SESSION One

Housing and Industrialization in Iran

ROAD, HOUSING AND URBAN DEVELOPMENT RESEARCH CENTER (BHRC)

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Necessity of the issue

- Housing shortage and the growing need to secure habitat in Iran, have prioritized mass housing construction projects to be used by various social groups, especially the low incomes.
- This issue may be observed in many developing countries where urban population is growing.
- Iran's location in high earthquake risk zone has drawn attentions to reinforcing existing buildings and also lightening buildings to increase their efficiency against earthquake.

These purposes would be achieved by application of new systems and technologies beside industrial housing construction policy in the society.
Industrial housing construction advantages

• Standardization of products and organization of production,
• Concentration on prefabrication of large housing complexes and pre-cast design,
• Reducing building mass or weight by use of light and prefabricated materials,
• Construction progress monitoring according to the scheduled plan, especially for poor working condition seasons,
• Quality control of elements during production.
Industrialization might develop in three categories of construction in Iran,

Including:

• Individual private housings,
• public investing in mass housing,
• Private investing in mass housing

Although the average of units in each project in first category is far less than two others, owing to high frequency of projects in this category, it is prominent to be noticed.

It means: “Industrialization” in individual projects is as important as in mass housing projects.

Now a days, only about 10% of building construction in Iran is done by industrial systems and methods.
## An overview of Construction method in Iran

<table>
<thead>
<tr>
<th>Type of structure</th>
<th>Cities</th>
<th>villages</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1385</td>
<td>1390</td>
<td>1385</td>
</tr>
<tr>
<td>Steel (%)</td>
<td>33.1%</td>
<td>31.7%</td>
<td>6.6%</td>
</tr>
<tr>
<td>Concrete (%)</td>
<td>14.5%</td>
<td>20.7%</td>
<td>5.7%</td>
</tr>
<tr>
<td>Others (%)</td>
<td>51.2%</td>
<td>46.6%</td>
<td>87.1%</td>
</tr>
<tr>
<td>Undeclared (%)</td>
<td>1.2%</td>
<td>0.9%</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

About 46.6% of cities houses and 78.7% of rural houses in Iran did not built by steel or concrete structure in 1390.

From 1385 to 1390, the ratio of using steel or concrete structure, about 5% increased.
Mehr project is a national project of housing for low incomes in Iran and it could be important as an opportunity for developing industrial construction.

<table>
<thead>
<tr>
<th>Type of contract</th>
<th>Construction Method</th>
<th>Total (Number of units)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Industrial (%)</td>
<td>Semi-industrial (%)</td>
</tr>
<tr>
<td>Private owner</td>
<td>5%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Tripartite</td>
<td>72%</td>
<td>5%</td>
</tr>
<tr>
<td>(Government, Bank, Mass producer)</td>
<td>25%</td>
<td>9%</td>
</tr>
<tr>
<td>Cooperative companies</td>
<td>25%</td>
<td>9%</td>
</tr>
<tr>
<td>Total</td>
<td>28.5%</td>
<td>5%</td>
</tr>
</tbody>
</table>

- In 72% of governmental and 25% of cooperative companies, construction industrial methods have been used.
- Most of these two categories are mass housing projects with average of 237 and 23 units per project.
- Only in 5% of projects with private owners (with average of 2.5 units in each project) industrial methods have been used.
Sustainability and Industrial construction
Introduction

Despite the positive points associated with it, industrialization should be in harmony with the natural environment, climate conditions, social aspects and vernacular architecture patterns. It should also provide sufficient flexibility in design and construction to go with the local conditions. Industrialization should support continuation of valuable construction traditions.

Method of evaluation for sustainability

To achieve a desirable architecture through industrialization, it is needed the features, potentials and limitations of each industrial and innovative system to be addressed from architectural design aspect so that proper decision can be made with respect to the considered conditions. Therefore, features, potentials and limitations of industrial products are introduced as indicators of sustainability and discussed in view of the perspective of various aspects affecting the architecture.
Indicators of sustainability

In adopting the optimal system for mass housing construction projects, the following three principal basics as indicators are focused:

- Various types of residential complexes considering form and function,
- Operability in construction and operation,
- Providing environmental sustainability.
Various types of residential complexes considering form and function

A: Volumetric types
(Ex.: Compact Cube, oblong cuboid, flight steps, separate volumetric units, composed bulks, fractured volumes- diagonal surfaces, and curved plates, solid and hollow volumes)

B: Altitudinal types (Ex.: Low rise, Medium rise, High rise)

C: Space organization of complexes
(Ex.: Separate blocks with vertical interface areas, Blocks around the open central space, Compact blocks with central vertical access in between, Lined blocks with vertical access in between)

D: space organization of residential units (Ex.: open plan and closed plan)

E: Dimensions and sizes (Ex.: Load bearing wall thickness, non-bearing wall thickness, roof thickness, span length and vertical height without separate structure)

F: openings (Ex.: opening dimensions, location, shape and material)
A. Capabilities and limitations of implementation
B. Durability
C. Maintenance
D. Conforming subsystems and procedures in façade and interior space division
E. Anticipated facilities
Providing environmental sustainability

Resiliency faced with:

A. Temperature
B. Humidity
C. Wind
D. Rainfall
E. Acoustics
F. Fire
G. Insects
H. Fungi
An investigation on strengths & weaknesses of some of the most common industrial systems or methods of construction regarding mentioned indicators

- As a sample, this investigation may help to evaluate the performance and potential of generalization of systems.

