New Technology, New Tectonics? - On Architectural and Structural Expressions with Digital Tools

TECTONICS
MAKING MEANING

NEW TECHNOLOGY, NEW TECTONICS? - ON ARCHITECTURAL AND STRUCTURAL EXPRESSIONS WITH DIGITAL TOOLS

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Topic: Tectonics, the poetics of technology

New digital tools are today heavily influencing the working methods and means of expression for architects and engineers. Here are great potentials for integration of architecture and structural technology, new expressions, high precision and quality in building, and effective, economical structures. A few, mainly experimental or future oriented architects are aware of the potentials. But the new possibilities and consequences of digital technology need to be articulated, analysed and presented to architects, structural engineers and the wider building industry.

Extensive discussions are today going on within the building trade about the development towards industrial building. The literature and research about tectonics are however to a very little extent taking the present situation into consideration and look ahead. The concept of tectonic were in the architectural discussion of the last decades brought forward in relation to a critique of modern technology and the consequences of mass-production. The hypotheses of this paper – and the research project still in its initial phase – is that we today are witnessing a development that may lead to a new kind of tectonics, with expressive potentials in building and constructions by the use of advanced geometry and technology that is not alienating but can make possible an architecture rich of meaning and experiences. Many architects and thinkers criticising the consequences of global modernisation and technology are influenced by phenomenology to find new (or return to old) paths for architecture. A question is if the capacity of digital technology to handle variation actually, in opposition to what one might expect, can give new possibilities to work according to the intentions of that critique. There are a lot of questions forming the background of this paper: What consequences can digital tools have for the architectural concept of tectonics? Do the digital tools establish closer relations between architecture and technique, more effective collaborations between architects and engineers? What architectural, tectonic expressions can it lead to? Rather than trying to give direct answers, the intention is here to start a discussion of these issues.

Notions of tectonics

The tectonic is a central concept in architecture, which can be seen in the distinguished Swedish architectural historian Elias Cornell's last book Rummet i arkitekturen (The Space in Architecture). (Cornell 1996) In the introduction to the book he makes an important distinction between the in architecture central aspects tectonics and stereotomics. Architecture is tectonic in the external appearance, in its construction; it is stereotomic in the spaces. Tectonic means in Cornell's definition "clearly built with constructive or building elements and parts, either they are necessary or only figurative". Stereotomic means the suspended, embracing or hollowed. The tectonic and stereotomic are seldom undiluted, but are often found together. Cornell sees them as important means to a comprehensive understanding of architecture as an art form, and a way to overcome the delusion that it is almost impossible to describe and interpret architectural space.

The concept tectonic has a long history in architecture. Sven-Olov Wallensten argues that the idea of the tectonic also is one of the decisive moments in the development towards modern architecture, where the discussions on the ornamental and the nature of classical orders later gave rise to a fundamental break with tradition. (Wallenstein 2004) He delineate the history of the concept from i.e. Heinrich Hübsch, Friedrich Schinkel, Karl Böttischer, Gottfried Semper, August Schmarsow to Fritz Neumeyer and Kenneth Frampton.
Frampton must be seen as responsible for the position the discussion on tectonics has had the last decades. He deals with the concept already in his important text "Towards a Critical Regionalism" (Frampton 1983) and his book Studies in Tectonic Culture has been influential. Here he studies the constructive and structural ways architectural spaces necessarily are created by, but it is not only about insights in constructive technology but about its expressive potential. (Frampton 1995) For him tectonics is a poetics of construction and he emphasises that the built first and foremost is a construction, that later becomes an abstract discourse on surfaces, volumes and planes.

The full tectonic potential in every building comes, according to Frampton, from its capacity to articulate both the poetic and the cognitive aspects of its substance. The tectonic stands in his view in opposition to the current tendency to deprecate detailing in favour of the overall image. Frampton makes,

with reference to Semper's distinction between symbolic and technical aspects of building, an interesting distinction between the representational and ontological aspects of tectonic form. This dichotomy is something in constant need of reformulation in the creation of architectural form, since every building type, technology, topography and temporal circumstances give different cultural situations and conditions.

