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## **The Ontology of Contemporary Construction**

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### **ABSTRACT**

The main aim of this study is to discuss the ontology of contemporary construction by considering the recent developments in structures. For this purpose, contemporary transparent surfaces of suspended glass systems are considered. These systems are compared with the framed structures of the modern, and Gothic structures in order to discuss the ontological differences between them. The three systems are compared according to the number of structural systems in the building, the type of structural materials, the ratio of transparent surfaces, the existence of perceivable deflection in each system, the elementary or non-elementary nature of the structure , the existence of small details at the joints, and the existence of ornamentation.

## **The Ontology of Contemporary Construction**

## 1. INTRODUCTION

Today, we more and more commonly see forms of architecture which create an excessive display of structure: larger overhangs, thinner roofs, and hi-tech details. They seem to deny the scientific laws of construction. These make ordinary people think that we are nearing a turning point in technological change, which will also cause a revolution in our life styles very soon. There are new materials that can be used for building purposes. There are some new systems that are totally different from all the previous ones. There are some new construction techniques that were previously unknown. These issues make it necessary to question the status of the changes in the engineering as well as in architectonic values in relation to the changes in the building technology.

Changes in the engineering and architectonic values can be categorized as developmental or ontological changes. [T. S. Kuhn (1982) used the concepts of developmental and revolutionary –paradigm- in order to understand the nature of changes in science and technology.] The use of a certain structural system for slightly larger distances with the help of some new adjustments, can be considered as a developmental change. Even the invention of a new type of structural system might be accepted as a developmental change. However, radical, but rational changes in the engineering and architectonic values, can cause ontological changes.

Ontology is “the science of being,” which provides a materialistic understanding of particular things by relating them to, or separating them from other things. C. P. Peirce’s (1955) phenomenology, which is seen as the “science of appearances,” can

be useful in respect of explaining the concept of “ontological change,” as well as the concept of ontology, as a philosophical method. Peirce’s psychological and rational phenomenology works in three stages. The first stage explains the quality or feeling of the “thing.” The second stage explains the “thing’s” separateness from other things. Finally, the third stage provides a synthesis, which assimilates the “thing” for the sake of understanding it. The existence of an ontological change can be discussed following these three stages. Thus, the method, which is suggested by Peirce, also consists of three stages. In order to discover the ontological differences, one first uses his/her experiences and feelings in order to relate the qualitative characteristics of the “thing” to others. The relationships between these qualities and the scientific categories, which already exist in the mind, are then discussed. Finally, a synthesis, which provides the final identification, is made.

The main aim of this study is to demonstrate that there has been an ontological change in the essence of contemporary building technology when compared to earlier technologies. All new materials, new systems and new techniques could have been examined for this purpose. However, since the “suspended glass systems with pre-stressed cable trusses” (SGSPCT) provide radical qualitative differences in the material space, the research objective of this particular study would be to have a discursive dialogue on the ontological differences caused by the advent of SGSPCT. This decision corresponds to the first stage of ontological thinking as a method. The second and third stages correspond to the development and conclusion of this study correspondingly.

Secondly, we compared the qualitative characteristics of SGSPCT with the corresponding characteristics of frame systems (as another contemporary building system), and Gothic structures (as a 'system' of the Middle Ages.) These systems were selected, because their qualitative characteristics are radically different from those of SGSPCT, and each of them represents an ontological change within the understanding of construction at that time. Gothic structures were revolutionary in comparison to traditional systems. Similar statements can be made in respect of the revolutionary effect of the frame system. Both Gothic structures, and frames created a feeling of insecurity in their users when they first appeared. The reason for this, is the radical lightness of these structures, or their radical forms in comparison to previous structures. (Billington, 1983) H. J. Cowan (1992) stated that many Gothic cathedrals collapsed, whilst the builders were developing the Gothic approach to structures. Similarly, D.P. Billington (1983) and M. GaenBler and R. Möller (1978) stated that, when the steel frame of the Eiffel Tower was first built, people did not trust the large and rectangular frame beneath it. As a result, G. Eiffel had to add a steel arch to this frame. Both Gothic structures and pre-cast frames affected people's feelings and offered radically different experiences of space in comparison to earlier structures.

G. Hartonian (1994) wrote about the "ontology of construction" by considering the Ancient Greek term, "techne" (the art of making), late classical architecture, and the buildings of three modern architects. This study highlights an ontological change between classical / traditional architecture and modern architecture. However, it does not explain the qualitative differences between the buildings with SGSPCT and the others.

The ontological characteristics of these three systems; SGSPCT, Gothic structures, and frames, are investigated with the help of the following questions, which reflect the qualitative differences of SGSPCT from other structures:

1. How many different structures are present in the building? Are they designed according to different engineering and architectonic values?
2. What is the character of the transparent surfaces, and what is the ratio of these transparent surfaces within the whole surface?
3. What is the relationship between the structure and the ornamentation?
4. Is there any change in the dimensions of the construction details?
5. Is the structure elementary, and, therefore, can enable the joining or separation (un-joining) of members?
6. Is the deflection / deformation perceivable?

