will be able to see some changes in the future. There are also some shortcomings regarding the controlling and supervision however, what is more important is again the acceptance of the society.

The financial problems and sick economy are of major issues that influence the construction time but the management is more important. Due to cultural beliefs it is more acceptable to have construction management and QS offices in each company instead of separate companies. Experienced people and companies know when and where to obtain their needs and usually have less problems and it takes them less time to build houses."

Interview with Dr Pirooz Hanachi, July 2005

Dr Hanachi believed that the cost and quality of technology were the two most important issues when applying a Modern Method of Construction. He said; "The problem of the Iranian construction industry is that non experts are involved and clients are too important in decision makings process. This is while that engineers and architects should be responsible for decision making and constructing the buildings.

We also have problems with regards to availability and recognition of the skilled labour. They should be classified and have a certificate according to their skills. These are the responsibilities of the Ministry of Work and Social Affairs.

While there is a good market in housing, it is obvious that many big international companies are interested in investing in the Iranian housing market however; the high risk of investment because of the political problems has stopped them from investing in Iran. There have been some efforts in this area which are not enough.

The government tries to apply new technologies in its new projects to advertise and to promote them in the society. We should be consistent in our programmes to see the result. We should inform and warn people and give them statistical information. Banks give mortgages but the only thing that they do not pay attention to is the national building regulations. They should only, for example, give mortgages to those buildings in which the national building regulations have been applied."

Interview with Dr Mahmoud Golabchi, July 2005

Dr Golabchi believed that, generally building technology in Iran had not improved enough in methods and material compared to the calculation and engineering sciences, however there was hope for change. He classified the reasons as follows:

"The scientific facilities and bases are not prepared. For example because of some reasons such as the war between Iran and Iraq which resulted in economic, political and social problems there has not been the possibility to import those materials which have been replaced with separating party walls in European countries. Buildings are mainly constructed by non experts and they are still built with traditional and old methods.

The government tends to be more a controller and supervisor than an executer. It tends to prepare facilities such as mortgages and loans for those who want to import and apply new technologies. If some engineers, for instance, intend to build a factory to produce Block & Beam they will make a massive profit; however if they produce light concrete panels instead, it is not guaranteed to make as much profit as before. In this situation the government role is to help and supervise investors in new technologies and building methods from a higher position. Ministry of Housing and Urban Development and also Saderat Bank of Iran are allocating long-term loans with low interest to approved projects which try to import new technologies, materials and methods. There is a special committee which is responsible for evaluation and confirmation or rejection of such projects.

The private sector has always been more important and stronger than the government and in the recent five or six years it has been importing new materials and methods most of which are applied in the building envelop. The reason for this is that the technologies which are applied, for instance, on the building envelope are more visible and attract more attention which may increase their success. However, this movement gradually influence the structure and shifts toward having faster, lighter and more reliable structures. The improvement in structural technologies is not as quick as those materials such as Reflex Glazing, Aluminium Cladding, Spider and such technologies, which are related to the envelope of the building. Yet, this movement will gradually shift all parts of the construction industry. However, this process is a long-term process and the private sector has been more active and effective than the government in this movement.

With regards to technology transfer, the first vision is to assume that the technology is separated from culture and is transferred from a place to another without any unwanted outcomes. In this situation there is not any problem in technology transfer and we should admire that the technology transfer from developed countries to developing countries is easily achievable. The second vision is that the technology is not separated from cultural issues and influences the culture and behaviour of the society. In this case, the process of application of the technology in other countries may not that simple and may be associated with unwanted consequences. However, if technology is modified and adapted to the society's needs, it will not be in contrast with architectural, cultural and traditional values of that society. Therefore, such technologies which answer the emergencies and necessities of the society and are in harmony with our needs would be successfully transferred and applied in our country.

When these technologies and materials are transferred, at the beginning, they would be evaluated and judged based on their economic and performance aspects. If such methods and materials are cost effective, they would be used without any recommendations or encouragements. New methods and materials, however, will not be economic unless they are applied broadly. For instance, Space Frame structures, which are very suitable for public buildings, are more expensive than common and conventional methods. If architects and engineers consider such methods in their projects as much as the manufacturers can reduce the costs, it can obviously be a good replacement for other structures."

With regard to cultural issues he believed that Iran had open minded people and we should not be worried about acceptance of people while technology is applied correctly."

Interview with Mr Ali Abdolalizadeh, Novembre 2007

Mr Abdolalizadeh believed that offsite construction was superior to onsite construction since the accuracy and quality in offsite products were improved. He said that, "there are some restrictions and shortcomings which make it difficult to introduce such methods to the Iranian construction industry. The background and the current situation of Iran with regards to different methods of offsite manufacturing is one of the issues which should be addressed.

Volumetric system does not have a long background in Iran. Mamout Company is the main manufacturer of such systems which was established in the 1970s; however, what they manufacture is more for transportation purposes such as refrigerated containers. There are some other companies which have been established recently among which Gostaresh Sanat Azarbayjan could be mentioned. Volumetric system is mainly used in some rural schools where transportation and access to skilled labour is restricted and it has been successful for such purposes. One of the best ways to advertise such methods is possibly these schools.

Pod systems have been exposed in some building exhibitions but they have not become common in Iran. Our people are used to and believe that bathrooms should be built with tiles and traditional methods. Therefore, if we, for instance, use fibreglass pods, people do not trust them assuming that fibreglass will break easily. If we want to introduce such methods and products in ordinary houses, they will not be accepted easily as people think there are probably some problems with these houses. And if we introduce such products in high class and expensive houses, they will not be accepted as such people prefer very expensive materials and products which may not be feasible.

In fact from four offsite systems which have been discussed in the questionnaire (Panel systems, Volumetric systems, Pods and Hybrid system), the first one (panel system) is the only one which is used in Iran. There are six factories which produce panels but this system is becoming abandoned due to the high weight of products. There are, however, some other systems which are developing and becoming more common such as prefabricated steel frame systems.

Some works have been done during President Khatami's period when Mass Building was defined for the first time in the law and mass builders were supported and granted some facilities. Now we have about 4,000 registered mass builders which are members of the Iranian Society of Mass Housing Builders. However, they are mainly small mass builders who build 50 to 200 units and therefore are not (financially) able to import new technologies.

To import such methods, mass builders should be able to build at least 1000 units. They should also be able to afford advertisement to introduce such new methods, and products, to the society. But, there are only six main developers in Iran among which Ekbatan and Sarmaye Gozari Maskan can be mentioned. At the moment Sarmayeh Gozari Maskan is constructing about 12,000 units and Ekbatan is building about 5,000 units around the country. The rest of mass housing companies produce below 1,000 units per annum and therefore are not able to introduce or import such methods.

During the Third National Developing Plan we started to clarify the definition, advantages and laws of mass building, and began to register and organise mass builders across the country. In the Fourth National Development Plan it was predicted to use the mass building organization to go towards new technologies. Here, I repeat that it is almost impossible to ask and urge small developers to introduce new technologies. The plan was to ask the Iranian Society of Mass Housing Builders to introduce new technologies. This is true that the mass building society was dominated by small builders but if we organize all of them, it would be about 120,000 houses/flats. The plan was to introduce new technologies and methods to all that 120,000 houses or at least to those houses which were constructed by major developers which meant decreasing the (technology) costs.

The new government, however, has other programmes and do not believe in mass building. The policy in the previous government was to allocate land to mass builders not people and housing co-operations unless they were builders themselves. We would ask them to go and buy houses from mass builders since, for example, housing co-operatives of doctors or teachers are not developers and can not build houses. The only thing they can do is to find proper mortgages and mass builders to buy house not to build. But the policy has changed now. One of our problems in construction is that non-experts are building houses. The new government does not believe in mass building policy and their new policy, as mentioned, is to allocate land to housing co-operations who may not be expert in construction.

In my lectures I would discuss that it would be economical for a major developer, who builds, for example, 10,000 houses a year with the average area of 100 square meters, to save one kilogram of steel per square meter which means 1,000 tons of steel across whole projects. It is still economical for them even if they pay the cost of 500 tons of steel for the research purposes. It was discussed that since we do not have such big developers, the society of mass builders could take the responsibility and shares the costs between the members. These were in theory discussed but as the government and the programmes changed, it was stopped in early stages.

Offsite manufacturing has mostly been used in façade systems which are more common and accepted than other systems. However, façade systems have their own problems around the world as the applied materials are changing too frequently. The reason is that the requirements from a facade which are sound and thermal insulation, aesthetic, structural and cost requirements should be satisfied together. However, since the speed of construction is a key issue, in some of our residential towers we are using some sorts of prefabricated systems which are prepared on site. This increases the speed of construction and also helps with structural stability.

Moreover, there have been some efforts toward offsite manufacturing of the Iranian architectural elements such as decorative plasters which were not very successful since the size of buildings are not standard in Iran.

We are sunk in our history. We try to experiment what the others have already tried. I have been engaged with this problem for eight years. Like many other developing countries, our labours in construction section are not educated and classified. In 1995 the Ministry of Labour and Social Affairs was required by law to classify and allocate certificates to all labour employed in construction industry. However, nothing has been done so far and we are still suffering from this problem.

One of the problems in developing countries is the lack of skilled labour in construction industry. Some people say that it is an advantage that labour cost is very low in Iran (20-30 US dollars per day) but I believe that labour cost is too high in Iran. As an example we can compare Peugeot 405 which is produced both in Iran and France. The Iranian one has many problems which are the result of the Iranian cheap labour. The situation is even worse in construction as the most uneducated labour are in this section. This results in disaster as they do not have any basic knowledge in construction and therefore, accuracy and tolerance of 1mm is somehow funny and unacceptable for them.

In short we need to support mass building and mass builders, train engineers and skilled labour and activate the financial system to allocate loans of at least 80% of the costs."

Interview with Mr Mehdi Tafazoli, Novembre 2007

Mr Tafazoli said that the construction industry in Iran was not developed however Iran had exceptional human resources. He said, "30 or 35 years ago Ekbatan residential complex was built in Iran and since then I have not seen any residential complex as good as Ekbatan in terms of quality, technology and city planning in Iran. This to me means being behind the world since Ekbatan was built a long time ago. It was built by the Iranian and international companies. Why did not we learn to repeat such a good example? I think we did have the capability but not the right management and this goes back to the government's involvement and policies. I think that the government has not been successful in its responsibilities.

Technology issues have been neglected for years. Only recently in the Forth National Development Plan, technology issues were discussed quite well but the programme was not followed perfectly since the government changed.

We need to produce about 1,000,000 houses per annum in Iran. This is while experience has proven that it is impossible to produce that many houses by applying traditional methods of construction alone. On the other hand we know that the government does not have the power to invest and build that many houses. Therefore, we need to concentrate on absorbing investments in the housing industry besides technology issues. Talking about my experience in the oil and gas sector, due to some political issues and since the government is the key player in this section, absorbing international investment is restricted. But in my idea the story is completely different in the housing sector since the demand is so high and people, not the government, are the main investors. In fact if we can absorb international investments, technology would automatically be imported.

The current governmental policies such as allocating land to building co-operations to produce 1,500,000 houses was, in my idea, a big mistake. How is it possible to build 1,000,000 houses with building co-operatives (Taavoni Maskan) and without any plans and capital? How can building co-operations without any capital import new technologies? Therefore my conclusion is that this plan will definitely fail and in fact we need to go toward absorbing international investment. There have been, however, some new contracts with some international companies like Malaysian ones to build houses in Iran.

In fact we face serious problems in the housing sector if the government becomes the main investor. The government can not and should not invest in this section. Now about 95% of the houses are built by the private sector.

I have always believed that the housing problems should not be searched in engineering and building performance. The housing problems should be searched in the economy since housing is an economic good. Now with such a sick economy that we have, this good becomes a tool to make as much profit as possible. It is fine if I build houses to make profit but when I see that if I buy a house this year, I can sell it with 40% profit next year, what business is more profitable than this? I am not sure about the number of houses which are empty at the moment but I have heard from a reliable source that about 500,000 houses are empty all around the country from which 350,000 belongs to Tehran. That is a huge number which shows a huge amount of capital is blocked by people who are making profit from it.

The lack of long-term planning is another issue. Culturally, we escape form any planning and we cannot follow programmes. Meanwhile introducing new methods of construction to Iran cannot be the answer of all problems and shortcomings. Housing needs planning. Housing is a package especially in financial and investment issues. New technologies are also necessary in this package. All governments after the Islamic Revolution have been unsuccessful in housing policies.

With regards to building regulations, we have high standard regulations. The problem is that they are not applied correctly and completely in practice. Our controlling system in the construction industry is having serious problems which should be addressed. The problem is also cultural. People are much more concerned about the appearance of the building than its safety and stability issues. However, people are not responsible for such cultural problems and it is the government who should be constant in its policies to inform the society and change the culture. The government's responsibility is not only to spend money and invest in the construction industry. The government's view should change from hardware to software which means that the government should change this situation by using its tools such as the media.

I believe that even right now in Tehran, which is the capital city of Iran, some construction projects are taking place which are using building methods which were used 40 years ago. Such buildings will definitely collapse even if there is an earthquake of 5 on the Richter scale."

Appendix 2

Questionnaire (English Version)

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

The Welsh School of Architecture

Offsite Methods of Construction

Introduction:
Offsite methods of construction are becoming more and more important in the construction and the government is encouraging the industry to apply such methods of construction. Offsite methods are known with different names such as Prefabrication, Offsite Production, and Offsite Manufacturing. Offsite products are manufactured in the factory and transported to site to be assembled. There are different offsite methods of construction which can be divided into four main categories as follows:

1. Panel systems
2. Volumetric systems
3. Hybrid systems
4. Pods

The aim of this questionnaire is to study the current situation of the construction industry and applicability of offsite methods in the UK and Iranian housing industry and to give some guidelines to improve the situation. It should take about 20 minutes to fill in the questionnaire. We would like to thank you in advance for your time.

Instruction:
It is important to answer the questions based on your experience. The aim is to understand whether designers/architects consider the mentioned issues when considering a method of construction or not. Please do not try to choose the right answer. **There is no right or wrong answer.** What is important is the reality of the current situation and what you usually do in practice when considering a method of construction. **Please choose only one answer per question unless indicated otherwise.**

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Section A

1- What criteria do you think about when considering a method of construction?

		Disagree Strongly	Disagree	Neither Agree Nor Disagree	Agree	Agree strongly
1	Previous experience……………………………………	☐	☐	☐	☐	☐
2	Speed of construction…………………………………	☐	☐	☐	☐	☐
3	Total costs………………………………………………	☐	☐	☐	☐	☐
4	Quality of products……………………………………	☐	☐	☐	☐	☐
5	Fewer skilled labour requirement in onsite methods…..	☐	☐	☐	☐	☐
6	Machinery availability………………………………	☐	☐	☐	☐	☐
7	Availability of details/ information……………………	☐	☐	☐	☐	☐
8	Availability of experienced contractors………………	☐	☐	☐	☐	☐
9	Availability of products in the market………………	☐	☐	☐	☐	☐
10	Effects on Design quality……………………………	☐	☐	☐	☐	☐
11	Effects on flexibility………………………………	☐	☐	☐	☐	☐
12	Being fashionable…………………………………	☐	☐	☐	☐	☐
13	Cultural issues / social acceptance……………………	☐	☐	☐	☐	☐
14	Client /costumer preferences …………………………	☐	☐	☐	☐	☐
15	Location of projects…………………………………	☐	☐	☐	☐	☐
16	Contract type………………………………………	☐	☐	☐	☐	☐
17	Size of projects……………………………………	☐	☐	☐	☐	☐
18	Ease of Planning/building approval…………………	☐	☐	☐	☐	☐
19	Climate / weather dependency ……………………	☐	☐	☐	☐	☐
20	Ease of future selling………………………………	☐	☐	☐	☐	☐
21	Governmental support………………………………	☐	☐	☐	☐	☐
22	Aesthetic matters……………………………………	☐	☐	☐	☐	☐
23	Enhanced sound resistance…………………………	☐	☐	☐	☐	☐
24	Enhanced U-Value…………………………………	☐	☐	☐	☐	☐
25	Insurance matters …………………………………	☐	☐	☐	☐	☐
26	Mortgage matters…………………………………	☐	☐	☐	☐	☐
27	Ease of construction (less complicated details)……….	☐	☐	☐	☐	☐
28	Management of Design / construction changes	☐	☐	☐	☐	☐
29	Environmental issues………………………………	☐	☐	☐	☐	☐
30	Health and Safety issues……………………………	☐	☐	☐	☐	☐
31	Resistance in natural disasters (e.g. Earthquake)………………………………	☐	☐	☐	☐	☐

2- In the previous question please select *in order* first to fifth issues which you think are the most important. (Please write the numbers in order) ………………………………………………………………………………

Section B

3- Have you ever applied offsite methods of construction in your projects?

