Integration between Space and Structure in Architectural Design Process

Mansour Yeganeh[1,*], Mohamdreza Bemanian[1], Teymoor Heydari[2], Mehdi Ahmadi[2]

[1.] Department of Architecture, Tarbiat Modares University, Tehran, Iran
M.yegane@modares.ac.ir, bemainan@modares.ac.ir
[2.] Islamic Azad University, Shahrekord Branch, Ardal Center, Iran
tm_heydari@yahoo.com, mehdiahmadi81@gmail.com

Abstract: Human architectures, like human beings themselves, are generally united, coordinated and targeted where components of fabricators systemize them completely. In the contemporary era, industrial revolution and their outcomes on the one hand and the need of impressive and bulky structures with the development of architectural science on the other led the ground for separation of theory and action and similarly separation of civil engineering from architecture. During this transition, structures are formed that often develop not only a coordinated and unified mould rather in a collection of mould with separated parts. By this way, whole architecture and their targets endanger and there may emerge a kind incompatibility between structure and space as the most real architectural components. In the process of architectural designing with worrisome essence, axial and tandem solution with criticism, test and error; programming is considered vital enough to reach to targeted modality along with beautiful form and space. The present research therefore, is an attempt to study the unanimous realization of structure and space and coordination in architectural planning.

[Mansour Yeganeh, Mohamdreza Bemanian, Teymoor Heydari, Mehdi Ahmadi. **Integration between Space and Structure in Architectural Design Process.** *Researcher* 2018;10(9):40-47]. ISSN 1553-9865 (print); ISSN 2163-8950 (online). http://www.sciencepub.net/researcher. 6. doi:10.7537/marsrsj100918.06.

Keywords: architectural Design process, solidarity and coordination, structure and space, realization, programming.

1. Introduction

Architecture is a phenomena or field at the intersection of science and art whose principles have developed in proportion to all advanced sciences and arts as well as the growth of human thoughts and endeavor. As such, in historical studies, architectural transition can well be known as outcome of two bases: transition and advancement in construction and technological aspects and; transition and metamorphosis in mental-philosophical insight of composers.

During industrial revolution, with the transformation like production of resistant material, invention of technical schools, division of the obligations of architects and civil engineers, separation of theory and practice, development of architectural science, and attention to economic advantage on one side and needs for bulky structural planning and construction prepared the ground for separation of architects and engineers. After this, the process of architectural planning came out of the worrisome stage completely. These two stages of the planning processes produce essential architectural effects which necessarily are indicators of the essence of architectural planning in order to reach to solidarity and compatibility of structure and space.

2. Architecture and its designing process

Architecture is outcome of a collection of specialties that as a whole, compile the generalization of that architecture. The architecture is compound of performance, architectural, spatial, environmental, contextual, semantic and symbolical aspects. Architecture is ascertained to respond to the set of existing situations. Essence of these situations probably is merely performance or may be at different social, economic, political, sentimental and idealistic levels. In every situation, basic assumption is on the fact that existing condition to the extent are not acceptable and thus new condition is essential. Thus, architectural creation of same performance is the solution to the problem or designing process. Architecture or design process is about selecting ingredients to reach to a universal stage that has wider than all essence. As a whole, anything and phenomena but systems, communication and combination bring genuineness and essence. Basis of architectural understanding with regard to it generality, is from components angle. In order to reach to the targeted architecture, the knowledge of its parts and their relation with general definition are necessary.

Process of architectural design begins based on three-dimensional mental setting. This designing is made by creative procedure from chaotic information and limited plan with pre-mental setting and future course of action of the architect. In other words, architectural designing process is based on the solution, not the problem. In a way, designers start architectural solution in the midst of their approximate answer and the process to reach to ultimate response is also linked with test and error. In other words, essence

of architectural planning process is towards analysis, composition and assessment of continuous plan. At present circumstances, important problem in this process, is the coordination among components to form an architectural opus with due attention to their expertise. In the meantime, structure and space enjoy particular importance because of being the real source of the architectural forms.

