A Review of Successful Housing System in Iran and the Introduction of Cob as a New Alternative in Iran's Industry

Reza Mirzaei

Department of Architecture, Birjand Branch, Islamic Azad University, Birjand, Iran
Aspiran0080@yahoo.com

Abstract—This study focuses on the analysis of the successful prefabricated systems in housing in Iran. Amongst the most important factors influencing the success of prefabricated systems in Iran are the weight, high assembling speed, resistance against earthquakes, being economical, quality control and system's flexibility for architectural plans.. In this paper the localized version of Cob, adaptable to Iranian housing system, is introduced for the first time. This paper is a study on Cob semi industrial system and Architectural- structural specifications. In introduction, author has considered history of house prefabrication house and analyzed Cob System.
[Reza Mirzaei. **A Review of Successful Housing System in Iran and the Introduction of Cob as a New Alternative in Iran's Industry.** *J Am Sci* 2012;8(10):180-184]. (ISSN: 1545-1003).
http://www.jofamericanscience.org. 27

Keywords: Constructional open system, prefabricated, Cob, the industrial production, semi-industrial production.

1. Introduction

House Prefabrication has been appeared after France Industrial Revolution. It is necessary to note that Prefabrication performed in small size. For example, some buildings such a Chaghazanbil (near to Shoosh in Iran) is used as a Prefabricated phase in an open system. Press police building has also constructed on the basis of modular system and firmed by leaden joints and it is a prefabricated house. In spite of this, industrial production in bulk hasn't been more than four decades historically in Iran and it hasn't been played important role to provide house in Constructional Programs.

Increasing population and lack of urban and rural houses need to produce house in industrial methods. Now, only 2-3% of buildings are constructed by using Industrial constructional products. So, using industrial methods and applying modern technical and management technology can be a useful solution to produce house.

2. Various methods of Industrialization

As for the flexibility in usage:

1-Closed prefabricated systems*:* These systems consist of unique parts which in turn play a key role in particles which is made of joints and packages only applicable to its specific system.

2-Open prefabricated systems: These are more varied compared to their closed counter parts, thus the assemblers are free to put the products in a verity of slots consequently building a system. In this system a unique standard is followed and all the parts are produced by a pre-defined module and in each project we can provide the parts from different companies. Overall in this system the produced parts are interchangeable.

3. The weight of the parts

1-Light Prefabricated systems: All the produced parts that weigh less than two tons are amongst this group. They are suitable for manual assembly and quite cost-effective when it comes to machinery costs. The factories that produce them are rather smaller and the parts are produced horizontally. All the machinery is smaller thus they cost less. The factories infrastructure is cheaper and their flexibility allows annual modification in house planning. Because of their light weight they can be sent to farther distances and the production lane is faster.

2-Heavy Prefabricated systems: They include the parts produced that are more than two tons. The factories are larger in size and all the horizontal and vertical parts are produced. Due to the largeness and the volume of the parts more powerful machinery is used which in turn is more expensive. What's more, they can only be sent to a close range and it is rather expensive. The assembly requires precision and heavy machinery.

3. Analysis of successful prefabricated systems in Iran

In recent years, many modern constructional methods have become popular in Iran. The studies on these systems show that each has their own limits, advantages and disadvantages. Amongst these some of them are more popular than others. Amongst which we can mention:

1- Lightweight Steel Framing
2-Lightweight Three Dimensional Sandwich Panels
3-Insulating Concrete Forms
4-TunnelConcrete Forming

5-Simple Constructional panels with shear walls and armed concrete

LSF, 3D and ICF are considered liner systems. And it should be mentioned that LSFcan be used as a load bearer wall or a simple constructional panel. And in fact ICF and Tunnel Concrete Forming are practical methods of building construction using armed concrete. In any case, since they provide unity and liner conjunctions, plates can be shaped more easily and have a more desirable quake behavior than their linier counterpart; whereas, linear systems are adaptable to different architectural designs.

In the next section we elaborate on each of the above mentioned systems.

4. LSF (Lightweight Steel Framing): these buildings are made of two main parts i.e. walls and ceiling. Walls are made of steel plates and for inner and outer parts plates made of plaster and cement are used and the middle part is used as an isolator for heat and noise. And the ceiling is made of lightweight steel or armed concrete. The thickness of the plates is 0.3 to 0.5 mm in the shapes of C, U or Z.

This structure can be a load bearing wall or a simple constructional panel with bracing or shear walls.

In the bearing wall system which is also known as plate framing each wall is made of a number of partitions in each floor which are joined from top and bottom to the vertical joints. Now that in the simple constructional framing which is also known as balloon framing, partitions are 3 to 4 stories high and are attached to the main column. In both systems, the distance between the columns is 400 to 600 mm.

