The Connotation of Tectonics in Architectural Theory

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Abstract. Tectonics is one of the most essential topics in architectural theory that refers to various qualities of architecture. It resembles the integration of structure and construction, the application of technical aspects, and the attention to detail creativity in a harmonious and systematic way that reflects the cultural and aesthetic qualities, and relates to different aspects of skills, methods, materials and proportions. With the introduction of the computer into the architectural design process, theories of architecture became more influenced by the possibilities of this tool. Classical tectonics had included digital aids to create a new version of tectonics known as Digital tectonics, which is an integrated process that resembles a new way of thinking about architecture to easily define the dynamic state of digital production. The paper aims to explore the connotation of tectonics (the classical and the digital) in architectural theory and its role as an art of construction and artistic design.

1. Introduction

Tectonics is a central concept in architecture that holds multiple meanings; the first submission of the concept was in the 19th century by Karl Botticher and Gottfried Semper, who were the most influential writers on this subject. The term had many etymological readings, and encompassed structural and cultural issues. Subsequently, the term was reinterpreted by Edward Sekler and Kenneth Frampton. The latter was a contemporary influential writer who developed a comprehensive analytical framework for the term, to become an inherent part of the architectural practices. With the advent of computer programs; the new significant tool in the design process, it became difficult to find an obvious overlap between the digital production of architecture and tectonics, and the concept of tectonics was thus subjected to extensive criticism. So, tectonics was redefined in a way that was commensurate with the development of architecture linking the classical theoretical concept with a modern one to achieve an effective integration between them. The paper will discuss the connotation of the term classified into two categories: Classical tectonics (that investigates the most important definitions of theorists to finally reach a comprehensive definition), and Digital Tectonics: (that discusses the term related to digital architecture in order to gain an understanding of new architectural forms from the tectonics' perspective).

2. The Classical Tectonics

The term tectonic as defined by the dictionary, relates generally to building and construction. The term holds the value of poetic of construction as well as its concern with material and structure. [1]

The term *Tectonics* is derived from the Greek term "Tekton" meaning carpenter or builder. The term was further developed shifting from the physical entity (carpentry), to the more comprehensive idea of construction, and became subsequently an aspect of poetry. [2]
The most important theoreticians who had defined the architectural tectonics were: Karl Botticher, Gottfried Semper, Eduard Sekler and Kenneth Frampton. Each had a different point of view that made the concept adopt several perspectives and involve many discrepancies.

2.1 Theorists' Definition of the term

A) Karl Botticher (1806-1889) a great significant writer on architectural tectonics, who had clarified the connotation of the tectonic in many distinctive ways. At one level, Botticher visualized a conceptual phase that was revealed through the appropriate correlation between constructional elements that were articulated and integrated. These elements were seen as shaping the "körper Bilden" or the body-form. At another level, Botticher introduced the difference between "Ontology" and "Representation". Ontology "Kernform" was related to functional, structural and cultural purposes, while Representation "Kunstform" was all about the aesthetical and expressional purposes of the substance. (See Figure 1) [1]

Botticher stressed the symbolic value of structural form through generating analogies between tectonic and natural organic forms. He emphasized the connection between substance (Ontology) which is a material entity, and the direct image of appearance (Representation). This interrelated relationship between (Ontology) and (Representation) created the sense of place, which is the core of tectonic thought, where tectonic is the amount of internal cohesion between the structural elements. Later this was considered as the basis of the comprehensive architectural concept. (See Figure 2)

B) Gottfried Semper (1803-1879), architect, theoretician and teacher, had defined the term "tectonic" initially in connection to lightweight architecture and the use of axe. Later, the term was used in his writing to describe architecture in general. To Semper, the essence of tectonics was to grasp the use of different materials in the building to create a cultural expression. Thus his notion of tectonics is essentially concerned with the form of architecture and the relation to culture. (See Figure 3) [3]

Semper linked the concept of tectonics with the material and handcraft, especially lightweight materials which are formed and structured by hand to create an architecture that holds the value of the cultural expression. (See Figure 4)
C) Eduard Sekler (1920-2017) an architectural historian and professor at Harvard University. He defined the "Tectonics" in terms of "Structure" and "Construction". He distinguished between these terms, defining structure as essential ordering principles of a work, while construction as a particular physical appearance of these principles, and finally tectonics as an expressive value crystallized from the two modes. Among the three: structure, construction and tectonics, the latter is the one most autonomously architectural; that is to say the architect might not have control over the conditions of structure and construction but he is undoubtedly the master of tectonic expression. His artistic touches and character would manifest themselves most clearly. In other words, Tectonics is the integration between structure and construction, the appearance of the building evokes emotional responses and motivates (empathy) through tectonic articulation. (See Figure 5)

