Digital Tectonic Tools

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Abstract. *Tectonics has been an inherent part of the architectural field since the Greek temples while the digital media is new to the field. This paper is built on the assumption that in the intermediate zone between the two there is a lot to be learned about architecture in general and the digital media in particular.*
A model of the aspects in the term tectonics – representation, ontology and culture – will be presented and used to discuss the current digital tools' ability in tectonics. Furthermore it will be discussed what a digital tectonic tool is and could be and how a connection between the digital and tectonic could become a part of the architectural education.

Keywords. *Tectonics, theoretical model, classification of digital tools, drawing tools, analytical tools, digital tectonic tools.*

Introduction

The understandings of tectonics are multiple and vary from etymologic readings of the term, to a debate in nineteenth century Germany, where the most influential writers on the subject - Gottfried Semper and Karl Bötticher - elaborated on the understanding to encompass a mutual dependency of structural logic and architectural expression and a focus on the cultural impact of how we build. Despite a re-introduction of the term by Kenneth Frampton (1995), the most influential contemporary writer on the subject, the description of the concept in connection to discussion of the digital displays a more simplistic understanding of the term as another word for the act of building.

With the emergence of the digital, the polemics about tectonics to some extent fell into oblivion. While this is not necessarily due to the emergence of the digital, it is however evident that as far as theoretical interests go, there is not much of an overlap between the digital and the tectonic. Neil Leach (2004) even characterizes the writings on tectonics by Kenneth Frampton as a counter-movement to the digital.

However, there might be useful lessons to be learned by connecting the threads between the ancient history of the tectonics to the recent one of the digital architecture. The lessons could have significant impact on the development and use of computer programmes and the education in the realm of architecture.

The aim of this paper is to discuss what a digital tectonic tool is and can be. Firstly the term tectonic will be investigated, through the writings by Gottfried Semper, Karl Bötticher and Kenneth Frampton, and presented through a model of the aspects involved. Secondly, this model will be superimposed onto the current groups of digital tools and a discussion of the present state of the digital

tectonics will be carried out. Thirdly, the model and the discussion lead to a discussion of the tools Neil Leach characterizes as tectonic and a discussion of what a digital tectonic tool is and the future for digital tectonics in terms of development of computer tools and education.

Tectonics

The term tectonic derives from the term tekton, signifying carpenter or builder. In Greek it appears in Homer, where it alludes to the art of construction in general. During the nineteenth century in Germany a new interest for Greece, its architecture and thereby the term tectonic arose.

Gottfried Semper (1803-1879), architect, theoretician and teacher, wrote in 1850 The Four Elements of Architecture in which he proposed the idea of elements (urformen), and suggested four: the enclosure, the roof, the hearth and the mound. The elements are motives derived from the applied arts, thus the element 'roof' should not be seen as limited to a roof but rather as an element (table, chair, roof or other) that derives from the making of a wooden structural framework.

Furthermore Semper classified the building crafts into the tectonics of the frame in which lightweight materials are joined together and stereotomics of the earthwork where mass is piled up. With these fundamental elements he was able to understand the dwelling types of Europe and see them as culturally determined expressions.

To Semper the term tectonic was thus initially very connected to lightweight architecture and the use of the axe, while later in his writings he used the term tectonic to describe architecture in general. His understanding of tectonics is that the use of different materiality in architecture should be seen as a cultural expression. With his focus on the materiality and cultural expression, his theory of tectonics is thus primarily concerned with the appearance of architecture.

The German architectural theoretician and archaeologist, Karl Bötticher (1806-89) was another very influential writer on architectural tectonics. In his work he introduced the distinction between ontology and representation where ontology was the part of architecture that has a purpose – the functional, cultural and structural considerations to name some. The representational on the other hand was without a function and detached from the rest of the building (Schwarzer, 1993). Böttticher saw the way to reach Architectonic (the sublime tectonic architecture) by combining the two and thereby uniting science and technology on one hand and art on the other. In the Die Tektonik der Hellenen (The tectonics of the Greek) from 1844 he argues that the representation of the Greek architecture – the partial painting of the buildings - were not detached from the ontological – the construction – of the building but rather that there was a close relationship in which the painting highlighted some parts of the construction and thereby helped to explain the architectural unity.