## **2. SGSPCT AND ARCHITECTURE**

New developments in technology and a need for transparency has resulted in the creation of various types of curtain wall and suspended glass systems. Suspended glass systems with pre-stressed cable trusses (SGSPCT) are considered as one of these systems. The materials used in SGSPCT belong to the category of advanced building technology. The current materials in use are glass, steel, and silicon. The glass used is of a specially produced type in order to reduce its brittle character. Steel is used in the formation of both pre-stressed cables and slender struts. (Rice, Dutton, 1995) It is also expected that the recent research done on nano-technology will be applied to these systems. (Coontz, 2000)

Suspended pre-stress cable structures usually combine some preparatory structural members in the main building structure, the steel tubular elements, the cable trusses and the glazed assemblies. (Rice, Dutton, 1995) There are different applications of SGSPCT in respect of its distance from the main building structure. SGSPCT can be situated within the main building structure, outside the building structure, or integrated with it. (Atakara, 2002) Figures 1, 2, and 3, correspond to these applications respectively. The formation of SGSPCT is effected in accordance with its distance from the main building structure.

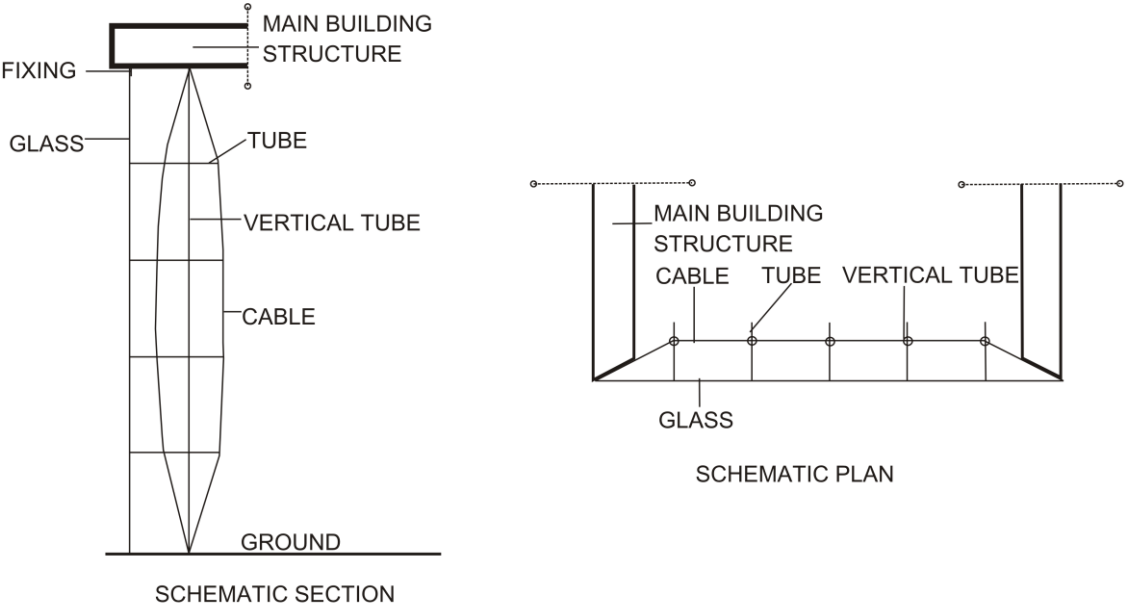


Figure 1. SGSPCT Between Floors System (by authors)

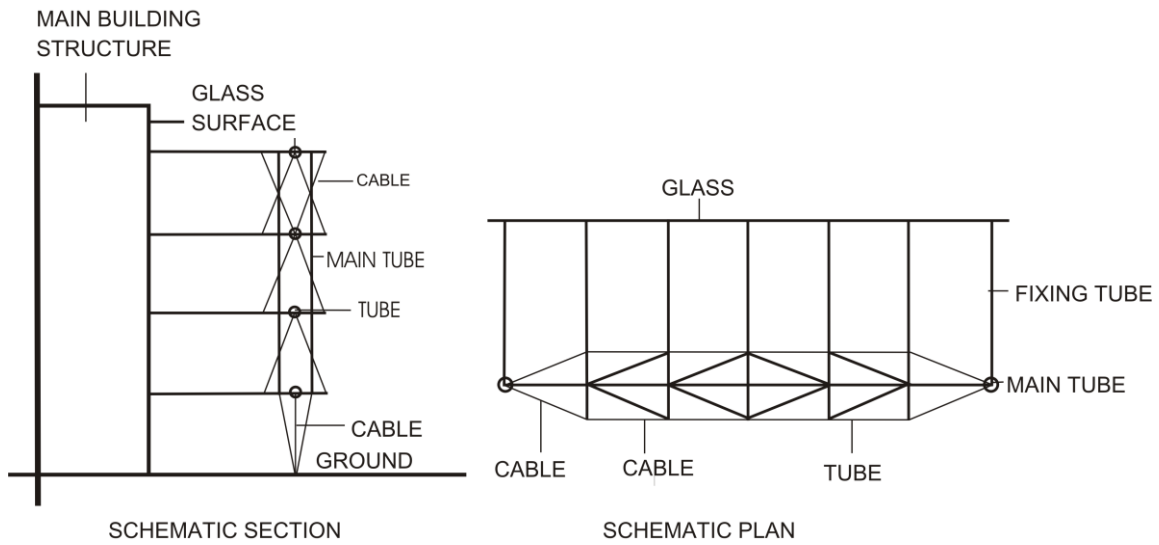


Figure 2. SGSPCT Distance Bridging System 1 (by authors)

