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KNOWLEDGE OF STRUCTURAL SYSTEM OF CONTEMPORARY ARCHITECTURAL APPROACHES

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After 1970, serious changes occured in the understanding of architectural form giving. The aim of this paper is to show that the required knowledge of structural system has been changed after 1970. In the first part of the paper, concept of structural form giving prossibilities is discussed from different architectural points of view and it is shown that, to end up with structurally optimum forms was necessary until 1970's. In the second part, importance of having the knowledge of 3 dimensional structural form and the way of modelling it for contemporary architectural approaches are emphesized with their reasons. In the third and last part, differences between the required structural system knowledge of contemporary architectural approaches are shown.

Contradictions between structural and arhitectural form can be minimized if architectural design procudure includes form giving procedure of the structural sytem. Because componts of structural form affects the interior and/or exterior form of the building. This is also important for the contemporary arhitectural approaches' for which building form is a means of expression.

Structural form is the form of structural system which transfers building loads to the ground. Components of structural form can be listed as; scale, proportion, geometric property of mass form, form of structural members and the form of addition of structural members (Fig. 1). Architectural form can be different that structural form, because it also includes additions and substructions in the form of mass, surface and / or line (Fig. 2).

Architectural form which includes structral form, is designed according to the functionality, economy and technological efficiency definitions of the architectural approach. Until 1970, it was accepted that architectural form must carry the properties of technologically optimum form. After 1970, in order to express subjects of technology and culture, architectural form was started to be used as a means of expression.

The required knowledge of structural systems for contemporary arhitectural approaches includes knowledge of technologically optimum

form, economomic advantages of having the technologically optimum form and architectural form possibilites from the point of view of contemporary architectural approaches.

Until 1970, architectural form possibilities was limited with technologically optimum form possibilities and essential properties of form. After 1970, only the essential properties of form limited the architectural form possibilities.

Technologically optimum form properties can be described as a result of construction of a building with minimum material, capital and power. Similarly structurally optimum form properties can be described as a result of design of a structural system which needs minimum structural material. All structural forms which have certain form properties can be accepted as forms which have optimum form properties in architecture. For example, use of short and deep beam is an structurally optimum form property for rigid frame systems.

Essential properties of form are such properties that prevent tarnsformation of a structural system to another. There is no relationship between essential properties of form and structural requirements like strength, stability and stiffness. The essential properties of form may determine both positive or negative structural behavior properties. For exaple, framed tubes must have short and deep beams in order to be accepted as framed tubes. Otherwise they must be accepted as rigid frame systems (1).

Arhitectural form properties of structural systems are defined according to be arhitectural appoaches which were accepted until 1970's. For example, it is known that structural behavior of framed tubes, which is a kind of high-rise structural system, are affected positively if these systems are designed as slender (1), square planned (2), narrower at the upper storeys (3), 50-55 storeys for reinforced concrete ones and 40-80 storeys for steel ones (4) and which have short and deep beams (1). But, which of these properties are technologically optimum form properties and which are essential form properties have not been differentiated. Depending on this and similar examples it can be said that, architectural form possibilities are not defined from the point of view of contemporary architectural approaches.

By examining existing classifications of structural systems it can be said that all structural systems which have different technologically optimum form properties are classified in a special group. This is appropriate for the architectural approaches which were accepted until 1970's. Differentiation of essential form properties and technologically optimum form properties is necessary or contemporary architectural approaches. In order to examine architectural form properties of structural systems from the point of view of contemporary architectural approaches, it is neces-

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sary to classify structural systems according to their essential form properties. Because, architectural form possibilities which can be reached by adding structural units can be determined only by classifying structural systems according to their essential form properties.

Knowledge of additvity of structural systems includes knowledge of two or three dimensional modelling of three dimensional structural systems. Consequently, knowledge of form and structural behavior relationship of primiray structural units becomes important. Two dimensional primeray structural units can be listed as; slabs, rigid frames, shear walls, arches and cables (Fig.3). By adding two dimensional structural units. Three dimensional primary units and other structural systems can be obtained. Three dimensional structural unitis can be listed as; domes, membranes and framed tubes (Fig.4). All structural systems are results of addition of the two or three dimensional primary units to themselves and/or to other primaray units (Fig.5).

Structural units can be added to themselves or to other structural units in three main ways. These are; adding structural units near each other, adding them on top of each other and adding them by integrating. Suspended bridge structural systems are examples of adtition of structural units near or on top of eachother. Shell structures with negative curvature are examples of integration of arch and cable systems. Trussed tubes are examples of integration of framed tubes and trusses. If adtition is made in the form of integration, the resultant structural system carries the diominant structural behavior properties. If addition is made in the form of adding systems near or on top of each other, architectural form properties of the place of addition must be determined seperately.