☐ Yes (please go to next question)
☐ No (please go to section C)

2

4- I apply offsite methods of construction because of:

		Disagree Strongly	Disagree	Neither Agree Nor Disagree	Agree	Agree strongly
1	Previous experience	☐	☐	☐	☐	☐
2	Higher speed of construction	☐	☐	☐	☐	☐
3	Reduced total costs	☐	☐	☐	☐	☐
4	Higher quality of products	☐	☐	☐	☐	☐
5	Fewer skilled labour requirement in offsite methods	☐	☐	☐	☐	☐
6	Machinery availability	☐	☐	☐	☐	☐
7	Availability of details/ information	☐	☐	☐	☐	☐
8	Availability of details/ information	☐	☐	☐	☐	☐
9	Availability of offsite products in the market	☐	☐	☐	☐	☐
10	Enhanced design quality	☐	☐	☐	☐	☐
11	Enhanced design flexibility	☐	☐	☐	☐	☐
12	Being modern and fashionable	☐	☐	☐	☐	☐
13	Cultural issues / social acceptance	☐	☐	☐	☐	☐
14	Client /costumer preferences	☐	☐	☐	☐	☐
15	Location of projects	☐	☐	☐	☐	☐
16	Contract type	☐	☐	☐	☐	☐
17	Size of projects	☐	☐	☐	☐	☐
18	Easier Planning approval	☐	☐	☐	☐	☐
19	Less climate / weather dependence	☐	☐	☐	☐	☐
20	Easier future selling	☐	☐	☐	☐	☐
21	Governmental supports	☐	☐	☐	☐	☐
22	Aesthetic matters	☐	☐	☐	☐	☐
23	Enhanced sound resistance	☐	☐	☐	☐	☐
24	Enhanced U-Value	☐	☐	☐	☐	☐
25	Easier Insurance matters	☐	☐	☐	☐	☐
26	More/ easier Mortgage/financial facilities	☐	☐	☐	☐	☐
27	Ease of construction (less complicated details)	☐	☐	☐	☐	☐
28	Design / construction changes are easier to manage	☐	☐	☐	☐	☐
29	Enhanced environmental issues	☐	☐	☐	☐	☐
30	Improved Health and Safety issues	☐	☐	☐	☐	☐
31	Better Resistance in natural disasters (e.g. Earthquake, Storm, Flood)	☐	☐	☐	☐	☐

5- In the previous question please select *in order* first to fifth issues which you think are the most important. (Please write the numbers in order) ……………………………………………………………

6- What kind of offsite methods have you ever used? (Please select all which apply)
☐ 1. Panel system ☐ 2.Volumetric System (Box systems)
☐ 3. Hybrid system (Mix of volumetric and panel system) ☐ 4.Pods
☐ 5. Other (please specify)……………………………………………………………

7- In how many projects have you applied offsite methods / product?
☐ 1-5 ☐ 6-25 ☐ 26-50 ☐ 50+

8- How many of those projects have been housing?
☐ 0 (please go to question 8) ☐ 1-5 ☐ 6-25 ☐ 26-50 ☐ 50+

9- In total what was the approximate proportion of offsite manufacture in your housing projects?
☐ 1-10% ☐ 10-25% ☐ 26-50% ☐ 51-75% ☐ 75-100%

10- What were the main components that were manufactured offsite? (Please select all which apply)
☐ Walls ☐ Floors ☐ Roofs ☐ Pods (Kitchen, Bathrooms) ☐ Volumetric

3

☐ 5. Other (please specify)..

Section C

11- I do not apply offsite methods of construction because of: (please go to section D if you answered section B)

		Disagree Strongly	Disagree	Neither Agree Nor Disagree	Agree	Agree strongly
1	Lack of Previous experience..............................	☐	☐	☐	☐	☐
2	Less Speed of construction..................................	☐	☐	☐	☐	☐
3	Higher Total costs..	☐	☐	☐	☐	☐
4	Decreased quality of products..........................	☐	☐	☐	☐	☐
5	More skilled labour requirement in offsite methods	☐	☐	☐	☐	☐
6	Lack of required Machinery	☐	☐	☐	☐	☐
7	Lack of required details/ information....................	☐	☐	☐	☐	☐
8	Lack of experienced contractors..................	☐	☐	☐	☐	☐
9	Lack of offsite products in the market............	☐	☐	☐	☐	☐
10	Lower Design quality...............................	☐	☐	☐	☐	☐
11	Reduced Design flexibility................................	☐	☐	☐	☐	☐
12	Being unfashionable..	☐	☐	☐	☐	☐
13	Cultural issues / social acceptance issues	☐	☐	☐	☐	☐
14	Client /costumer preferences issues	☐	☐	☐	☐	☐
15	Location of projects...	☐	☐	☐	☐	☐
16	Contract type..	☐	☐	☐	☐	☐
17	Size of projects..	☐	☐	☐	☐	☐
18	Difficulties of Planning/building approval	☐	☐	☐	☐	☐
19	More Climate / weather dependency	☐	☐	☐	☐	☐
20	Future selling problems	☐	☐	☐	☐	☐
21	Lack of Governmental support......................	☐	☐	☐	☐	☐
22	Aesthetic matters..	☐	☐	☐	☐	☐
23	Reduced sound resistance................................	☐	☐	☐	☐	☐
24	Reduced U-Value..	☐	☐	☐	☐	☐
25	Reduced U-Value	☐	☐	☐	☐	☐
26	Mortgage/ financial facilities difficulties	☐	☐	☐	☐	☐
27	Construction complexity (more complicated details)	☐	☐	☐	☐	☐
28	Construction complexity (more complicated details)	☐	☐	☐	☐	☐
29	Environmental issues.......................................	☐	☐	☐	☐	☐
30	Health and Safety issues..................................	☐	☐	☐	☐	☐
31	Less Resistance in natural disasters (e.g. Earthquake)	☐	☐	☐	☐	☐

12- In previous question, please select *in order* first to fifth issues which are the most important. (Please write the numbers in order) ....

13- Would you consider offsite methods if you have the opportunity?

☐ Yes, Definitely ☐ Yes, Maybe ☐ No, I prefer onsite methods

Section D

14- At what stage of a project do you usually think about a construction method?

☐ 1. Appraisal (Feasibility Stage) ☐ 2.Outline proposals (Planning Stage)
☐ 3. Detailed proposals (Building regulations) ☐ 4. Tender Stage
☐ 5. Construction Stage ☐ 6. Other stages (Please indicate)

4

15- At what stage of a project is the construction method usually fixed?

☐ 1. Appraisal (Feasibility Stage) ☐ 2.Outline proposals (Planning Stage)
☐ 3. Detailed proposals (Building regulations) ☐ 4. Tender Stage
☐ 5. Construction Stage ☐ 6. It changes even during construction

16- At what stage of a project do you usually contact a *manufacturer* to ask for advice?

☐ 1. Appraisal (Feasibility Stage) ☐ 2.Outline proposals (Planning Stage)
☐ 3. Detailed proposals (Building regulations) ☐ 4. Tender Stage
☐ 5. Construction Stage ☐ 6. Other stages (Please indicate)

17- At what stage of a project do you usually contact a *contractor* to ask for advice?

☐ 1. Appraisal (Feasibility Stage) ☐ 2.Outline proposals (Planning Stage)
☐ 3. Detailed proposals (Building regulations) ☐ 4. Tender Stage
☐ 5. Construction Stage ☐ 6. Other stages (Please indicate)

18- At what stage of a project do you usually contact an *engineer* to ask for advice?

☐ 1. Appraisal (Feasibility Stage) ☐ 2.Outline proposals (Planning Stage)
☐ 3. Detailed proposals (Building regulations) ☐ 4. Tender Stage
☐ 5. Construction Stage ☐ 6. Other stages (Please indicate)

19- At what stage do all/most key bodies involved in a project (the client, designer, engineer, contractor and manufacturer) meet each other for the first time?

☐ 1. Appraisal (Feasibility Stage) ☐ 2.Outline proposals (Planning Stage)
☐ 3. Detailed proposals (Building regulations) ☐ 4. Tender Stage
☐ 5. Construction Stage ☐ 6. They usually do not have an opportunity to meet each other

20- Who is more influential in decision making for the construction method? (Please rank from (1) Most Influential to (6) Least Influential)

☐ Client
☐ Contractor
☐ Designer/ Architect
☐ Structural Engineer
☐ Manufacturer
☐ QS

Section E

21- What house type do you design more frequently?

☐ 1. Houses ☐ 2. Flats/Apartments ☐ 3. Other (please indicate)

22- What housing project sizes do you design more frequently?

☐ 1-5 units ☐ 5-10 units ☐ 11-50 units ☐ 50 or more units

23- What is the commonest area of houses / flats that you design?

☐ 40-60 m² ☐ 61-80 m² ☐ 81-100 m² ☐ 100+ m²

24- What number of storeys is more available/ common to design in housing projects?

☐ 1-2 ☐ 3-4 ☐ 5-10 ☐ 10+

25- How long does it usually take to get a full planning permission?

☐ Less than one month ☐ One to two months
☐ Two to four months ☐ More than four months (please indicate how long it takes)

Section F

26- How much usually does the design change during a project?

☐ 1. No changes ☐ 2. Few changes
☐ 3. Some changes ☐ 4. Considerable changes

27- At what stage of a project is the design usually fixed?

☐ 1. Appraisal (Feasibility Stage) ☐ 2.Outline proposals (Planning Stage)
☐ 3. Detailed proposals (Building regulations) ☐ 4. Tender Stage
☐ 5. Construction Stage ☐ 6. It changes even during construction

28- If any, at what stage are the changes most common?

☐ 1. Appraisal (Feasibility Stage) ☐ 2. Outline proposals (Planning Stage)

- ☐ 3. Detailed proposals (Building regulations) ☐ 4. Tender Stage
- ☐ 5. Construction Stage ☐ 6. There are no changes

29- Who is usually more responsible for changes? (Please rank in order from (1) Least responsible to (6) Most responsible. Please write the number in provided space)

- ☐ Client
- ☐ Contractor
- ☐ Designer/ Architect
- ☐ Structural Engineer
- ☐ Manufacturer
- ☐ QS

30- What are the most common reasons for changes? (Please rank in order from (1) Least responsible to (7) most responsible. Please write the number in provided space)

- ☐ Cost issues
- ☐ Client preferences
- ☐ Contractor preferences
- ☐ Architectural / Design issues
- ☐ Manufacturers' issues
- ☐ Onsite issues
- ☐ Other (please specify) ....

Section G

31- Please indicate whether you agree or disagree with the following sentences regarding different methods of construction in the UK/Iran.

	Disagree Strongly	Disagree	Neither Agree Nor Disagree	Agree	Agree strongly
I prefer to see an example of a method before using it	☐	☐	☐	☐	☐
Standardization improves the design quality	☐	☐	☐	☐	☐
Standardization improves the construction quality	☐	☐	☐	☐	☐
I prefer to use locally manufactured products	☐	☐	☐	☐	☐
Manufacturers are willing to give out details/information to help me in my job	☐	☐	☐	☐	☐
I think offsite methods of construction are more fashionable	☐	☐	☐	☐	☐
People ask about the method of construction when buying a	☐	☐	☐	☐	☐
People prefer modern looking buildings more than traditional looking ones	☐	☐	☐	☐	☐

Section H

32- Please indicate whether you agree or disagree with the following sentences regarding offsite methods of construction in the UK/Iran.

	Disagree Strongly	Disagree	Neither Agree Nor Disagree	Agree	Agree strongly
Offsite methods are cheaper than onsite methods in total..........	☐	☐	☐	☐	☐
Lifespan of offsite products is longer................................	☐	☐	☐	☐	☐
Offsite methods are faster than onsite methods..................	☐	☐	☐	☐	☐
Offsite methods need more time than traditional ones in design stage	☐	☐	☐	☐	☐
There is enough variety in offsite products in the market	☐	☐	☐	☐	☐
Offsite products have better quality than onsite ones...............	☐	☐	☐	☐	☐
Small builders prefer to apply offsite methods.....................	☐	☐	☐	☐	☐
Major developers prefer to apply offsite methods..................	☐	☐	☐	☐	☐
Offsite methods are compatible with the Building Regulations	☐	☐	☐	☐	☐

Offsite methods are suitable for the Iran climate.....................	☐	☐	☐	☐	☐
Designers need to know more about offsite methods..............	☐	☐	☐	☐	☐
They improve design quality...	☐	☐	☐	☐	☐
They are more complicated than traditional methods...............	☐	☐	☐	☐	☐
There is huge demand for such methods.............................	☐	☐	☐	☐	☐
Current supply can answer the demand	☐	☐	☐	☐	☐
Insurance is a concern in such methods.............................	☐	☐	☐	☐	☐
Mortgage / Financial facilities is a concern in such methods ...	☐	☐	☐	☐	☐
Society is gradually showing more interest in such methods ...	☐	☐	☐	☐	☐
They are becoming more common in housing.....................	☐	☐	☐	☐	☐
It is more difficult to get planning / building permission in offsite methods..	☐	☐	☐	☐	☐
Governmental support is encouraging the construction industry to apply offsite methods...	☐	☐	☐	☐	☐

Section I

Company:

How many staff does your company have?

☐ 1-5 ☐ 6-15 ☐ 16-25 ☐ 25-50 ☐ 50-100 ☐ 100+

Years of experience:

☐ 1-2 ☐ 3-5 ☐ 6-10 ☐ 10+

Job Title: ....

Degree / Qualifications: ....

Please describe in one line your responsibilities:

....

....

Age (optional): ☐ 20-25 ☐ 26-30 ☐ 31-40 ☐ 41-50 ☐ 50+

Sex (optional): ☐ Female ☐ Male

E-mail address: ....

Comments:

....

....

....

....

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....

Please if you would like to know about the results of the questionnaire, contact hashemia@cf.ac.uk after six month.

7

Questionnaire (Farsi Version)

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

The Welsh School of Architecture

روش های پیش ساخته در صنعت ساختمان سازی

مقدمه:

روش های مدرن و پیش ساخته در صنعت ساختمان، در اکثر نقاط دنیا به صورت گسترده ای استفاده می شوند. در روش های پیش ساخته ، قطعات در کارخانه تولید، و سپس به محل پروژه برای نصب منتقل می گردند. روش های پیش ساخته را می توان به چهار گروه عمده تقسیم بندی کرد:

1. پانل سیستم (Panel System)
2. سیستم حجمی(Volumetric System)
3. سیستم آشپز خانه یا حمام پیش ساخته(Pods)
4. سیستم ترکیبی پانل و پاد(Hybrid System)

هدف از تهیه این پرسشنامه مطالعه امکان استفاده از این روش ها در صنعت ساختمان سازی ایران می باشد.

توضیحات:

لطفا سوالات مطرح شده را بر اساس تجربیات شخصی خود پاسخ دهید. در این پرسشنامه هیچ جواب درست یا غلطی وجود ندارد و تنها هدف ، مطالعه شرایط حل حاضر صنعت ساختمان ایران است.

لطفا فقط یک پاسخ برای سوالات چند گزینه ای انتخاب کنید مگر اینکه در سوال غیر از این ذکر شده باشد.

با تشکر صمیمانه از همکاری شما

آرمان هاشمی
دانشجوی دکترای معماری
دانشگاه کاردیف ،
اساتید راهنما: Professor Richard Weston, Mr. Christopher Powell
Email: hashemia@cf.ac.uk

1

بخش الف: انتخاب روش های ساختمانی

1- درانتخاب روش های ساخت چه معیار هایی را معمولا در نظر می گیرید؟ (لطفا شرایط واقعی را در نظر بگیرید و نه شرایط ایده آل را)

		کاملا موافقم	موافقم	نه مخالفم نه موافقم	مخالفم	کامل مخالفم
1	تجربه قبلی (آشنایی با روش)	☐	☐	☐	☐	☐
2	سرعت ساخت	☐	☐	☐	☐	☐
3	قیمت تمام شده..	☐	☐	☐	☐	☐
4	کیفیت محصولات	☐	☐	☐	☐	☐
5	نیاز به کارگر ماهر..	☐	☐	☐	☐	☐
6	در دسترس بودن ماشین آلات مورد نیاز	☐	☐	☐	☐	☐
7	در دسترس بودن محصولات و مواد اولیه مورد نیاز..................	☐	☐	☐	☐	☐
8	وجود جزئیات طراحی و اطلاعات مورد نیاز	☐	☐	☐	☐	☐
9	وجود پیمان کاران با تجربه..	☐	☐	☐	☐	☐
10	تاثیرات بر کیفیت طراحی	☐	☐	☐	☐	☐
11	تاثیرات بر انعطاف پذیری (flexibility) در طراحی	☐	☐	☐	☐	☐
12	مدرن و شیک بودن محصولات..	☐	☐	☐	☐	☐
13	تطابق با مسائل فرهنگی و اجتماعی	☐	☐	☐	☐	☐
14	سلیقه مشتری	☐	☐	☐	☐	☐
15	محل احداث پروژه	☐	☐	☐	☐	☐
16	نوع قرارداد	☐	☐	☐	☐	☐
17	اندازه پروژه	☐	☐	☐	☐	☐
18	تاثیرات بر تهیه پروانه ساخت	☐	☐	☐	☐	☐
19	تاثیر پذیری از آب و هوا و شرایط جغرافیایی	☐	☐	☐	☐	☐
20	فروش در آینده	☐	☐	☐	☐	☐
21	حمایت های دولتی	☐	☐	☐	☐	☐
22	مسائل زیبایی شناسی	☐	☐	☐	☐	☐
23	مسائل مربوط به عایق صوتی	☐	☐	☐	☐	☐
24	مسائل مربوط به عایق حرارتی	☐	☐	☐	☐	☐
25	مسائل مربوط به بیمه..	☐	☐	☐	☐	☐
26	مسائل مربوط به تسهیلات بانکی	☐	☐	☐	☐	☐
27	پیچیدگی روش ساخت(جزئیات ساده تر و آسانی ساخت)	☐	☐	☐	☐	☐
28	مدیریت پروژه در صورت تغییرات در طول طراحی و ساخت	☐	☐	☐	☐	☐
29	تطابق با مسائل زیست محیطی	☐	☐	☐	☐	☐
30	ایمنی در زمان ساخت	☐	☐	☐	☐	☐
31	مقاومت در برابر بلایای طبیعی (زلزله)	☐	☐	☐	☐	☐

2- در سوال قبلی لطفا 5 مورد از مهمترین موارد را به ترتیب اولویت ذکر کنید ....