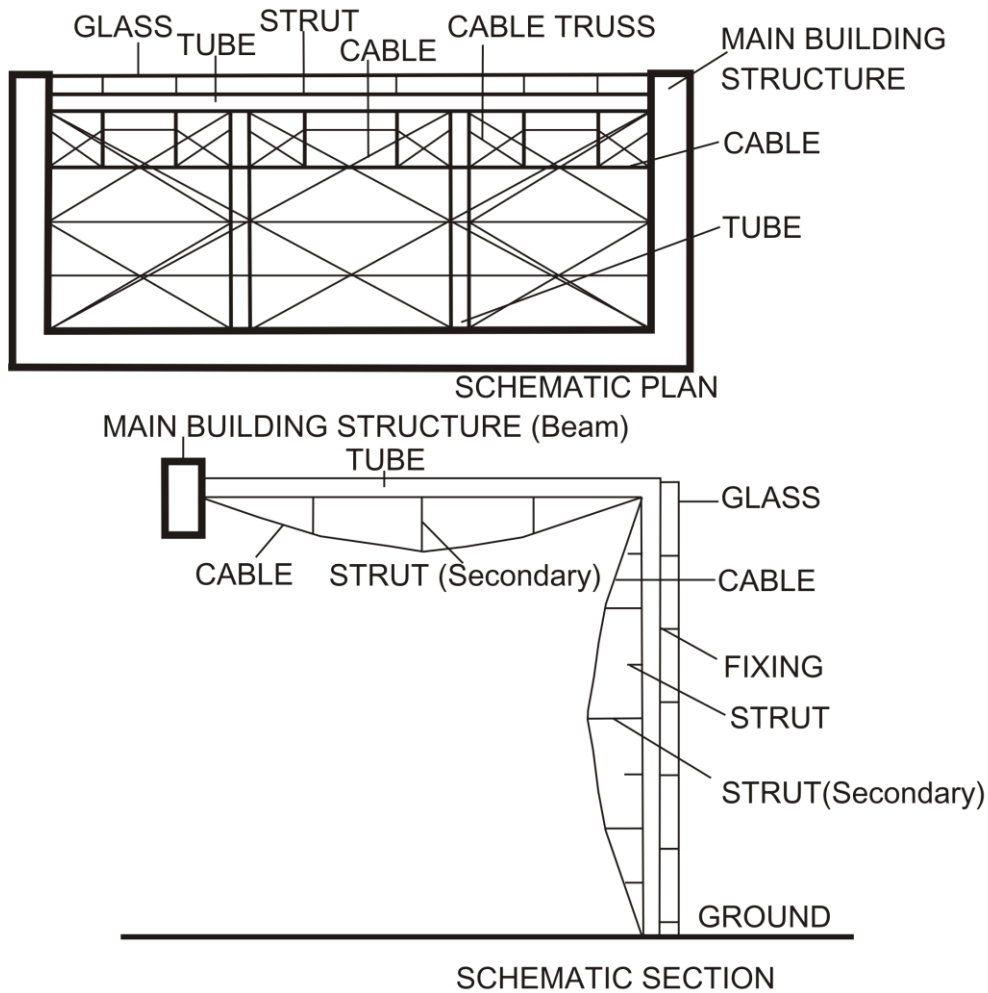


Figure 3. SGSPCT Distance Bridging System 2 (by authors)

The following qualitative characteristics of SGSPCT can be followed from the photograph and system drawings of the Science Museum in Paris, which is shown in Figure 4.