What connected the representational and ontological aspects were a sense of space which included not only vision but also tactility and hearing. To Bötticher an understanding of tectonics was to grasp how the single elements of the building were connected in a harmonious and organic spatial whole.

More recently, the term was re-introduced during the beginning of the 90ties as a critical movement. The architectural theorist Kenneth Frampton is one of the leading characters of this debate. In the book Studies in Tectonic Culture, Kenneth Frampton sets out to find the remains of our architectural culture, which he in one term phrases 'tectonic'. Frampton addresses what he sees as a tendency of commodification of architectural form – a devaluation of architecture because of the dominating discourse of economics and rationality "…we are confronted with the time-honored challenge…how to maintain the tectonic trajectory in the face of a postindustrial civilization that seeks nothing less than the reduction of the entire world

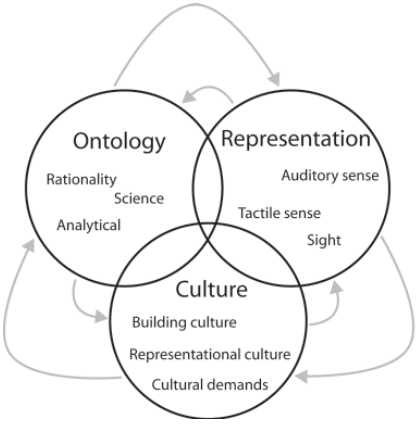

Figure 1: Elements in tectonics

to one vast commodity." (Frampton, 1995, p. 376) With this somewhat gloomy outlook, Frampton however remarks that "For all its marginality, tectonic culture still possesses a vestigially resistant core, particularly as this is manifest in its proclivity for the tactile." (Frampton, 1995, p. 377)

Frampton argues with a quote from Aris Konstantinidis for a connection between topos and tectonics: "In areas where we can find nothing but stone, we shall build with that stone, that is the local stone…The finite location; the climate, the topography and the materials available in each area determine the constructional method, the functional disposition, and finally the forms." (Frampton, 1995, p. 335).

A collective understanding of tectonics

To sum up, tectonics is equally an ancient Greek term, a movement in nineteenth century German art-theory and a contemporary critical movement against a devaluation of architecture. There are discrepancies in the interpretations of what tectonics is - for instance Bötticher stresses the importance of the dependence between ontology and representation, Semper disregards the significance of the structure and stresses the cultural significance of building, while Frampton interprets this cultural significance to relate to site-specific architecture. To be able to use the term tectonic about a certain kind of architecture is therefore to some extent a construct, but a necessary one.

I will here argue for my understanding of tectonics which is a mediation between the theorists presented. Firstly I will follow Bötticher in his argument about representation and ontology - this is what I believe is the centre of tectonic architecture: that expression is a representation of the substance in the building and not a separate matter. To some extent this calls for honesty in the representation of materials and structure but – unlike in structuralism – there is still left room for decoration as long as it does not conceal the substance of the architecture. An example of this is Sydney Opera House where the concrete structure of the arches holding up the 'sails' of the building is covered by tile-lids formed in a way that at the same time conceals and explains the fanned structure. Secondly in the argument for the cultural impact of tectonics, I follow Frampton and Semper – the cultural aspect of tectonics is almost completely overlooked by Bötticher. Frampton remarks "It is characteristic for our secular age that we should overlook the cosmic associations evoked by these dialogically opposed modes of construction; that is to say the affinity of the frame for the immateriality of sky and the propensity of mass form not only to gravitate toward the earth but also to dissolve in its substance." (Frampton, 1995, p. 7). Semper's distinction of the four elements can be seen as a language to decipher these cosmic associations. A use of the elements' cultural symbolism can again be seen in the Sydney Opera House where the practical functions are hidden in the heavy base, while the focus is drawn to the expressive, light 'sails' that frame the public part of the building.