Frampton argues that our built environment is produced in an interplay of three aspects – topos, place; typos, building type; and the tectonic. The tectonic is according to Frampton the aspect best suited to counter present tendencies to legitimise architecture in discourses outside its own discipline. Architecture as an academic field needs to lead a theoretical and conceptual development of its own, which today seems more important than ever; a discourse of its own but in clear relation to adjacent fields.

Tectonics, as it has been treated during last decades, was introduced in connection to a discussion influenced by phenomenology. The relation to phenomenology is still quite strong today, and in the initial architectural discussion this philosophy was mainly used as an instrument for critique of the modern technology. Tectonics was here to some extent formulated as a defensive concept in relation to the machine age, where references to tradition was to be preserved. This has lead to a debate often with remarkably culture conservative overtones, and the distinctly normative features in the discussion on tectonics have remained until today. (Wallenstein 2004) The Swedish philosopher Sven-Olov Wallenstein notes that many influenced by phenomenology and especially interpreters of Martin Heidegger have wanted to see an unmistakable proximity to a romantically tinted critique of technological modernity. But he notes that there is also an essential distance from such a critique that needs to be accounted for. Heidegger's meditations on space and place can and have been interpreted in radically divergent ways in architectural theory. The interpretations done by Norberg-Schulz, Frampton and Cacciari all start from the sense of a "loss of place", but the conclusions they draw are radically different. (Wallenstein 2007) The more radical standpoint of Cacciari is however not the most widespread among architectural theorists drawing from phenomenology.

The structural engineer Dan Engström has argued that tectonics has been a fashionable word among architects, but the concept has been used indistinctly. For him, tectonics is not to uncritically show construction and load bearing elements. "Tectonic architecture manifests and elucidates the constructive function of a building as a support for a spatial idea. It creates constructive readability." (Engström 2004) Tectonic architecture makes parables to other constructions, and alludes to values outside a scientific conceptual sphere. Tectonic architecture makes use of techniques (bearing structure, elements and details) to create experiences and associations. The construction is here part of the building's idea content, a part of the manifestation of the intentions of the architecture.

The concept of tectonics refers, according to Anne Beim in her Tectonic Visions in Architecture, to meaning of construction in architecture and "tectonic vision" is defined as: "Visionary investigations into new materials, technologies, structures, and practices of construction, as means to construct (new) meaning in architecture." (Beim 2004) Beim states that tectonics today mostly is used to describe aesthetic issues, materiality and the intentions behind constructive solutions, which means interpretations of technology and construction beyond mere instrumental definitions. Building technology and construction practice can become a matter of signification – tectonics – but only when handled consciously and intentionally.

Tectonics of cultural an industrial production

Industrialisation and mass-production have lead to an architectural and building culture giving prominence to homogeneity and general standards to satisfy the conventional customer. Today there are however signs that diversification and variety are market strategies that the building industry has to adapt to, and where new technology can make it manageable. (Nilsson 2007a) Even though Beim touches upon the influence of new digital technology on building trade and construction, these consequences are not analysed or explored in her book. What is missing and necessary today is a continuation with updated studies of architects working with digital tools and analyses of realised architecture.
Computers have changed the way of working with architecture and building projects during the last decade. Most of the work is now digitalised and projects are imagined, designed and communicated through digital tools. These have made it possible to generate and handle other kinds of forms than the orthogonal mostly used in modernism, and also started to change some notions of architecture. (Nilsson 2003; Nilsson 2004)
At the Architectural Biennale in Venice 2004 it was obvious that the concern today is more about materialisation and factual construction than about mere experiments in form. Structural principles are explored and the differences between structural skeleton and enclosing surfaces – between the tectonic and the stereotomic – are starting to dissolve or put into new relations. Expression of, or division into, carrying and carried elements are not done in the continuous surfaces of many projects of today, where building parts, spaces and place get new relations. (Forster 2004; Nilsson 2006)

