Non-standardization based on Standardization

——The methodology of diversification for the industrialized buildings

In the future the individual will be able to order from the warehouse the housing that is right for him. It is possible that present-day technology would already be capable of this, but the present-day building industry is still almost completely dependent on traditional, craftsmanly construction methods.

--Walter Gropius, “Wohnhaus-Industrie”, 1923

Gropius was so longsighted. At present even in some undeveloped areas Architectural Industrialization is not a newly-emerged thing any more.

The economic committee of United Nations declares that Industrialization means **continuity, organization, research & development, standardization, integration** and **mechanization**. As for architecture, it also means architecture and constructional techniques dependent on **prefabrication**, **Mass-produced** building components were available from 18th century. With these techniques all components such as wall, floor slab, beam, column and staircase are mass produced under strict quality control and minimal on site activities (Rollet, 1986; Trikha, 1999).

In view of the large-scale of this domain, this paper can’t contain everything but only one typical element: **standardization**. Standardization is a foundational technique of architectural industrialization. As what CIAM (Congrès International d'Architecture Moderne) mentioned, “the most efficient method of production is that which arises from rationalization and standardization. Rationalization and standardization act directly on working methods both in modern architecture (conception) and in the building industry (realization)” (Conrads 1970:110).

1 A review of some definitions interrelated

1.1. **Standardization:** in industry, the development and application of standards that permit large production runs of component parts that can be readily fitted to other parts without adjustment. Standardization allows for clear **communication** between industry and its suppliers, relatively low cost, and manufacture on the basis of **interchangeable** parts. (Encyclopædia Britannica)

1.2. **Mass production:** application of the principles of specialization, division of labour, and standardization of parts to the manufacture of goods. Such manufacturing processes attain high rates of output at low unit cost, with lower costs expected as volume rises. (Encyclopædia Britannica)

1.3. **Prefabrication:** is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete **assemblies** or **sub-assemblies** to the construction site where the structure is to be located. (Wikipedia)

2 To standardize, not to be standardized

2.1 The basic characteristics of standardization

Usually standards are required when it is necessary to ensure that components made by different manufacturers will either work together or work in the same manner. The greatest advantage of standardization is that it brings about easier and clearer technical communication in the cooperation among partners. In addition, training and specialization are in simpler demand. Therefore the cost and the time are reduced. Standardization can also achieve quality control. What must be emphasized is that the objects to be standardized cover not only products but also processes. Standardization is particularly beneficial to mass production.

Accompanying the advantages, the disadvantages of standardization are evident as well. Standardizing means to change things so that all of them will have the same features. That also means less individuality even monotony sometimes.

So interestingly, standardization itself is individual though it stands in opposition to individuality. Some architects promote it in the meanwhile the others are sick of it. And all of them are reasonable because they confront different situations. Acting as a technical element standardization can win acceptance easily. But architecture obviously goes far beyond technology and always gives expression to the complexity of humanity. Standardization indicates common lifestyles, common behaviors and

common values in sociology. In other words, whom standardization fits for are standardized people.

2.2 Primitive standardization

There were already some kinds of thoughts of standardization before industrial society came to the world. They constantly involved basic building technology, aesthetic and politics. In ancient times the building technology was so undeveloped, the standards of architecture were always representatives of successful techniques and widely accepted aesthetics. With standardization the relative advanced experiences could be transmitted easily and extensively. This was helpful for the backward areas above all.

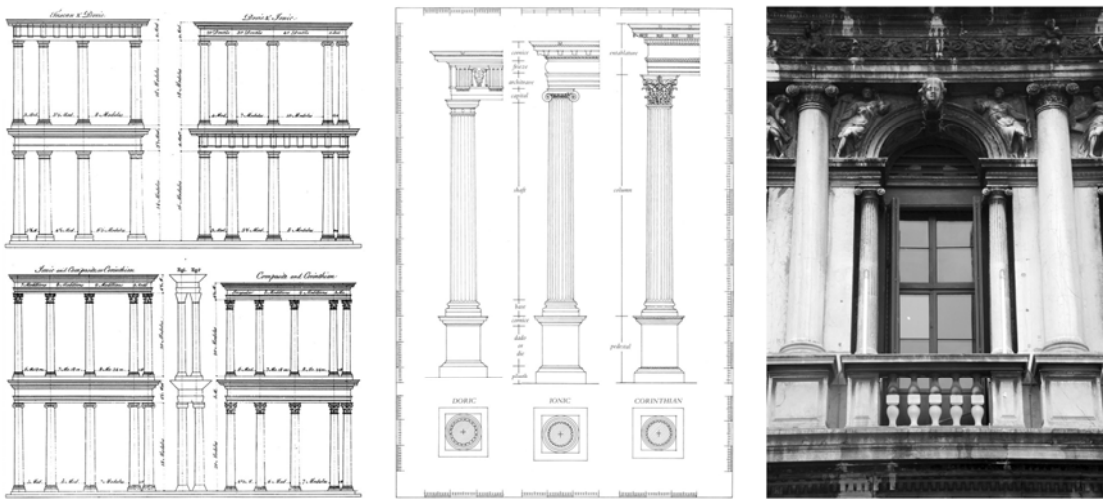

Figure 1 There were many typical standardized components in old western buildings, e.g. columns

A typical case is “Yingzao Fashi” (or “Ying-tsao-fa-shih”, means Codes of Construction), a book of technical regulations published by the feudal royal government of the Northern Song Dynasty in China. It comprised a unified set of architectural standards for builders, architects, and literate craftsmen as well as for the engineering agencies of the central government. Through this book we can find the high achievements in standardization of architectural design in Song Dynasty. Especially with respect to the applications of wooden structure, according to the different kinds of buildings, they worked out correspondingly a series of different measurements about the length and cross section of the structural members, including columns, frames, beams, rafters, etc., thus assuring both economy and durability. The book provides standard dimensional measurements for all the components. “Most of the book is documentation of the inherited traditions of craftsmen and architects passed down by word of mouth.” (Wikipedia) “Yingzao Fashi” gave an impetus to traditional Chinese architecture. Craftsmen on different skill levels could acquire the same technology then kept buildings away from low-quality.