بخش ب: انتخاب روش های پیش ساخته ساختمانی

3- تا به حال از روش ها و یا قطعات پیش ساخته در ساختمان سازی استفاده کرده اید؟

☐ 1- بلی(لطفا به سوال بعدی رجوع کنید)

☐ 2- خیر (لطفا به بخش ج رجوع کنید)

4-از روش های پیش ساخته به دلایل زیر استفاده می کنم.

		کاملا موافقم	موافقم	نه مخالفم نه موافقم	مخالفم	کامل مخالفم
1	تجربه قبلی	☐	☐	☐	☐	☐
2	سرعت بیشتر ساخت	☐	☐	☐	☐	☐
3	قیمت تمام شده پائین تر	☐	☐	☐	☐	☐
4	کیفیت بالاتر..	☐	☐	☐	☐	☐
5	نیاز کمتر به کارگر ماهر در روش های پیش ساخته	☐	☐	☐	☐	☐

2

		کاملا موافقم	موافقم	نه مخالفم نه موافقم	مخالفم	کامل مخالفم
6	وجود ماشین آلات مورد نیاز	☐	☐	☐	☐	☐
7	وجود جزئیات طراحی و اطلاعات مورد نیاز	☐	☐	☐	☐	☐
8	وجود پیمان کاران با تجربه	☐	☐	☐	☐	☐
9	وجود محصولات پیش ساخته در بازار	☐	☐	☐	☐	☐
10	افزایش کیفیت طراحی	☐	☐	☐	☐	☐
11	افزایش انعطاف پذیری (flexibility) در طراحی	☐	☐	☐	☐	☐
12	مدرن و شیک بودن محصولات..	☐	☐	☐	☐	☐
13	تطابق با مسائل فرهنگی و اجتماعی	☐	☐	☐	☐	☐
14	سلیقه مشتری	☐	☐	☐	☐	☐
15	محل احداث پروژه	☐	☐	☐	☐	☐
16	نوع قرارداد	☐	☐	☐	☐	☐
17	اندازه پروژه	☐	☐	☐	☐	☐
18	تهیه آسانتر پروانه ساخت	☐	☐	☐	☐	☐
19	تاثیر پذیری کمتر از آب و هوا و شرایط جغرافیایی	☐	☐	☐	☐	☐
20	فروش آسانتر در آینده	☐	☐	☐	☐	☐
21	حمایت های دولتی	☐	☐	☐	☐	☐
22	مسائل زیبایی شناسی	☐	☐	☐	☐	☐
23	عایق بهتر صوتی	☐	☐	☐	☐	☐
24	عایق بهترحرارتی	☐	☐	☐	☐	☐
25	بیمه آسانتر	☐	☐	☐	☐	☐
26	تسهیلات بانکی بیشتر..	☐	☐	☐	☐	☐
27	پیچیدگی کمتر(جزئیات ساده تر و آسانی ساخت)	☐	☐	☐	☐	☐
28	مدیریت راحتتر در صورت تغییرات در طول طراحی و ساخت......	☐	☐	☐	☐	☐
29	تطابق با مسائل زیست محیطی	☐	☐	☐	☐	☐
30	ایمنی بیشتر در زمان ساخت	☐	☐	☐	☐	☐
31	مقاومت بالاتر در برابر بلایای طبیعی (زلزه)	☐	☐	☐	☐	☐

5- در سوال قبلی لطفا 5 مورد از مهمترین موارد را به ترتیب اولویت ذکر کنید ....

6- چه نوع از روش های پیش ساخته را تا به حال استفاده کرده اید؟(لطفا همه مواردی را که استفاده کرده اید علامت بزنید)

☐ 1- سیستم پانل(Panel Systems) ☐ 2- سیستم حجمی (مثلا یک خانه پیش ساخته کامل)(Volumetric System)

☐ 3- سیستم آشپز خانه یا حمام پیش ساخته (Pods) ☐ 4- سیستم ترکیبی پانل و پاد(Hybrid system)

☐ 5- روش های دیگر (لطفا نام ببرید)

7- در چه تعداد از پروژه خود از روش های پیش ساخته استفاده کرده اید؟

☐ 1-5 ☐ 6-25 ☐ 26 -50 ☐ 50 +

8- چه تعداد از آن ها پروژه های مسکونی بوده اند؟

☐ 0 (لطفا به سوال 9 رجوع کنید) ☐ 1-5 ☐ 6-25 ☐ 26-50 ☐ 50 +

9- در پروژه های مسکونی شما چند درصد قطعات به صورت پیش ساخته تولید شده اند؟

☐ 1-10% ☐ 10-25% ☐ 26-50% ☐ 51-75% ☐ 75-100%

10- در پروژه های شما چه قطعاتی به صورت پیش ساخته استفاده شده اند؟ (لطفا همه مواردی را که استفاده شده اند را علامت بزنید)

☐ دیوار ها ☐ کف ☐ سقف ☐ آشپز خانه / حمام ☐کل یک اتاق یا خانه

بخش ج: انتخاب روش های رایج ساختمانی

در صورتی که به سوال 3 پاسخ داده اید لطفا به سوال 14 مراجعه کنید

11- از روش های پیش ساخته به دلایل زیر استفاده نمی کنم.

		کاملا موافقم	موافقم	نه مخالفم نه موافقم	مخالفم	کامل مخالفم
1	نداشتن تجربه قبلی (عدم آشنایی با روش های پیش ساخته)	☐	☐	☐	☐	☐
2	سرعت کمتر ساخت	☐	☐	☐	☐	☐
3	قیمت تمام شده بالاتر..	☐	☐	☐	☐	☐
4	کیفیت ساخت پایین تر..	☐	☐	☐	☐	☐
5	نیاز بیشتر به کارگر ماهر در روش های پیش ساخته	☐	☐	☐	☐	☐

3

		کاملا موافقم	موافقم	نه مخالفم نه موافقم	مخالفم	کاملا مخالفم
6	عدم وجود ماشین آلات مورد نیاز	☐	☐	☐	☐	☐
7	عدم وجود جزئیات طراحی و اطلاعات مورد نیاز	☐	☐	☐	☐	☐
8	عدم وجود پیمان کاران با تجربه	☐	☐	☐	☐	☐
9	عدم وجود محصولات پیش ساخته در بازار	☐	☐	☐	☐	☐
10	کاهش کیفیت طراحی	☐	☐	☐	☐	☐
11	کاهش انعطاف پذیری (flexibility) در طراحی	☐	☐	☐	☐	☐
12	عدم مدرن و شیک بودن محصولات	☐	☐	☐	☐	☐
13	عدم تطابق با مسائل فر هنگی و اجتماعی	☐	☐	☐	☐	☐
14	عدم تطابق با سلیقه مشتری	☐	☐	☐	☐	☐
15	مشکلات مربوط به محل احداث پروژه......................................	☐	☐	☐	☐	☐
16	نوع قرارداد	☐	☐	☐	☐	☐
17	اندازه پروژه	☐	☐	☐	☐	☐
18	تهیه سخت تر پروانه ساخت	☐	☐	☐	☐	☐
19	تاثیر پذیری بیشتر از آب و هوا و شرایط جغرافیایی	☐	☐	☐	☐	☐
20	فروش سخت تر در آینده	☐	☐	☐	☐	☐
21	عدم حمایت های دولتی	☐	☐	☐	☐	☐
22	مسائل زیبایی شناسی	☐	☐	☐	☐	☐
23	مسائل مربوط به عایق صوتی	☐	☐	☐	☐	☐
24	مسائل مربوط به عایق حرارتی	☐	☐	☐	☐	☐
25	بیمه سخت تر	☐	☐	☐	☐	☐
26	مشکلات مربوط به تسهیلات بانکی	☐	☐	☐	☐	☐
27	پیچیدگی بیشتر(جزئیات بیشتر ومشکلات ساخت)	☐	☐	☐	☐	☐
28	مدیریت پیچیده تر در صورت تغییرات در طول طراحی و ساخت ...	☐	☐	☐	☐	☐
29	عدم تطابق با مسائل زیست محیطی	☐	☐	☐	☐	☐
30	ایمنی کمتر در زمان ساخت	☐	☐	☐	☐	☐
31	مقاومت پائین تر در برابر بلایای طبیعی (زلزله)	☐	☐	☐	☐	☐

12- در سوال قبلی لطفا 5 مورد از مهمترین موارد را به ترتیب اولویت ذکر کنید ....

13 آیا از روش های پیش ساخته در صورت فراهم بودن موقعیت استفاده خواهید کرد؟

☐ 1- بله, حتما ☐ 2- بله شاید ☐ 3- خیر روش های متداول را ترجیح می دهم

بخش د: روند انتخاب روش های ساختمانی

14-در چه مرحله ای از انجام یک پروژه به روش ساخت فکر می کنید؟

☐ 1- فاز 0 (مطالعات) ☐ 2- فاز 1 (طراحی اولیه)
☐ 3- فاز 2 (نقشه های اجرایی) ☐ 4- مرحله مناقصه
☐ 5- فاز 3 (ساخت) ☐ 6- سایر مراحل (لطفا توضیح دهید)

15-در چه مرحله ای از انجام یک پروژه روش ساخت ثابت شده و دیگر تغییر نمی کند ؟

☐ 1- فاز 0 (مطالعات) ☐ 2- فاز 1 (طراحی اولیه)
☐ 3- فاز 2 (نقشه های اجرایی) ☐ 4- مرحله مناقصه
☐ 5- فاز 3 (ساخت) ☐ 6- حتی در زمان اجرای پروژه تغییرات حادث می شود

16-در چه مرحله ای از انجام یک پروژه معمولا با تولید کننده جهت مشورت و گرفتن اطلاعات تماس می گیرید؟

☐ 1- فاز 0 (مطالعات) ☐ 2- فاز 1 (طراحی اولیه)
☐ 3- فاز 2 (نقشه های اجرایی) ☐ 4- مرحله مناقصه
☐ 5- فاز 3 (ساخت) ☐ 6- سایر مراحل (لطفا توضیح دهید)

17-در چه مرحله ای از انجام یک پروژه معمولا با پیمان کار جهت مشورت و گرفتن اطلاعات تماس می گیرید؟

☐ 1- فاز 0 (مطالعات) ☐ 2- فاز 1 (طراحی اولیه)
☐ 3- فاز 2 (نقشه های اجرایی) ☐ 4- مرحله مناقصه
☐ 5- فاز 3 (ساخت) ☐ 6- سایر مراحل (لطفا توضیح دهید)

18-در چه مرحله ای از انجام یک پروژه معمولا با مهندس سازه جهت مشورت و گرفتن اطلاعات تماس می گیرید؟
- ☐ 1- فاز 0 (مطالعات)
- ☐ 2- فاز 1 (طراحی اولیه)
- ☐ 3- فاز 2 (نقشه های اجرایی)
- ☐ 4- مرحله مناقصه
- ☐ 5- فاز 3 (ساخت)
- ☐ 6- سایر مراحل (لطفا توضیح دهید)

19-در چه مرحله ای از انجام یک پروژه تمامی افراد مرتبط با پرژه (کارفرما / پیمان کار/ مهندس سازه و معمار و ...) با یکدیگر ملاقات می کنند؟
- ☐ 1 - فاز 0 (مطالعات)
- ☐ 2- فاز 1 (طراحی اولیه)
- ☐ 3- فاز 2 (نقشه های اجرایی)
- ☐ 4- مرحله مناقصه
- ☐ 5- فاز 3 (ساخت)
- ☐ 6- معمولا هیچ وقت چنین امکانی وجود ندارد

20-چه کسی بیشترین تاثیر را در انتخاب روش ساخت دارد (لطفا به ترتیب اهمیت از 1 (موثرترین) تا 6 (کم اثرترین) لیست کنید)
- ☐ کار فرما
- ☐ پیمانکار
- ☐ طراح (آرشیتکت)
- ☐ مهندس سازه
- ☐ تولید کننده
- ☐ مترور (بخش متره برآورد)

بخش ه: انواع پروژه های ساختمانی

21 ساختمان هایی مسکونی که طراحی می کنید معمولا از چه نوعی هستند؟
- ☐ 1- ساختمان های تک واحدی
- ☐ 2- آپارتمان
- ☐ 3- غیره (لطفا توضیح دهید)

22- ساختمان هایی مسکونی که طراحی می کنید معمولا از نظر تعداد واحد در کدام مجموعه قرار می گیرند
- ☐ 1-5 واحد
- ☐ 6 -10 واحد
- ☐ 10-50 واحد
- ☐ بیشتر از 50 واحد

23-ساختمان هایی مسکونی که طراحی می کنید معمولا از نظر مساحت زیر بنا در کدام مجموعه قرار می گیرند؟
- ☐ 40-60 m²
- ☐ 61-80 m²
- ☐ 81-100 m²
- ☐ + 100m²

24-ساختمان هایی مسکونی که طراحی می کنید معمولا از نظر تعداد طبقات در کدام مجموعه قرار می گیرند؟
- ☐ 1-2 طبقه
- ☐ 3-4 طبقه
- ☐ 5-10 طبقه
- ☐ بیشتر از 10 طبقه

25-چه مدت طول می کشد تا اجازه ساخت ساختمان هایی مسکونی گرفته شود؟
- ☐ کمتر از 1ماه
- ☐ 1 تا 2 ماه
- ☐ 2 تا 4 ماه
- ☐ بیشتر از 4 ماه (لطفا مشخص کنید چند ماه طول می کشد) ..... ماه

بخش و: تغییرات در ساختمان

26- معمولا طراحی در طول اجرای پروژه چقدر تغییر می کند؟
- ☐ 1- تغییری نمی کند
- ☐ 2- تغییرات جزیی
- ☐ 3- تغییرات زیاد
- ☐ 4- تغییرات خیلی زیاد

27-درچه مرحله ای از اجرای پروژه طراحی دیگر تغییر نمی کند؟
- ☐ 1 - فاز 0 (مطالعات)
- ☐ 2- فاز 1 (طراحی اولیه)
- ☐ 3- فاز 2 (نقشه های اجرایی)
- ☐ 4- مرحله مناقصه
- ☐ 5- فاز 3 (ساخت)
- ☐ 6- تغییرات حتی در زمان اجرا صورت می گیرد

28- درچه مرحله ای از اجرای پروژه بیشترین تغییرات در طراحی صورت می گیرد؟
- ☐ 1 - فاز 0 (مطالعات)
- ☐ 2- فاز 1 (طراحی اولیه)
- ☐ 3- فاز 2 (نقشه های اجرایی)
- ☐ 4- مرحله مناقصه
- ☐ 5- فاز 3 (ساخت)
- ☐ 6- تغییری صورت نمی گیرد

29- چه کسی در طول اجرای یک پروژه مسول بیشترین تغییرات است؟ ((لطفا به ترتیب از 1 (بیشترین مسولیت) تا 6 (کمترین مسولیت) لیست کنید)
- ☐ کار فرما
- ☐ پیمانکار
- ☐ طراح (آرشیتکت)
- ☐ مهندس سازه
- ☐ تولید کننده
- ☐ مترور (بخش متره برآورد)

30-مهمترین دلایل تغییرات چیست؟ (لطفا به ترتیب اهمیت از 1 (مهم ترین دلیل) تا 6 (کم اهمیت ترین دلیل) لیست کنید)
- ☐ مسایل مالی
- ☐ سلیقه کارفرما
- ☐ سلیقه پیمانکار
- ☐ سلیقه طراح (آرشیتکت)
- ☐ سلیقه تولید کننده
- ☐ مسایل مربوط به اجرا حین ساخت
- ☐ سایر موارد (لطفا مشخص کنید)

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بخش ز : سوالات کلی

31- لطفا نظر خود را در مورد روش های مختلف ساخت در ایران بیان کنید.

		کاملا موافقم	موافقم	نه مخالفم نه موافقم	مخالفم	کامل مخالفم
1	من ترجیح می دهم از روشی استفاده کنم که قبلا امتحان شده و تمامی جوانب آن بررسی شده است......	☐	☐	☐	☐	☐
2	استاندارد کردن اندازه قطعات باعث افزایش کیفیت طراحی می شود	☐	☐	☐	☐	☐
3	استاندارد کردن اندازه قطعات باعث افزایش کیفیت ساخت می شود	☐	☐	☐	☐	☐
4	من ترجیح می دهم از محصولت تولید داخل به جای محصولات خارجی استفاده کنم	☐	☐	☐	☐	☐
5	تولید کنندگان و فروشندگان معمولا جزئیات طراحی و اطلاعات مورد نیاز را جهت آسانی کار طراحان ارائه می دهند	☐	☐	☐	☐	☐
6	به نظر من محصولات روش های جدید ساختمانی شیکترند....................	☐	☐	☐	☐	☐
7	مردم در مورد روش ساخت ساختمان هنگام خرید سوال می کنند............	☐	☐	☐	☐	☐
8	مردم ساختمان های مسکونی با نمای مدرن را به ساختمان های مسکونی با نمای متداول ترجیح می دهند(استفاده از محصولات جدید در نمای ساختمان به جای محصولات متداول مثل سنگ و آجر	☐	☐	☐	☐	☐

بخش ک : روش های پیش ساخته

32- لطفا نظر خود را در مورد روش های پیش ساخته در ایران بیان کنید.