The new tools seem to promote new and closer collaborations between architects and engineers. Some engineers are influential in the idea development of architecture, where structural play of forces and efficient structures become important parts of the idea and expression. (Balmond 2002) Others are developing digital tools making constructive aspects manageable in the architectural design process. Examples of this are Specialist Modelling Group established 1998 within Foster & Partners under the direction of Hugh Whitehead, and Smart Geometry Group with i.e. Robert Aish from Bentley Systems, Lars Hesselgren from KPF, and J Parrish from ArupSport. (Aish 2003; Whitehead 2003) There is a growing interest for design from structural principles, and for the relation between architecture and structural mechanics. (Olsson 2005) The constructive principles developed by Frei Otto (Nerdinger 2005; Otto 1995) have gained new attention and inspired architects to apply them in combination with digital technology. (Spuybroek 2004)

We can see new architectural expressions drawing from actual forces in the structure, with a great understanding of construction and how to make it efficient. But these possibilities are not seen by everyone. Neil Leach has argued that today's architectural culture in certain areas still has a broadly Heideggerian outlook, which remains critical of technology in general, and reluctant to embrace digital technology in particular. (Leach 2002)

This in spite of radical changes in industrial production and its previous basis, and architecture and building industry being influenced by new manufacturing methods. (Kieran & Timberlake 2004) Digitally directed industrial production is not dependent upon long series of identical products; we are moving from the mechanical to the digital, and also from "mass-production" to "mass-customisation". New technology makes long series of identical elements obsolete, industrially produced components can be unique, optimal in the construction.

The industrial foundations of modernism are dissolving, and standardization and repetition are not necessary to produce better product to lower cost and constant quality. The modernistic logic of standardization and its economical, technological assumptions are already obsolete, according to Mario Carpo, and if used in the technological environment of today it can lead to wrong decisions. (Carpo 2004) Prefabricated elements can today be made optimal and unique, following the lines of forces in construction and having other geometries, opening up possibilities for new architectural expressions as well as more economical, resource efficient and sustainable building. Here are new possibilities for interesting development of different tectonic expressions in architecture.

Architecture and construction where expressive, symbolical, functional and technological aspects interlace in other ways emerge. Digitally governed production could foster new modes of meaning creation. New conceptions and definitions of objects are emerging with parametric design. Are we today actually witnessing a development of a new kind of "tectonic"with expressive potentials of construction through advanced geometry and technical possibilities, new digital and material technologies that might not be alienating but rather carrying potentials for a "critical architecture" of experiences? There is a need and scope for conceptual elucidation of tectonics in architecture, through a development of a conscious, open and critical approach to the new technological and industrial paradigm. (Nilsson 2007b) The representational and ontological aspects of tectonic form could be put in new relations, counteracting a opposition between good detailing and material treatment on one side, and overarching image and spatial idea on the other. There are generative potentials in digitally enabled and non-standard architecture that may be carried over to corporeal and social encounters that transcend the act of mere signification – or one might say, that avoid the production of the scenographic, to use the terms of Kenneth Frampton. (Frampton 1983) Consequently, there are potentials for the tectonic aspects of architecture in digital technology, but the conceptual framework as well as architectural thinking and practice need to be developed.

Algorithmic tectonics

In the collaboration between Toyo Ito and Cecil Balmond on the Serpentine Gallery Pavilion 2002 they started with two ideas, quite simple and based on structural thinking. One for a floor that swelled up to support a flat roof; the other for a flat roof composed exclusively of random cross lines and supported only by the line of the exterior walls, in all forming an absolute box. They went for the second idea, where Balmond found a simple algorithm for getting the seemingly chaotic pattern of lines.

"Propose an algorithm: half to a third of adjacent sides of the square. The 1/2 to 1/3 rule traces four lines in the original square that do not meet. (Choose the half point instead of each side, the trace 1/2 to 1/2 closes back on itself like a billiard ball bouncing perfectly around a square enclosure.) The half to a third rule forces one to go out of the original square to create a new square so that the rule, the algorithm, may continue. Continue for six cycles and a primary structure is obtained. Then if these lines are all extended, a pattern of many crossings results. Some are primary for load bearing, some will serve as bracings to secondary and the rest will be a binding motif of the random across the surface of the box typology." (Balmond 2006)