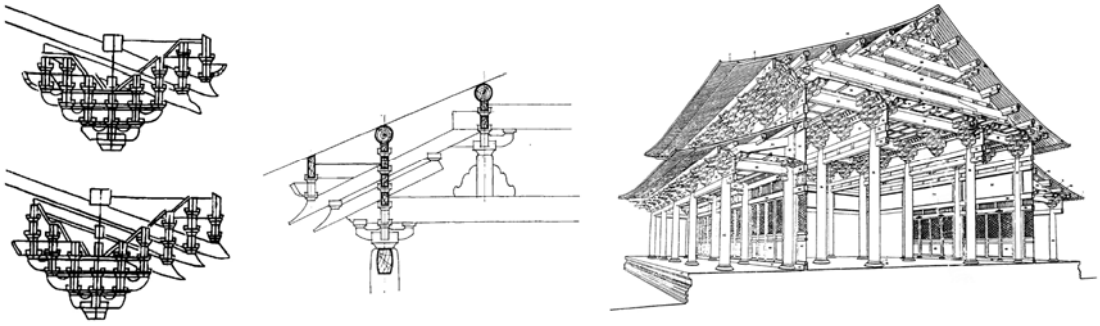

Figure 2 Pictures from “Yingzao Fashi”, a book of technical regulations of traditional Chinese architecture

2.3 Technical facility and restriction

As what already mentioned above, standardization has been functioning as a technical facility as well as a restriction from its very beginning. “Yingzao Fashi” again, it’s moreover a representation of the

social class system even behaved like a code of laws. According to its Cai-fen system craftsmen could be ware of the sizes of all components easily. And yet they are under the controls of many mathematical formulae. The buildings are often with hi-quality, hi-acceptability but less individuality.

As a general knowledge, in the ancient periods there were not so extended divisions of labour as today. Naturally, there were not so various lifestyles either. Furthermore, the upper classes stood on the opposite to diversification to maintain the society in a stable condition. Then the virtues of standardization carried off more opportunities to take effect.

But the instinctive individuality of the human kind has never disappeared. People are always fond of facilities but are sick of restrictions. As to standardization, what people prefer in essence is “to standardize” but not “to be standardized”.

3 The standardized buildings in modern time

In the last century there were large demands for dwelling houses almost all over the world especially in the post-war period. More efficient methods of construction were urgently in need of. The assumption about architectural industrialization of Gropius encountered an opportune moment to be carried out. Furthermore, a breakthrough of prefabrication was not beyond expectation. Common requirement became a motive force to standardization. And standardization enjoyed an advantageous position. Individual requirements were turned into a secondary character.

Gropius was not the only one who thinking over the standardized buildings at that time. In 1928 Le Corbusier published a little book Pour Bâtir: Standardiser et Tayloriser (For Building: Standardizing and Tailoring), expounding a tension between freedom and order, which he thought could be mediated by architecture as an art and as a system of industrialized building.

The industrialization and standardization of architecture had obtained great achievements in many countries throughout Europe. Prefabricated systems became almost universal by the mid-1960s in the countries of the former Soviet bloc, developed largely from such German prototypes as the Splanemannsiedlung in Berlin-Lichtenberg and the experiments with mass production techniques. From the mid-1950s the Soviet Academy of Architecture insisted a sort of theory that architecture be practiced as a technical rather than aesthetic pursuit, “Architects into the Factories”, as the reigning propaganda slogan. The trend of architecture industrialization even reached China which following the Soviet. Many countries, such as France, Denmark, Sweden, etc., had their own well-known standardized building system.

In spite of many different national conditions and diverse architects holding different views, the technical manners of standardization appear as if largely identical but with minor differences. From the angle of construction the standardized buildings are all characterized by prefabrication. Modularity turns into the commonest train of thought though the objects and the levels embody diversity.

Figure 3 Le Corbusier's Modulor theory and Briey Unité (Source: from internet)

To achieve modularity architects must make choice of the basic unit at first. The ordinary basic units adopted by most architects include: ① Modulor, the scale of harmonic measures (fig. 3); ② Grids determined by particular numerals. They were even applied in a lot of old buildings (fig. 4); ③ Rooms, usually with equipments (fig. 5); ④ Building components, mostly panel systems (fig. 6) and frameworks (fig. 7). Putting aside the differences among the basic units, these industrialized buildings also differ

from each other in the degree of factory-manufactured. For instance, according to U.S. Department of Housing and Urban Development there are four types of factory-built housing in America: manufactured homes, modular homes, panelized homes, pre-cut homes. Manufactured homes are typically 80 to 90 percent complete in factory, modular homes 70 to 85 percent. Panelized homes require more on-site labor than modular or manufactured homes. Pre-cut homes —in which building materials are cut into the correct sizes at a factory, according to design specifications, transported to the site, and assembled there — require the most on-site labor. The following table shows a great deal of differences between site-built and factory-built.