		کاملا موافقم	موافقم	نه مخالفم نه موافقم	مخالفم	کامل مخالفم
1	در مجموع روش های پیش ساخته ارزانتر از روش های متداول ساختمانی هستند	☐	☐	☐	☐	☐
2	طول عمر مفید محصولات پیش ساخته بیشتر است	☐	☐	☐	☐	☐
3	روش های پیش ساخته از روش های متداول ساختمانی سریعترند..........	☐	☐	☐	☐	☐
4	روش ها پیش ساخته نیاز به صرف وقت بیشتری در مرحله طراحی دارند..	☐	☐	☐	☐	☐
5	محصولات پیش ساخته موجود در بازار به اندازه کافی متنو ع نیستند........	☐	☐	☐	☐	☐
6	محصولات پیش ساخته کیفیت بهتری نسبت به محصولات متداول دارند..	☐	☐	☐	☐	☐
7	پیمانکاران کوچک استفاده از روش های پیش ساخته را ترجیح می دهند..	☐	☐	☐	☐	☐
8	پیمانکاران عمده استفاده از روش های پیش ساخته را ترجیح می دهند	☐	☐	☐	☐	☐
9	روش های پیش ساخته با قوانین و مقررات ساختمانی مطابقت دارند.........	☐	☐	☐	☐	☐
10	روش های پیش ساخته با شرایط آب و هوایی ایران مطابقت دارند	☐	☐	☐	☐	☐
12	طراحان نیاز دارند تا روش های پیش ساخته را بهتر بشناسند.............	☐	☐	☐	☐	☐
13	این روش ها کیفیت طراحی را با لا تر می برد..................................	☐	☐	☐	☐	☐
14	این روش ها از روش های متداول پیچیده ترند.................................	☐	☐	☐	☐	☐
15	تقاضای زیادی برای روش ها و محصولات پیش ساخته وجود دارد.........	☐	☐	☐	☐	☐
16	عرضه محصولات پیش ساخته توانایی پسخ گویی به تقاضای موجود را دارد..	☐	☐	☐	☐	☐
17	مسایل بیمه ساختمان یکی از موانع موجود بر سر راه گسترش روش های پیش ساخته هستند...	☐	☐	☐	☐	☐
18	مسایل مربوط به ارائه تسهیلات بانکی یکی از موانع موجود بر سر راه گسترش روش های پیش ساخته هستند....................................	☐	☐	☐	☐	☐
19	جامعه به تدریج تمایل بیشتری به استفاده از این روش ها نشان می دهد......	☐	☐	☐	☐	☐
20	روش های پیش ساخته به تدریج در حال متداول شدن در صنعت ساختمان هستند..	☐	☐	☐	☐	☐
21	گرفتن مجوز های ساختمانی در این روش ها سخت تر هستند.................	☐	☐	☐	☐	☐
22	حمایت های دولتی در ترغیب صنعت ساختمان به استفاده از روش های جدید ساخت موثربوده اند....	☐	☐	☐	☐	☐

بخش ل: طبقه بندی

سوالات این بخش صرفا جهت طبقه بندی پرسشنامه ها می باشد. با تشکر فراوان از همکاری شما.

نام شرکت:

شرکت شما چه تعداد کارمند دارد؟

☐ 1-5 ☐ 6 -15 ☐ 16 -25 ☐ 26 -50 ☐ 51 -100 ☐ 100+

چند سال سابقه کار دارید؟

☐ 1-2 ☐ 3-5 ☐ 6-10 ☐ 10+

عنوان شغلی شما : ....

مدرک تحصیلی شما : ....

لطفا وظایف خود را در شرکت به صورت مختصر بیان کنید:

....
....
....
....

سن: ☐ 20 -25 ☐ 26-30 ☐ 31- 40 ☐ 41-50 ☐ 50+

جنسیت : ☐ زن ☐ مرد

آدرس ایمیل (E-mail): ....

اگر نظر خاصی در مورد قسمت های مختلف این پرسشنامه یا سایر موارد دارید لطفا بیان فرمایید:

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لطفا در صورت تمایل جهت آگاهی از نتایج این پرسشنامه با ایمیل hashemia@cf.ac.uk پس از شش ماه تماس حاصل فرمایید.

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Appendix 3 (Questionnaire results)

Question 1

Previous experience

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	4	4.5	4.6	2.0	9.2
	Neither Agree Nor Disagree	13	14.8	14.9	3.0	44.8
	Agree	53	60.2	60.9	4.0	243.7
	Agree strongly	17	19.3	19.5	5.0	97.7
	Total	87	98.9	100.0		
Missing	999	1	1.1			
Total		88	100.0			395.4

Speed of construction

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	1.1	1.1	1.0	1.1
	Disagree	2	2.3	2.3	2.0	4.5
	Neither Agree Nor Disagree	8	9.1	9.1	3.0	27.3
	Agree	42	47.7	47.7	4.0	190.9
	Agree strongly	35	39.8	39.8	5.0	198.9
	Total	88	100.0	100.0		422.7

Total costs

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	1.1	1.2	1.0	1.2
	Disagree	2	2.3	2.3	2.0	4.7
	Neither Agree Nor Disagree	13	14.8	15.1	3.0	45.3
	Agree	46	52.3	53.5	4.0	214.0
	Agree strongly	24	27.3	27.9	5.0	139.5
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			404.7

Quality of products

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	3	3.4	3.5	2.0	7.0
	Neither Agree Nor Disagree	2	2.3	2.3	3.0	7.0
	Agree	32	36.4	37.2	4.0	148.8
	Agree strongly	49	55.7	57.0	5.0	284.9
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			447.7

skilled labour requirement

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	3	3.4	3.6	2.0	7.2
	Neither Agree Nor Disagree	11	12.5	13.3	3.0	39.8
	Agree	34	38.6	41.0	4.0	163.9
	Agree strongly	35	39.8	42.2	5.0	210.8
	Total	83	94.3	100.0		
Missing	999	5	5.7			
Total		88	100.0			421.7

Machinery availability

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	3	3.4	3.7	2.0	7.3
	Neither Agree Nor Disagree	11	12.5	13.4	3.0	40.2
	Agree	35	39.8	42.7	4.0	170.7
	Agree strongly	33	37.5	40.2	5.0	201.2
	Total	82	93.2	100.0		
Missing	999	5	5.7			
	System	1	1.1			
	Total	6	6.8			
Total		88	100.0			419.5

Availability of products and raw materials

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	2	2.3	2.4	2.0	4.8
	Neither Agree Nor Disagree	11	12.5	13.1	3.0	39.3
	Agree	44	50.0	52.4	4.0	209.5
	Agree strongly	27	30.7	32.1	5.0	160.7
	Total	84	95.5	100.0		
Missing	999	3	3.4			
	System	1	1.1			
	Total	4	4.5			
Total		88	100.0			414.3

Availability of details/ information

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	1.1	1.2	1.0	1.2
	Disagree	4	4.5	4.7	2.0	9.3
	Neither Agree Nor Disagree	15	17.0	17.4	3.0	52.3
	Agree	29	33.0	33.7	4.0	134.9
	Agree strongly	37	42.0	43.0	5.0	215.1
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			412.8

Availability of experienced contractors

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	1.1	1.2	1.0	1.2
	Disagree	3	3.4	3.5	2.0	7.1
	Neither Agree Nor Disagree	10	11.4	11.8	3.0	35.3
	Agree	38	43.2	44.7	4.0	178.8
	Agree strongly	33	37.5	38.8	5.0	194.1
	Total	85	96.6	100.0		
Missing	999	3	3.4			
Total		88	100.0			416.5

Effects on design quality

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	1.1	1.2	1.0	1.2
	Disagree	2	2.3	2.4	2.0	4.7
	Neither Agree Nor Disagree	11	12.5	12.9	3.0	38.8
	Agree	35	39.8	41.2	4.0	164.7
	Agree strongly	36	40.9	42.4	5.0	211.8
	Total	85	96.6	100.0		
Missing	999	3	3.4			
Total		88	100.0			421.2

Effects on flexibility

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	7	8.0	8.4	2.0	16.9
	Neither Agree Nor Disagree	14	15.9	16.9	3.0	50.6
	Agree	38	43.2	45.8	4.0	183.1
	Agree strongly	24	27.3	28.9	5.0	144.6
	Total	83	94.3	100.0		
Missing	999	5	5.7			
Total		88	100.0			395.2

Being modern and fashionable

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	9	10.2	10.5	2.0	20.9
	Neither Agree Nor Disagree	19	21.6	22.1	3.0	66.3
	Agree	30	34.1	34.9	4.0	139.5
	Agree strongly	28	31.8	32.6	5.0	162.8
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			389.5

Cultural issues / social acceptance

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	3	3.4	3.5	1.0	3.5
	Disagree	12	13.6	14.1	2.0	28.2
	Neither Agree Nor Disagree	29	33.0	34.1	3.0	102.4
	Agree	26	29.5	30.6	4.0	122.4
	Agree strongly	15	17.0	17.6	5.0	88.2
	Total	85	96.6	100.0		
Missing	999	3	3.4			
Total		88	100.0			344.7

Client /costumer preferences

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	1.1	1.2	1.0	1.2
	Disagree	11	12.5	12.8	2.0	25.6
	Neither Agree Nor Disagree	32	36.4	37.2	3.0	111.6
	Agree	31	35.2	36.0	4.0	144.2
	Agree strongly	11	12.5	12.8	5.0	64.0
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			346.5

Location of projects

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	1.1	1.2	1.0	1.2
	Disagree	3	3.4	3.5	2.0	7.0
	Neither Agree Nor Disagree	15	17.0	17.4	3.0	52.3
	Agree	45	51.1	52.3	4.0	209.3
	Agree strongly	22	25.0	25.6	5.0	127.9
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			397.7

Contract type

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	16	18.2	18.6	2.0	37.2
	Neither Agree Nor Disagree	26	29.5	30.2	3.0	90.7
	Agree	33	37.5	38.4	4.0	153.5
	Agree strongly	11	12.5	12.8	5.0	64.0
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			345.3

Size of projects

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	1.1	1.2	1.0	1.2
	Disagree	7	8.0	8.3	2.0	16.7
	Neither Agree Nor Disagree	18	20.5	21.4	3.0	64.3
	Agree	36	40.9	42.9	4.0	171.4
	Agree strongly	22	25.0	26.2	5.0	131.0
	Total	84	95.5	100.0		
Missing	999	4	4.5			
Total		88	100.0			384.5

Ease of Planning/building approval

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	9	10.2	10.8	1.0	10.8
	Disagree	10	11.4	12.0	2.0	24.1
	Neither Agree Nor Disagree	39	44.3	47.0	3.0	141.0
	Agree	21	23.9	25.3	4.0	101.2
	Agree strongly	4	4.5	4.8	5.0	24.1
	Total	83	94.3	100.0		
Missing	999	5	5.7			
Total		88	100.0			301.2

Climate / weather dependency

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	1.1	1.2	1.0	1.2
	Disagree	4	4.5	4.7	2.0	9.3
	Neither Agree Nor Disagree	12	13.6	14.0	3.0	41.9
	Agree	41	46.6	47.7	4.0	190.7
	Agree strongly	28	31.8	32.6	5.0	162.8
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			405.8

Ease of future selling

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	2.3	2.3	1.0	2.3
	Disagree	14	15.9	16.1	2.0	32.2
	Neither Agree Nor Disagree	24	27.3	27.6	3.0	82.8
	Agree	37	42.0	42.5	4.0	170.1
	Agree strongly	10	11.4	11.5	5.0	57.5
	Total	87	98.9	100.0		
Missing	999	1	1.1			
Total		88	100.0			344.8

Governmental support

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	6	6.8	7.4	1.0	7.4
	Disagree	12	13.6	14.8	2.0	29.6
	Neither Agree Nor Disagree	37	42.0	45.7	3.0	137.0
	Agree	19	21.6	23.5	4.0	93.8
	Agree strongly	7	8.0	8.6	5.0	43.2
	Total	81	92.0	100.0		
Missing	999	6	6.8			
	System	1	1.1			
	Total	7	8.0			
Total		88	100.0			311.1

Aesthetic matters

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	4	4.5	4.6	2.0	9.2
	Neither Agree Nor Disagree	9	10.2	10.3	3.0	31.0
	Agree	28	31.8	32.2	4.0	128.7
	Agree strongly	46	52.3	52.9	5.0	264.4
	Total	87	98.9	100.0		
Missing	999	1	1.1			
Total		88	100.0			433.3

Enhanced sound resistance

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	1	1.1	1.1	2.0	2.3
	Neither Agree Nor Disagree	9	10.2	10.3	3.0	31.0
	Agree	45	51.1	51.7	4.0	206.9
	Agree strongly	32	36.4	36.8	5.0	183.9
	Total	87	98.9	100.0		
Missing	999	1	1.1			
Total		88	100.0			424.1

Enhanced U-Value

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	1.1	1.2	1.0	1.2
	Neither Agree Nor Disagree	10	11.4	11.6	3.0	34.9
	Agree	40	45.5	46.5	4.0	186.0
	Agree strongly	35	39.8	40.7	5.0	203.5
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			425.6

Insurance matters

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	5	5.7	5.9	1.0	5.9
	Disagree	5	5.7	5.9	2.0	11.8
	Neither Agree Nor Disagree	33	37.5	38.8	3.0	116.5
	Agree	33	37.5	38.8	4.0	155.3
	Agree strongly	9	10.2	10.6	5.0	52.9
	Total	85	96.6	100.0		
Missing	999	3	3.4			
Total		88	100.0			342.4

Mortgage matters

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	3	3.4	3.5	1.0	3.5
	Disagree	10	11.4	11.6	2.0	23.3
	Neither Agree Nor Disagree	42	47.7	48.8	3.0	146.5
	Agree	24	27.3	27.9	4.0	111.6
	Agree strongly	7	8.0	8.1	5.0	40.7
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			325.6

Ease of construction (less complicated details)

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	4	4.5	4.7	2.0	9.4
	Neither Agree Nor Disagree	13	14.8	15.3	3.0	45.9
	Agree	39	44.3	45.9	4.0	183.5
	Agree strongly	29	33.0	34.1	5.0	170.6
	Total	85	96.6	100.0		
Missing	999	3	3.4			
Total		88	100.0			409.4

Management of Design / construction changes

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	2.3	2.4	1.0	2.4
	Disagree	1	1.1	1.2	2.0	2.4
	Neither Agree Nor Disagree	23	26.1	27.1	3.0	81.2
	Agree	39	44.3	45.9	4.0	183.5
	Agree strongly	20	22.7	23.5	5.0	117.6
	Total	85	96.6	100.0		
Missing	999	3	3.4			
Total		88	100.0			387.1

Environmental issues

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	3	3.4	3.5	2.0	7.1
	Neither Agree Nor Disagree	19	21.6	22.4	3.0	67.1
	Agree	34	38.6	40.0	4.0	160.0
	Agree strongly	29	33.0	34.1	5.0	170.6
	Total	85	96.6	100.0		
Missing	999	3	3.4			
Total		88	100.0			404.7

Health and Safety issues

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Neither Agree Nor Disagree	16	18.2	18.6	3.0	55.8
	Agree	41	46.6	47.7	4.0	190.7
	Agree strongly	29	33.0	33.7	5.0	168.6
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			415.1

Resistance in natural disasters (e.g. Earthquake)

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	1	1.1	1.2	2.0	2.3
	Neither Agree Nor Disagree	11	12.5	12.8	3.0	38.4
	Agree	28	31.8	32.6	4.0	130.2
	Agree strongly	46	52.3	53.5	5.0	267.4
	Total	86	97.7	100.0		
Missing	999	2	2.3			
Total		88	100.0			438.4

