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Circular Tectonics? – A critical discussion of how the architectural discipline can drive ecological continuity.

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ABSTRACT: Responding to the pressing global ecological challenges, recent environmental- and economic research call for a transition towards 'circular economy'. This call gathers a series of emerging schools of thought rooted in ecological thinking, pointing to the fact that these challenges imply development of advanced interdisciplinary design approaches based on holistic concepts and a nuanced understanding of value. By suggesting the concept of 'Circular Tectonics' this paper outlines a critical entrance to the question of the possible role of the architectural discipline in the transition towards circular economy. This because tectonic thinking holds a series of potentials for establishing an ecology of means related to ends in architecture by linking its value (or meaning) to its construct. Associating the notion of tectonics with that of circularity, the paper aims to establish a critical framework for gathering, evaluating, and synthesizing ideas about ecological continuity, that feed into a circular architectural practice.

1 INTRODUCTION

The increasing complexity of elements, industries, and stakeholders that govern architectural practice is highly influenced by the growing ecological crises that now more than ever calls for a nuanced view on how to improve and develop the built environment. Consequently, research perspectives that respond to the scope of the multiple challenges facing society must necessarily be outlined, discussed, and developed. (Orr 1992; Guattari 2014). Serious issues such as; the global population growth, continuous migration from rural areas to cities, severe climate changes, scarcity of resources etc. are evidently asking for novel ways to plan and construct buildings and cities. Evidently, this need for change affects the architectural discipline and calls for action; by developing research topics and approaches that can inform novel ways of interdisciplinary collaboration that provides viable ways to develop the built environment.

This need for new approaches involves developing strategies for integrating a wide field of knowledge that draws on disciplines where subtle, but nevertheless vital dimensions in architecture as; aesthetics, culture, and social aspects, are often oppressed in favor of topics relying on scientific arguments and measurable standards (Leatherbarrow & Wesley 2018). These modes of knowledge and collaboration involves an increasing number of disciplines, industries, technologies, and policy areas, which besides planning and structural engineering counts health science, energy- and environmental engineering, material technology, life cycle analysis, human nutrition etc. Integration of knowledge across disciplines can be found in recent environmental and economic research and it is a growing demand, and a general political concern in the call for a circular economy (COM, 2017). As for the concept of a circular economy it gathers a series of emerging interdisciplinary schools of thought such as; 'Cradle to Cradle' and 'Natural Capitalism', 'Industrial Ecology' and 'Human Ecology' (Webster 2017, p.11-23). These discourses all take point of departure in various types of ecological thinking. They address the fact that the wide-ranging environmental challenges call for interdisciplinary wide-ranging approaches to the planning and

design of our future buildings and cities, if we are to arrive at sustainable answers that enrich all parts of our global community.

Ecological thinking per se marks a potential to make the vital; aesthetic, cultural, and social dimensions of architecture driving forces in responding to the environmental challenges, rather than risking oppressing them in the process. This observation has motivated us to enter the call for circular economy from an architectural point of view and to write this paper. In summary, the architectural discipline is facing a need to simultaneously maintain and develop its core task as a spatial and culturally based discipline that aim at enriching the everyday life of people through construction. At the same time, it has to respond to and improve its 'modes of knowledge and collaboration' next to its core task. It is our idea that this challenge can be read as a tectonic endeavor, in the sense that it presents us with new questions regarding how we build. It becomes the task of 'ecologically linking' an increasing number of knowledge areas as we build in collaboration with multiple new parties. The aim of this paper is to point at central questions and dilemmas across this diverse field in order to frame the discussion for what we call; "Circular Tectonics".

1.1 *Aim*

By proposing the concept of 'Circular Tectonics' this paper seeks to map and position ways to develop or employ tectonic thinking as a critical means to reach a circular architectural practice. This is done by associating theories and methodologies linked to tectonics (e.g. materiality, joinery, detailing, contextual positioning, spatial construction) with the idea of 'circularity' (e.g. ecology, re-use, re-cycle and cradle-to-cradle). In this process, the paper gathers and juxtaposes various research areas, arguments and references that define 'tectonics' and 'circularity' respectively. As these research areas have not earlier been discussed as a conceptual entity we cannot refer to existing schools of thought or speak on the basis of extensive research into the topic 'circular tectonics'. Consequently, the paper is organized as a critical reading that questions the state of the art of circular architectural practice using tectonics as a lens. Thus it leads to our basic research question; *Can tectonic thinking be applied to establish a critical framework for gathering, evaluating, and synthesizing ideas about ecological continuity, that feed into a circular architectural practice?*

2 ARCHITECTURE IN A CIRCULAR PERSPECTIVE

As argued in the introduction the call for circular economy marks a potential to let aesthetic, cultural, and social dimensions of architecture become part of the driving forces responding to the pressing global environmental challenges. Furthermore, architecture seems to hold great assets to contribute to developing circular economies that will benefit societies in a broader perspective. This due to the multi-dimensional range of the discipline and its fundamental role as spatial framework of everyday life. The topic of circularity thus seems vital to the current development and discussion of architectural theory and practice. As a way to respond to these circumstances, a growing body of knowledge, especially case studies and design- and material experiments are emerging within architectural practice and research, and they set out to analyze the implications of circular thinking from an architectural perspective. Examples from Denmark are; Kasper Guldager Jensen from the design office GXN and John Sommer from the contracting firm MT Højgaard, who presented their first models exemplifying the business case for a circular approach in construction in 2015 with their book; "Building a Circular Future" (GXN et al., 2015); Søren Nielsen partner of Vandkunsten Architects, showcased their full scale experiments in the "Nordic Built Component Reuse" project and published their results in the book "Re-Beauty" (Vandkunsten, A.M. Manelius ed. 2017); CINARK Center for Industrialized Architecture have tested 'circular-low-impact concepts' in full scale - creating wall constructions by use of little processed, non-polluting natural materials with low CO2 emissions for the Circular Exhibition at KADK in 2017 (Madsen, U. et al. 2017). Finally, "Circle House " (2018) has proposed a building