Use of Computer tools in Architectural design

We will now turn to the newest development in tectonic theory – digital tectonics. Firstly a broad

overview of the different groups of digital tools applied to architecture will be presented and discussed in relation to the model in figure 1 and secondly a closer look upon Neil Leach, who reintroduced the term tectonic by declaring a group of tools valid digital tectonic tools, will be taken in order to discuss what a tectonic tool could be in relation to the digital media.

Twenty-five years after the introduction of AutoCad, the digital media has become much more than a mimic of the pencil drawing and physical model of the architect. As Mitchell (1999) has remarked upon, the media has evolved from being so simple that it inhibited the architect in his visual language, to being so advanced that the digital is the only place where it is possible to create the complex shapes. Many layers of this digital development are still present and evident in the palette of tools that the architect uses today.

Beginning from the simplest, there are the two-dimensional drawing-aids and image-production (such as AutoCad, Photoshop and Illustrator) that could be characterized – as Kvan et al (2004) does - as the digital versions of the drawing boards and collage-production.

A step up the ladder in complexity we find the three-dimensional modelling programs, which are primarily used for spatial investigations and used in the production of digital snap-shots of the architectural object as a supplement to or instead of the perspective drawing (e.g. ArchiCad, FormZ, 3d Studio Viz). The complexity of these programs has evolved over the years and took a major leap with the general introduction of the Bezier-curve in the 1980'ties (Lenz 2000).

Another step up the ladder we find a separate branch of the three-dimensional programmes - the parametric modelling programs recently introduced. These programs shift the attention from the production of images to the production of geometrical relations in the architectural form and introduce mathematical formulas as generative factors to the shapes. Some of the programs have a link to the production, for instance Catia, which is – as Mitchell (1999) remarks – also increasingly necessary because the geometries described in the three-dimensional universe is not reproducible in the standard plan and elevation format.

The last group of programmes is the analytical tools which primarily enter the architectural realm through specialist consultants. Potentially the architectural consequences of the analyses in these tools can have a great impact on the architectural form and must therefore likewise be considered as a computer tool connected to architecture. To describe the phenomenon, Branco Kolarevic (2004) coins the term 'Performative Architecture'; architecture that needs to perform extraordinarily in a special area for instance acoustics, climate or construction and therefore requires analysis of this area and a response in the architectural form.

'Representational' tools

Returning to the model of the term tectonic, the programmes roughly fall into two groups – one that supports the representational aspects of tectonics and one that focuses on the ontological aspects.

The two-dimensional and three-dimensional drawing programmes can be characterized as supporting the investigations into the representational aspects of tectonics. Representational is in this sense, however, limited to a representation of the visual character of the architecture and not, as Bötticher understands representation, explanatory to the ontological aspects. With this said, the representational character of these programmes is evident in their ability to shed light on the visual aspects of the space created. The digital media's ability to represent the visual character of architecture has been discussed thoroughly by for instance Moloney and Issa (2003), who are concerned with the computer's difficulty in the representation of materials. This group of tools has been criticized for their over-emphasis on the aesthetics and imagery in the architecture. While there is of course always some set of intentions behind an architec-

tural image, it could be argued, as Ostwald (2004) and Kvan et al (2004) have done, that these tools' emphasis on the visual character takes away the focus from an inner logic.

Many theorists, such as Williams (1999), Stacey (2004) and Chris Abel (2004), emphasize the computer's abilities in architecture by arguing for the connection between the digital representation of architecture and the tectonic – in the sense of a direct link from the digital model to the manufacturing process, which enables a realization of practically any conceivable geometry. This line of thought encompasses an understanding of tectonics as simply 'to build'. As it was argued before, the concept of tectonics is more extensive than that and therefore the sole focus on representational aspect – even with the ability to build the digital idea in 1:1 – can not be considered tectonic. Likewise the representational programmes are lacking a tectonic ability to combine what they represent with the ontology of the building.

'Ontological' tools

The analytical tools are concerned with analysis, evaluation and optimization of given parameters in construction, acoustics, interior climate etc. and can as such be said to work within the ontological aspects of tectonics. This can only be said with some modifications, though. What Bötticher meant with the ontological aspect of tectonics was rather the underlying logic of the structure than the actual width of a beam or column. The analytical tools of today are mainly useful (and used) to optimize performance in various fields. The character of the programs is deterministic which means that one question corresponds to one answer and by continuously asking questions (for instance about a geometry of an architectural space) an understanding of the usefulness in a rationalist sense is obtained.