- A few of industrial systems that currently have greater scope of application and prevalence in the construction industry of the country regarding production and implementation:
  - Tunnel Form system
  - Integrated concrete casting method
  - Autoclaved Aerated Concrete (AAC)
  - Reinforced concrete buildings with Insulating Concrete Forms (ICF)
  - Light Steel Frame (LSF) construction system
  - Shotcrete tree-dimensional (3D) panels
Tunnel Form system

Tunnel form system is a precast construction system with application in large projects. The system consists of enormous steel or aluminum forms and involves simultaneous concreting of Load bearing components (slabs and shear walls). Form operations in the tunnel form system are done in two ways: full tunnel and half-tunnel approach (flying table).

Structurally, the tunnel form acts like a box, and as an integrated, three dimensional element reacts against vertical and lateral loads.
Integrated concrete casting method

Unlike the tunnel system, roof and wall are concreted separately in this system, so that all external and internal walls are initially shuttered and concreted in one step; after complete concrete setting, form are removed upward and then shuttering and concreting operations for slabs begins.
Autoclaved Aerated Concrete (AAC)

Due to lightness and high thermal resistance, Autoclaved Aerated Concrete or AAC is adopted in the construction industry, particularly in mass housing construction, despite its complex and expensive production process. AAC is commonly used in Iran as non-load bearing partitions. But since it has been tried in this study to compare the construction systems against each other, the AAC construction system is detailed next.
Reinforced concrete buildings with Insulating Concrete Forms (ICF)

This system is some type of implementation method with reinforced concrete load bearing walls in which the produced blocks act as Insulating Concrete Form. This system is employed in small residential units in industrialized countries.

The main structural materials in the system include:
Panels on both sides are made of polystyrene, the clamp between two panels which is made of plastics, metal rod or polystyrene, in-situ concrete in between panels and shotcrete around the panels.
Light Steel Frame (LSF) construction system

Light steel frame system is a construction system that has application in short and medium height buildings. The system consists of three main ingredients: cold rolled steel sheet as structural component, Gypsum thin plates as a covering of the inner surface layer (lining) and the sound-thermal insulation panel. Load bearing walls in this system are divided into two categories: load bearing gravitational and shear walls. This system is erected by connecting studs to master runners using diagonal metal elements or resistant covers such as plain or corrugated sheet metals, wooden plates or multi-layer boards.
Three-dimensional building panels composed of polystyrene insulation layer, mesh, shear ties, reinforcing lattice and concrete. The panels are used in the construction industry in the following manners:

- Semi-precast buildings with separate roof and wall sandwich panels composed of polystyrene middle layer and shotcrete,
- Buildings with 3D double layered sandwich panels and in-situ middle layer concrete.
Some limitations of studies Industrial systems which make them inappropriate in common housing

1. Efficiency for mass housing construction projects, because of their industrial structure.

(Ex.: tunnel method and the integrated form, due to the need for special and extensive equipment is not cost effective in small-scale projects. For example, tunnel form is proposed for minimum 8 floors and 500 residential units),

2. Requiring employment of skilled workforce and special equipment with indigenous features for implementation of some systems,

3. Restrictions of load bearing walls in architecture design. Span length and height of column in all these methods are faced with constraints,

4. Restrictions in shape, size and location of openings,

5. Limitation in number of floors (Ex. : 3D panels, LSF, ICF ..),
• 6. vulnerability against moisture (for some systems like LSF),

• 7. Necessity of thermal insulation to enhance heat capacity, which would in turn substantially raise project costs (for example, the tunnel construction method and the integrated forms, due to low thickness and minimal heat capacity of thin concrete wall require heat and humidity insulation),

• 8. Lack of adequate space to move cranes, application of some systems is often faced with difficulties in the implementation phase, (Ex. :the tunnel construction method and the integrated concrete casting),

• 9. Limitation in providing the underground floors without combining with other systems (Ex. :the tunnel construction method, 3D panels, LSF, ICF ..),

• 10. Economically inefficient if specific elements for structure are ordered.
Recommendations

1. Developing industrialization in individual projects is as important as in mass housing.

2. To be succeed and generalized new systems and technologies, following issues should be considered:
   - Transferor characteristics,
   - Transferee characteristics and conditions,
   - Learning context
   - nature of the transferred technology
   - mode of transfer

3. To select appropriate technology which have the most compatibility with project features, a checklist for evaluating the indicators is needed.
THANK YOU FOR YOUR ATTENTION