Variable	Valid	Missing	Mean	Median	Mode	Variance	Sum	Valid percentage * Likert Scale
Quality of products	86	2	4.4767	5	5	0.5112	385	447.7
Resistance in natural disasters (e.g. Earthquake)	86	2	4.3837	5	5	0.5687	377	438.4
Aesthetic matters	87	1	4.3333	5	5	0.7132	377	433.3
Enhanced U-Value	86	2	4.2558	4	4	0.5691	366	425.6
Enhanced sound resistance	87	1	4.2414	4	4	0.4643	369	424.1
Speed of construction	88	0	4.2273	4	4	0.6374	372	422.7
skilled labour requirement	83	5	4.2169	4	5	0.6597	350	421.7
Effects on design quality	85	3	4.2118	4	5	0.7165	358	421.2
Machinery availability	82	6	4.1951	4	4	0.6528	344	419.5
Availability of experienced contractors	85	3	4.1647	4	4	0.7345	354	416.5
Health and Safety issues	86	2	4.1512	4	4	0.5063	357	415.1
Availability of products and rau materials	84	4	4.1429	4	4	0.5336	348	414.3
Availability of details/ information	86	2	4.1279	4	5	0.8893	355	412.8
Ease of construction (less complicated details)	85	3	4.0941	4	4	0.6815	348	409.4
Climate / weather dependency	86	2	4.0581	4	4	0.7613	349	405.8
Total costs	86	2	4.0465	4	4	0.6331	348	404.7
Environmental issues	85	3	4.0471	4	4	0.7120	344	404.7
Location of projects	86	2	3.9767	4	4	0.6818	342	397.7
Previous experience	87	1	3.9540	4	4	0.5327	344	395.4
Effects on flexibility	83	5	3.9518	4	4	0.8025	328	395.2
Being modern and fashionable	86	2	3.8953	4	4	0.9654	335	389.5
Management of Design / construction changes	85	3	3.8706	4	4	0.7569	329	387.1
Size of projects	84	4	3.8452	4	4	0.9035	323	384.5
Client /costumer preferences	86	2	3.4651	3	3	0.8399	298	346.5
Contract type	86	2	3.4535	4	4	0.8860	297	345.3
Ease of future selling	87	1	3.4483	4	4	0.9479	300	344.8
Cultural issues / social acceptance	85	3	3.4471	3	3	1.1073	293	344.7
Insurance matters	85	3	3.4235	3	3	0.9375	291	342.4
Mortgage matters	86	2	3.2558	3	3	0.8044	280	325.6
Governmental support	81	7	3.1111	3	3	1.0250	252	311.1
Ease of Planning/building approval	83	5	3.0120	3	3	1.0120	250	301.2

Question 2

Qestion2-First

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	5.0	5.7	7.4	7.4
	2.0	23.0	26.1	33.8	41.2
	3.0	2.0	2.3	2.9	44.1
	4.0	10.0	11.4	14.7	58.8
	5.0	2.0	2.3	2.9	61.8
	8.0	1.0	1.1	1.5	63.2
	9.0	2.0	2.3	2.9	66.2
	10.0	2.0	2.3	2.9	69.1
	11.0	2.0	2.3	2.9	72.1
	13.0	3.0	3.4	4.4	76.5
	15.0	2.0	2.3	2.9	79.4
	17.0	3.0	3.4	4.4	83.8
	19.0	1.0	1.1	1.5	85.3
	22.0	3.0	3.4	4.4	89.7
	23.0	1.0	1.1	1.5	91.2
	27.0	1.0	1.1	1.5	92.6
	29.0	1.0	1.1	1.5	94.1
	31.0	4.0	4.5	5.9	100.0
	Total	68.0	77.3	100.0	
Missing	999.0	20.0	22.7		
Total		88.0	100.0		

Question2-Second

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	3.0	3.4	4.4	4.4
	2.0	5.0	5.7	7.4	11.8
	3.0	15.0	17.0	22.1	33.8
	4.0	5.0	5.7	7.4	41.2
	5.0	3.0	3.4	4.4	45.6
	6.0	2.0	2.3	2.9	48.5
	7.0	1.0	1.1	1.5	50.0
	8.0	1.0	1.1	1.5	51.5
	9.0	2.0	2.3	2.9	54.4
	10.0	4.0	4.5	5.9	60.3
	12.0	2.0	2.3	2.9	63.2
	13.0	3.0	3.4	4.4	67.6
	14.0	1.0	1.1	1.5	69.1
	15.0	3.0	3.4	4.4	73.5
	17.0	2.0	2.3	2.9	76.5
	19.0	3.0	3.4	4.4	80.9
	22.0	4.0	4.5	5.9	86.8
	23.0	2.0	2.3	2.9	89.7
	24.0	1.0	1.1	1.5	91.2
	29.0	1.0	1.1	1.5	92.6
	30.0	3.0	3.4	4.4	97.1
	31.0	2.0	2.3	2.9	100.0
	Total	68.0	77.3	100.0	
Missing	999.0	20.0	22.7		
Total		88.0	100.0		

Question2-Third

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	2.0	2.3	2.9	2.9
	2.0	3.0	3.4	4.4	7.4
	3.0	4.0	4.5	5.9	13.2
	4.0	10.0	11.4	14.7	27.9
	5.0	2.0	2.3	2.9	30.9
	6.0	1.0	1.1	1.5	32.4
	7.0	4.0	4.5	5.9	38.2
	8.0	2.0	2.3	2.9	41.2
	9.0	2.0	2.3	2.9	44.1
	10.0	3.0	3.4	4.4	48.5
	11.0	2.0	2.3	2.9	51.5
	12.0	3.0	3.4	4.4	55.9
	13.0	3.0	3.4	4.4	60.3
	15.0	1.0	1.1	1.5	61.8
	16.0	1.0	1.1	1.5	63.2
	17.0	1.0	1.1	1.5	64.7
	19.0	8.0	9.1	11.8	76.5
	20.0	2.0	2.3	2.9	79.4
	22.0	5.0	5.7	7.4	86.8
	24.0	3.0	3.4	4.4	91.2
	29.0	3.0	3.4	4.4	95.6
	30.0	1.0	1.1	1.5	97.1
	31.0	2.0	2.3	2.9	100.0
	Total	68.0	77.3	100.0	
Missing	999.0	20.0	22.7		
Total		88.0	100.0		

Question2-Fourth

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	1.0	1.1	1.5	1.5
	3.0	3.0	3.4	4.5	6.0
	4.0	5.0	5.7	7.5	13.4
	5.0	1.0	1.1	1.5	14.9
	6.0	1.0	1.1	1.5	16.4
	7.0	1.0	1.1	1.5	17.9
	8.0	2.0	2.3	3.0	20.9
	9.0	1.0	1.1	1.5	22.4
	10.0	2.0	2.3	3.0	25.4
	11.0	2.0	2.3	3.0	28.4
	12.0	5.0	5.7	7.5	35.8
	13.0	2.0	2.3	3.0	38.8
	14.0	2.0	2.3	3.0	41.8
	15.0	7.0	8.0	10.4	52.2
	16.0	1.0	1.1	1.5	53.7
	17.0	4.0	4.5	6.0	59.7
	19.0	2.0	2.3	3.0	62.7
	21.0	1.0	1.1	1.5	64.2
	22.0	4.0	4.5	6.0	70.1
	23.0	2.0	2.3	3.0	73.1
	24.0	3.0	3.4	4.5	77.6
	27.0	2.0	2.3	3.0	80.6
	28.0	3.0	3.4	4.5	85.1
	29.0	4.0	4.5	6.0	91.0
	30.0	1.0	1.1	1.5	92.5
	31.0	5.0	5.7	7.5	100.0
	Total	67.0	76.1	100.0	
Missing	999.0	21.0	23.9		
Total		88.0	100.0		

Question2-Fifth

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.0	1.0	1.1	1.6	1.6
	3.0	4.0	4.5	6.6	8.2
	4.0	3.0	3.4	4.9	13.1
	5.0	3.0	3.4	4.9	18.0
	7.0	5.0	5.7	8.2	26.2
	10.0	2.0	2.3	3.3	29.5
	11.0	3.0	3.4	4.9	34.4
	12.0	2.0	2.3	3.3	37.7
	13.0	3.0	3.4	4.9	42.6
	14.0	1.0	1.1	1.6	44.3
	16.0	1.0	1.1	1.6	45.9
	17.0	3.0	3.4	4.9	50.8
	19.0	2.0	2.3	3.3	54.1
	21.0	1.0	1.1	1.6	55.7
	22.0	3.0	3.4	4.9	60.7
	23.0	1.0	1.1	1.6	62.3
	24.0	2.0	2.3	3.3	65.6
	25.0	1.0	1.1	1.6	67.2
	27.0	1.0	1.1	1.6	68.9
	28.0	1.0	1.1	1.6	70.5
	29.0	6.0	6.8	9.8	80.3
	30.0	1.0	1.1	1.6	82.0
	31.0	11.0	12.5	18.0	100.0
	Total	61.0	69.3	100.0	
Missing	999.0	27.0	30.7		
Total		88.0	100.0		

Item	First	Second	Third	Fourth	Fifth	Sum
1.0	7.4	4.4	2.9	1.5		16.2
2.0	33.8	7.4	4.4		1.6	47.2
3.0	2.9	22.1	5.9	4.5	6.6	41.9
4.0	14.7	7.4	14.7	7.5	4.9	49.1
5.0	2.9	4.4	2.9	1.5	4.9	16.7
6.0		2.9	1.5	1.5		5.9
7.0		1.5	5.9	1.5	8.2	17.0
8.0	1.5	1.5	2.9	3.0		8.9
9.0	2.9	2.9	2.9	1.5		10.3
10.0	2.9	5.9	4.4	3.0	3.3	19.5
11.0	2.9		2.9	3.0	4.9	13.8
12.0		2.9	4.4	7.5	3.3	18.1
13.0	4.4	4.4	4.4	3.0	4.9	21.1
14.0		1.5		3.0	1.6	6.1
15.0	2.9	4.4	1.5	10.4		19.3
16.0			1.5	1.5	1.6	4.6
17.0	4.4	2.9	1.5	6.0	4.9	19.7
18.0						0.0
19.0	1.5	4.4	11.8	3.0	3.3	23.9
20.0			2.9			2.9
21.0				1.5	1.6	3.1
22.0	4.4	5.9	7.4	6.0	4.9	28.5
23.0	1.5	2.9		3.0	1.6	9.0
24.0		1.5	4.4	4.5	3.3	13.6
25.0					1.6	1.6
26.0						0.0
27.0	1.5			3.0	1.6	6.1
28.0				4.5	1.6	6.1
29.0	1.5	1.5	4.4	6.0	9.8	23.2
30.0		4.4	1.5	1.5	1.6	9.0
31.0	5.9	2.9	2.9	7.5	18.0	37.3

Question 3

Have you ever applied offsite methods of construction in your projects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	49	55.7	55.7	55.7
	No	39	44.3	44.3	100.0
	Total	88	100.0	100.0	

Question 4

Previous experience

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	4.1	4.3	1.0	4.3
	Disagree	4	8.2	8.5	2.0	17.0
	Neither Agree Nor Disagree	13	26.5	27.7	3.0	83.0
	Agree	17	34.7	36.2	4.0	144.7
	Agree strongly	11	22.4	23.4	5.0	117.0
	Total	47	95.9	100.0		
Missing	999	2	4.1			
Total		49	100.0			366.0

Higher speed of construction

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Agree	15	30.6	30.6	4.0	122.4
	Agree strongly	34	69.4	69.4	5.0	346.9
	Total	49	100.0	100.0		469.4

Reduced total costs

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree	6	12.2	12.5	2.0	25.0
	Neither Agree Nor Disagree	16	32.7	33.3	3.0	100.0
	Agree	14	28.6	29.2	4.0	116.7
	Agree strongly	12	24.5	25.0	5.0	125.0
	Total	48	98.0	100.0		
Missing	999	1	2.0			
Total		49	100.0			366.7

Higher quality of products

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree	2	4.1	4.1	2.0	8.2
	Neither Agree Nor Disagree	8	16.3	16.3	3.0	49.0
	Agree	19	38.8	38.8	4.0	155.1
	Agree strongly	20	40.8	40.8	5.0	204.1
	Total	49	100.0	100.0		416.3

Fewer skilled labour requirement in offsite methods

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	3	6.1	6.3	1.0	6.3
	Disagree	9	18.4	18.8	2.0	37.5
	Neither Agree Nor Disagree	8	16.3	16.7	3.0	50.0
	Agree	18	36.7	37.5	4.0	150.0
	Agree strongly	10	20.4	20.8	5.0	104.2
	Total	48	98.0	100.0		
Missing	999	1	2.0			
Total		49	100.0			347.9

Machinery availability

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.3	1.0	2.3
	Disagree	2	4.1	4.5	2.0	9.1
	Neither Agree Nor Disagree	15	30.6	34.1	3.0	102.3
	Agree	18	36.7	40.9	4.0	163.6
	Agree strongly	8	16.3	18.2	5.0	90.9
	Total	44	89.8	100.0		
Missing	999	5	10.2			
Total		49	100.0			368.2

Availability of details/ information

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree	5	10.2	11.4	2.0	22.7
	Neither Agree Nor Disagree	8	16.3	18.2	3.0	54.5
	Agree	16	32.7	36.4	4.0	145.5
	Agree strongly	15	30.6	34.1	5.0	170.5
	Total	44	89.8	100.0		
Missing	999	5	10.2			
Total		49	100.0			393.2

Availability of details/ information

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.3	1.0	2.3
	Disagree	5	10.2	11.4	2.0	22.7
	Neither Agree Nor Disagree	14	28.6	31.8	3.0	95.5
	Agree	15	30.6	34.1	4.0	136.4
	Agree strongly	9	18.4	20.5	5.0	102.3
	Total	44	89.8	100.0		
Missing	999	5	10.2			
Total		49	100.0			359.1

Availability of offsite products in the market

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree	6	12.2	14.0	2.0	27.9
	Neither Agree Nor Disagree	8	16.3	18.6	3.0	55.8
	Agree	21	42.9	48.8	4.0	195.3
	Agree strongly	8	16.3	18.6	5.0	93.0
	Total	43	87.8	100.0		
Missing	999	6	12.2			
Total		49	100.0			372.1

Enhanced design quality

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.3	1.0	2.3
	Disagree	3	6.1	7.0	2.0	14.0
	Neither Agree Nor Disagree	6	12.2	14.0	3.0	41.9
	Agree	18	36.7	41.9	4.0	167.4
	Agree strongly	15	30.6	34.9	5.0	174.4
	Total	43	87.8	100.0		
Missing	999	6	12.2			
Total		49	100.0			400.0

Enhanced design flexibility

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.2	1.0	2.2
	Disagree	6	12.2	13.3	2.0	26.7
	Neither Agree Nor Disagree	12	24.5	26.7	3.0	80.0
	Agree	15	30.6	33.3	4.0	133.3
	Agree strongly	11	22.4	24.4	5.0	122.2
	Total	45	91.8	100.0		
Missing	999	4	8.2			
Total		49	100.0			364.4

Being modern and fashionable

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	4.1	4.5	1.0	4.5
	Disagree	3	6.1	6.8	2.0	13.6
	Neither Agree Nor Disagree	12	24.5	27.3	3.0	81.8
	Agree	12	24.5	27.3	4.0	109.1
	Agree strongly	15	30.6	34.1	5.0	170.5
	Total	44	89.8	100.0		
Missing	999	5	10.2			
Total		49	100.0			379.5

Cultural issues / social acceptance

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.3	1.0	2.3
	Disagree	10	20.4	23.3	2.0	46.5
	Neither Agree Nor Disagree	23	46.9	53.5	3.0	160.5
	Agree	7	14.3	16.3	4.0	65.1
	Agree strongly	2	4.1	4.7	5.0	23.3
	Total	43	87.8	100.0		
Missing	999	6	12.2			
Total		49	100.0			297.7

Client /costumer preferences

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.3	1.0	2.3
	Disagree	9	18.4	20.5	2.0	40.9
	Neither Agree Nor Disagree	20	40.8	45.5	3.0	136.4
	Agree	11	22.4	25.0	4.0	100.0
	Agree strongly	3	6.1	6.8	5.0	34.1
	Total	44	89.8	100.0		
Missing	999	5	10.2			
Total		49	100.0			313.6

Location of projects

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree	7	14.3	16.3	2.0	32.6
	Neither Agree Nor Disagree	9	18.4	20.9	3.0	62.8
	Agree	17	34.7	39.5	4.0	158.1
	Agree strongly	10	20.4	23.3	5.0	116.3
	Total	43	87.8	100.0		
Missing	999	5	10.2			
	System	1	2.0			
	Total	6	12.2			
Total		49	100.0			369.8

Contract type

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.2	1.0	2.2
	Disagree	6	12.2	13.3	2.0	26.7
	Neither Agree Nor Disagree	18	36.7	40.0	3.0	120.0
	Agree	17	34.7	37.8	4.0	151.1
	Agree strongly	3	6.1	6.7	5.0	33.3
	Total	45	91.8	100.0		
Missing	999	4	8.2			
Total		49	100.0			333.3

Size of projects

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.3	1.0	2.3
	Disagree	1	2.0	2.3	2.0	4.5
	Neither Agree Nor Disagree	7	14.3	15.9	3.0	47.7
	Agree	26	53.1	59.1	4.0	236.4
	Agree strongly	9	18.4	20.5	5.0	102.3
	Total	44	89.8	100.0		
Missing	999	5	10.2			
Total		49	100.0			393.2

Easier Planning approval

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	4.1	4.5	1.0	4.5
	Disagree	12	24.5	27.3	2.0	54.5
	Neither Agree Nor Disagree	23	46.9	52.3	3.0	156.8
	Agree	5	10.2	11.4	4.0	45.5
	Agree strongly	2	4.1	4.5	5.0	22.7
	Total	44	89.8	100.0		
Missing	999	5	10.2			
Total		49	100.0			284.1

Less climate / weather dependence

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.3	1.0	2.3
	Disagree	5	10.2	11.4	2.0	22.7
	Neither Agree Nor Disagree	16	32.7	36.4	3.0	109.1
	Agree	18	36.7	40.9	4.0	163.6
	Agree strongly	4	8.2	9.1	5.0	45.5
	Total	44	89.8	100.0		
Missing	999	5	10.2			
Total		49	100.0			343.2