The horizontal elements in structural systems, considering light steel as the load bearer for gravitational loads. Some of these are placed are also under other pressures too. The ceiling of the structure is also can be made of wooden plates, cement or armed concrete. The cover of the ceiling with armed concrete provides a unified plate between steel column and concrete thus making up for a steel-concrete ceiling.

One can categorize the main load in the following four groups:

A. Bracing system with diagonal parts
B. Shear wall system using thin steel plates
C. Shear wall system using oriented strand board
D. The shear wall system using armed concrete

In bracing systems using diagonal parts, input forces braced in the aperture are more than the two parts in the beginning and the end of the normal cross steel structures. And as it was mentioned before these parts can bare the lateral forces of the wind and earthquake.

A desirable performance is expected of the thin steel plate shear walls. Plus the steel plate prevents the ricocheting of the pressure from the other parts. However, considering the lateral input forces in play in steel shear walls the application of this system in Iran needs more laboratorial research and analysis.

In the shear wall system using oriented strand boards, OSBs will provide the shear strength needed against the lateral forces. What's more, the high resistance and light weightiness of the structure will lead to a decrease in quake forces. Despite all these, since they are not produced in Iran and the possibility of fire and the climate of Iran they are not the best choice.

The shear wall armed concrete is considered as one of the most desirable lateral resistive structures in LSF, especially when the number of floors is more than two. All the lateral loads are born by the shear wall and the armed concrete and LSF has nothing to do with the lateral powers and simply bears gravitational loads. In this system, the exact details of the pressing parts and the structural shear walls and the main flexural parts are absolutely most important.

The important point is that all the connections in this structural system are screw connections using automatic screws and all are simple connections. And only in special cases wielding is used.

5. 3D panel using sandwich panels and concrete*:* The pre-fabricated houses or the individual wall and ceiling sandwich plates are made of panels, which are basically a polystyrene insulator as thick as 40 – 90 mm, there are also two networks of steel, 3 to 6 mm, welded diagonally in the sides to steel wires as thick as 3 mm.

The sandwich panels are transported to workshop in pieces of 1X3 meters. Then concrete seeds as big as 4 to 7 cm are thrown on the plates and we will have a 3D sandwich panel. In these types of structures in pre-fabricated constructions with sandwich plates, when we consider the role of 3D panels, it would be one of a load bearer wall. Thus, panels on the walls with sandwich plates not only are bears the gravitational load, it can also be used as a shear wall. As a matter of fact, the overall thickness of armed concrete in both parts of polystyrene layer will provide the suitable resistance for external forces. It should be mentioned that the resistance in the width is caused by two forces the resistance of concrete and the resistance made by steel.

Provided there are enough diagonal wires, the ceiling panels in this system will play the role of one-sided semi-composite segment. In determining the shear strength of the plates of the 3D panels, only the

shear strength of the diagonal bars are considered and the shear strength of concrete is ignored

It is also noticeable that all the joints in this structure are liner. The liner joints distribute the power homogenously. And it also increases the degree of uncertainty in the system and thus it makes it possible for the power to rely and there will be a tension in the structure.

6. Insulating Concrete Forms:

Insulating concrete forms is considered another implementation method of armed concrete. In this system polystyrene insulators are expanded and shape as both sides of the armed concrete wall and after reinforcement the layer will be permanent in the work. Generally, we can categorize the permanent insulators concerning the EPS in the core form of the concrete. Which are flat, caved networks and screen networks. The latter two, are used rarely due to their in coherence. However, the flat one can be widely used even in the reigns prone to sever earthquakes. The flat ones are also categorize under three groups:

A. The horizontal permanent insulator form
B.The panel permanent insulator form
C.The vertical permanent insulator form

Each method due to the ease of forming, reinforcement and fast implementation has its advantages and draw backs. However, the structural system resulted from each of the methods mentioned above are quite usual. Thus, as there is no limitation in bar emplacement in concrete cohesion will be in the mid layers of concrete and it can shape the needed flexibility. The roof can be a rigid one, block ceiling joists or a load bearer one.

All the joints can be designed flexural and one can design the borders in a way to improve the openings.

7. Tunnel Concrete Forming: Another method of housing is Tunnel Concrete Forming which is named due to the simultaneous forming of the ceiling and the walls. In this method walls and the armed concrete ceiling are reinforced, formatted at the same time, and concerting the walls and slabs are also done simultaneously. In this method, not only do the speed and the quality increase but also improves the unification of the parts and joints, structural performance and the quake behavior of the system.

The main load bearer parts of this structure are the shear walls and flat slabs. All the joints are liner thus gravitational and lateral loads are transferred to the foundation. Cohesion of the shear walls throughout the height of the structure prevents the concentration of tension and minimizes the twisting effect. Also the symmetrical and orderly plan of structure will lead to a more desirable quake behavior in the system.