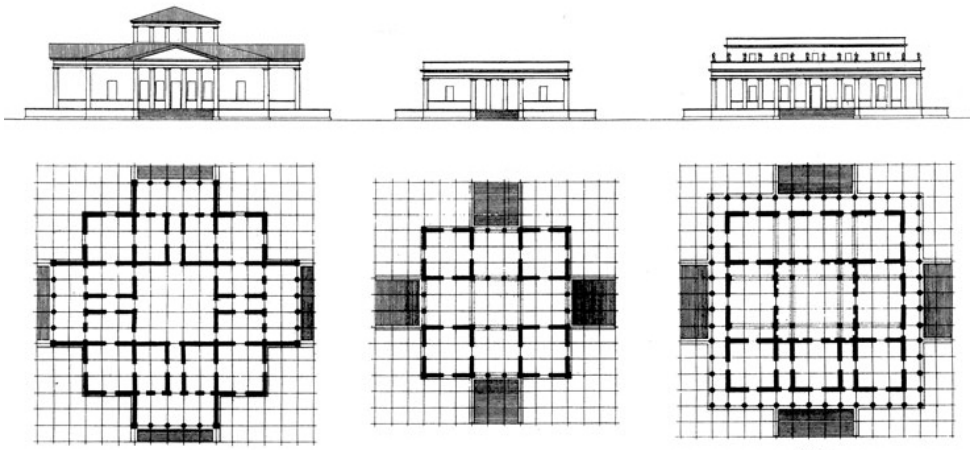

Figure 4 Square grids applied in old buildings (Source: from internet)

Figure 5 Room units being assembled (Source: Home Delivery, 2008; Elemente + Systeme, 2008)

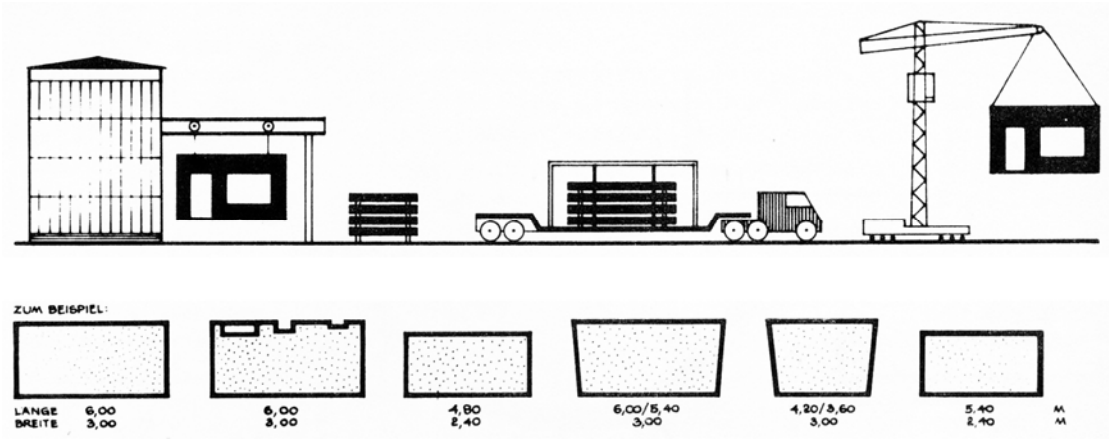

Figure 6 A typical panel system WBS 70 (Source: Wohnungsbauserie 70, 1973)

Figure 7 Standardized wood and steel frameworks

TABLE 1: COMPARISONS OF SITE-BUILT AND FACTORY-BUILT HOUSING

Most Typical Characteristic	Site-Built	Factory-Built
Construction location	On site of finished home	In controlled factory setting
Pre-site construction	None	70-90%
On-site construction time	3-6 months	1-2 days
Quality control	Middle	High
Set date of completion	Varies	Guaranteed
Foundation	Permanent, concrete or concrete block	Generally permanent, concrete or concrete block
Applicable codes	Local or State	State or HUD-Code
Acquired from	Local contractor	Manufacturer or dealer
Site prep and finish work	Local Contractor	Local contractor or "turnkey" finish crew
Limit to builder location from site	Varies	500 miles
Design variations	Wide	Moderate to narrow
Share of housing market	Half	25-35%
Zoning restrictions	None	None to moderate
Market appeal	Wide	Wide

Adapted from "Factory and Site-Built Housing—A Comparison for the 21st Century," (Source: NAHB Research Center, 1998)

4 Non-standardization with a standardized foundation

In the above table we can find not many drawbacks in factory-built housing. But less freedom of design —the inevitable outcome of standardization— is still a sensitive problem to those individualized architects.

4.1 Brief descriptions of non-standardization

4.1.1. Where the restrictions stay

In pursuit of limited selection sets and rationalized organizations the basic technical logic of standardization is contrary to individuality in essence. Standardization means somewhat simplification, some secondary factors that probably take important roles in other situations are neglected. Unfortunately individuality is among these disregarded factors because standardization only pays close attention to common requirements and mass production.

In a concrete category architectural standardization takes effect in the building components. And in an abstract category, that is the logic of the connection of the building components. Consequently the restrictions on architecture design are from these two aspects. Here the logic of design gives place to the logic of manufacture. Figure 8 is an example that some rooms become not so reasonable because they must fit for a specific standardized shape.

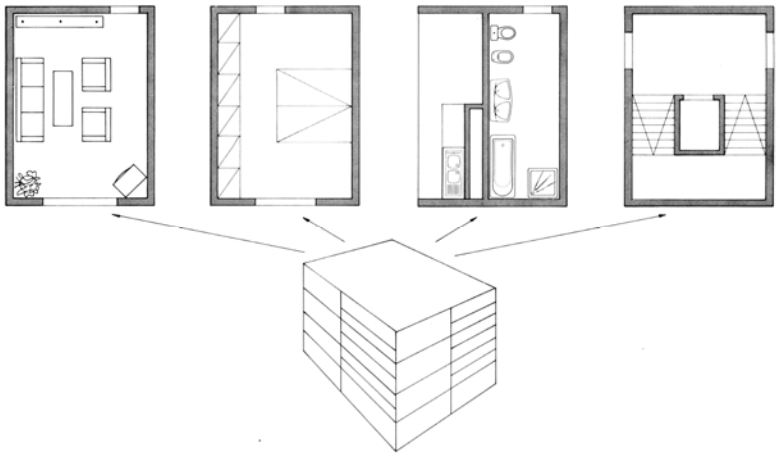

Figure 8 Standardized units sometime result in irrationalities if design losses its status (Source: Bauen Industrialisiert, 1976)

The restrictions become very strong forces when the standards behave as building codes.