Easier future selling

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree	10	20.4	22.2	2.0	44.4
	Neither Agree Nor Disagree	24	49.0	53.3	3.0	160.0
	Agree	7	14.3	15.6	4.0	62.2
	Agree strongly	4	8.2	8.9	5.0	44.4
	Total	45	91.8	100.0		
Missing	999	4	8.2			
Total		49	100.0			311.1

Governmental supports

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	4.1	4.7	1.0	4.7
	Disagree	12	24.5	27.9	2.0	55.8
	Neither Agree Nor Disagree	19	38.8	44.2	3.0	132.6
	Agree	8	16.3	18.6	4.0	74.4
	Agree strongly	2	4.1	4.7	5.0	23.3
	Total	43	87.8	100.0		
Missing	999	6	12.2			
Total		49	100.0			290.7

Aesthetic matters

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.2	1.0	2.2
	Disagree	7	14.3	15.6	2.0	31.1
	Neither Agree Nor Disagree	12	24.5	26.7	3.0	80.0
	Agree	16	32.7	35.6	4.0	142.2
	Agree strongly	9	18.4	20.0	5.0	100.0
	Total	45	91.8	100.0		
Missing	999	4	8.2			
Total		49	100.0			355.6

Enhanced sound resistance

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree	3	6.1	6.7	2.0	13.3
	Neither Agree Nor Disagree	8	16.3	17.8	3.0	53.3
	Agree	24	49.0	53.3	4.0	213.3
	Agree strongly	10	20.4	22.2	5.0	111.1
	Total	45	91.8	100.0		
Missing	999	4	8.2			
Total		49	100.0			391.1

Enhanced U-Value

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree	2	4.1	4.8	2.0	9.5
	Neither Agree Nor Disagree	8	16.3	19.0	3.0	57.1
	Agree	21	42.9	50.0	4.0	200.0
	Agree strongly	11	22.4	26.2	5.0	131.0
	Total	42	85.7	100.0		
Missing	999	7	14.3			
Total		49	100.0			397.6

Easier Insurance matters

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree	7	14.3	16.7	2.0	33.3
	Neither Agree Nor Disagree	27	55.1	64.3	3.0	192.9
	Agree	6	12.2	14.3	4.0	57.1
	Agree strongly	2	4.1	4.8	5.0	23.8
	Total	42	85.7	100.0		
Missing	999	7	14.3			
Total		49	100.0			307.1

More/ easier Mortgage/financial facilities

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.3	1.0	2.3
	Disagree	11	22.4	25.6	2.0	51.2
	Neither Agree Nor Disagree	25	51.0	58.1	3.0	174.4
	Agree	4	8.2	9.3	4.0	37.2
	Agree strongly	2	4.1	4.7	5.0	23.3
	Total	43	87.8	100.0		
Missing	999	6	12.2			
Total		49	100.0			288.4

Ease of construction (less complicated details

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.3	1.0	2.3
	Disagree	4	8.2	9.3	2.0	18.6
	Neither Agree Nor Disagree	4	8.2	9.3	3.0	27.9
	Agree	24	49.0	55.8	4.0	223.3
	Agree strongly	10	20.4	23.3	5.0	116.3
	Total	43	87.8	100.0		
Missing	999	6	12.2			
Total		49	100.0			388.4

Design / construction changes are easier to manage

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.3	1.0	2.3
	Disagree	6	12.2	14.0	2.0	27.9
	Neither Agree Nor Disagree	5	10.2	11.6	3.0	34.9
	Agree	19	38.8	44.2	4.0	176.7
	Agree strongly	12	24.5	27.9	5.0	139.5
	Total	43	87.8	100.0		
Missing	999	6	12.2			
Total		49	100.0			381.4

Enhanced environmental issues

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree	6	12.2	14.3	2.0	28.6
	Neither Agree Nor Disagree	15	30.6	35.7	3.0	107.1
	Agree	14	28.6	33.3	4.0	133.3
	Agree strongly	7	14.3	16.7	5.0	83.3
	Total	42	85.7	100.0		
Missing	999	7	14.3			
Total		49	100.0			352.4

Improved Health and Safety issues

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree	1	2.0	2.3	2.0	4.7
	Neither Agree Nor Disagree	9	18.4	20.9	3.0	62.8
	Agree	23	46.9	53.5	4.0	214.0
	Agree strongly	10	20.4	23.3	5.0	116.3
	Total	43	87.8	100.0		
Missing	999	6	12.2			
Total		49	100.0			397.7

Enhanced Resistance in natural disasters (e.g. Earthquake)

		Frequency	Percent	Valid Percent	Liker Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.0	2.2	1.0	2.2
	Disagree	3	6.1	6.7	2.0	13.3
	Neither Agree Nor Disagree	6	12.2	13.3	3.0	40.0
	Agree	19	38.8	42.2	4.0	168.9
	Agree strongly	16	32.7	35.6	5.0	177.8
	Total	45	91.8	100.0		
Missing	999	4	8.2			
Total		49	100.0			402.2

Variable	Valid	Missing	Mean	Median	Mode	Variance	Sum	Valid percentage * Likert Scale
Higher speed of construction	49	0	4.693877551	5	5	0.216836735	230	469.4
Higher quality of products	49	0	4.163265306	4	5	0.722789116	204	416.3
Resistance in natural disasters (e.g. Earthquake)	45	4	4.022222222	4	4	0.976767677	181	402.2
Enhanced design quality	43	6	4	4	4	1	172	400
Improved Health and Safety issues	43	6	3.976744186	4	4	0.547065338	171	397.7
Enhanced U-Value	42	7	3.976190476	4	4	0.657955865	167	397.6
Availability of details/ information	44	5	3.931818182	4	4	0.995243129	173	393.2
Size of projects	44	5	3.931818182	4	4	0.669661734	173	393.2
Enhanced sound resistance	45	4	3.911111111	4	4	0.673737374	176	391.1
Ease of construction (less complicated details	43	6	3.88372093	4	4	0.914728682	167	388.4
Design / construction changes are easier to manage	43	6	3.813953488	4	4	1.15503876	164	381.4
Being modern and fashionable	44	5	3.795454545	4	5	1.282769556	167	379.5
Availability of offsite products in the market	43	6	3.720930233	4	4	0.872646733	160	372.1
Location of projects	43	6	3.697674419	4	4	1.025470653	159	369.8
Machinery availability	44	5	3.681818182	4	4	0.826638478	162	368.2
Reduced total costs	48	1	3.666666667	4	3	0.992907801	176	366.7
Previous experience	47	2	3.659574468	4	4	1.142460685	172	366
Enhanced design flexibility	45	4	3.644444444	4	4	1.143434343	164	364.4
Availability of details/ information	44	5	3.590909091	4	4	1.038054968	158	359.1
Aesthetic matters	45	4	3.555555556	4	4	1.116161616	160	355.6
Enhanced environmental issues	42	7	3.523809524	3.5	3	0.889663182	148	352.4
Fewer skilled labour requirement in offsite methods	48	1	3.479166667	4	4	1.446365248	167	347.9
Easier Planning approval	44	5	2.840909091	3	3	0.74154334	125	343.2
Less climate / weather dependence	44	5	3.431818182	3.5	4	0.809196617	151	343.2
Contract type	45	4	3.333333333	3	3	0.772727273	150	333.3
Client /costumer preferences	44	5	3.136363636	3	3	0.818181818	138	313.6
Easier future selling	45	4	3.111111111	3	3	0.737373737	140	311.1
Easier Insurance matters	42	7	3.071428571	3	3	0.506968641	129	307.1
Cultural issues / social acceptance	43	6	2.976744186	3	3	0.689922481	128	297.7
Governmental supports	43	6	2.906976744	3	3	0.848283499	125	290.7
More/ easier Mortgage/financial facilities	43	6	2.88372093	3	3	0.629014396	124	288.4

Question 5

Question5-1st

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	3	6.1	9.4	9.4
	2	18	36.7	56.3	65.6
	3	1	2.0	3.1	68.8
	4	2	4.1	6.3	75.0
	6	1	2.0	3.1	78.1
	7	2	4.1	6.3	84.4
	9	1	2.0	3.1	87.5
	10	1	2.0	3.1	90.6
	11	1	2.0	3.1	93.8
	12	1	2.0	3.1	96.9
	17	1	2.0	3.1	100.0
	Total	32	65.3	100.0	
Missing	999	17	34.7		
Total		49	100.0		

Question5-2nd

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	9	18.4	28.1	28.1
	3	5	10.2	15.6	43.8
	4	4	8.2	12.5	56.3
	5	3	6.1	9.4	65.6
	6	2	4.1	6.3	71.9
	8	2	4.1	6.3	78.1
	10	2	4.1	6.3	84.4
	11	1	2.0	3.1	87.5
	22	2	4.1	6.3	93.8
	27	1	2.0	3.1	96.9
	28	1	2.0	3.1	100.0
	Total	32	65.3	100.0	
Missing	999	17	34.7		
Total		49	100.0		

Question5-3rd

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	2.0	3.1	3.1
	3	3	6.1	9.4	12.5
	4	5	10.2	15.6	28.1
	5	1	2.0	3.1	31.3
	7	2	4.1	6.3	37.5
	9	1	2.0	3.1	40.6
	10	3	6.1	9.4	50.0
	11	2	4.1	6.3	56.3
	12	1	2.0	3.1	59.4
	15	2	4.1	6.3	65.6
	17	3	6.1	9.4	75.0
	21	1	2.0	3.1	78.1
	23	2	4.1	6.3	84.4
	24	1	2.0	3.1	87.5
	27	4	8.2	12.5	100.0
	Total	32	65.3	100.0	
Missing	999	17	34.7		
Total		49	100.0		

Question5-4th

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	2.0	3.1	3.1
	3	2	4.1	6.3	9.4
	4	3	6.1	9.4	18.8
	5	1	2.0	3.1	21.9
	8	1	2.0	3.1	25.0
	10	3	6.1	9.4	34.4
	11	1	2.0	3.1	37.5
	12	5	10.2	15.6	53.1
	15	3	6.1	9.4	62.5
	22	1	2.0	3.1	65.6
	24	2	4.1	6.3	71.9
	28	2	4.1	6.3	78.1
	30	4	8.2	12.5	90.6
	31	3	6.1	9.4	100.0
	Total	32	65.3	100.0	
Missing	999	17	34.7		
Total		49	100.0		

Question5-5th

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	4.1	6.5	6.5
	2	1	2.0	3.2	9.7
	3	1	2.0	3.2	12.9
	4	4	8.2	12.9	25.8
	5	2	4.1	6.5	32.3
	7	1	2.0	3.2	35.5
	10	1	2.0	3.2	38.7
	11	1	2.0	3.2	41.9
	12	2	4.1	6.5	48.4
	15	1	2.0	3.2	51.6
	17	4	8.2	12.9	64.5
	22	1	2.0	3.2	67.7
	23	2	4.1	6.5	74.2
	24	1	2.0	3.2	77.4
	27	2	4.1	6.5	83.9
	28	1	2.0	3.2	87.1
	30	1	2.0	3.2	90.3
	31	3	6.1	9.7	100.0
	Total	31	63.3	100.0	
Missing	999	18	36.7		
Total		49	100.0		

Item	First	Second	Third	Fourth	Fifth	Sum %
1	9.4			3.1	6.5	19.0
2	56.3	28.1	3.1		3.2	90.7
3	3.1	15.6	9.4	6.3	3.2	37.6
4	6.3	12.5	15.6	9.4	12.9	56.7
5		9.4	3.1	3.1	6.5	22.1
6	3.1	6.3				9.4
7	6.3		6.3		3.2	15.7
8		6.3		3.1		9.4
9	3.1		3.1			6.3
10	3.1	6.3	9.4	9.4	3.2	31.4
11	3.1	3.1	6.3	3.1	3.2	18.9
12	3.1		3.1	15.6	6.5	28.3
13						0.0
14						0.0
15			6.3	9.4	3.2	18.9
16						0.0
17	3.1		9.4		12.9	25.4
18						0.0
19						0.0
20						0.0
21			3.1			3.1
22		6.3		3.1	3.2	12.6
23			6.3		6.5	12.7
24			3.1	6.3	3.2	12.6
25						0.0
26						0.0
27		3.1	12.5		6.5	22.1
28		3.1		6.3	3.2	12.6
29						0.0
30				12.5	3.2	15.7
31				9.4	9.7	19.1

Question 6

What kind of offsite methods have you ever used?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	2.0	2.0	2.0
	1	34	69.4	69.4	71.4
	1&2	1	2.0	2.0	73.5
	1&2&4	1	2.0	2.0	75.5
	1&3	4	8.2	8.2	83.7
	1&3&4	2	4.1	4.1	87.8
	1&4	1	2.0	2.0	89.8
	1&5	2	4.1	4.1	93.9
	999	3	6.1	6.1	100.0
	Total	49	100.0	100.0	

Question 7

In how many projects have you applied offsite methods / product

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5	41	83.7	91.1	91.1
	6-25	3	6.1	6.7	97.8
	50+	1	2.0	2.2	100.0
	Total	45	91.8	100.0	
Missing	999	3	6.1		
	System	1	2.0		
	Total	4	8.2		
Total		49	100.0		

Question 8

How many of those projects have been housing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	16	32.7	35.6	35.6
	1-5	28	57.1	62.2	97.8
	6-25	1	2.0	2.2	100.0
	Total	45	91.8	100.0	
Missing	999	3	6.1		
	System	1	2.0		
	Total	4	8.2		
Total		49	100.0		

Question 9

total what was the approximate proportion of offsite manufacture in your housing projects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-10%	10	20.4	23.3	23.3
	11-25%	19	38.8	44.2	67.4
	26-50%	10	20.4	23.3	90.7
	51_75%	4	8.2	9.3	100.0
	Total	43	87.8	100.0	
Missing	999	5	10.2		
	System	1	2.0		
	Total	6	12.2		
Total		49	100.0		

Question 10

What were the main components that were manufactured offsite

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	2.0	2.0	2.0
	1	20	40.8	40.8	42.9
	1&2&3	6	12.2	12.2	55.1
	1&2&4	2	4.1	4.1	59.2
	1&3	11	22.4	22.4	81.6
	1&3&4	3	6.1	6.1	87.8
	1&4	1	2.0	2.0	89.8
	2.00	1	2.0	2.0	91.8
	2&3	1	2.0	2.0	93.9
	999	3	6.1	6.1	100.0
	Total	49	100.0	100.0	

Question 11

Lack of Previous experience

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.1	1.0	7.1
	Disagree	4	10.3	14.3	2.0	28.6
	Neither Agree Nor Disagree	7	17.9	25.0	3.0	75.0
	Agree	8	20.5	28.6	4.0	114.3
	Agree strongly	7	17.9	25.0	5.0	125.0
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			350.0

Less Speed of construction

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	3	7.7	10.7	1.0	10.7
	Disagree	16	41.0	57.1	2.0	114.3
	Neither Agree Nor Disagree	7	17.9	25.0	3.0	75.0
	Agree	2	5.1	7.1	4.0	28.6
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			228.6

Higher Total costs

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.6	3.6	1.0	3.6
	Disagree	10	25.6	35.7	2.0	71.4
	Neither Agree Nor Disagree	10	25.6	35.7	3.0	107.1
	Agree	4	10.3	14.3	4.0	57.1
	Agree strongly	3	7.7	10.7	5.0	53.6
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			292.9

Worse Quality of products

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	3	7.7	10.7	1.0	10.7
	Disagree	15	38.5	53.6	2.0	107.1
	Neither Agree Nor Disagree	7	17.9	25.0	3.0	75.0
	Agree	3	7.7	10.7	4.0	42.9
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			235.7

More skilled labour requirement in offsite methods

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	6	15.4	21.4	2.0	42.9
	Neither Agree Nor Disagree	4	10.3	14.3	3.0	42.9
	Agree	15	38.5	53.6	4.0	214.3
	Agree strongly	3	7.7	10.7	5.0	53.6
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			353.6

Lack of required Machinery

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	5	12.8	17.9	2.0	35.7
	Neither Agree Nor Disagree	6	15.4	21.4	3.0	64.3
	Agree	11	28.2	39.3	4.0	157.1
	Agree strongly	6	15.4	21.4	5.0	107.1
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			364.3

Lack of required details/ information

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.6	3.7	1.0	3.7
	Disagree	2	5.1	7.4	2.0	14.8
	Neither Agree Nor Disagree	6	15.4	22.2	3.0	66.7
	Agree	15	38.5	55.6	4.0	222.2
	Agree strongly	3	7.7	11.1	5.0	55.6
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			363.0

Lack of experienced contractors

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	3	7.7	11.1	2.0	22.2
	Neither Agree Nor Disagree	4	10.3	14.8	3.0	44.4
	Agree	16	41.0	59.3	4.0	237.0
	Agree strongly	4	10.3	14.8	5.0	74.1
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			377.8

Lack of offsite products in the market

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	3	7.7	11.1	2.0	22.2
	Neither Agree Nor Disagree	8	20.5	29.6	3.0	88.9
	Agree	13	33.3	48.1	4.0	192.6
	Agree strongly	3	7.7	11.1	5.0	55.6
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			359.3

Lower Design quality

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.1	1.0	7.1
	Disagree	8	20.5	28.6	2.0	57.1
	Neither Agree Nor Disagree	14	35.9	50.0	3.0	150.0
	Agree	3	7.7	10.7	4.0	42.9
	Agree strongly	1	2.6	3.6	5.0	17.9
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			275.0