D) Kenneth Frampton (b1930), a critic, historian, and professor of architecture, who had re-introduced the term tectonic as a critical movement. Frampton endowed the term artistic dimension by describing the tectonic as "poetic of construction" or a distinctive way of construction where it focuses on one of the aspects of the aesthetic expression of architecture. Kenneth Frampton in his book "Studies in Tectonic Culture" in 1995 had extracted the main factors that describe the essential tectonic elements in architecture. The factors did not exist by themselves alone, but inter-related with each other. The main Tectonic factors in architecture were identified as follows: object, details, joint, material, construction, structure, and interaction. Tectonics from Frampton's perspective should take environmental issues and local culture in its consideration. Frampton gave the term "Tectonics" an artistic dimension describing it as a "poetic of construction". He considered Tectonics as a culture imposing itself as one of the most important solutions against the prospect of culture degeneration and architectural commodification that prevailed in the 19th century. (See Figure 6)
2.2 **The Procedural definition of the term**

After presenting the most important theoreticians who had significant contributions in defining the architectural term "Tectonics", we can compose a clear image about this term, by collecting all the aspects that tectonics focused on. (Table 1)

| Tectonics according to Botticher:          | Tectonics according to Semper:          |
|-------------------------------------------|-----------------------------------------|
| Ontology                                  | Material                                |
| Representation                            | Handicraft                              |
| Architectonic                             | Cultural expression                     |
| Sense of place                            |                                        |
| Natural organic forms                     |                                        |

| Tectonics according to Sekelr:             | Tectonics according to Frampton:        |
|-------------------------------------------|-----------------------------------------|
| Construction                              | Culture                                 |
| Structure                                 | Science                                 |
| Empathy                                   | Art                                     |
| Tectonic culture                          | Technology                              |
| Poetic of construction                    |                                        |

Accordingly, the procedural definition of Classical Tectonic can be expressed as follows:

*Tectonics is the essence of architecture that deals with the aesthetic aspects of structure, construction, and materials. It tends to consider the handicrafts, details and joints as an essential part of architectural practice and as an important means of showing cultural expression by using the simplest techniques and materials. Tectonics creates emotional interaction between people, nature, and culture by its dependence on the human ability to understand the inspirational relations between the elements of the building. (See Figure 7)*
A. Palazzetto dello Sport, Rome, 1961, Pier Luigi Nervi. The perfect integration between structure and construction

B. Sagrada Familia, Rome, Antonio Gaudi. Details enrich the architectural capacity; enhance it in artistic and decorative sense.

C. Notre Dame du Ronchamp, Paris, Le Corbusier. 1950 The Ingenuity of joining

D. Waterfall House, Pennsylvania, F. L. Wright. 1935 Full interaction between architecture and environment

**Figure 7.** The embodiment of Tectonics essential elements.

**Figure 8.** Classical tectonics essential factors.
The paper summarizes the essential factors of tectonics, to three main aspects, constituting a "triad of tectonics". These aspects are: (See Figure 8)

- Technique; represented by construction, technology, and representation.
- Culture; represented by art, handcraft empathy.
- Material; represented by structure, science, and ontology.

3. The Digital Tectonics
At the end of the 20th century, architecture had entered a brand new era after the propagation of Frank Gehry's proposal of Guggenheim Museum, to be executed in Bilbao, Spain. (See Figure 9). Frank Gehry used the computer techniques that gave an opportunity to start a new era for free-form architecture, thus the digital production of architectural form began to appear. Furthermore, the traditional focus on site Archi-tectonics; its static and motionless space, along with constraints imposed on the structure, gradually exceeded and was replaced by the multi-dimensional and virtual digital environment. [6]

Figure 9. Guggenheim Museum, Frank Ghery, Bilbao, Spain, 1997.