4.1.2. The thoughts of non-standardization

Actually at the very beginning of the practices of standardization the antecessors already recognized the inherent conflict between individuation and standardization. All the time design flexibility is one of the emphases that architects concern about. Where there is a type of standardization, there is surely a type of non-standardization.

Standardization is relative in reality. There are hardly any completely standardized buildings. Nowadays as a result of the development of prefabrication, the completely non-standardized buildings are similarly rare. Non-standardization implies a compromise, a balance and a coexistent relationship between individuation and standardization. Non-standardization based on standardization is undoubtedly **an advanced stage of standardization**.

Non-standardization can be specific to the rooms, the building components and the abstract logics.

4.1.3. The fundamental strategies

In consideration of the main topic about non-standardization with a standardized foundation, the ideal strategies should not be the destructions of standardization technology. The advantages of standardization are what we want to reserve in the meanwhile the restrictions ought to be weakened.

For the architects, there are two standpoints should not be disregarded. ① The logic of design takes precedence over the logic of manufacture; ② The standards should be regard as options rather than rules. In any case, the dominator of architecture design is still architect. Architecture can be standardized on occasion, but architect never.

The customers' requirement is another determinant. Obviously, mass customers with similar lifestyles result easily in the accomplishment of the high-level standardization.

4.2 Non-standardization in practice

There are really many compromise proposals for non-standardization, in other words, for design flexibility. Nevertheless, It seems that they are not far beyond our imagination because they are so uncomplicated. What impress us are not the theories but frequently the project examples. And even so the theories can still serve as necessary reference resources.

4.2.1. Various options —varied types of prefabricated buildings

Factory-built housing in America is a clear illustration. It contains four types of buildings that differ in assembly line, manufacture mode, quality control and the percentage of pre-site construction. The architects can make their selections after comprehending on-site environment, local codes and the customers' acquirement. Varied options act as a compensation for standardization to bring about more flexibility.

An essential precondition is adequate works of research and development. Technical support is also urgently requested.

4.2.2. The separation of standardized and non- parts

Without enough developed standardization technology, the architects get less access to non-standardization. In this case the restriction from standardization become outstanding. But there will always be a space for flexibility.

Figure 9 Non-standardized parts bring individuality to the buildings

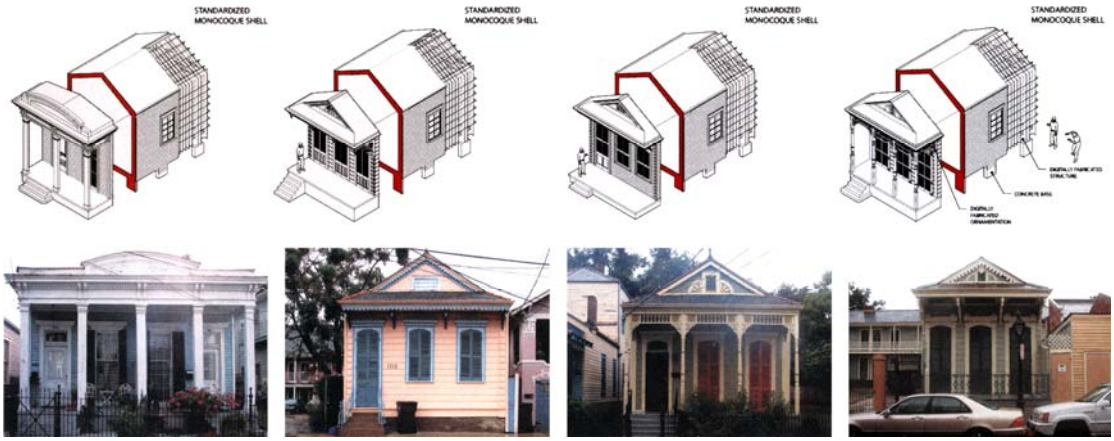

Figure 10 Larry Sass' Fabricated Housing for New Orleans. The buildings clearly consist of two parts: standardized and non-standardized (Source: Home Delivery, 2008)

As what mentioned above, completely standardized buildings are rare. Drawing lesson from product design, we think that most buildings can be divided into standardized parts and non-standardized parts. The non-standardized components bring individuality to the buildings. In the early periods of architectural industrialization some individual attachments were often appended to the monotonous main bodies to make them identifiable.

4.2.3. 2D and 3D Composition

The present professional education of architecture has given full consideration to construction technology, so some design techniques keep pace with the logic of industrialization and standardization. 2D and 3D composition have been obligatory courses for a long time in universities all over the world. What the students do in class is very similar to what the architects do in their projects.

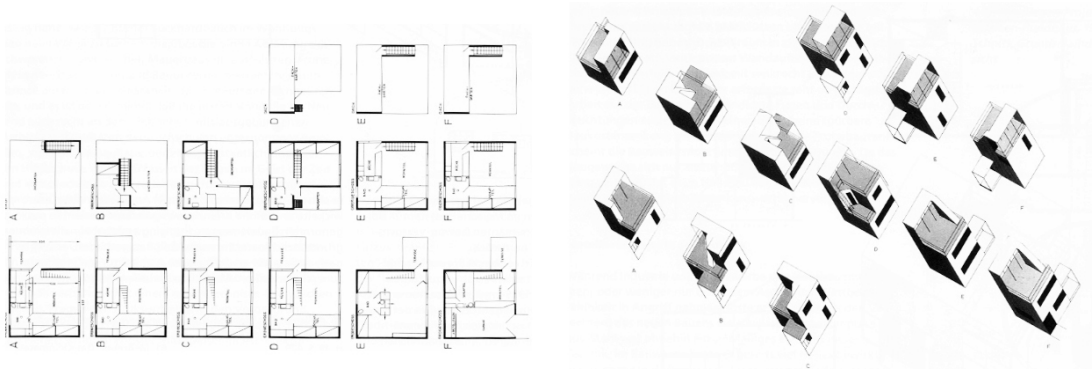

Figure 11 Kleinhaus, 1927, varied layouts (Source: Das Haus für alle, 1994)

Figure 12 From the early time till now, from 2D to 3D, composition behaves as a common design technique for diversification

With this ordinary technique, the architects may do a good job on the composition of planes and spaces with some standardized units. Flexibility only exists in the spatial relation and the logic of constitution. No more theory here, but just design techniques.