This system also needs openings to enter and exit the tunnel forms this will lead to an increase in the distribution of structural walls and an outstanding increase in the lateral resistance in one length rather than the other. Thus, it is necessary to design the structure in a way that the shear walls are distributed in both lengths of the construction. In this way, not only are the load bearer parts provided but also the degree of uncertainty in the structural system in both length are provided.

8. Simple Constructional panels with shear walls and armed concrete: Simple Constructional panels with shear walls and armed concrete is made of prefabricated columns in living room and the ceiling is hollow. Armed concrete shear wall, based on the places that has been predicted for them are established as fixed concrete. Thus, gravitational loads are carried out by the simple constructional panels and armed concrete, and the other weights are carried out by the ceilings diagram. All the joints are between columns and the panels are prefabricated in the workshop. In order to increase the capacity and to decrease the danger of any friction usually a plate of steel antennas is used.

Structure unification is one of the most important issues in the regulations and guidelines regarding the implementation of the armed concrete. By following this important point especially in prefabricated structures will lead to an augmentation in shapelessness and flexibility of the structure and thus can be easily manipulated in the process of implementation of the steels.

Nowadays, there are different methods of industrial construction of houses in the world as follow:

Arxx-g80-rima metek- tridpanel
Quadlock- armopanel-intergrd- tracoba-puma

That some of them don't have the necessary efficiency because they can't resist against earthquake. Author has bone much research on Prefabricated housing system in Russia and visited Moscow housing factories named DCK1 and DCK2 and he considers Cob housing system as a effective method in Iran conditions and he has compiled this paper to describe Prefabricated housing system.

9. Structural Procedures in Design:

9-1 In view of quality parameters in prefabricated housing system, Cob System is an effective and economical method that Moscow Research Institute has been confirmed it as a "Snippy". This system is used to operate major residential and office prefabricated house and building but "Snippy" Research Institute has been used it to construct residential house.

9-2 the main basis of this system is concrete frame and prefabricated parts will be connected after constructing frame. This system can use in earthquake areas such as Iran. The sample of this usage is found in Tashkent.

9-3 deign of connections is according to principles and details of high ranking building. (According to Nitherb Approval in 1989)

9-4 thickness of final cover of floors is 160mm that itstolerance is to 1300km/m^2.

9-5 structural thicknessof floor cover has been considered 80mm on the basis of computations by cob system and the height of floors has been described 3000-3200mm. Any changes in these standards need to recomputation, review and change in structural and architectural plans.

9-6 in this system, outside walls can be forms as follow:

Bearing, non bearing wall, new prefabricated structures, cavity wall, prefabricated, non-prefabricated, semi prefabricated walls, walls made with fine grained materials and frame walls.

9-7 walls and inside partitions should be made by light and nonstructural materials that have long life. For example, light concrete is recommended to operate inside partitions. Current concrete thickness is 80mm for inside walls.

9-8 cob system can be used in two different forms.

9-8-1- Prefabricated parts are constructed completely in the factory and transferred to building site.

9-8-2- Some parts are constructed and cast in building site in the winter that construction process is confronted many difficulties and it is recommended to take Variant1. Our country that has specification of torrid zones, Variant 2 can be better solution.

9-9 other abilities of Cob system are as follow:

9-9-1- using prestressed concrete in floor cover;

9-9-2-using porous concrete in floor cover ;(thermal and sound insulation false are created by constructing false ceiling under these covers.

9-9-3- To make various Prefabricated parts such as: Prefabricated installation duct, Prefabricated drop box, Prefabricated volume block if necessary, Prefabricated diaphragm.

9-9-4-New cover of floor by using light materials

9-9-5- Making hollow cover

9-9-6- Making Prefabricated floor cover in operation place in specific agricultural forms

9-9-7- Various performances of decorative columns

9-9-8- Making Prefabricated parts of floor in the same size

9-9-9- Floor cover with flexible connections

9-9-10- Using reinforced concrete

1-9-11- Useful method to construct one and two floor houses (villa…)

9-9-12- Using open system to produce constructional parts including floor, column, partitions and loading walls

9-9-13- usable in structures that their tolerable are more than 3000 - 4000km/m^2 (by considering structure weight)

9-9-14- Not needing prefabricated beam and bridge. In this system, floor and column are only main structure and they are economic in this view.

10. TECHNICAL AND ECONOMICAL SPECIFICATIONS OF SYSTEM (TABLE I):

10-1-In Cob System, common maximum bay is 6m.

Of course in special situations such as: making specific parts, concrete connections with loading more than current limit, etc, span size can be changed to 7.2, 9, 12m.