In order to acquire an architectural response, knowledge of ingredients of architecture and ability to change a system to the following systems and their analysis are necessary. In other words, in all aspects of designing, composed elements and systems must be attached to each other in a way that it will help form a unit. At the time these elements and systems are distinguished like architectural ingredients in it. It is with the whole structure, architectural system would be accomplished, a system that is formed with complete aim and unique essence (D.K. Cheng, 2005:3). As a whole, structural needs and effective rules in the architectural planning can be divided into three groups:

1. Operational needs, 2. Aesthetic standards; 3. Execution regulation; 4. Needs during operation.

Operational needs are the most important reasons of the existing structures. Aesthetic standards are related to existing culture and values of society. Execution regulations are often related to time, expenditure and qualitative standards of structure. And needs during operation and expectedly are related during the use of the building.

3. "Entirety" definition

In one definition it can be said that “entirety” is a cohesive collection of parts that was formed under opposite influence or chaotic reaction to each other, in a way that ingredient in the course of overtaking could be understood with coherent collection. An entirety is a different thing or more than accumulation of its fatalistic ingredient. Entirety cannot be constructed by assimilating individual part as a mental art that is unable to make coherent a coordinated structure of entirety has ever made or understood (Arnheim, 1974:5).

Generalization can be explained by distinguishing entirety from collection. Jean Piaget counts the fundamental difference of entirety with collection of self-relying components from composition itself in collection and organized components to follow continuation of relation among them (Piaget, 1995: 29) and elements of every generality support those rules. The basis of such rules defines the generalization to the degree of construction or order. Architecture is also under the command of its essence, structure and structure base. However, in ‘structure’, not only the collection of elements but that needs a language instruction too, in order to arrange them. Thus, this ‘structure’ is a collection of elements that systematically placed with each other and formed the whole unit.

A cohesive generalization possesses solidarity that interprets the highest form values. Existence of solidarity contains an order employing not only reciprocity but conformity with complexity. Beautification comes from connection between order and complexity and to reach to the equilibrium solidarity in generalized space is needed (Arnhein, 1974:12). Unity and integration of components is not only with the connection and being together, unity is acquired when the components of a plan are designed with a distinguished aims. Thus, in order to understand an exact building and encouragement to human aestheticism, their understanding as an entirety is essential. The condition of this oneness and integration needs coordination and connection of all components forming one architectural opus such as structure, architectural space etc.

4. Oneness and coordination of structure and space

Development of architectural science and structures in the contemporary era, necessitate their expertise. But this skillfulness shows that experts of each of these fields should not have y experience in other fields and lack collective knowledge that is essential for creating an integrated structure. In order to access to masonry with integrated generality, the knowledge of components such as structure, space and manner of their coordination and solidarity are necessary as well.

4.1. Structure

From the time immemorial, man has been helpless of utilizing proper quantity of material to solidify a structure against earthly forces and other dangerous weights. But, since aesthetic sense is a human character, it always dominated in the structure as against solidity and economic conditions.

To define in one sentence, ‘structure’ is the power to create resistance in the material and constellation from the integrated building elements that resist the opposite live or dead weight and transfer them to the ground. Structure necessarily contains equilibrium, resistance, firmness, arrangement, attention to material properties, imitating from course of power and geometry (Zarkesh, 2005:48). The real aim of the structure is to surround the space and protect it from natural factors, safeguard it space for human activity, and resist lateral forces. Form of a structure also directly influence it role in creating and defining an architectural atmosphere. As a whole, construction and design of every kind of structure is based on three basic principles: determining ultimate goal, determining primary and secondary needs and, selecting the materials that is necessary to conduct and searched upon a complete artistic opus.

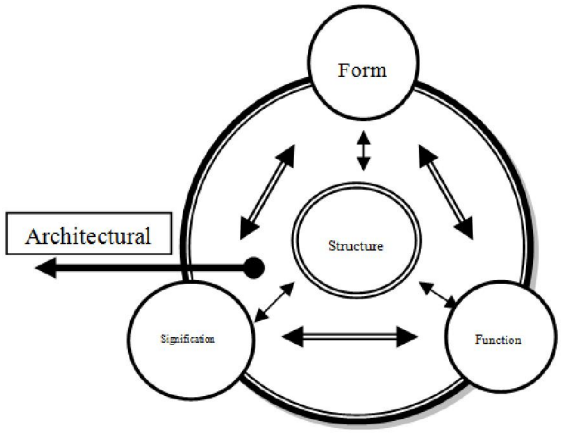

Diagram 1: Relaitionship between characters of architectural space and structure process of personification or imagination of structure is an art that fundamentally being acquired through internal experience and direct knowledge and the result is not merely dialectic and syllogistic. Or according to Doric Mills, structural technology is a root of knowledge but coming out with a form is an art.