From an investigation into one of these analytical tools within the room acoustical field – the room acoustical simulation program 'CATT' - it is concluded that the aim of the programme is optimization of a developed scheme and not a dialogue to support development of architectural concepts (Schmidt and Kirkegaard, 2004). Recent attempts to try to develop tools capable of supporting the initial design stages of architecture, e.g. the programme Acousalle (Faist et al, 1997), fail due to a lack of understanding of the architectural process and values - for instance Acousalle sets off by determining the overall geometry to be limited to a box.

This character of the programs is not surprising due to their background - they are developed for and by technical specialists. The application of such tools is thus still an application of a tool developed within a different background.

Especially when comparing the tools to a tectonic understanding of architecture, these 'ontological' tools lack an ability to create a link between the ontological and representational aspects.

Digital tectonic tools

Leach argues in the publication Digital Tectonics (2004) for an emergent tectonic potential of the digital. He sees the computer's ability to test designs in terms of technical ability as its primary tectonic capacity and describes the computer as "…an efficient search-engine that is premised on the notion of efficiency". Leach envisions that the designer would supply the edge-conditions for the design and then with little interference let the computer decide the configuration with regards to structural, acoustical, environmental, constructional or programmatic issues. While Leach is on the right track with a focus on the interaction with the computer tools, his acceptance of deterministic programmes with a sole focus on technical aspects and efficiency can hardly be called tectonic, when limiting tectonics to only covering one aspect of the three. With Leach's understanding of tectonics there is no room for an ideal connection between representation and ontology, only optimi-

zation and rationalism.

However, with this said, I agree with Leach that there is a tectonic potential in the digital revolution – or rather that we need to nurture a tectonic sensitivity in our digital medias since the computer is our most promising tool. Instead of writing off the tectonic, I support Leach re-introduction of the term in connection with the digital in order to investigate and support the tectonic tendencies.

Coming back to the aim of the paper – to propose a clarification of what a digital tectonic tool is or can be – the first issue to be addressed here is the limitations of the digital. "...how can the digital be tectonic? And how – for that matter – can tectonic be digital? Surely, most would argue, the digital belongs to a completely immaterial world of computer algorithms, and the tectonic, by contrast, to a resolutely material world of construction.", as Leach (2004) puts it. However, if this was the case, then the discussion about 'digital' versus tectonic belongs in a time when the first master builder moved out of the building site and into an office, adding an abstract layer to the architectural production. While the digital can be argued to be even more abstract, it does not change that the sketch and card board model were also detached from the materiality, force of gravity and tactility in architecture. If we accept that the tectonic production did not end with the master builder, then the focus shifts from being a matter of which tools we use, to how we use them and which tools get developed.

Secondly in the discussion of what a tectonic digital tool is, it is important to stress that in the discussion of tectonics – as well as in digital tectonics - it is important to remember the full extent of the term and not limit the understanding of tectonics to be equivalent to 'building'. A digital tectonic tool needs to enable a specific way of working with architecture by combining ontology and representation while considering the building's cultural impact. In this sense none of the current computer tools can be called 'tectonic'. On the other hand, it is obvious that some tools are closer to possessing a tectonic quality and less resistant towards the creation of tectonic architecture.

Surprisingly enough the 'ontological' engineering tools are today closer to being tectonic than the representational ones. For instance the development within the acoustic field is interesting. This field has taken a full loop from being a subjective field with only rules of thumb applied to – around 1900 - becoming an 'objective' science applied to architecture. Today the introduction of auralization – the process of rendering audible (by physical or mathematical modelling) the sound field of a source in a space – makes it possible for instance to hear how a concert will sound in an un-built room. The ability is still mainly being used as a gimmick to impress clients and is not yet systematically used to base design decisions on, but recent studies have showed the reliability of the programmes (e.g. Pancharatnam, 2003).