10-2- Structure of Cob System has been designed in current condition and it can tolerate earthquake 9 Richter. It is recommended five floors in seismic place 7 Richter and maximum three floors in seismic place 8-9 Richter. Additionally, it is recommended that tall building controls with diaphragm according to special calculations.

10-3- In Cob System, it can be constructed prefabricated building in 16 floors.

(According to above notes) regarding earthquake line passes though our country, it is recommended thatbuildings construct to 5 floors.

TABLE I: ESTIMATE OF CONSUMED MATERIALS IN 1M^2 IN COB SYSTEM

Human source Number/hour	concrete Consumption		Iron Consumption	Kind of cover
	In workshop	Prefabricated m^3		
0.8	0.03	0.157	14.74	Cob1
0.8	0.02	0.158	13.41	Cob2.5
0.5	0.01	0.139	6.5	Cob4
0.46	0.12	0.11	9.2	Cob5

10-4- Section size of columns is 20.80cm to 5floors and 20.60cm to 6-8floors and it is necessary for upper floors to calculate precisely and specific local situation.

10-5- Thickness of loading walls is considered about 12cm as architecture has more open space in architectural plan.

10-6- Thickness of shear wall is 16cm (by considering dead and live load on them). If the required shear walls is considered 100% to five floors: it is necessary for floors 6, 7 and 8 to construct 65% shear walls and for floors 9-13to construct 30% shear walls. This estimation is on the basis of constructing building in the placeswhere its earthquakeis maximum 9 Richter.

10-7- Connection of columns to foundation parts isn't one side and one piece. It is necessary that foundation perform in the placing of concrete then prefabricated parts of columns will be connected according details of it.

Conclusion:

Regarding our country needs to construct house on the one hand and There are many failures in management and planning departments on the other hand , the industrial and semi-industrial productions of house are proper and effective methods.

It is necessary to note that earthquake, various climates and economic are the main factors to determine semi-industrial building production policy in IRAN. It is also necessary to study in new housing methods. Cob system that considered a semi-industrial method has the main factors and it can be proper replacement for traditional house production in IRAN.

Corresponding Author:
Dr. Reza Mirzaei
Moscow State University of Architecture
Russia , Moscow
E – mail:aspiran00800@yahoo.com

Reference:

1. Owzari, RafizadehSholeh, House and Revolution seasonal magazine No.105, spring 2004, house technology.
2. Paper Set of the seventh conference of house development policies in Iran, Ministry of Development and Housing, 2000
3. Grigorif Vladimirosilwich, researches and studies on Cob system, 2007
4. Ron Hodkinson and John Fenton. Lightweight construction materials and techniques. Lightweight Electric/Hybrid Vehicle Design. 2000, Pages 173-198.
5. Miquel Casafont. Alfredo Arnedo. FrancescRoure. Antonio Rodríguez-Ferran. Experimental testing of joints for seismic design of lightweight structures.Thin-Walled Structures. Volume 44, Issue 2, February 2006, Pages 197-210.
6. Xu Ling. Liu jing. Analysis on housing system of lightweight steel structures and joint connection behavior. Fourth International Conference on Advances in Steel Structures. Proceedings of the Fourth International Conference on Advances in Steel Structures 13–15 June 2005, Shanghai, China. 2005, Pages 875-880.
7. Julián Salas. Marina Alvarez and JanerVeras. Lightweight insulating concretes. International Journal of Cement Composites and Lightweight Concrete. Volume 8, Issue 3, August 1986, Pages 171-180.
8. J.J. del Coz Díaz. P.J. García Nieto. C. BetegónBiempica. M.B. Prendes Gero. Analysis and optimization of the insulating light concrete design by finite element method.Applied Thermal Engineering. Volume 27, Issues 8-9, June 2007, Pages 1445-1456.
9. Donald L. Dean. A new idea in sandwich panel construction. International Journal of Mechanical Sciences. Volume 19, Issue 3, 1977, Pages 177-191.
10. OmidRezaifar. M.Z. Kabir. Dynamic behaviour of 3D-panel single-storey system using shaking table testing. Engineering Structures. Volume 30, Issue 2, February 2008, Pages 318-337.
11. Bing Wang. Linzhi Wu. Experimental investigation of 3D sandwich structure with core reinforced by composite columns. Materials & Design. Volume 31, Issue 1, January 2010, Pages 158-165.
12. Can Balkaya.ErolKalkan. Seismic vulnerability, behavior and design of tunnel form building structures. Engineering Structures. Volume 26, Issue 14, December 2004, Pages 2081-2099.
13. Can Balkaya. ErolKalkan. Nonlinear seismic response evaluation of tunnel form building structures. Computers & Structures. Volume 81, Issue 3, February 2003, Pages 153-165.

9/1/2012