4.2.4. Individual units

In contrast with the concerns about the relation or logic among basic units, the basic units themselves can also be highly individualized to result in individual buildings. These individual units are often in uncomplicated arrangement. And as basic units they usually are not requested in various types in a single building, even there is only one type if the architect considers the basic unit is outstanding enough.

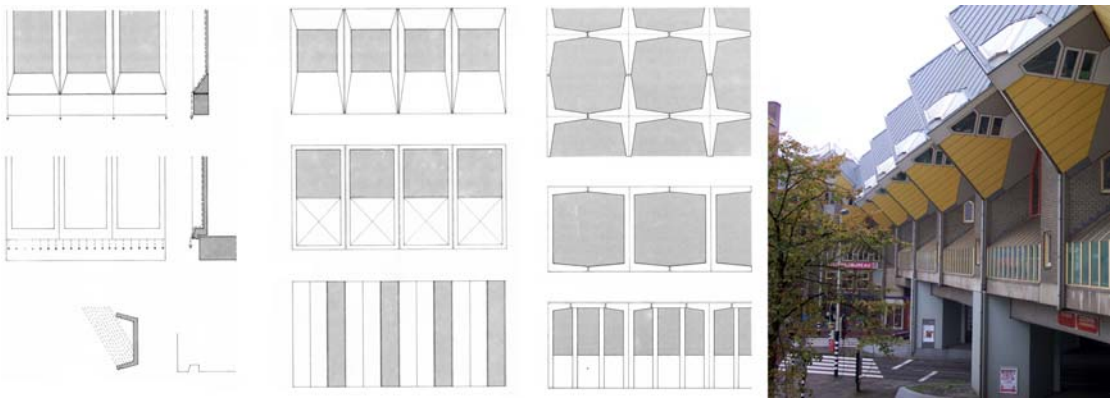

Figure 13 To individualize basic units is a simple method to make buildings individual

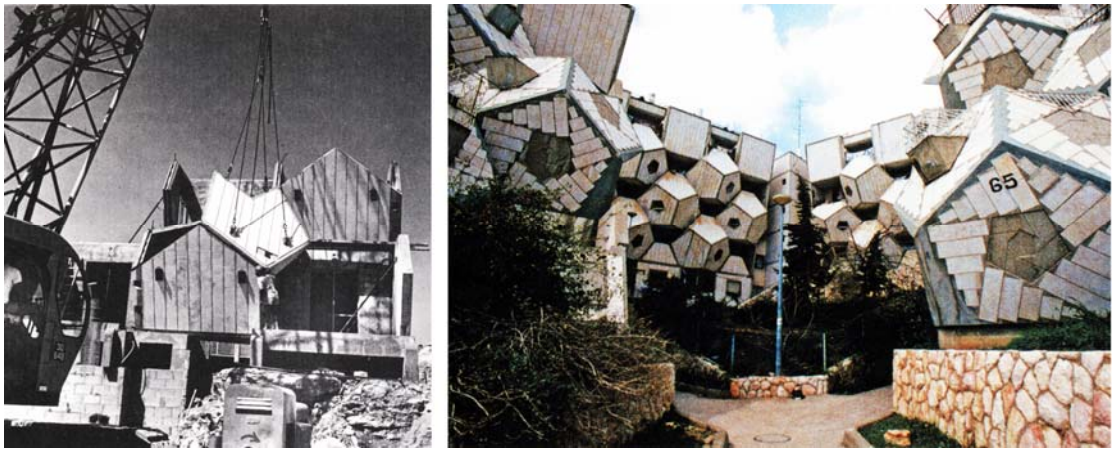

Figure 14 Individualized 2D units form individualized 3D units (Source: Home Delivery, 2008)

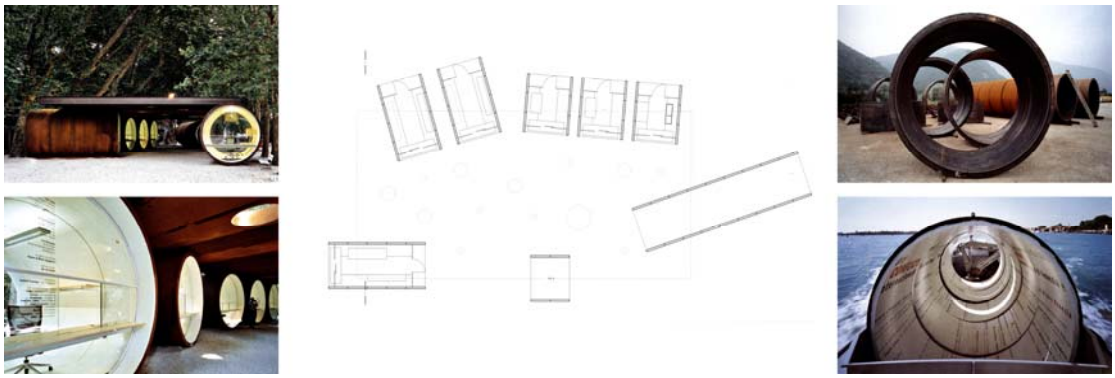

Figure 15 Pavillon in Venice. Architects: Archea Associate, C+S Associate (Source: Elemente + Systeme, 2008)

So in a standardized project, what can be individualized are either the basic units or their arrangements. Individual units + simple arrangement (fig. 13), or simple units + individual arrangement (fig. 12), or individual units + individual arrangement (fig. 15) are all appropriate selections.

4.2.5. Appropriate parameters

Although we can hardly give a precise definition to “appropriate parameters”, it is none the less very important to standardization. All building systems have their own series of parameters. The parameter is in nature a compromise among dimension of human figures, construction technology and diversification. The tendency of standardization and non-standardization exist together in the series of parameters. The result is a kind of balance between them.