Ito argues that an approach based on algorithms offers greater freedom, but it is also a tool for thoughts since it is very hard to imagine randomness on your own. Algorithms enables you to create unpredictable complexity and hybrid situations, which are still calculable and manageable. Ito argues that in the 20th century we were taught that there is only one solution, but that is true only when you narrow down the conditions and discard various possibilities. Something other emerges when you instead widen the territory and increase the number of variable elements. Computers have made that possible, and it is today easier to analyse complex, network-like structures. The spatial movement of the Serpentine Galley – made possible to imagine, calculate, manufacture and assemble within a tight time-frame by digital technology – gave a hint of spaces that are qualitatively different from what we are used to. Algorithms will be important in architectural thinking in the future, and Ito means that we will probably learn how to speak of a new kind of rationality. (Ito 2006)

Within the realm of architecture, according to Ito, you cannot avoid the transformation of an open-ended concept into built form through materialization and communication with society. Architecture always involves, in its stage of realisation, separating inside from outside, detailing, choice of material, etc. With hope of becoming more free from limitations, he turns to computers, trying to make borders between e.g. inside and outside as blurred as possible, but "it is not possible to eradicate the distinction completely because that would imply leaving the realm of architecture". (Ito 2004)

Fluid form-finding tectonics

Lars Spuybroek actively explores the possibilities of computers in design processes and the design of buildings. He sees the computer as a very powerful conceptual device, which is still a very instrumental machine through its possibility to synthesise in new ways perception and action as well as construction.(Spuybroek 2002)

Spuybroek describes our conceptions of our bodies as continuously expanding in a complex interaction with our environment. Questions of posture, perception and activity are architectural questions, and he names this relationship "motor geometry", the abstract movement in the geometry of building, that relates directly to real movement of the body.(Spuybroek 2004) Artefacts, technical products becomes integrated in the motor system of the body. That is why we i.e. do not experience the car as just an instrument we are sitting in but something we become a part of when we drive. Movement and action are parts of the body; space is the haptic potential, the haptic sphere of action. (Spuybroek 1998; Spuybroek 2002)

Spuybroek seems to find objects and buildings like prosthesis working like vehicles that adds movement to the body, that adds a new repertoire of action. Here the body creates a haptic field centred upon itself, in which every outer event becomes related to this bodily network of movements in the material world making constantly changing constructions. (Spuybroek 1998; Spuybroek 2000)

Heavily influenced by the form-finding processes of the architect-engineer Frei Otto – with inspiration from nature and practical experimentation – Spuybroek's projects are despite their complexity based on factual construction, on transformational principles where the consolidation or stabilisation of the structure is a self-supporting, self-engineering aspect of the system. It is not the mere image of architecture that is explored, but the use of new tools in the actual construction of space. Strongly connected to the manufacturing process and structural principles new tectonic possibilities emerge as well as experiences of architecture.

The water pavilion H2Oexpo, in Neltje Jans, 1997, is an exhibition building not intended to "contain" an exhibition in a regular way. Besides being an advanced technical installation generating the changing atmospheres of the rooms, the construction is in itself a topological structure with continuously changing inclinations of floors, walls and ceiling, that blends into each other. There are no windows to the outside showing the horizon, which makes the experience of space a very bodily experience, where you have to rely on you own motor system to balance and move around.

When architectural elements are connected through geometrical continuity a number of unexpected social effects also emerge, something seen in the pavilion and further explored in later projects like the office for V2_Lab in Rotterdam 1998. Here the space is designed to facilitate ordinary office functions in more distinct and determined spaces, but also to trigger new situations and behaviours in areas less formally determined with folding floors and curving, transparent textiles. The geometric "vagueness" in some spaces has shown a special potential, where active meetings can be staged or more relaxed conversations take place, all intensifying the working relations. (Spuybroek 2000; Spuybroek 2004)

Technological swarm tectonics

For Kas Oosterhuis and the office ONL computers and information technology has lead to radical changes in conceptions of the role of the architect, the process of design and the concrete buildings and architectural objects. Building parts are today potential senders and receivers of information in real time, they can exchange and treat data that constantly can generate new or changing configurations. Today buildings can, like modern cars, have a multitude of processors sensing, calculating and reacting to external factors. Just like cars can show a responsive behaviour, responsive buildings can react to changing conditions.(Oosterhuis 2003)

He talks about a "swarm architecture" that is developed in real-time considering the process of design and construction as well as the way the building functions, where all building elements act as intelligent actors, as active members in a swarm, concious of their environment, constantly calculating and reacting.