Reduced Design flexibility

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.4	1.0	7.4
	Disagree	6	15.4	22.2	2.0	44.4
	Neither Agree Nor Disagree	11	28.2	40.7	3.0	122.2
	Agree	7	17.9	25.9	4.0	103.7
	Agree strongly	1	2.6	3.7	5.0	18.5
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			296.3

Being unfashionable

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.1	1.0	7.1
	Disagree	10	25.6	35.7	2.0	71.4
	Neither Agree Nor Disagree	12	30.8	42.9	3.0	128.6
	Agree	4	10.3	14.3	4.0	57.1
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			264.3

Cultural issues / social acceptance issues

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.6	3.7	1.0	3.7
	Disagree	11	28.2	40.7	2.0	81.5
	Neither Agree Nor Disagree	9	23.1	33.3	3.0	100.0
	Agree	5	12.8	18.5	4.0	74.1
	Agree strongly	1	2.6	3.7	5.0	18.5
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			277.8

Client /costumer preferences issues

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.1	1.0	7.1
	Disagree	9	23.1	32.1	2.0	64.3
	Neither Agree Nor Disagree	13	33.3	46.4	3.0	139.3
	Agree	3	7.7	10.7	4.0	42.9
	Agree strongly	1	2.6	3.6	5.0	17.9
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			271.4

Location of projects

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.6	3.7	1.0	3.7
	Disagree	3	7.7	11.1	2.0	22.2
	Neither Agree Nor Disagree	12	30.8	44.4	3.0	133.3
	Agree	11	28.2	40.7	4.0	163.0
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			322.2

Contract type

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	4	10.3	14.3	2.0	28.6
	Neither Agree Nor Disagree	14	35.9	50.0	3.0	150.0
	Agree	10	25.6	35.7	4.0	142.9
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			321.4

Size of projects

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	4	10.3	14.8	2.0	29.6
	Neither Agree Nor Disagree	13	33.3	48.1	3.0	144.4
	Agree	9	23.1	33.3	4.0	133.3
	Agree strongly	1	2.6	3.7	5.0	18.5
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			325.9

Difficulties of Planning/building approval

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.1	1.0	7.1
	Disagree	4	10.3	14.3	2.0	28.6
	Neither Agree Nor Disagree	16	41.0	57.1	3.0	171.4
	Agree	6	15.4	21.4	4.0	85.7
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			292.9

More Climate / weather dependency

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.4	1.0	7.4
	Disagree	4	10.3	14.8	2.0	29.6
	Neither Agree Nor Disagree	16	41.0	59.3	3.0	177.8
	Agree	5	12.8	18.5	4.0	74.1
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			288.9

Future selling problems

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.1	1.0	7.1
	Disagree	6	15.4	21.4	2.0	42.9
	Neither Agree Nor Disagree	10	25.6	35.7	3.0	107.1
	Agree	10	25.6	35.7	4.0	142.9
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			300.0

Lack of Governmental support

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.1	1.0	7.1
	Disagree	8	20.5	28.6	2.0	57.1
	Neither Agree Nor Disagree	9	23.1	32.1	3.0	96.4
	Agree	7	17.9	25.0	4.0	100.0
	Agree strongly	2	5.1	7.1	5.0	35.7
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			296.4

Aesthetic matters

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.1	1.0	7.1
	Disagree	6	15.4	21.4	2.0	42.9
	Neither Agree Nor Disagree	15	38.5	53.6	3.0	160.7
	Agree	5	12.8	17.9	4.0	71.4
	Total	28	71.8	100.0		
Missing	999	11	28.2			
Total		39	100.0			282.1

Reduced sound resistance

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	5	12.8	18.5	1.0	18.5
	Disagree	11	28.2	40.7	2.0	81.5
	Neither Agree Nor Disagree	9	23.1	33.3	3.0	100.0
	Agree	2	5.1	7.4	4.0	29.6
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			229.6

Reduced U-Value

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	5	12.8	18.5	1.0	18.5
	Disagree	11	28.2	40.7	2.0	81.5
	Neither Agree Nor Disagree	9	23.1	33.3	3.0	100.0
	Agree	2	5.1	7.4	4.0	29.6
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			229.6

Reduced U-Value

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.6	3.8	1.0	3.8
	Disagree	3	7.7	11.5	2.0	23.1
	Neither Agree Nor Disagree	20	51.3	76.9	3.0	230.8
	Agree	2	5.1	7.7	4.0	30.8
	Total	26	66.7	100.0		
Missing	999	13	33.3			
Total		39	100.0			288.5

Mortgage/ financial facilities difficulties

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	1	2.6	3.7	1.0	3.7
	Disagree	5	12.8	18.5	2.0	37.0
	Neither Agree Nor Disagree	19	48.7	70.4	3.0	211.1
	Agree	1	2.6	3.7	4.0	14.8
	Agree strongly	1	2.6	3.7	5.0	18.5
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			285.2

Construction complexity (more complicated details)

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	8	20.5	29.6	2.0	59.3
	Neither Agree Nor Disagree	9	23.1	33.3	3.0	100.0
	Agree	10	25.6	37.0	4.0	148.1
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			307.4

Construction complexity (more complicated details)

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree	6	15.4	22.2	2.0	44.4
	Neither Agree Nor Disagree	12	30.8	44.4	3.0	133.3
	Agree	7	17.9	25.9	4.0	103.7
	Agree strongly	2	5.1	7.4	5.0	37.0
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			318.5

Environmental issues

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.4	1.0	7.4
	Disagree	14	35.9	51.9	2.0	103.7
	Neither Agree Nor Disagree	5	12.8	18.5	3.0	55.6
	Agree	6	15.4	22.2	4.0	88.9
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			255.6

Health and Safety issues

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	2	5.1	7.7	1.0	7.7
	Disagree	12	30.8	46.2	2.0	92.3
	Neither Agree Nor Disagree	9	23.1	34.6	3.0	103.8
	Agree	3	7.7	11.5	4.0	46.2
	Total	26	66.7	100.0		
Missing	999	13	33.3			
Total		39	100.0			250.0

Reduced Resistance in natural disasters (e.g. Earthquake)

		Frequency	Percent	Valid Percent	Likert Scale	Valid Percent * Likert Scale
Valid	Disagree Strongly	3	7.7	11.1	1.0	11.1
	Disagree	11	28.2	40.7	2.0	81.5
	Neither Agree Nor Disagree	8	20.5	29.6	3.0	88.9
	Agree	4	10.3	14.8	4.0	59.3
	Agree strongly	1	2.6	3.7	5.0	18.5
	Total	27	69.2	100.0		
Missing	999	12	30.8			
Total		39	100.0			259.3

	Valid	Missing	Mean	Median	Mode	Variance	Sum	Valid percentage * Likert Scale
Lack of Previous experience	28	11	3.5	4	4	1.518518519	98	350
Less Speed of construction	28	11	2.285714286	2	2	0.582010582	64	228.6
Higher Total costs	28	11	2.928571429	3	2	1.105820106	82	292.9
Worse Quality of products	28	11	2.357142857	2	2	0.682539683	66	235.7
More skilled labour requirement in offsite methods	28	11	3.535714286	4	4	0.924603175	99	353.6
Lack of required Machinery	28	11	3.642857143	4	4	1.052910053	102	364.3
Lack of required details/ information	27	12	3.62962963	4	4	0.857549858	98	363
Lack of experienced contractors	27	12	3.777777778	4	4	0.717948718	102	377.8
Lack of offsite products in the market	27	12	3.592592593	4	4	0.712250712	97	359.3
Lower Design quality	28	11	2.75	3	3	0.787037037	77	275.0
Reduced Design flexibility	27	12	2.962962963	3	3	0.96011396	80	296.3
Being unfashionable	28	11	2.642857143	3	3	0.682539683	74	264.3
Cultural issues / social acceptance issues	27	12	2.777777778	3	2	0.871794872	75	277.8
Client /costumer preferences issues	28	11	2.714285714	3	3	0.804232804	76	271.4
Location of projects	27	12	3.222222222	3	3	0.641025641	87	322.2
Contract type	28	11	3.214285714	3	3	0.470899471	90	321.4
Size of projects	27	12	3.259259259	3	3	0.584045584	88	325.9
Difficulties of Planning/building approval	28	11	2.928571429	3	3	0.661375661	82	292.9
More Climate / weather dependency	27	12	2.888888889	3	3	0.641025641	78	288.9
Future selling problems	28	11	3	3	3	0.888888889	84	300.0
Lack of Governmental support	28	11	2.964285714	3	3	1.146825397	83	296.4
Aesthetic matters	28	11	2.821428571	3	3	0.670634921	79	282.1
Reduced sound resistance	27	12	2.296296296	2	2	0.754985755	62	229.6
Reduced U-Value	27	12	2.296296296	2	2	0.754985755	62	229.6
Reduced U-Value	26	13	2.884615385	3	3	0.346153846	75	288.5
Mortgage/ financial facilities difficulties	27	12	2.851851852	3	3	0.515669516	77	285.2
Construction complexity (more complicated details)	27	12	3.074074074	3	4	0.686609687	83	307.4
Construction complexity (more complicated details)	27	12	3.185185185	3	3	0.772079772	86	318.5
Environmental issues	27	12	2.555555556	2	2	0.871794872	69	255.6
Health and Safety issues	26	13	2.5	2	2	0.66	65	250
Reduced Resistance in natural disasters (e.g. Earthquake)	27	12	2.592592593	2	2	1.01994302	70	259.3

[redacted]

Question 12

Q12-1st

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	7	17.9	46.7	46.7
	2	1	2.6	6.7	53.3
	7	1	2.6	6.7	60.0
	8	1	2.6	6.7	66.7
	9	2	5.1	13.3	80.0
	17	1	2.6	6.7	86.7
	22	1	2.6	6.7	93.3
	31	1	2.6	6.7	100.0
	Total	15	38.5	100.0	
Missing	999	24	61.5		
Total		39	100.0		

Q12-2nd

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	5.1	14.3	14.3
	3	1	2.6	7.1	21.4
	5	2	5.1	14.3	35.7
	6	1	2.6	7.1	42.9
	8	3	7.7	21.4	64.3
	9	2	5.1	14.3	78.6
	10	1	2.6	7.1	85.7
	11	1	2.6	7.1	92.9
	23	1	2.6	7.1	100.0
	Total	14	35.9	100.0	
Missing	999	25	64.1		
Total		39	100.0		

Q12-3rd

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	5.1	14.3	14.3
	2	1	2.6	7.1	21.4
	3	1	2.6	7.1	28.6
	4	2	5.1	14.3	42.9
	7	3	7.7	21.4	64.3
	8	1	2.6	7.1	71.4
	11	1	2.6	7.1	78.6
	13	1	2.6	7.1	85.7
	22	1	2.6	7.1	92.9
	28	1	2.6	7.1	100.0
	Total	14	35.9	100.0	
Missing	999	25	64.1		
Total		39	100.0		

Q12-4th

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	2.6	6.7	6.7
	4	1	2.6	6.7	13.3
	5	2	5.1	13.3	26.7
	6	2	5.1	13.3	40.0
	8	1	2.6	6.7	46.7
	9	1	2.6	6.7	53.3
	10	1	2.6	6.7	60.0
	11	1	2.6	6.7	66.7
	12	1	2.6	6.7	73.3
	17	1	2.6	6.7	80.0
	21	1	2.6	6.7	86.7
	24	1	2.6	6.7	93.3
	99	1	2.6	6.7	100.0
	Total	15	38.5	100.0	
Missing	999	24	61.5		
Total		39	100.0		

Q12-5th

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	8	1	2.6	9.1	9.1
	9	1	2.6	9.1	18.2
	10	1	2.6	9.1	27.3
	11	1	2.6	9.1	36.4
	13	2	5.1	18.2	54.5
	15	1	2.6	9.1	63.6
	27	1	2.6	9.1	72.7
	30	1	2.6	9.1	81.8
	31	2	5.1	18.2	100.0
	Total	11	28.2	100.0	
Missing	999	28	71.8		
Total		39	100.0		

Item	First	Second	Third	Fourth	Fifth	Sum
1	46.7		14.3	6.7		68
2	6.7	14.3	7.1			28
3		7.1	7.1			14
4			14.3	6.7		21
5		14.3		13.3		28
6		7.1		13.3		20
7	6.7		21.4			28
8	6.7	21.4	7.1	6.7	9.1	51
9	13.3	14.3		6.7	9.1	43
10		7.1		6.7	9.1	23
11		7.1	7.1	6.7	9.1	30
12				6.7		7
13			7.1		18.2	25
14						0
15					9.1	9
16						0
17	6.7			6.7		13
18						0
19						0
20						0
21				6.7		7
22	6.7		7.1			14
23		7.1				7
24				6.7		7
25						0
26						0
27					9.1	9
28			7.1			7
29						0
30					9.1	9
31	6.7				18.2	25

Question 13

Would you consider offsite methods if you have the opportunity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, Definitely	17	43.6	54.8	54.8
	Yes, Maybe	14	35.9	45.2	100.0
	Total	31	79.5	100.0	
Missing	999	8	20.5		
Total		39	100.0		

Question 14-19

At what stage of a project do you usually think about a construction method?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Appraisal (Feasibility Stage)	20	22.7	23.0	23.0
	Outline proposals (Planning Stage)	50	56.8	57.5	80.5
	Detailed proposals (Building regulations)	17	19.3	19.5	100.0
	Total	87	98.9	100.0	
Missing	999	1	1.1		
Total		88	100.0		

At what stage of a project is the construction method usually fixed?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Appraisal (Feasibility Stage)	1	1.1	1.1	1.1
	Outline proposals (Planning Stage)	9	10.2	10.3	11.5
	Detailed proposals (Building regulations)	46	52.3	52.9	64.4
	Tender Stage	6	6.8	6.9	71.3
	Construction Stage	9	10.2	10.3	81.6
	It changes even during construction	16	18.2	18.4	100.0
	Total	87	98.9	100.0	
Missing	999	1	1.1		
Total		88	100.0		

At what stage of a project do you usually contact a manufacturer to ask for advice?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Appraisal (Feasibility Stage)	16	18.2	18.4	18.4
	Outline proposals (Planning Stage)	26	29.5	29.9	48.3
	Detailed proposals (Building regulations)	40	45.5	46.0	94.3
	Tender Stage	1	1.1	1.1	95.4
	Construction Stage	3	3.4	3.4	98.9
	Other stages (Please indicate)	1	1.1	1.1	100.0
	Total	87	98.9	100.0	
Missing	999	1	1.1		
Total		88	100.0		

At what stage of a project do you usually contact a contractor to ask for advice?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Appraisal (Feasibility Stage)	4	4.5	4.7	4.7
	Outline proposals (Planning Stage)	14	15.9	16.3	20.9
	Detailed proposals (Building regulations)	30	34.1	34.9	55.8
	Tender Stage	15	17.0	17.4	73.3
	Construction Stage	23	26.1	26.7	100.0
	Total	86	97.7	100.0	
Missing	999	2	2.3		
Total		88	100.0		

At what stage of a project do you usually contact an engineer to ask for advice?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Appraisal (Feasibility Stage)	6	6.8	7.0	7.0
	Outline proposals (Planning Stage)	57	64.8	66.3	73.3
	Detailed proposals (Building regulations)	22	25.0	25.6	98.8
	Other stages (Please indicate)	1	1.1	1.2	100.0
	Total	86	97.7	100.0	
Missing	999	2	2.3		
Total		88	100.0		

At what stage do all/most key bodies involved in a project (the client, designer, engineer, contractor and manufacturer) meet each other for the first time?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Appraisal (Feasibility Stage)	8	9.1	9.5	9.5
	Outline proposals (Planning Stage)	24	27.3	28.6	38.1
	Detailed proposals (Building regulations)	21	23.9	25.0	63.1
	Tender Stage	3	3.4	3.6	66.7
	Construction Stage	20	22.7	23.8	90.5
	They usually do not have an opportunity to meet each other	8	9.1	9.5	100.0
	Total	84	95.5	100.0	
Missing	999	4	4.5		
Total		88	100.0		

Question 20

Who is more influential in decision making for the construction method? (1st)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	22	25.0	25.6	25.6
	Contractor	2	2.3	2.3	27.9
	Designer/ Architect	55	62.5	64.0	91.9
	Structural Engineer	6	6.8	7.0	98.8
	Manufacturer	1	1.1	1.2	100.0
	Total	86	97.7	100.0	
Missing	999	2	2.3		
Total		88	100.0		

Who is more influential in decision making for the construction method?(2nd)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	20	22.7	28.6	28.6
	Contractor	4	4.5	5.7	34.3
	Designer/ Architect	20	22.7	28.6	62.9
	Structural Engineer	23	26.1	32.9	95.7
	Manufacturer	2	2.3	2.9	98.6
	QS	1	1.1	1.4	100.0
	Total	70	79.5	100.0	
Missing	999	18	20.5		
Total		88	100.0		

Who is more influential in decision making for the construction method?(3rd)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	10	11.4	15.4	15.4
	Contractor	10	11.4	15.4	30.8
	Designer/ Architect	6	6.8	9.2	40.0
	Structural Engineer	23	26.1	35.4	75.4
	Manufacturer	13	14.8	20.0	95.4
	QS	3	3.4	4.6	100.0
	Total	65	73.9	100.0	
Missing	999	23	26.1		
Total		88	100.0		