The quantity of the parameters is not the most important matter according to some specialists. Monotone is not the inevitable outcome of the little amount of the parameters either. The reverse is also true.

Fig. 16 shows several types of house layout with only three parameters, 2.4m, 3.6m, 4.8m. This example is from industrialized houses in China in 1980s. The spatial relations among the rooms are still flexible to some degree.

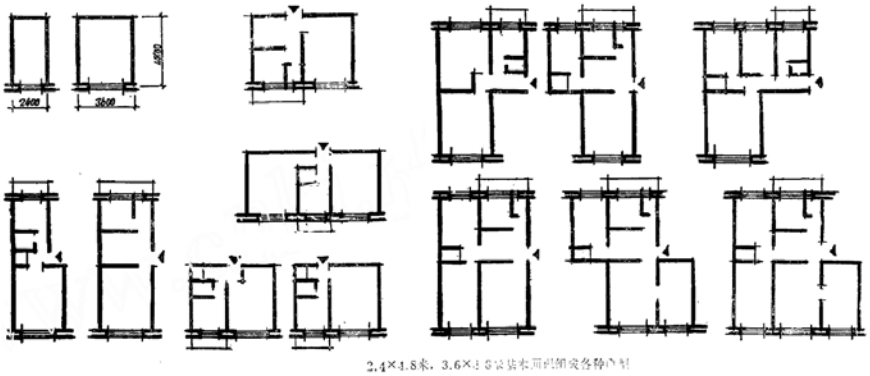

Figure 16 Several layouts based on 2.4X4.8m and 3.6X4.8m units. China, 1980s. (Source: http://www.cnki.net)

Fig. 17(left) is a plan of SCSD project. SCSD is an open building system in America which consists of a two-way, 5 foot by 5 foot rectilinear grid. All of the rooms, from small to large, from classroom to WC, are in accordance with the meshes. SCSD becomes a successful example of the great adaptability of a single abstract unit. It demonstrates to us the importance of an “appropriate parameters”.

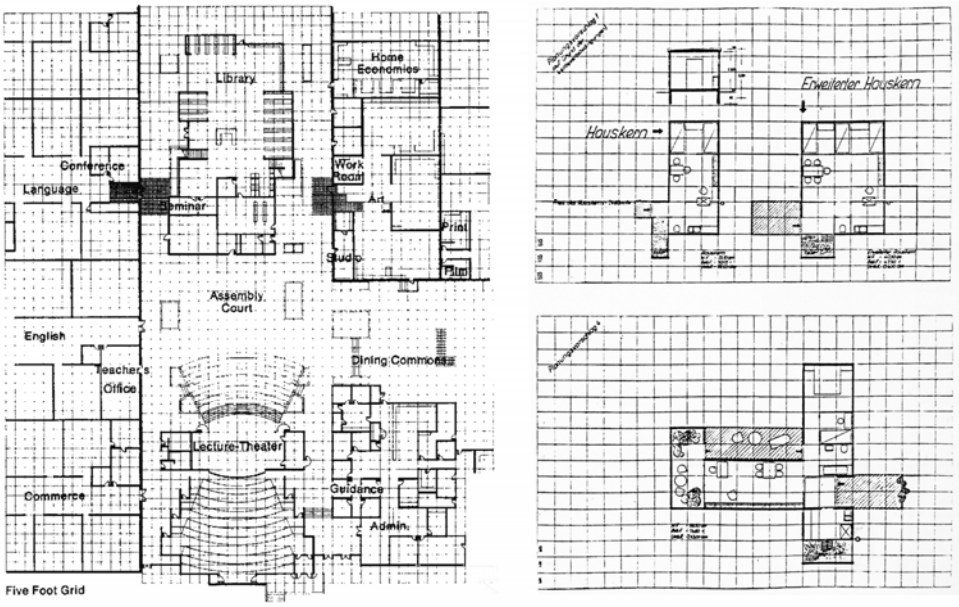

Figure 17 Square grids applied in modern buildings (Source: http://crscenter.tamu.edu; Das Haus für alle, 1994)

4.2.6. "Architects into the Factories" again

Differing from the former propaganda slogan, "architects into the factories" is meaningful to current standardized and non-standardized architecture in other ways. It implies a pre-design section before prefabrication. Architects should get wise to what happen in factories. And then they can integrate prefabrication technology with building construction. Furthermore, architects can even create some individual components taking advantage of prefabrication. "Architects into the factories" means more initiatives for individuality.

A Vineyard, weinguts in Fläsch, in Switzerland is an appropriate footnote. The architects created an individual arrangement of the bricks. It reflects their comprehensive understanding of standardization and prefabrication technology. They are the masters of the tools.