It is because of the fact that sketching or imagination of a structure itself is a kind of art and a kind of inspiration, from internal experiences a kind of temperamental skill and personal feeling (Margolios, 2005:26). According to Edward Troja.

4.2. Space

Architectural space is defined on the basis of Euclidean geometry and philosophy of existence. Space based on Euclidean geometry is a qualitative space and heed to the definition of things and spatial connection between them. Space based on existence philosophy is human semantic environment. The space possesses symbolic, traditional and digestible language and its elements include place, route, axis and fragment. Apart, every period has a general definition of space that is known as "common definition of various locations/places". Form in the definition of space is based on existence and structure has also studied as one of effective component in creating space in this scope (Zarkesh,2005:47).

Table1: Definition of structure and its specialties

	Definition	Obligations	Visual condition	Operation	Rate of participation in creating resistance
Structure	Cohesive composition from resistant building elements	Resistance- equilibrium- firmness- arrangement- geometry- order, attention to material properties, imitating from load pass	Apparent	Surrounding space, standing up the structure, transfer of force from ground, creation of structure forms in the architectural composition	Active
			Hidden		inactive
			Semi-hidden		

Table2: Definition of space and it characteristics

	Kind of space	Definition	Elements	Specialties	Space quality	Receiver
Space	Euclidean space	Limited space among elements and surrounding space on it	Self-space-surrounding and opposite impacts	Real space human surrounding, limited operation	Effect from space itself and it surrounding	Interior and exterior space
	Semantic space	Human existing space	Place, route, axis and fragment	Surrounding with sense, possessing symbolic, digestible and traditional language	Influenced from form	Structure subjects, form, order, place (house, institution, city) common definition of different places

4.3. Unity and coordination of structure and space

Architecture has close relationship with structure and in reality these two are attached to each other and are inseparable. In case of separation, firmness and beauty of a building would vanish. There are a lot of examples of these conjunctions in the native and traditional architectures as well as different classical and gothic buildings. But in the contemporary era, a number of structures have cropped up, which are based on separation of structure and space. If the building is merely based on structure, it is neither influenced by structural aestheticism nor aesthetic programming. In fact, relation of architectural sense with structural aestheticism is divulging. The things that must be taken care are performance, integration and widening of space and attention to other qualitative dimension of space is necessarily unimportant. In other words, construction is based on beauty and visual perception. In this condition structure includes static performance, aesthetic properties (based on proportional and

harmonious description or structure with standard expression, or structure with symbolic expression). Against this type of buildings, some of the buildings are thought upon in free space where strong building materials are used to cover small openings. In other words, this structural form is not prevalent and does not give basic contribution in creating resistance. (Zarkesh,2006:47).

Uniformity of space and structure is defined on the basis of coordination and solidarity of components. Every building has entirety that led to the formation of solidarity (Groter, 1997:551). Space, as a whole, is taken into consideration that unwillingly accompanies structure. The time entirety is defined under the influence of ecological, economic, cultural factors, space and structure are determined in relation to it and in coordination with each other (Zarkesh, 2006:48). In other words, structure is a part attached to space and as a result both structure and space together express a thing.

Figure 1: separation between structure and space

Macdonald describes the unanimity among structure and space as: under this kind of relation building is constructed where important aspects are applied at one ratio and technical points of structure and programs reach to the successful conclusion (Macdonald, 1974:29). By this way, all changes in entirety lead to the changes in parts and every kind of changes in parts including structure and space would follow in components including structure and space and other entirety.

Desires and possibilities of structure form some other components and space programming. Therefore, space in the zonal limit, capacities and strength of structures and remaining components are exposed.

And therefore, the form of space is also form of structure and structure comes into being with its attachment with space and definition, logic or reality. Explaining the subject, Miss Pierre Von (1983) said structure, in conformity with the space, is the first real source of architecture. It forms an idea that is related to the sphere of arts. However, building does not deny its own rules, which are valuable sources of work description.