With the aid of computation, novel forms, materials or constructional methods were evolved and allowed for new possibilities to be realized as an idea or built form. Traditional architecture with its stagnant interpretation of tectonic factors would never explain the dynamic state of digital production, which raised the need to introduce a new variable to tectonics that is able to generate, interpret, and improve the architectural form. Classical tectonics had included digital aids to create a new version of tectonics known as Digital tectonics [7]

3.1 Theorists' Definition of the term
A) Zaha Hadid, The architect Zaha Hadid has long formed extraordinary architectural production worn by art, motion, and flexibility. With the development of ideas and techniques, Zaha took the advantages of tectonic theory as a sophisticated methodology of architectural design. She considered it as the main method to embody the dynamic ideas of fluid architecture by computer techniques, and to regulate the inspirational relationship between force and form, as well as the relationship between aesthetics and structural elements. Zaha found tectonics as a key concept that integrates the beneficial use of computer design with dynamic architecture. The dynamic state of architectural tectonics in this aspect worked in accordance with four systems: Situational system, Structural system, Kinetic system, Assembly and regulation system [8]. (See Figure 10)

B) Neil Leach, A British architect and theorist, in his Digital Tectonics (2004), he described computers as “…an efficient search-engine that is premised on the notion of efficiency”. He emphasized computer's ability to test design and help designers by giving a maximal potential of configuration regarding structural, acoustical, environmental, constructional or programmatic issues. Leach defined (digital) as an immaterial world of computer algorithms whereas (tectonics) decisively related to the material world of construction. In order to investigate and support the tectonics tendencies, Leach re-
introduced the term by linking it with the digitality. He envisioned that there is a tectonics potential, since the computer is our promising tool; we need to nurture tectonics sensitivity by the digital media. Digital tectonic tools need to facilitate a specific way of dealing with architecture by uniting ontological and representational aspects, and considering the building’s cultural aspects as an impact to allow a continuous dialogue between the ontological and representational layers of architecture. Any change in ontological aspects will be manifested in representational part of the program [9]. (See Figure 11)

![Figure 10. Tectonics from Zaha's perspective.](image1)

![Figure 11. Tectonics from Leach's perspective.](image2)

C) Patrick Schumacher, an architectural theorist, who claimed that the theory of architecture realized the rationality of tectonics articulation as a strategy of "expression", which is not a self-service, and must remain subjected to interest in facilitating social functions. From his viewpoint, in order to reach tectonics' articulation, architects need to undertake engineering investigations and then choose the options that best fit their primary task; achieving social requirements that have been introduced through adaptive differentiation of structures and adaptive variation of envelopes in accordance with the environmental performance of the building (in relation to exposure to sunlight, wind, rain, etc.). That would give many opportunities for differential tectonics articulation, and the construction environment would be more visible and navigable than the modern repetition system. With the development of sophisticated computer design tools - both in architecture and in engineering disciplines- tectonics articulation had inevitably increased [10]. (See Figure 12)

D) Philip Beesley and Thomas Seebohm, in their Digital Tectonic Design, had clarified digital tectonics in terms of the way of constructional assemblies. They saw the importance of the integration between digital tools and traditional constructional techniques. They also linked the term to both the ontological and the representational, arguing that digital tectonics is “a systematic use of geometric and spatial ordinances, used in combination with details and components directly related to contemporary construction”. [11] (See Figure 13)
Figure 12. Tectonics from Schumacher’s perspective.

Figure 13. Tectonics from Beesley and Seebohm’s perspective.

3.2 The procedural definition of Digital Tectonics

By summing up all the aspects that digital tectonics focused on, Table 2. conclude the following:

Table 2. Theoreticians’ concept of Digital Tectonics.

**Digital tectonics according to Zaha Hadid**

| Dynamic Architecture | Computer Design | Tectonics |

**Digital tectonics according to Neil Leach**

| Ontology | Representation | Cultural Demands |

**Digital tectonics according to Patrick Schumacher**

| Engineering and Architectural Integration | Sophisticated Design tools | Tectonics’ articulation |

**Digital tectonics according to Beesley and Seebohm**

| Details and Constructional Elements | Geometric and Spatial ordainances | Digital Tectonics |
Accordingly, the procedural definition of Digital Tectonic can be expressed as follows: 

**Digital Tectonics is a new methodology of architectural design that emphasizes the integration between aesthetic and technical aspects, or a mixture of the abstract and concrete. It is described as the poetics of the digitally conceived, structurally clarified and directly manufactured architecture.**

The Digital tectonics is a matter of an integrated process. It is not the inclusion of technology in architecture or an updating of a traditional term, but it is a new way of thinking about architecture.