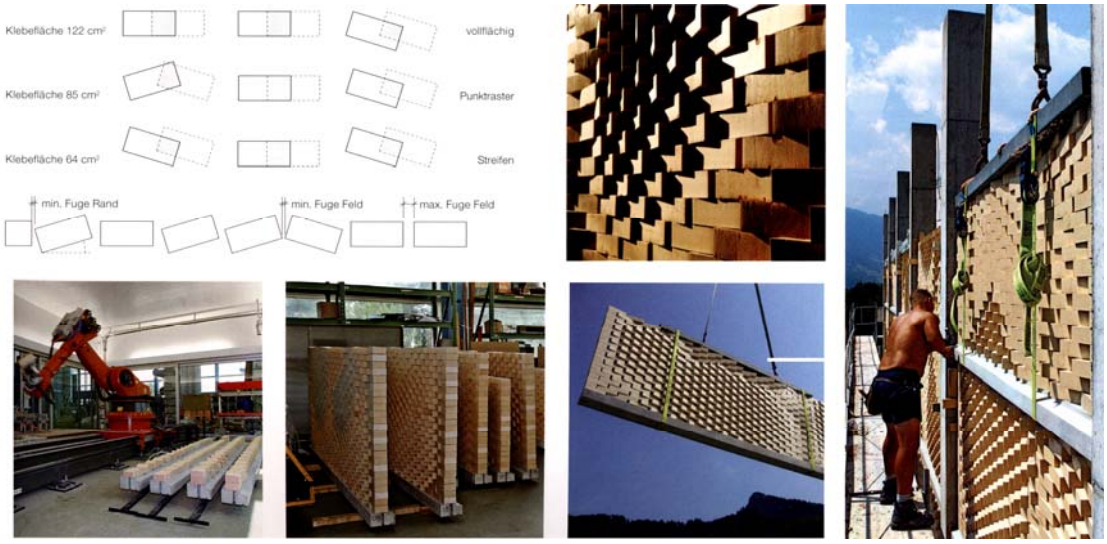

Figure 18 The manufacture of the wall of weinguts in Fläsch (Source: Elemente + Systeme, 2008)

5 Non-standardization in the 21st century

In the new century the communications among different areas and various people become more and more convenient. Of course the technical communications all over the world are in the same situation. Globalization is actuality no other than a new style of overall standardization. But in the

meantime post-industrial society brings much more space to individuality. So we are partly standardized as well as partly differentiated. Either standardization or non-standardization of architecture therefore has got to be put a new face on. Nevertheless, prefabrication technology should not be discarded on account of its excellence in performance and infinite possibilities.

5.1 Digitized standardization and non-standardization

Nowadays computer has already proved itself to be an all-purpose tool. Most architects consider computer no more than a drawing instrument. But naturally there are some exceptions.

To establish a digital library is obviously much easier than to build up a physical warehouse. With digital technology we can imagine a library of fully designed and engineered components that need only be assembled and minimally adapted in CAD files to create a great quantity of unique solutions with great efficiency. The large number of options gives expression to both standardization and non-standardization.

Figure 19 is Greg Lynn's digital experiment. He holds over 100 physical models produced in a variety of materials and the complete digital record of the design development and presentation. In their software system a given file often refers to other files; important parts of an AutoCAD drawing may be located outside the file—in a library or a base drawing.

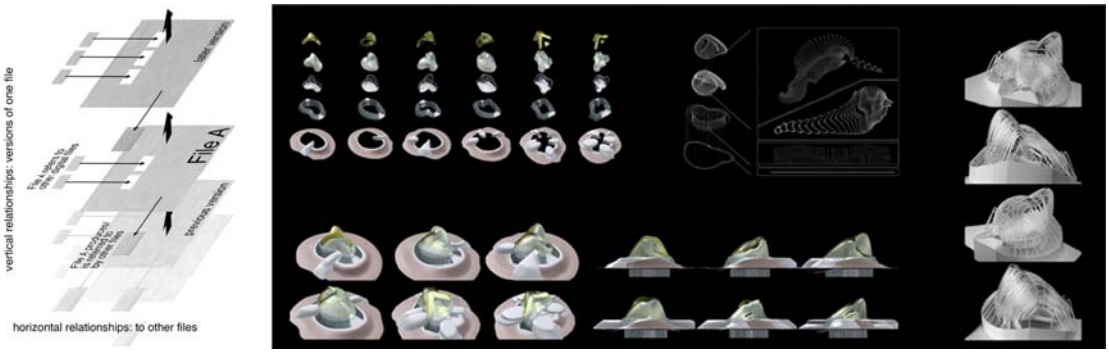

Figure 19 Greg Lynn's Embryological House: case study in the preservation of digital architecture (Source: http://www.docam.ca)

5.2 Prefabrication for individual buildings: standardization serves as a assistant of non-standardization

In the early stages of architectural industrialization mass production was in a dominant position almost everywhere. The standardization technology must comply with the common requirements. But at present, increasingly developed and efficient prefabrication technology also gains widespread popularity in many construction projects which have little to do with mass production. Some architects have studied a lot on non-standardization design based on standardization technology.

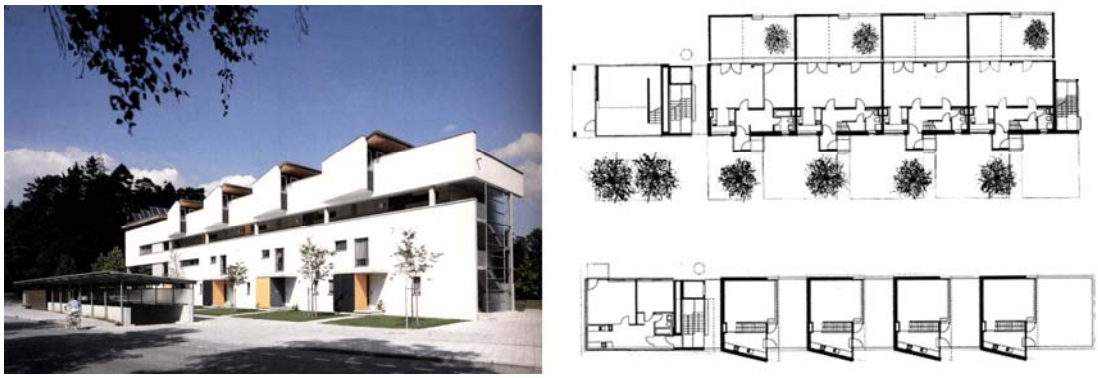

Figure 20 A individualized facade and its simplex plan (Source: Systembauweise im Wohnungsbau, 2001)

The HTA Association's (chaired by Tsutomu Kamo) "Honeycomb Tube Architecture" treats honeycomb tube as a basic unit. Precast prestressed concrete (PC) technology is their construction method and joint methods are the same for any derivation of hexagrams or hexagons. The architects declare that HTA can accommodate the vertiginously changing functions and usages of urban

residential architecture designed for lifelong occupancy as well as those of multifunctional, mixeduse architecture. But without computer simulation technology, the formulation, analysis and development would not be possible. A member of the HTA Association Watanabe said, “PC affords the manufacturing of a wide variety of products in small quantities.”