With approach, Macdonald further says that structure is preconceived notion for architecture. Similarly, he believes that making a building structure must exhibit the attachment with each other and as such points of structure are taken into account at the first stage. By this way, study shows that structure has been formed on the basis of technical rules but has conformity with space program as well. In this condition, structure also place the possibilities under the jurisdiction of space and becomes compatible with them. In every situation, structure may possibly be hidden, semi-hidden and visible. Though influenced by relative logic but once under the effect of space and other components, structure is not free. Thus, according to Macdonald, it doesn't produce visual expression.

Figure 2: coordination between structure and space Egyptian Pyramids

Majority of the buildings have formed taking into consideration two aspects of beauty: structure and space. For instance ancient and traditional architectures are different samples of integrated constructions. Gothic church can be taken into consideration from the operational and structural

beauty as well as from the safeguard of aesthetic sense point of view. Egyptian Pyramids are with all their perfection and unanimity of structure and space. In Iranian architecture, too, spatial beauty is always together with advanced structure and this unanimity has reached to its peak in every aspect of aestheticism.

In contemporary period also, large number of buildings have been constructed on the basis of integration and perfection and one of them is the Yokohama Port Terminal. In this structure, elements of pillars, walls, roofs are not visible.

Table 3: Architectural specialties based on separation of space and structure

<table>
<tr><td colspan="4">Specialties</td><td>Types of architecture based on separation of structure and space</td><td rowspan="8">Architecture based on separation of structure and space</td></tr>
<tr><td colspan="4">Use of new technology, creation of structure with new operation, big openings, elevated, high resistant material, use of light material, less attention to philosophic aspects of space</td><td>New structures</td><td rowspan="6">Architecture with structure priority on space</td></tr>
<tr><td colspan="4">Designing through engineers or participation of at least architect, attention mostly on performance, structure mostly on previous form</td><td>Plans based on engineering design</td></tr>
<tr><td>Performance, integration, bulky, less attentive to qualitative space dimension, building influenced from aesthetic sense of structure (not space)</td><td colspan="3">structure with static performance expression</td><td rowspan="4">Designing possessing visual expression</td></tr>
<tr><td rowspan="2">Relation of structure from proportion point of view

Order between structure components</td><td>Structure with proportional expression</td><td rowspan="3">Structure possessing aesthetic properties</td></tr>
<tr><td>Structure with harmonious expression</td></tr>
<tr><td>Structure having exact scale from aesthetic point of view</td><td>Structure with scale expression</td></tr>
<tr><td>Seismology, code messaged building, architecture based on advanced technology, with the thought of structuralisms, structure based on environment and crystallography,</td><td>Structure with symbolic expression</td></tr>
<tr><td colspan="4">Free space, strong building material to cover small opening, use of low level structure, inactive form of structure</td><td>Symbolic architecture</td><td>Architecture with space priority on structure</td></tr>
</table>

Figure3: Yokohama Port Terminal: Unanimity of Space and Structure.

Beauty of structure often is part of inseparable beauty from building but is not enough to guarantee the beauty. It can be concluded that knowledge and understanding of structure as part of architecture, are the most desirable and structure cannot be completed unless putting together architectural beauty (Salvadori, 2001:2).

In the building design, with every step, structure with architecture and equipment must be composed in order to create complete shape. Engineers and architects must have close relations from the first stage to the final stage. Designing process that is formed on the basis this kind of relation creates a successful, economic and beautiful building. This relation led to the creation of new and varied possibilities for reaching to the future architectural systems. In the section of design and execution of buildings, communicative and participative skills enjoy much importance among various expertises (Margolios, 2004:12).

Figure 4: combination between art and technology.

Figure 5: In the high rise buildings, the building is under the influence of structural beauty.

Cooperation of structural engineers in the design process is in the field of behavior and resistance of materials and that how the material could be applied in the most suitable way. But design is not only considering science of calculation and methods and structure, too, is not merely keeper of building/structure. Rather all the instances including art, common sense, ability and pleasure and that engineering calculation are included the last stage of it. If architecture has designed with enough skills and sensitivity, it would participate in creating beautiful image for the building. Separation of technology and art is also incorrect and undesirable. These two are not only opposite and deniable rather understanding of this technology is often inseparable part of art, which also help technology for giving better service to humanity. And this matter, nowhere is real than the connection between two aspect of architecture and structure, a connection between elegance and science that come from for securing the most fundamental material and intellectual needs of human being (Ibid, 19).