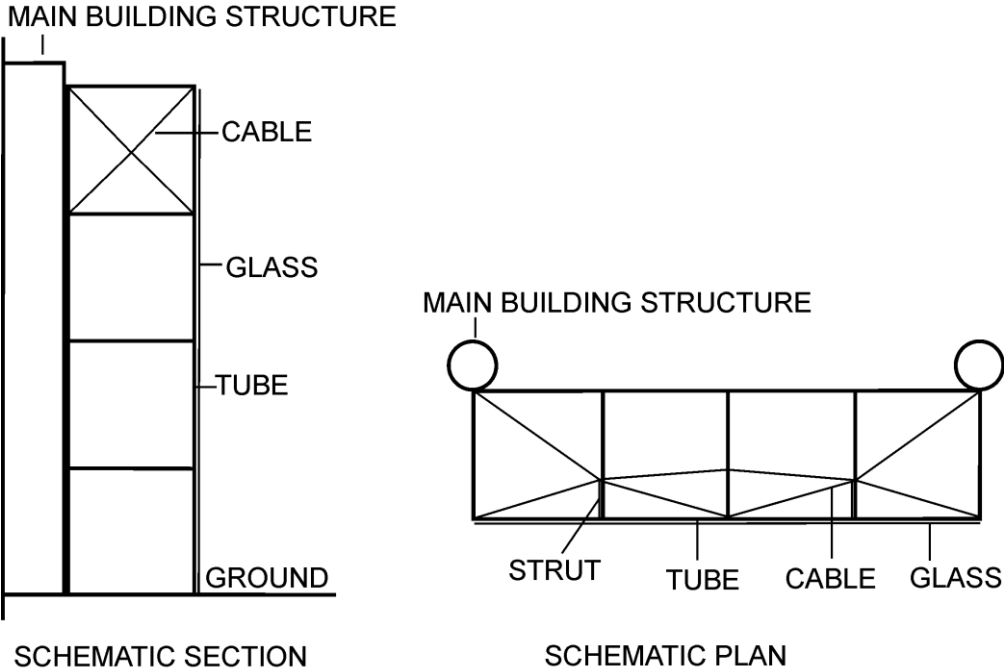


Figure 4. System drawings of the Science Museum in Paris (by authors)

Number of structures, which have qualitative differences: There are two main structural systems in the buildings, which have SGSPCT. One is the system of SGSPCT, and the other is the main building structure. The qualitative characteristics



of these two systems are radically different from each other. All details have a structural role including the glass surface in SGSPCT. Even construction details on the glass surface and the pieces of glass have structural roles. However, the main building structure contains non-load bearing elements (non-structure), as well as structural elements. (Rice, Dutton, 1995) The light and transparent mass of SGSPCT differs qualitatively from the heavier and less transparent mass of the main building structure. (see the photograph in Figure 4)

Transparency: SGSPCT is added to the main building in order to create a large transparent surface within the mass of the building. “Dematerialization” became possible because of the lightness of the structure, which carries the glass surface. (Figure 1, 2, 3, 4)

Dimension of construction details: Although all the construction details are structural and designed by structural engineers, their dimensions are much smaller than the dimensions of construction details of the main building structure. (see the photograph in Figure 4)

Relationship between structure and ornamentation: These cable truss systems represent a new approach to architectonics. The minimized details of the structure replace the ornamentation, whilst supporting the pieces of the glass surface with the least visual obstruction. (see the photograph in Figure 4) Both the technical and architectonic characteristics of the system are the outcomes of structural engineering methods. (Rice, 1994)

Existence of perceivable deflection: In whatever way SGSPCT is used in a building, the glass surface deflects much more than the main building structure, and other modern structural systems. The deflection of SGSPCT is perceivable. In other words, perceivable deflection is permitted for these systems when the engineering principles are taken into consideration. (Rice, Dutton, 1995)

Elementary nature of the structure: As with other modern structural systems, it is possible to analyze each member of an SGSPCT individually. However, non-structure is also analyzed as if it is structure during the preparation of engineering calculations. (see the drawings in Figure 4)

### **3. GOTHIC STRUCTURES AND ARCHITECTURE**

During the Post Classical period in Europe, buildings evolved from one style to another in a process of constant change. During this time the dominant buildings in Europe were churches, cathedrals, castles and palaces.

Number of structures which have qualitative differences: Most parts of these buildings are structural. (Simson,1962; Moore,1890) However, Gothic structures combine two different structures. The first is the structural masonry walls, and the second is a composition of the buttress / columns and the ribs within these walls and vaults. (see the plan, section, and photographs of Saint Nicholas Cathedral in Figure 5) These two structures support each other in providing resistance for different types of loads. Walls resist dead load, whilst buttress / columns and ribs contribute to resisting

lateral loads. If you remove one of these systems, the other might function alone, if there is no extraordinary loading, such as, e.g. an earthquake loading. We know this from the ruins of Gothic cathedrals, which do not have walls and vaults, but their ribs are still there. Still, it is not possible to consider the individual pieces in these structures (such as pieces of stone) independently.