The following classification can be reached if high-rise building structural systems, which are mentioned in written sources, are classified as described above.

- Rigid frame systems,
- Shear wall systems,
- Rigid frame plus shear wall systems,
- Framed tubes; bundled, coupled and tube in tube systems which are the results of addition of framed tubes (Figure 6).
- Trussed tubes; bundled, coupled and tube in tube systems which are the resulsts of addition of trussed tubes,
- Tube in tube systems which are the result of addition of framed tubes and shear wall systems,
- Tube in tube systems which are the result of addition of trussed tube and shear wall systems.

The above structural systems wich are mentioned in the same group

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have the same essential architectural form properties and if there is no essential form property of any architectural form component, all architectural form properties of that component can be reached by that group of structural systems.

In order to determine architectural form possibilites from the point of view of architectural approaches which were accepted until 1970, all structural systems listed above must be handled seperately. Because, all of them have different technoloically optimum form properties.

Having the knowledge of structural systems which is described above has a different importance for all contemporary arhitectural approaches. Contemporary architectural approaches and reasons of their occurance must be understood inorder to clarify the importance of having the kind of structural system knowledge explained above.

Having the technoloigically optimum form properties was generally accepted until 1970's. Technology was expressed in this way until 1950's. Because, after 1950's the technology used was started to be accepted as ordinary. After 1950's, the first attempts of Post Modernism started to be seen (5). Nearly all contemporary architectural approaches have the property of creating such structural forms that expression of technology or culture is realized clearly or not clearly. This kind of an architecture enables creation of different effects on the user.

Comtemporary arhictectural approaches are generally classified as Late Modernism, Classicism, High-tech and Deconstructivism. But, if they are classified according to the required structural system knowledge; it can be that only for few examples like R.Meier; the required structural system knowledge is similar to Modernism's. Also, for Expressionism like Modernist architectural approaches, architectural form possibilites are limited only by essential architectural form properties. According to above explanations, contemporary architectural approaches can be classified as follows:

1. Architectural approaches in which having the technologically optimum form properties is targeted,
2. Architectural approaches in which having the technologically optimum form properties is not targeted,
   a. Approaches in which expression of technology is realized,
   b. Approaches in which expression of culture is realized.

The architectural approaches, in which having the technologically optimum form is not targeted and expression of culture is realized, are named as Classicist architectural approaches. In this kind of an architecture; forms in nature, industry, architecture and etc. are used in different combinations. Because of this, the required structural system knowledge

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for Classicism can generally be explained as knowledge of architectural form possiillities of existing structural systems.

For the contemporary architectural approaches in which expression of technology is realized, this situation may change. For some High-tech examples in which the form of an existing kind of structural system is exagerated, the required structural system knowledge is similar to the knowledge required in Classicist design. In Expressionist and Deconstuctivist architecture, wellknown technological properties are not used. Especially in Deconstructivism the use of standart technological properties is rejected. Creation of this kind of an architectural form requires the following kinds of structural system knowledge.

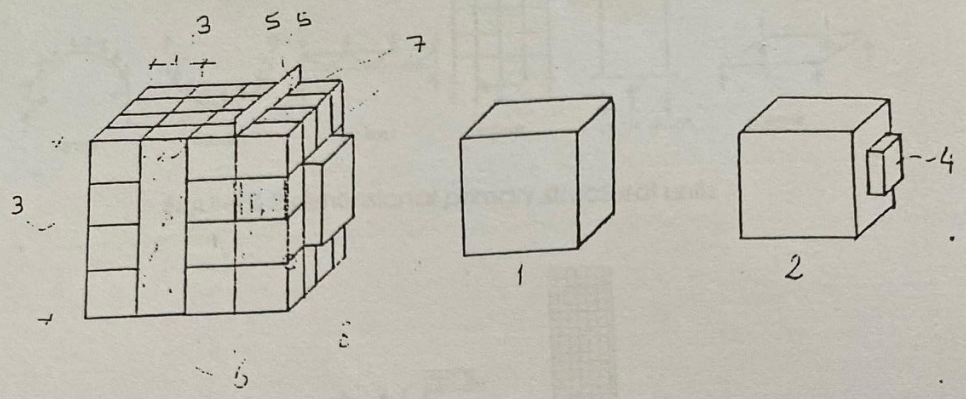
- Optimum and essential architectural form properties of existing primary structural units,

- Architectural form possibilities of structural system which are realized by addition of existing primary structural units to themselves or to other primary structural units,

- Knowledge about architectural form possibilities which are not realized.

Architectural form possibilities of structural systems which are realized by addition of existing primary structural units can give new structural systems which have different technologically optimum form properties and structural systems which have different architectural form properties. High-rise structural systems like trussed tube and bundled tube were discovered in 1960's in this way. By having the knowledge about architectural form possibilites which are not realized, new primary structural units which have different essential form properties can be designed.