The significance of this, in tectonic terms, is firstly that through the ability to hear architecture the digital media is coming one step closer to the materiality of build architecture. By adding another dimension – sense – to the expressiveness of the architecture, the focus on the image is reduced, which has been one of the discrepancies between the digital and the tectonic. By hearing the materials as well as seeing them there is, for instance, suddenly a representational difference between materials looking like stone and actual stone because they will not sound alike. While the acoustical simulation programmes are far from being straight forward for architects at the moment, this is only a matter of refining the interface and the structure of the programme. The possibilities are evident. The hearing added to the vision will give a closer understanding of the connection between the space and the materiality.

Secondly such a development is significant because such a digital tectonic tool allows a continuous dialogue between the ontological and representational layers of architecture. Changes in the ontological aspects of the building – for in-

stance by changing materials or the logics behind the constructional system – will become evident in the representational part of the program. In the case of the acoustical program it will be possible to hear and see the difference the changes make as well as detect the changes in a number of 'objective' parameters such as reverberation time, sound pressure etc. Thereby the choice in ontology will move from being only a technical solution to being able to encompass the bodily experience in the architectural field. One of the most important aspects of this is to recognize that there is never only one solution to the technical dimension in architecture – we are always confronted with a choice where the answer will have to be a subjective one.

Discussion – implications to the architectural education

Even thought there is, as argued here, a tectonic potential in the digital, the use of tectonics requires a background in the architectural education. The fact remains that no matter how intelligent digital tools we develop, tectonics will never be able to come into existence with a push of a button. A sensible and tectonically interested architect needs to think about what buttons to push, rather. Especially in terms of the cultural significance of the way we use materials and build, is not likely to become inherent in a computer program and therefore the teaching in tectonics as a field is necessary to complement the introduction of digital tectonic tools in architectural schools.

While the actual 'tool-teaching' – the teaching of how to work with different computer tools - still takes up a substantial part of the curriculum, the impressive level of computer literacy among the new students decreases the need to teach these tools as a separate skill – as Kieferle and Herzberger (2003) have argued – and increases the possibility to teach the digital tools within a meaningful context of theory or design. This context could become tectonics.

On a practical level this could take place across courses by introducing the term in architectural history, analysing the representational, ontological and cultural layers of a chosen piece of architecture in terms of tectonic theory as well as digitally, and working with design projects in the same way. This development could be supported by a mixture of the analytical and the image-generating drawing tools described or by newly developed digital tectonic tools. What is especially important is that through the digital tools, the students learn to question both the representation and the ontological aspects of their design. Equally the cultural connotations of the project can be discussed within a tectonic frame. The deliberate introduction of tectonics in connection to the digital can thus create an awareness of the various aspect of tectonics and an awareness of where various digital tools can support the design in the different aspects of tectonics.

Conclusion

A connection between the ancient term in architecture, tectonic, and the new development of the digital is investigated. A model of the aspects in the term tectonics – representation, ontology and culture - was presented and used to discuss the current digital tools' ability in tectonics. Furthermore a discussion was carried out that focused on what a digital tectonic tool is and could be and how a connection between the digital and tectonic could become a part of the architectural education.

One of the main points of the paper was that it is important to keep the full understanding of tectonics in mind when discussing tectonics. Tectonics is not only another word for building, but signifies an ideal relationship between ontology and representation, while seeing the production of architecture as a cultural expression that can be enhanced by a deliberate use of materials and building methods.

Secondly it was concluded that the current digital tools can roughly be characterized in two groups - the ontological and representational - but that it is difficult to find any that really transcends the boundary between these fields, which is important for a digital tool to be tectonic. This does, however, not signify that the digital does not have a potential in supporting the creation of tectonic architecture, but that a continuous development of the tools and a deliberate use of the current ones is necessary. In the area of development of new tools, it was concluded that the ontological tools were closest to possessing a tectonic potential. One tool – CATT, a room acoustical simulation program – was highlighted for being able to connect ontology and representation. In the area of deliberate use, it was concluded that a continuing focus on tectonics in the architectural education is necessary and that this could become an integrated part of the teaching in digital tools.

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