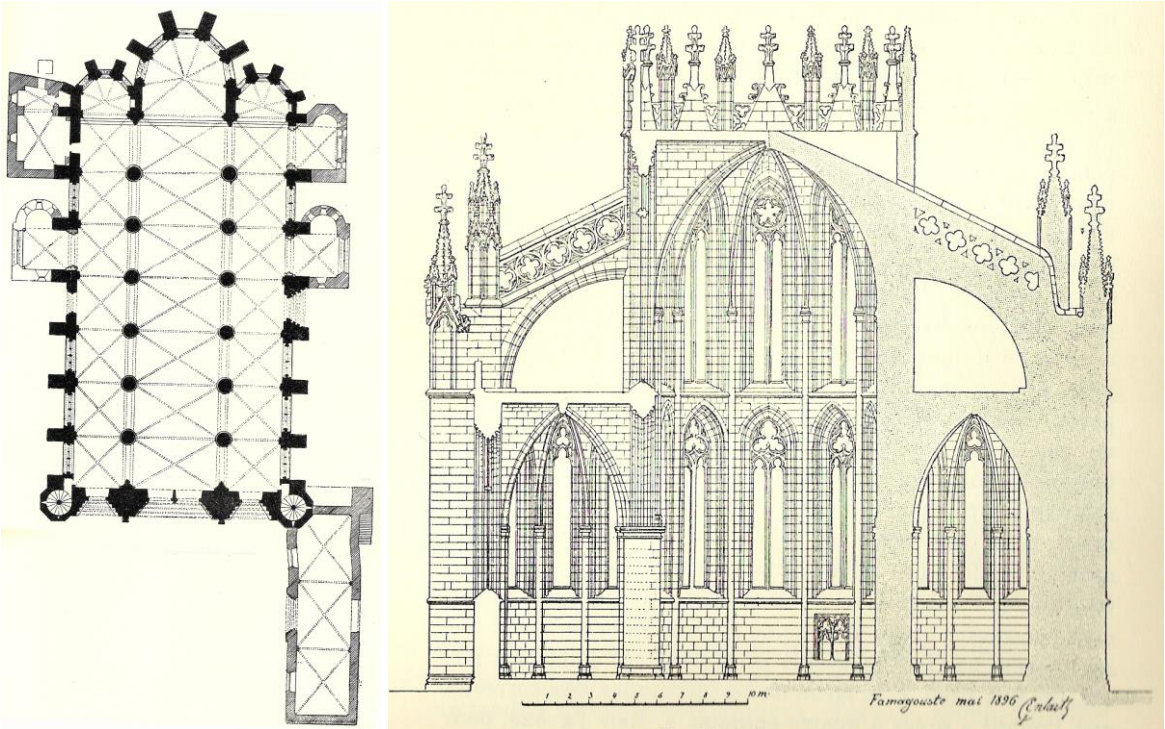


Figure 5. Structure of Gothic cathedrals

Transparency: Although Gothic structures are much lighter than other traditional / classical structures, they do not have radically large transparent surfaces in comparison to other classical / traditional buildings. It is expected from these buildings to be mystical and dark.

Relationship between structure and ornamentation: After exhausting the structural possibilities of their style, the Gothic builders turned to decorative elaboration. (Braziller, 1961; Moore, 1890). Their style is dramatic, upward reaching and aspiring. The continuous lines of the ornamentation and structure direct and lead the eye to the high upper parts of the sublime building. (see the detail photograph in Figure 5) In many of the Gothic buildings the structure looks ornamental, because of the marvelous continuity of high-relief ribs and buttress / columns. (Howe, 2003; Moore, 1890; Tobey, 2003) These lines of structure are integrated with the lines of ornamentation, which are very detailed.

Dimensions of construction details: The pieces of stone are connected to each other with various wet joints. However these details do not attract attention, because of the dominant visual effects of buttress / columns, ribs and ornamentation. According to Hartoonian (1994) these dominant lines form "linaments," which cover and conceal the structure and construction details. (see the photographs in Figure 5)

Elementary nature of the structure: Structure is not elementary. All parts and pieces are well integrated. Stone pieces are integrated, as well as the two structures within the building.

Existence of perceivable deflection: Gothic builders observed and paid attention to the deflection and deformation of the members and parts of these structures, in order to design better structures. It can be stated that these -comparatively- light stone structures were not designed to eliminate perceivable movements and deformations. (Cowan, 1992)

#### **4. FRAME STRUCTURES AND ARCHITECTURE**

Modern structures are radically different from Gothic ones. They are also much lighter than the previous structures, because the materials and structures used are different. Manufactured materials, such as concrete and steel, are preferable to natural ones, such as stone and adobe.

One of the most significant reasons for the evolution of frames has been the consideration of labour costs versus material costs. This has resulted in an emphasis on formal (usually rectangular) simplicity and repetition, even at the expense of the costs of construction materials (by not using resistant forms), in order to ensure that labour productivity is maintained at the optimum level.

Number of structural systems: Frames can consist of one structural system. Although it is possible to use frames with other systems (such as domes, shear walls etc.), a building can exist with only a frame structure. The distances between the frame members are filled with non-load bearing walls or transparent surfaces. Although rigid infill walls might affect the system (as they do in the Gothic cathedrals), structural engineering calculations of frames depend on the singularity of the structural system.

The structural systems and non-load bearing walls of Mustafa Bey Apartment in Kyrenia can be seen in its plans, sections and perspective, which is shown in Figure 6.