As a result, it can be said that, architectural form possibilities and constraints of structural systems must be well known for a contemporary design procedure. If it is accepted that, contemporary architectural approaches are not a fashion, the necessity of making additions to the terminology of structural systems can be discussed together with the necessary structural system knowledge and ways of teaching it. The terminology, which may be added to the existing terminology of structural systems, are required to express the structural systems which have the same essential form properties under the same heading.



1. Geometric property of structural mass form
2. Geometric property of architectural mass form
3. Scale
4. Form of additions in the form of mass
5. Form of additions in the form of surface
6. Form of additions in the form of line
7. Form of structural members

Figure 1. Some components of architectural form

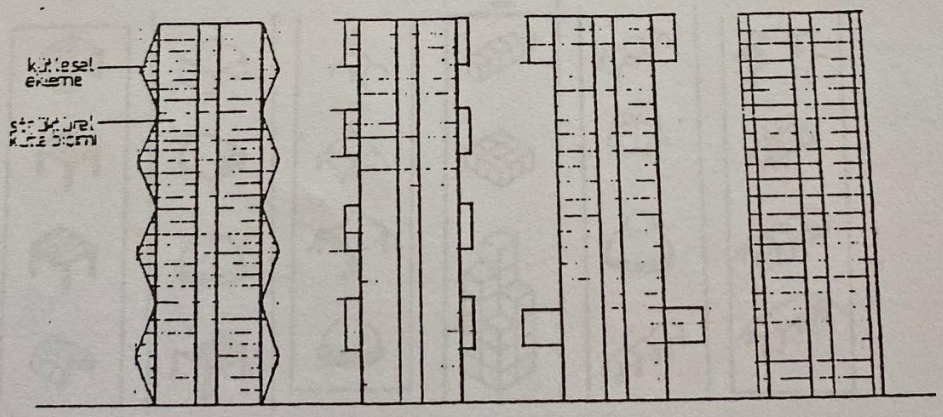


Figure 2. Differentation examples of structural and architectural form.