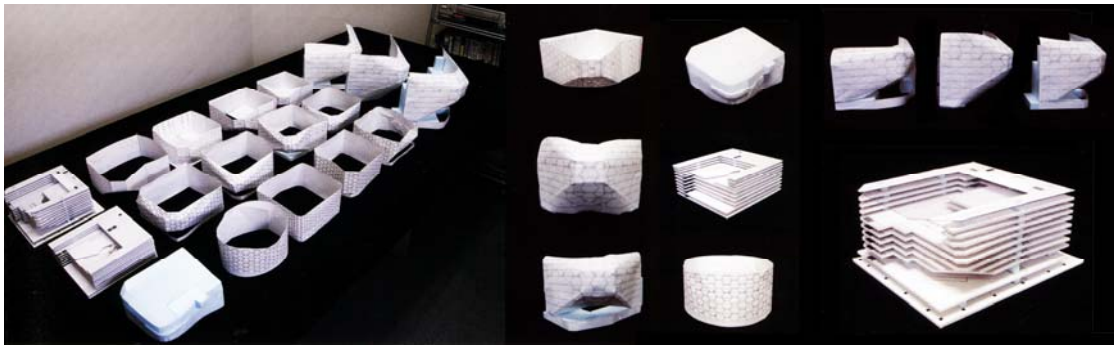

Figure 21 Varied study models of HTA (Source: Honeycomb Tube Architecture, 2007)

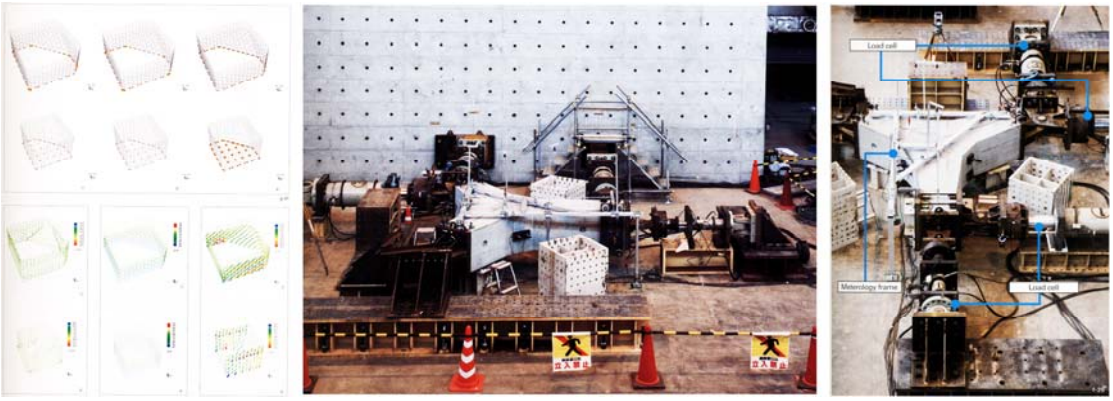

Figure 22 Structures study and manufacture of HTA (Source: Honeycomb Tube Architecture, 2007)

Douglas Gauthier and Jeremy Edmiston’s BURST*008 relies on digital technique in the same measure. These two architects apparently interest in creating a system of production. They use the computer and collateral technologies as tools to draw and fabricate architecture. At first they plug the client’s configuration into the program Form Z with the formula which explodes all 1,100 non-identical pieces apart. Then these pieces are assigned placement on more than 300 sheets of standard 4X8 plywood. Laser cut is the final process of manufacture.

*Figure 23 Douglas Gauthier and Jeremy Edmiston’s BURST*008 (Source: Home Delivery, 2008)*

They are all the best annotations of what is “non-standardization based on standardization”. We can find that the architects change direction to non-standardized design soon after they develop a new standardization technology.

5.3 Standardized tool, non-standardized design

In a developed prefabrication system what can be standardized are not only building components

but also some tools and abstract objects. For instance, assembly line is an outcome of standardized production process. Standardized tool, or in other words, standardization limited within factory is another feasible choice.

The individuals' opinions can easier participate in the design process if there are mature standardized software platform. The digital library and the programs applied in HTA, BURST*008 just mentioned before are quite right some kinds of software platform. Contemporary manufacture technology expands the application of these platforms. In some cases the clients can even finish their unique design with standardized software, send them back to the factories and then they will get the products what they want. Here only the software is standardized component. We should probably consider it as a new inspiration for the non-standardized buildings.

Figure 24 A webpage of an online factory enabling individual to design (Source: from internet)

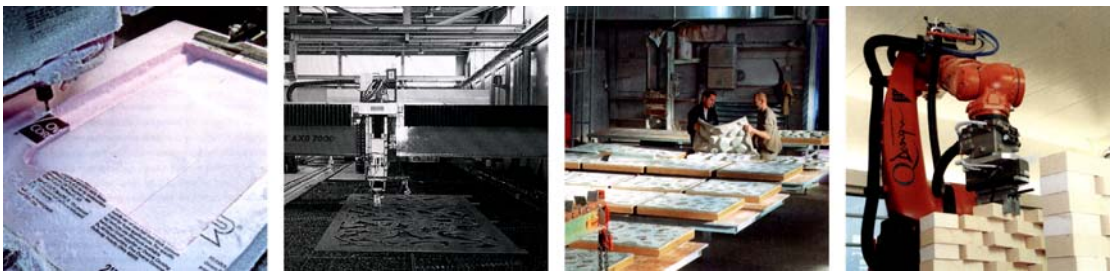

Figure 25 New standardization in factory calls for new manufacture technologies (Source: Elemente + Systeme, 2008)

Architectural standardization and prefabrication are renewed in the new century. While non-standardized architecture, interestingly, has never separated from them. Even if there are inherent contradictions between them, standardization can provide strong supports to individuality of architecture.

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