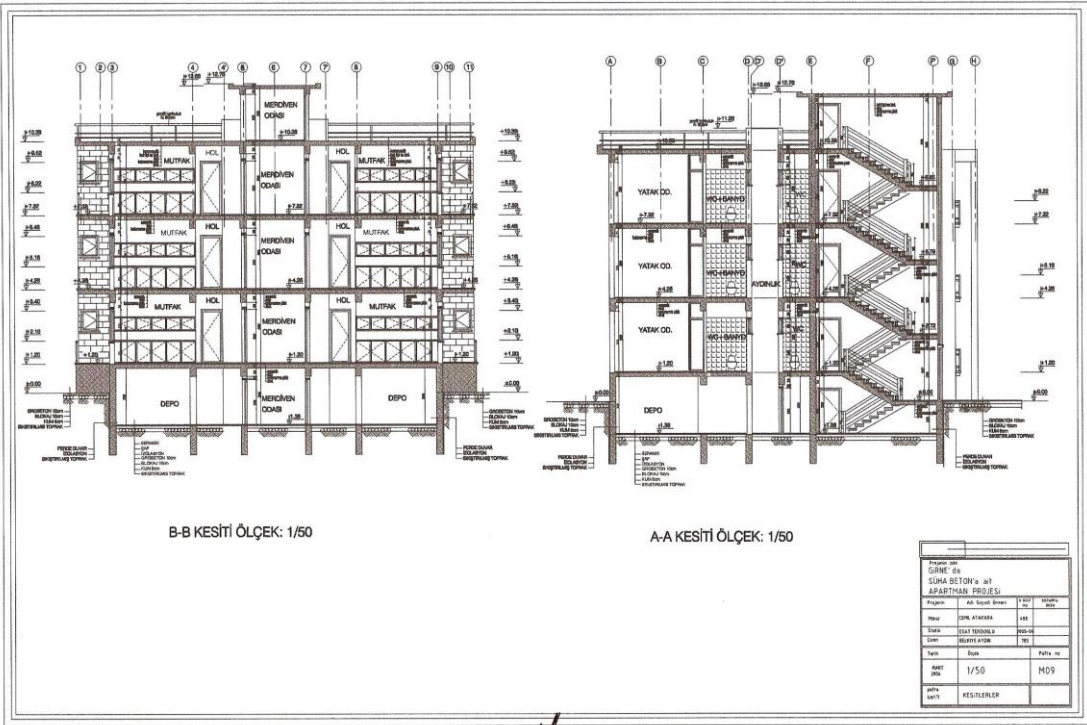


Figure 6. An example of a frame system (by authors)

Transparency: The modern materials are used in frame systems in such a way as to provide much more transparent surfaces than those of the Gothic and other traditional / classical structures. (see the large windows of Mustafa Bey Apartment in the photograph within Figure 6) Contemporary architecture has provided various ways of using the possibility of transparency. (Leatherbarrow, Mostafavi, 2005)

Relationship between structure and ornamentation: Two basic factors make most of these structures a product of scientific rationalism. The elimination of traditional / classical ornamentation is the first of these; remembering A. Loss's statement that, ornamentation was a crime, when frames first appeared for the purposes of mass production. The standardization of the building elements and the processes of production is the second factor. Since these structures are highly standardized, they are very economical and they can be constructed very quickly. (see the simplicity and the level of standardization of Mustafa Bey Apartment in Figure 6)

Dimensions of construction details: It is very often mentioned in Modernist architectural literature that the details of the members of the ordinary frames (and pre-cast frames) have been developed with simplicity and practicality in mind. (Barry, 1979) However, it would also be much better to replace the term "practical" with the term "operational," because if one thinks about the considerations of the cross-sections of structural members, the details of the connections of these members, the internal reinforcement used, and the possibility of pre-stressing, and the amount of calculation that has been done in order to design these members and joints, then it becomes nearly impossible to say that any of these systems are simple and practical than the traditional / classical buildings. There are limited types of each element and

joints in the structure. (Barry, 1979) Here, the joint plays a very important role as it both separates and joins the members simultaneously. According to Hartoonian (1994) the joints of modern structures substitute the ornamentation in traditional buildings. Figure 8 shows an open joint of a pre-cast frame system. However, the joint details (such as reinforcement) are not usually perceivable from outside in both the rigid frames and the pre-cast frames. The Modernist discourse highlights the honesty of these structures, because of the clear differentiation between the structural and non-structural members. However, this discourse can be brought into question by considering the hidden complexities of the joints. The joint details are not visible, nor is there any other ornamentation.

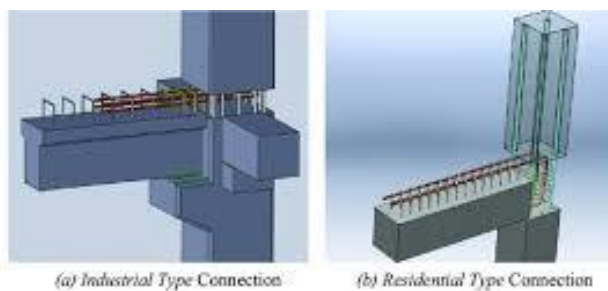


Figure 8. Open joints of a pre-cast frame.

Elementary nature of the structure: What makes frames and pre-cast frames operational and applicable is that each of their members has to be viewed as a “free body.” Structural engineers use the concept of the free body in order to be able to analyze the internal forces in the members of a structure, and to define the relationship between each separated body. This is the understanding, which made the existence of pre-cast and rigid frames possible. (see Figure 6)



Perceivable deflection: These systems are designed mathematically by structural engineers in order to avoid having any perceivable deflection and movement. Such an occurrence in the modern buildings is accepted as a sign of non-performance / failure, or a probable collapse. However, non-perceivable movement, which is within safety limits, is permitted.