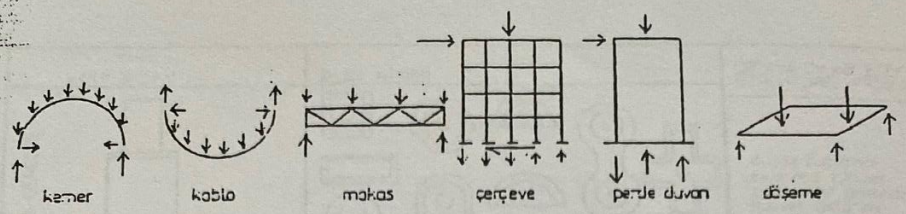


Figure 3 2 dimensional primary structural units

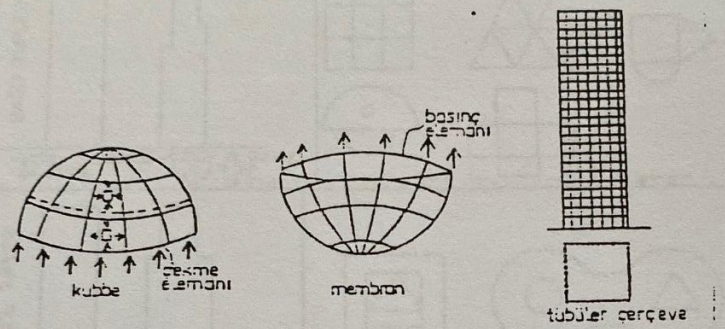


Figure 4. 3 dimensional primary structural units

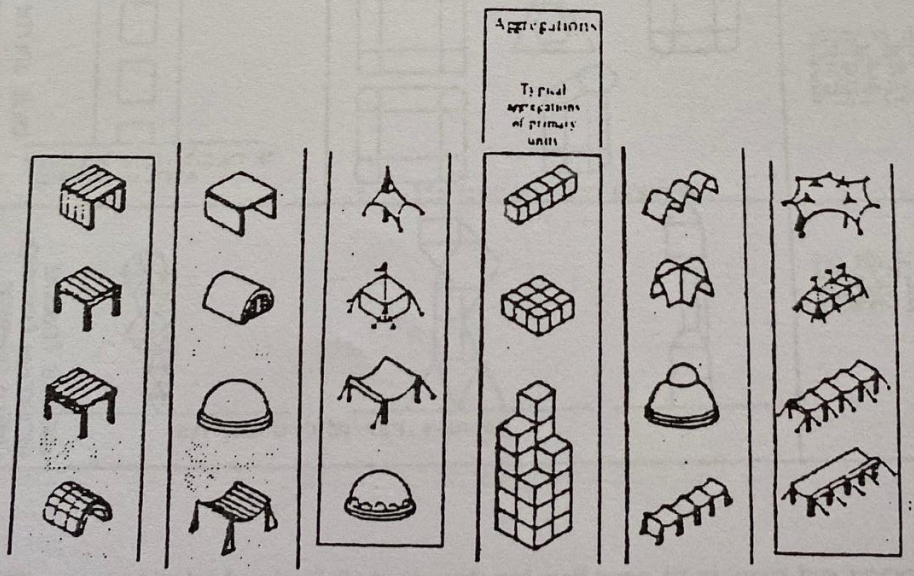


Figure 5. Addition of primary structural units (6)

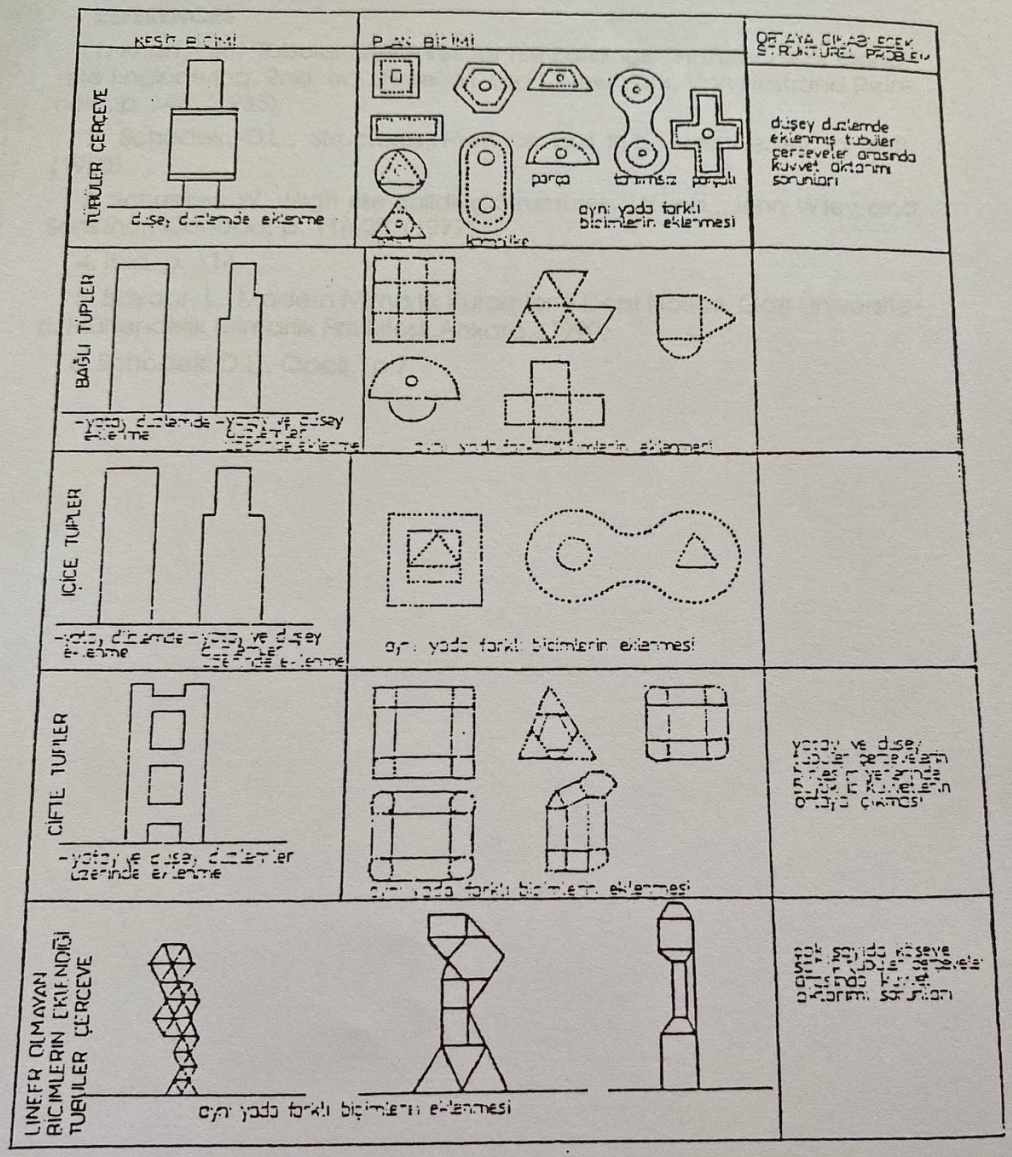


Figure 6. High rise building structural systems that can be reached by adding framed tubes to each other.

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