As a whole, in the ordinary and simple buildings where the needs of structure are simple, ignoring the planning principle to get to standards and demand of beautification and performance to extend can be fulfilled but it is impossible to ignore such principle in the big buildings as that are the real effect on the performance and beauty.

Figure 6: Structure is based on its own truth.

Figure 7: Skeleton and structure of Kalaterva is based on specialties of material and attachment of luxuriant and space.

Today, with respect to needs and construction of big buildings, architects are not competent to understand all structural and equipment dimensions and necessarily follow the cooperation of other experts. In order to create the relation of builder and strengthen the leading role of architect, acquaintance of architect to designing rules and understanding are basic conditions.

In all stages of planning, knowledge of behavior, exact calculation, correct designing, confident and secure execution of building are pressing needs of architects and engineers. In the meantime, knowledge of basic definition of behavior is needed to coordinate between architectural planning and structural calculation. Principally, a successful architect cannot accomplish without exact knowledge of behavior of structure.

One structural system, in order to respond to the operational needs, must resist the applied weight that is the most important obligation of it. Form of structure, selected for resisting opposite forces can possibly be influenced by operational needs and spatial geometry or possibly geometry of structure is selected in proportion to the bigger force that is named as 'force route' (Golabchi,2004:8).

In cooperation between architects and engineers, their different roles are being identified. In their relation, real obligation of structure engineer is to present a design that is response to the needs from engineering, execution, economic and aesthetic point of view (Ibid, 13).

For this reason, leading the project through architect to transform the mental setting to the final execution plan must go along with considering all factors and compilers in all stages and even selection of the final course. Acquaintance with the essence of planning process and lateral knowledge of architect from other expertise is also needed.

Table 4. Architectural specialties based on unanimity and harmony between space and structure

Architectural specialties based on unanimity and harmony between space and structure	Connection between structure and space	Two-way relation between Function, form and Signification with each other, presence of relation between above builders with the structure in the mould of architectural space
	Specialties	Knowledge of structure in totality, conformity between order and complexity, complete and close composition, space and structure influenced from entirety and other components, space and structure coincident and in connection to each other, space and structure inseparable, activation of form in resistance, use of maximum strength, closeness in form and space, lack of changes of space and or structure or other components, structure possessing hidden, semi-hidden and revealed existence, lack of visual expression.
	Receiver	Form, function, signification, space, environment, definition, signification aspects
	Fewcase studies/instances	Native and traditional architectures, classical architecture, gothic architecture and (Yokohama River Terminal, Egyptian Pyramids, old Temples, etc)

5. Conclusion

Architecture, like human being, is an integrated, unanimous and targeted and essence of its understanding is possible through component angle. Process of architectural design begins with initial three dimensional mental planning that is acquired from the data classification, limitations, mental background and architect creativeness. In other words, planning pertains to the solution of the problem. In this way, architect begins planning with the approximate response and assesses and composes them until he reaches to the final conclusion.

However, enormous development in architectural and structural science calls the help of other experts. The important point in the planning process is the manner to access to total integration with different factors. In order to reach to the target, knowledge of the idea of whole architecture is necessary. Similarly, it is also important to understand the behavior of structure and acquaintance of experts from different architectural angles including performance and aestheticism. In a word, in order to continue relation between these experts they need common language that can be acquired with the lateral identification by other expert domains. The aforementioned identification can take place during academic degree (through establishing opposite and two-way relation during training, growing relation with the executive and all dimensional and comprehensive architectural education affairs) or during professional job can.

In this process, architect at the time of analysis, assessment and all other stages must search the problem and point of view of experts. The final plan is acquired from such analysis and assessment. It is not in the way that architect must initially lead the plan and then include other components gradually.

Architect must have the strength and skills of creative art and use it to access to a real beautiful form and space. He must not make the structure merely as a protecting element. Since the structure is also a part of architecture, it can be considered as part of beautification. Thus in order to access to a targeted and integrated worthy architectural project leadership, architect must be in such direction. In sum, the utmost the final selection follow through the analysis, assessment and composition of all the components forming a particular architecture.

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9/25/2018