Oosterhuis argues that we today are able to put design, production and construction closer. With networks of machines communicating directly we can produce an endless variety of building elements, visually rich and complex, but still based on simple rules. This process of mass-customisation is based on file-to-factory production methods, in which everything is different in absolute size and positioning.(Oosterhuis 2005)
By using inflatable building elements, intricate constructions with pneumatic cylinders and moving parts, screens, fibre optics, loudspeakers etc., buildings can be created that change form as well as atmosphere through parameters as user actions and weather conditions. An interactive architecture of "hyperbodies", like the installation "MUSCLE", Paris, 2004 or iWeb pavilion, Delft, 2007, is aiming at a two-way communication between human beings and the environment they are occupying, between building elements and users.

The work of ONL is highly technological, following the rationale of contemporary industrial thinking, and the actual function of the building is of main concern in its interaction with men and matter on the specific site. Oosterhuis is trying to balance the bottom-up and top-down aspects of design – buildings as systems communicating with local conditions of use, climate and specific environment, as well as with more global, urban, symbolic and cultural aspects. But the top-down concepts applied are never traditional or conventional symbols. The connection to the surroundings and the legitimation of the building on the site can never be done by returning to history or established norms. He argues that many urbanists seem to develop a xenophobic fear of alien bodies thinking that buildings grow from the ground. Oosterhuis rather sees the potential in bringing something unforeseen to a place, something never experienced before, that are forcing us to think differently and put us in another state of conciousness. (Oosterhuis 2006)

There are other strong, practical arguments for developing swarm-like architecture. Building components like columns, trusses, walls, floors can become actuators cooperating with each other to perform and respond to changes in the physical environment. Such adaptive constructs could react in real time to resist local forces acting on the structure, and may be used to stabilise and make buildings and bridges stronger and more efficient then traditional constructs. (Oosterhuis 2006) Non-standard architecture not only widens the possible experiences of built structures for clients and users, but can also open up a territory of potential profitable economic and structural efficiency.

The Acoustic Barrier and Hessing Cockpit in Utrecht, 2005, was designed by ONL from the two perspectives of an strict inner logic of a few parametric details – all based on the same algorithm but all unique in their adaptation to their position in the structure and its relation to the surroundings – and an external gesture. On the site you experience a very specific and in the landscape surprisingly well-fitted and expressive structure.

The design of this coherent complex of unique pieces of steel and glass was made possible by the parametric detail of Acoustic Barrier, that immediately connects the styling of the surface to the construction and manufacturing of it. "Architecture, construction and manufacturing are one, in much the same way as body, skin and hair are one."(Oosterhuis 2005) The integrated architectural, structural and production concept of Acoustic Barrier shows that – thanks to the direct connection between the design model and the manufacturing machines through scripting based on simple rules – a complex building can be an expressively and efficiently engineered product, within a regular budget.

The building design has tectonic qualities in its effective, but strangely undulating, structure in a very contemporary way, it is grounded in and has a clear relation to its context by the way it adjust to it and function, but it is at the same time a strange object, something alien invoking new thoughts. These new architectures emerging from new kinds of industrial production and design tools, require new thinking and conceptions of architecture both from the perspective of the designer and the person experiencing the built environment.

Returning to the initial questions, I hope my argument is clear that we today actually are witnessing a development that through new technical possibilities and advanced geometry could promote a new kind of tectonic. The new digital and material technologies might not at all be alienating, but rather have capacity to overcome alienation and through perceptual experiences make people feel at one with the contemporary world. They could also make possible other kinds of thinking and collaborations, developing new expressions grounded in structural insights and conditions. There are ways to further the tectonic in architecture, by developing a concious and open view on the new technological and industrial paradigm.

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