## 5. CONCLUSION

Qualitative differences between Gothic cathedrals, buildings with frame systems, and suspended glass systems (SGSPCT), which are explained in this study, are outlined in Table 1.

Table 1. Qualitative differences between Gothic cathedrals, buildings with frame systems, and suspended glass systems (SGSPCT)

	<b>Gothic structure</b>	<b>Frames</b>	<b>SGSPCT</b>
<b>Number of structural systems</b>	Double structure	Single structure	At least two structures
<b>Ratio of transparent surfaces</b>	Opaque surface although there are more openings than classical buildings	Possibility of having large glass surfaces or non-load bearing infill walls	Dematerialization of totally transparent surfaces.
<b>Relationship between structure and ornamentation</b>	Highly ornamented	Ornamentation does not exist	Structural detail as an ornament
<b>Size of details at the joints</b>	Joints between stone pieces are hidden by "linaments."	Small details, which are hidden at joints	Exposed and small details
<b>Being elementary</b>	Integrated masonry structure	Elementary	Highly elementary

<b>Existence of perceivable deflection</b>	Designers were learning by observing the cracks and perceivable movements.	Movement within safety limits, no cracks, no perceivable deflection.	No cracks are allowed. Perceivable deflection is allowed only in SGSPCT.
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If one studies the differences between Gothic structures, buildings with frame structures, and buildings with SGSPCT by using Table 1, the following comparative statements are applicable. (see Figure 7)

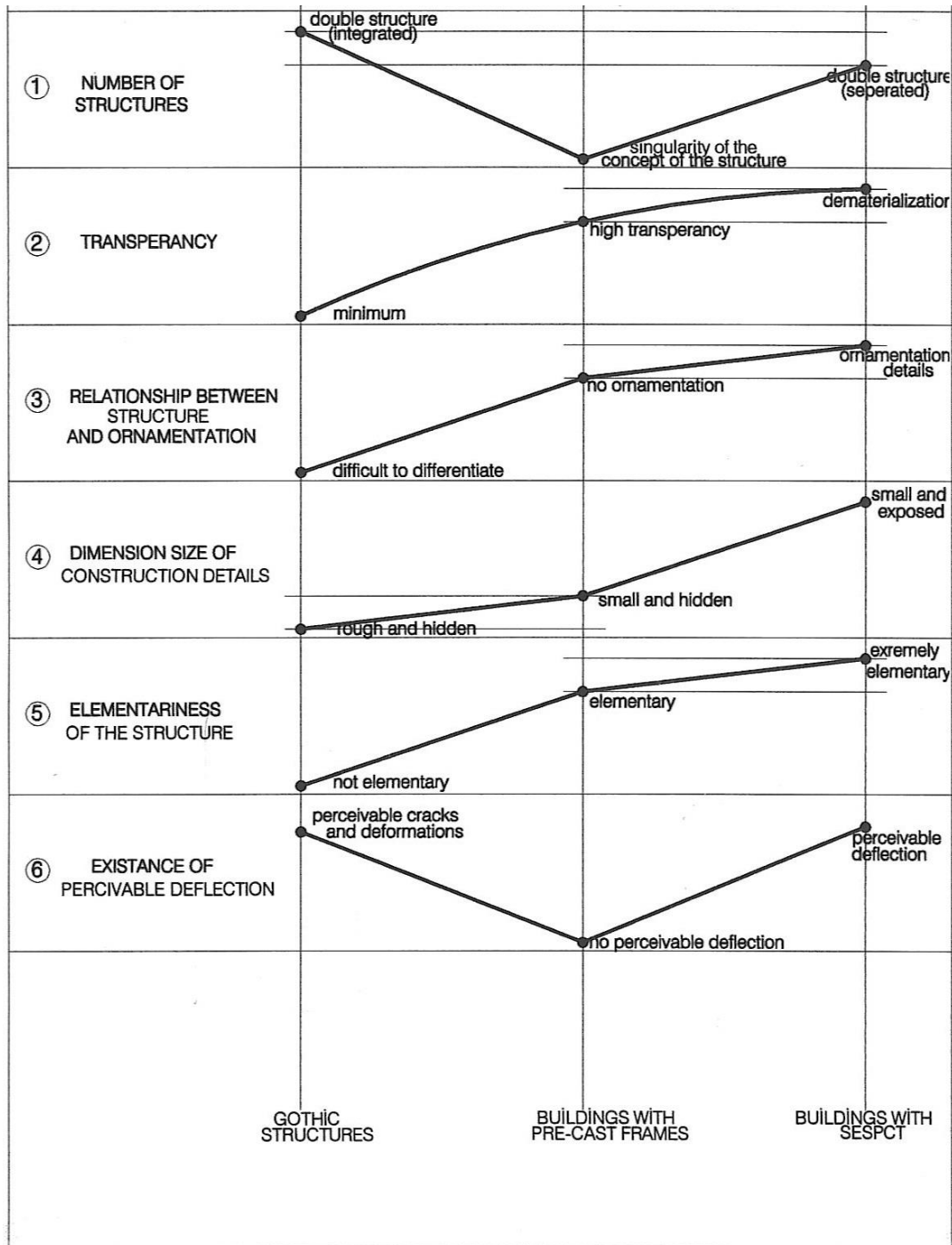


Figure 7. Comparison of the characteristics of Gothic structures, Precast frame structures and structures of SGSPCT (by authors)