Who is more influential in decision making for the construction method?(4th)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	9	10.2	14.1	14.1
	Contractor	22	25.0	34.4	48.4
	Designer/ Architect	1	1.1	1.6	50.0
	Structural Engineer	15	17.0	23.4	73.4
	Manufacturer	13	14.8	20.3	93.8
	QS	4	4.5	6.3	100.0
	Total	64	72.7	100.0	
Missing	999	24	27.3		
Total		88	100.0		

Who is more influential in decision making for the construction method?(5th)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	3	3.4	4.7	4.7
	Contractor	20	22.7	31.3	35.9
	Designer/ Architect	1	1.1	1.6	37.5
	Structural Engineer	4	4.5	6.3	43.8
	Manufacturer	26	29.5	40.6	84.4
	QS	10	11.4	15.6	100.0
	Total	64	72.7	100.0	
Missing	999	24	27.3		
Total		88	100.0		

Who is more influential in decision making for the construction method?(6th)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	1	1.1	1.6	1.6
	Contractor	7	8.0	10.9	12.5
	Structural Engineer	2	2.3	3.1	15.6
	Manufacturer	9	10.2	14.1	29.7
	QS	45	51.1	70.3	100.0
	Total	64	72.7	100.0	
Missing	999	24	27.3		
Total		88	100.0		

Question 21-25

What house type do you design more frequently?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	House	6	6.8	7.2	7.2
	Flats/Apartments	66	75.0	79.5	86.7
	Other (please indicate)	11	12.5	13.3	100.0
	Total	83	94.3	100.0	
Missing	999	5	5.7		
Total		88	100.0		

What housing project sizes do you design more frequently?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5 Units	12	13.6	14.6	14.6
	6-10 Units	35	39.8	42.7	57.3
	11-50 Units	20	22.7	24.4	81.7
	50+ Units	15	17.0	18.3	100.0
	Total	82	93.2	100.0	
Missing	999	6	6.8		
Total		88	100.0		

What is the commonest area of houses / flats that you design?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	40-60 m^2	2	2.3	2.4	2.4
	61-80 m^2	10	11.4	12.2	14.6
	81-100 m^2	22	25.0	26.8	41.5
	100+ m^2	48	54.5	58.5	100.0
	Total	82	93.2	100.0	
Missing	999	6	6.8		
Total		88	100.0		

What number of storeys is more available/ common to design in housing projects?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-2	7	8.0	8.4	8.4
	3-4	20	22.7	24.1	32.5
	5-10	47	53.4	56.6	89.2
	10+	9	10.2	10.8	100.0
	Total	83	94.3	100.0	
Missing	999	5	5.7		
Total		88	100.0		

How long does it usually take to get a full planning permission?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than one month	1	1.1	1.5	1.5
	1-2 Months	17	19.3	25.0	26.5
	2-4 Months	31	35.2	45.6	72.1
	More than four months	19	21.6	27.9	100.0
	Total	68	77.3	100.0	
Missing	999	20	22.7		
Total		88	100.0		

Question 26-28

How much usually does the design change during a project

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No changes	1	1.1	1.1	1.1
	Few changes	47	53.4	54.0	55.2
	Some changes	28	31.8	32.2	87.4
	Considerable changes	11	12.5	12.6	100.0
	Total	87	98.9	100.0	
Missing	999	1	1.1		
Total		88	100.0		

At what stage of a project is the design usually fixed

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Outline proposals (Planning Stage)	1	1.1	1.2	1.2
	Detailed proposals (Building regulations)	14	15.9	16.3	17.4
	Construction Stage	11	12.5	12.8	30.2
	It changes even during construction	60	68.2	69.8	100.0
	Total	86	97.7	100.0	
Missing	999	2	2.3		
Total		88	100.0		

If any, at what stage are the changes most common?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Appraisal (Feasibility Stage)	1	1.1	1.2	1.2
	Outline proposals (Planning Stage)	51	58.0	59.3	60.5
	Detailed proposals (Building regulations)	27	30.7	31.4	91.9
	Construction Stage	7	8.0	8.1	100.0
	Total	86	97.7	100.0	
Missing	999	2	2.3		
Total		88	100.0		

Question 29

Who is usually more responsible for changes?(1st)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	42	47.7	48.8	48.8
	Contractor	11	12.5	12.8	61.6
	Designer/ Architect	28	31.8	32.6	94.2
	Structural Engineer	5	5.7	5.8	100.0
	Total	86	97.7	100.0	
Missing	999	2	2.3		
Total		88	100.0		

Who is usually more responsible for changes?(2nd)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	13	14.8	18.1	18.1
	Contractor	12	13.6	16.7	34.7
	Designer/ Architect	18	20.5	25.0	59.7
	Structural Engineer	25	28.4	34.7	94.4
	Manufacturer	3	3.4	4.2	98.6
	QS	1	1.1	1.4	100.0
	Total	72	81.8	100.0	
Missing	999	16	18.2		
Total		88	100.0		

Who is usually more responsible for changes?(3rd)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	13	14.8	19.7	19.7
	Contractor	11	12.5	16.7	36.4
	Designer/ Architect	9	10.2	13.6	50.0
	Structural Engineer	22	25.0	33.3	83.3
	Manufacturer	10	11.4	15.2	98.5
	QS	1	1.1	1.5	100.0
	Total	66	75.0	100.0	
Missing	999	22	25.0		
Total		88	100.0		

Who is usually more responsible for changes?(4th)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	2	2.3	3.1	3.1
	Contractor	19	21.6	29.2	32.3
	Designer/ Architect	5	5.7	7.7	40.0
	Structural Engineer	18	20.5	27.7	67.7
	Manufacturer	14	15.9	21.5	89.2
	QS	7	8.0	10.8	100.0
	Total	65	73.9	100.0	
Missing	999	23	26.1		
Total		88	100.0		

Who is usually more responsible for changes?(5th)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	1	1.1	1.5	1.5
	Contractor	12	13.6	18.2	19.7
	Designer/ Architect	7	8.0	10.6	30.3
	Structural Engineer	4	4.5	6.1	36.4
	Manufacturer	26	29.5	39.4	75.8
	QS	16	18.2	24.2	100.0
	Total	66	75.0	100.0	
Missing	999	22	25.0		
Total		88	100.0		

Who is usually more responsible for changes?(6th)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	5	5.7	7.6	7.6
	Contractor	2	2.3	3.0	10.6
	Designer/ Architect	5	5.7	7.6	18.2
	Manufacturer	13	14.8	19.7	37.9
	QS	41	46.6	62.1	100.0
	Total	66	75.0	100.0	
Missing	999	22	25.0		
Total		88	100.0		

Question 30

What are the most common reasons for changes?(1st)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cost issues	23	26.1	26.7	26.7
	Client preferences	23	26.1	26.7	53.5
	Architectural / Design issues	16	18.2	18.6	72.1
	Onsite issues	23	26.1	26.7	98.8
	Other	1	1.1	1.2	100.0
	Total	86	97.7	100.0	
Missing	999	2	2.3		
Total		88	100.0		

What are the most common reasons for changes?(2nd)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cost issues	21	23.9	28.4	28.4
	Client preferences	29	33.0	39.2	67.6
	Contractor preferences	3	3.4	4.1	71.6
	Architectural / Design issues	8	9.1	10.8	82.4
	Onsite issues	12	13.6	16.2	98.6
	Other	1	1.1	1.4	100.0
	Total	74	84.1	100.0	
Missing	999	14	15.9		
Total		88	100.0		

What are the most common reasons for changes?(3rd)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cost issues	14	15.9	19.7	19.7
	Client preferences	18	20.5	25.4	45.1
	Contractor preferences	9	10.2	12.7	57.7
	Architectural / Design issues	17	19.3	23.9	81.7
	Onsite issues	13	14.8	18.3	100.0
	Total	71	80.7	100.0	
Missing	999	17	19.3		
Total		88	100.0		

What are the most common reasons for changes?(4th)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cost issues	10	11.4	14.9	14.9
	Client preferences	4	4.5	6.0	20.9
	Contractor preferences	10	11.4	14.9	35.8
	Architectural / Design issues	15	17.0	22.4	58.2
	Manufacturers' issues	4	4.5	6.0	64.2
	Onsite issues	23	26.1	34.3	98.5
	Other	1	1.1	1.5	100.0
	Total	67	76.1	100.0	
Missing	999	21	23.9		
Total		88	100.0		

What are the most common reasons for changes?(5th)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cost issues	4	4.5	6.1	6.1
	Contractor preferences	32	36.4	48.5	54.5
	Architectural / Design issues	10	11.4	15.2	69.7
	Manufacturers' issues	16	18.2	24.2	93.9
	Onsite issues	4	4.5	6.1	100.0
	Total	66	75.0	100.0	
Missing	999	22	25.0		
Total		88	100.0		

What are the most common reasons for changes?(6th)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cost issues	1	1.1	1.5	1.5
	Client preferences	1	1.1	1.5	3.0
	Contractor preferences	9	10.2	13.6	16.7
	Architectural / Design issues	3	3.4	4.5	21.2
	Manufacturers' issues	46	52.3	69.7	90.9
	Onsite issues	4	4.5	6.1	97.0
	Other	2	2.3	3.0	100.0
	Total	66	75.0	100.0	
Missing	999	22	25.0		
Total		88	100.0		

What are the most common reasons for changes?(7th)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client preferences	1	1.1	5.3	5.3
	Contractor preferences	2	2.3	10.5	15.8
	Architectural / Design issues	1	1.1	5.3	21.1
	Other	15	17.0	78.9	100.0
	Total	19	21.6	100.0	
Missing	999	69	78.4		
Total		88	100.0		

Question 31

I prefer to see an example of a method before using it

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	2	2.3	2.3	2.3
	Disagree	7	8.0	8.0	10.3
	Neither Agree Nor Disagree	21	23.9	24.1	34.5
	Agree	37	42.0	42.5	77.0
	Agree strongly	20	22.7	23.0	100.0
	Total	87	98.9	100.0	
Missing	999	1	1.1		
Total		88	100.0		

Standardization improves the design quality

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	15	17.0	17.4	17.4
	Neither Agree Nor Disagree	17	19.3	19.8	37.2
	Agree	32	36.4	37.2	74.4
	Agree strongly	22	25.0	25.6	100.0
	Total	86	97.7	100.0	
Missing	999	2	2.3		
Total		88	100.0		

Standardization improves the construction quality

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	3	3.4	3.4	3.4
	Neither Agree Nor Disagree	7	8.0	8.0	11.5
	Agree	49	55.7	56.3	67.8
	Agree strongly	28	31.8	32.2	100.0
	Total	87	98.9	100.0	
Missing	999	1	1.1		
Total		88	100.0		

I prefer to use locally manufactured products

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	12	13.6	14.1	14.1
	Disagree	19	21.6	22.4	36.5
	Neither Agree Nor Disagree	37	42.0	43.5	80.0
	Agree	11	12.5	12.9	92.9
	Agree strongly	6	6.8	7.1	100.0
	Total	85	96.6	100.0	
Missing	999	3	3.4		
Total		88	100.0		

Manufacturers are willing to give out details/information to help me in my job

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	3	3.4	3.6	3.6
	Disagree	18	20.5	21.4	25.0
	Neither Agree Nor Disagree	22	25.0	26.2	51.2
	Agree	36	40.9	42.9	94.0
	Agree strongly	5	5.7	6.0	100.0
	Total	84	95.5	100.0	
Missing	999	4	4.5		
Total		88	100.0		

I think offsite methods of construction are more fashionable

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	1	1.1	1.1	1.1
	Disagree	4	4.5	4.6	5.7
	Neither Agree Nor Disagree	36	40.9	41.4	47.1
	Agree	31	35.2	35.6	82.8
	Agree strongly	15	17.0	17.2	100.0
	Total	87	98.9	100.0	
Missing	999	1	1.1		
Total		88	100.0		

People ask about the method of construction when buying a house

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	8	9.1	9.5	9.5
	Disagree	20	22.7	23.8	33.3
	Neither Agree Nor Disagree	23	26.1	27.4	60.7
	Agree	28	31.8	33.3	94.0
	Agree strongly	5	5.7	6.0	100.0
	Total	84	95.5	100.0	
Missing	999	4	4.5		
Total		88	100.0		

People prefer modern looking buildings more than traditional looking ones

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	2	2.3	2.3	2.3
	Disagree	13	14.8	14.9	17.2
	Neither Agree Nor Disagree	16	18.2	18.4	35.6
	Agree	38	43.2	43.7	79.3
	Agree strongly	18	20.5	20.7	100.0
	Total	87	98.9	100.0	
Missing	999	1	1.1		
Total		88	100.0		

Question 32

Offsite methods are cheaper than onsite methods in total

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	3	6.1	6.4	6.4
	Disagree	15	30.6	31.9	38.3
	Neither Agree Nor Disagree	16	32.7	34.0	72.3
	Agree	11	22.4	23.4	95.7
	Agree strongly	2	4.1	4.3	100.0
	Total	47	95.9	100.0	
Missing	999	2	4.1		
Total		49	100.0		

Lifespan of offsite products is longer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	6	12.2	13.3	13.3
	Neither Agree Nor Disagree	16	32.7	35.6	48.9
	Agree	19	38.8	42.2	91.1
	Agree strongly	4	8.2	8.9	100.0
	Total	45	91.8	100.0	
Missing	999	4	8.2		
Total		49	100.0		

Offsite methods are faster than onsite methods

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	3	6.1	6.5	6.5
	Neither Agree Nor Disagree	1	2.0	2.2	8.7
	Agree	21	42.9	45.7	54.3
	Agree strongly	21	42.9	45.7	100.0
	Total	46	93.9	100.0	
Missing	999	3	6.1		
Total		49	100.0		

Offsite methods need more time than traditional ones in design stage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	2	4.1	4.3	4.3
	Disagree	5	10.2	10.9	15.2
	Neither Agree Nor Disagree	8	16.3	17.4	32.6
	Agree	23	46.9	50.0	82.6
	Agree strongly	8	16.3	17.4	100.0
	Total	46	93.9	100.0	
Missing	999	3	6.1		
Total		49	100.0		

There is enough variety in offsite products in the market

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neither Agree Nor Disagree	6	12.2	13.0	13.0
	Agree	21	42.9	45.7	58.7
	Agree strongly	19	38.8	41.3	100.0
	Total	46	93.9	100.0	
Missing	999	3	6.1		
Total		49	100.0		

Offsite products have better quality than onsite ones

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	1	2.0	2.2	2.2
	Disagree	5	10.2	11.1	13.3
	Neither Agree Nor Disagree	12	24.5	26.7	40.0
	Agree	18	36.7	40.0	80.0
	Agree strongly	9	18.4	20.0	100.0
	Total	45	91.8	100.0	
Missing	999	4	8.2		
Total		49	100.0		

Small builders prefer to apply offsite methods

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	3	6.1	6.7	6.7
	Disagree	21	42.9	46.7	53.3
	Neither Agree Nor Disagree	14	28.6	31.1	84.4
	Agree	5	10.2	11.1	95.6
	Agree strongly	2	4.1	4.4	100.0
	Total	45	91.8	100.0	
Missing	999	4	8.2		
Total		49	100.0		

Major developers prefer to apply offsite methods

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	3	6.1	6.8	6.8
	Neither Agree Nor Disagree	13	26.5	29.5	36.4
	Agree	22	44.9	50.0	86.4
	Agree strongly	6	12.2	13.6	100.0
	Total	44	89.8	100.0	
Missing	999	5	10.2		
Total		49	100.0		

Offsite methods are compatible with the Building Regulations

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	2	4.1	4.4	4.4
	Neither Agree Nor Disagree	17	34.7	37.8	42.2
	Agree	19	38.8	42.2	84.4
	Agree strongly	7	14.3	15.6	100.0
	Total	45	91.8	100.0	
Missing	999	4	8.2		
Total		49	100.0		

Offsite methods are suitable for Iran climate

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	5	10.2	11.1	11.1
	Neither Agree Nor Disagree	23	46.9	51.1	62.2
	Agree	14	28.6	31.1	93.3
	Agree strongly	3	6.1	6.7	100.0
	Total	45	91.8	100.0	
Missing	999	4	8.2		
Total		49	100.0		

Designers need to know more about offsite methods

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neither Agree Nor Disagree	3	6.1	6.7	6.7
	Agree	20	40.8	44.4	51.1
	Agree strongly	22	44.9	48.9	100.0
	Total	45	91.8	100.0	
Missing	999	4	8.2		
Total		49	100.0		

They improve design quality

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	2	4.1	4.4	4.4
	Disagree	3	6.1	6.7	11.1
	Neither Agree Nor Disagree	15	30.6	33.3	44.4
	Agree	14	28.6	31.1	75.6
	Agree strongly	11	22.4	24.4	100.0
	Total	45	91.8	100.0	
Missing	999	4	8.2		
Total		49	100.0		

They are more complicated than traditional methods

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree Strongly	1	2.0	2.3	2.3
	Disagree	10	20.4	22.7	25.0
	Neither Agree Nor Disagree	11	22.4	25.0	50.0
	Agree	18	36.7	40.9	90.9
	Agree strongly	4	8.2	9.1	100.0
	Total	44	89.8	100.0	
Missing	999	5	10.2		
Total		49	100.0		