As classical tectonics had many factors incorporated in architectural form (object, joint, details, structure, construction, and interaction) extracted by Frampton in his book "Studies in Tectonic Culture", Lim and Liu in their book: "New Tectonics: Towards a New Theory of Digital Architecture", suggested strategies linked to digital architecture such as: Generation (that represents the use of computer programs at form-finding process level), Optimization (that ranges between improving shape to improving space), Fabrication (that deals with the production and assemblage of the durable structure of free-form architecture), and Simulation (that represents the inspiration from nature and the transformation of living systems into a real architectural experience) [12]. (See Figure 14)

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**Figure 14. Digital tectonics strategy.**

A. Soumaya Museum, Fernando Romero, Mexico
(Represent form generation strategy)

B. Guangzhou Opera House, Zaha Hadid, China
(Represent form optimization strategy)

C. US Embassy, Kieran Timberlake, London
(Represent form fabrication strategy)

D. Florence New Station, Italy
(Represent form simulation strategy)
The paper summarizes the essential factors of digital tectonics, to three aspects, describes them as a "triad of digital tectonics". These aspects are: (See Figure 15)

- Tool; represented by sophisticated programs and technical aspects
- Articulation; represented by poetic, aesthetic and cultural dimensions
- Assembles; represented by the way of assembling building elements

### 4. Comparison between Classical and Digital Tectonics

- There is no major difference between the earlier definition of classical tectonics and digital tectonics; both of them stress the relationship between construction, materials and expression. The deeper meaning of architecture and tectonics remains constant (they still reveal the truth of building and its surroundings), but the technical aspect has changed because of the new ability of the digital tool. Both classical and digital tectonics represents a clear a way to express art and technology. This is the essence of the notion of tectonics, which reveals the concept of architecture. Tectonics is the art of building that emerges as an act of responding to context, science, and forces.

#### Table 3. Comparison between classical and digital tectonics.

| Nature            | Classical Tectonics | Digital Tectonics | Similarities                                      |
|-------------------|---------------------|-------------------|--------------------------------------------------|
| Case              | Concrete            | Process oriented  |                                                  |
| Importance        | Emphasis on aesthetic of detailing | Emphasis on sophisticated technique | They both represent a clear way of expression |
| Focus             | Stress on the relation between construction, material, and expression | Stress on the relation between aesthetic and technical aspects | They both reveal the truth of building |
| Factors or strategies | Analytical factors: Object, joint, details, material, structure, construction, interaction | Strategies: generation, fabrication, motion, information, simulation | |
| Essential elements | Culture, Material, and technique | Tool, articulation, assembles | |

Figure 15. Digital tectonics factors.
• Classical tectonics is more tangible and concrete for its emphasis on detailing in terms of materials and constructions. Digital tectonics is more abstract and process-oriented for its emphasis on technique in terms of assemblies of the building components, where the architect who masters the programs and controls all aspects of technology and aesthetics, seems to be a modern *tekton*. Classical tectonics also stress on the relation between construction, material and cultural expression, whereas digital tectonics stress on the interaction between technical and aesthetic aspects. (Table 3)

5. Conclusions

• Tectonics is the integration of structure and construction, the application of technical aspects, and the attention to detail creativity in a harmonious and systematic way that reflects the cultural and aesthetic qualities. It is a good mean to understand architecture comprehensively as an art and technical form.
• The concept of tectonics is linked to emotional, psychological and aesthetical aspects. It produces an interaction between people, nature, and culture by its depending on the human ability to understand the inspirational relations between construction and structure
• Traditional architecture would never explain the dynamic state of digital production. This raised the need to input a new variable to tectonics to be able to generate, interpret, and improve the architectural form.
• Digital tectonics is a new version of classical one; digital is realized as ethereal, absolute and a disregard to the laws of nature, while tectonics is palpable, material and arising as a reaction to the laws of nature
• The deeper meaning of architecture and tectonics remains constant (they still reveal the truth of building and its surrounding), but the technical aspect has been changed because of the new potentials of the digital tool.
• The paper extracted three indicators for classical tectonics (Technique, Culture, and Material), and three for digital tectonics (Tools, Assemblies, and Articulation).
• The tectonic theory provides a creative way of thinking about architecture that grasps the building component, analyzes its system, and evaluates the building qualities.

6. References

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