1. The number of structural systems: Gothic structures had double structural systems in an integrated form. However, concepts of modern structures do not contain dual or multiple systems, as it is in the case of frame structures. On the other hand, the buildings with SGSPCT necessarily contain at least two

separated structural systems. One of these is the structural system of the main building, which is usually a rigid frame system. The other one is the structure of the SGSPCT. SGSPCT replaces the non-structural surfaces, which exist in frames and in pre-cast frames.

2. The amount of transparent surfaces: All these structures were accepted as very light structures when they first appeared. Gothic structures minimized the sizes of the stone pieces used, and allowed a much lighter structure than previous structures. Frames are lighter than any Gothic and traditional / classical structures. They also provide more transparent surfaces than earlier structures. In this case, with the exception of the elements of the frame, all surfaces can be transparent. On the other hand, SGSPCT can be described as the system, which achieves ultimate “dematerialization.” The structural elements are designed so as not to reduce the transparency of these surfaces. There are no non-structural members, such as mullions, in the system. Only some nodes exist, which hold the glass pieces together at the corners, and a web of cables.

3. The relationship between structure and ornamentation: Gothic structures are highly ornamented and it would be fair to say that it is not clear where the ornamentation begins and where the structure ends. On the other hand, the world perspective, which created the modern frames, sees ornamentation as a crime. Thus, a frame is a rough structure, although its joint details are very

well designed. However, if one recalls Hartoonian's (1994) conclusion about modern buildings, it can be stated that the careful detailing at the joints has replaced ornamentation. In the case of SGSPCT, the structural members and joints resemble ornamentation (especially because of their dimensions), although they are designed rationally and calculated carefully by the structural designers.

4. The dimensions of joint details: The wet details of stone construction are rough in Gothic structures. Only the ornamentation is very detailed in these buildings. On the other hand, the joints of frames are much more complicated and very well designed. However, these joints are not visible externally, whereas the extremely fine details of SGSPCT are very strikingly visible from the outside. The articulated bolts and the V brackets, which are the main factors in the dematerialization of these surfaces, attract attention. P. Rice, the designer of these systems, designed the joint details without first knowing or imagining anything about the actual architectonic outcome of SGSPCT. (Rice, Dutton, 1995)

5. The elementary nature of the structure: Small pieces of stone in Gothic structures form integrated masonry structures. There is a general continuity between the masonry pieces. However, the members of the frames are joined together by very well designed joints. The structural analysis of modern structures depends on the concept of the "free body," which is possible

because of the elementary nature of the structure. The theory is based on separation, and the members themselves are also separated. On the other hand, the structure of SGSPCT is more elementary. In other words, the number of structural members and the number of joints in the same area are considerably higher than in that of the frames.

6. The existence of perceivable deflection: The designers of Gothic structures, at that time, were trying to produce the lightest form of cut stone masonry, and, for this reason cracks in the system were acceptable to them. They learned more about these structures through experience and by observing the cracks. However, modern frames correspond to another “paradigm” with its abstract knowledge and education. If cracks appear in contemporary buildings, as they did in Gothic structures, this is viewed as a failure. Modern systems cannot make any perceivable deflection. On the other hand, SGSPCT is not allowed to crack, but it is allowed to have a perceivable deflection, because it forms only a “semi-structural” part of a framed building.

In conclusion it can be stated that radical ontological differences exist between Gothic structures and buildings with frame structures. There is no similarity in any of the answers given to any of the questions in respect of these two structures. The differences between buildings with frame systems and buildings with SGSPCT are less radical. Similarities do exist between the ratio of their transparent surfaces, and

the elementary nature of their structures. However, there are radical differences in the answers to the other questions. (see Figure 7)

Since most of the differences between buildings with frames and the buildings with SGSPCT can be tracked throughout all the stages of ontological understanding (the feeling of radical differences in quality, the rational analysis of these differing qualities for both systems, and the synthetic comparison of these qualities again for both systems) ontological differences exist between the construction of buildings with frame systems, and buildings with SGSPCT. These differences indicate that there are differences in the structural engineering value system (such as the permission of perceivable deflection for the glass surface), and architectonic values (such as the new relationship between the construction details and the ornamentation).

There are also ontological differences between Gothic structures and buildings with SGSPCT, which can be seen in Figure 7.

One can also imagine some further changes in the use of SGSPCT. It is worth asking whether it is possible for a building to only have SGSPCT as its structural system, or not. In other words, Is it possible to have a “non-structural structure”?

Similarly, the feeling of difference can be increased when technology goes one step further with the use of nano-technology together with SGSPCT. Thus, one might question the possibility of having buildings moving / changing. Considering this

possibility one might ask whether or not SGSPCT forms an intermediate step in preparing us for some more radical changes in structures.

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