system developed in collaboration by 3XN/GXN, Vandkunsten Architects and Lendager Architects and a number of industry partners. It has now been built as a testbed to show design for disassembly principles, adaptive structural concepts and reusability applied for social housing (GXN, 2018). These examples provide key insights into various construction concepts and proof different types of business cases, organizational set-ups, and not the least specific design solutions for 'circular buildings'. However, it is our observation that they also witness a present need to study the question of 'value' in greater detail, which is central for the transition to a circular economy defined as being; 'restorative by design' (Webster 2017, p. 17). Especially, when considering the great range of transformation that our buildings and cities are to undergo in order to answer to the pressing environmental challenges, the question of how to assess and validate means in relation to ends in architecture becomes vital. As urban densification continues to intensify we constantly have to select and prioritize: Were and how to densify? What to restore, and what to demolish? How to alter and/or transform? Which materials to use and maybe reuse?

In the outline of principles for a circular economy leading environmental researchers and economists actually conceive economy as a broad and fundamental entrance to an understanding of society as such, stating that: *'Looking beyond the current take-make-dispose extractive industrial model, a circular economy aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources, and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital. It is based on three principles: Design out waste and pollution, Keep products and materials in use, Regenerate natural systems'* (Ellen MacArthur 2018). It is our observation that this emphasis on 'positive society-wide benefits' resonates with our understanding of the purpose and role of architecture in society, which includes immeasurable social and cultural aspects in the overall 'calculation' of values. In addition, it can be observed how the implementation of a circular economy in architecture necessarily raises new questions regarding building construction as we have to 'ecologically link' an increasing number of knowledge areas.

This focal role of construction is evident in the case studies and research by design experiments described above. Here the concept of circular economy, defined by complexity economist Eric Beinhocker as; *'restorative by design, and which aims to keep products, components and materials at their highest utility and value, at all time*', is being translated into specific strategies such as; 'Design for Disassembly'(DfD) marking a significant leap forward (Webster 2017, p. 17). However, when taking a second look at for example the 101 recommendations proposed in the "Circle House" project there is a tendency to adopt a rather narrow conception of 'value'. Especially, when looking from an architectural point of view. Only 3 of the 101 recommendations; #35, #44, and #52 refer to a conception of value, which include core values of architecture seen as 'construction of a spatial enrichment of everyday life'. Recommendation #35, states that *'circular construction must be described so that it becomes attractive to live in'* (Circle House 2018, p. 89). However, throughout the report, main focus is directed to the cost of materials as such, whether measured as CO2 footprint or amounts, now emphasizing the potential of reuse adding to the bottom line for the developer in the event of disassembly. How the conception of circularity adds to architectural qualities is not elaborated upon, which raises a series of additional questions:

> *Is there a risk that we end up designing 'only for disassembly', rather than creating attractive architectural spaces that enrich human life to the broader benefit of society?*
>
> *Is it possible to discuss the 'value' of components or systems outside their specific architectural and urban context?*
>
> *Is there even a role for the polyhistoric knowledge of the architect in the design team of Design-for-Disassembly construction systems and components, or do system-engineering and life-cycle analysis suffice?*

It is our observation that a narrow conception of 'value' is not sufficient to trigger the full potential of the architectural discipline and its possible contribution to a transition to circular economy: On the one hand, it is crucial that the non-negotiable calculable economic aspects and technical conditions that govern the transition to a circular economy are taken seriously. The review of the experimental studies above witness important actions and results in this direction, where architects reach out and enter fruitful collaboration with engineers, economists, material technologists etc. Yet on the other hand, it is our observation that the spatial, societal, and cultural dimensions of architecture have to be included much more as part of the concepts and directly addressed. How do we for example 'calculate' the positive circular economical contribution resulting from a work of high architectural quality? For example an office space that provides a nuanced understanding of the human need for spatial intimacy or privacy in combination with engaging spaces that invite to physical movement and dialogue between colleagues. Spaces that reduce our stress-level and stimulate the overall well-being of the employees. When held together with recent research into health and architecture, the previous mentioned narrow conception of value is clearly insufficient. In research where neuroscience is associated with architectural quality and vice versa the multiple effects of architecture in regard of e.g. stress levels and physical recovery is tested and documented (Fisher 2016, Fich et. al. 2014). How can we position and liberate this particular 'value potential' held by architecture, which evidently resonate with 'the circular call', when taking the statement; *'focusing on positive society-wide benefits'* seriously (Ellen MacArthur 2018)? If we can critically address these questions, that all revolve around our conception of 'value' related to architectural construction, then maybe the need for demolition and disassembly would be lessened?

Figure 1. Demolition in process. Photo courtesy: Anne Beim

Technology and our ability to use it in meaningful ways is central in this matter. Whereas the call for circular economy emphasizes the question of construction and our ability to construct, the above reading of state of the art studies into circular architecture shows that there is a lurking pitfall to suppress the qualitative societal and cultural aspects of architectural 'value' in the process. In this case, there is a risk for the architect to step outside her/his own specific field of knowledge and competencies, and hereby fail to actually contribute to the circular transition. However, a similar pitfall lurks in the current tendency to address the question of sustainability and environmental viability in architecture from a declared aesthetic point of view then omitting the need to incorporate 'hard science'. Whereas it is easy to agree with the argument that aesthetics in the construction of space can be a central signifier of 'robustness' in a work of architecture,

it is also clear that this argument easily fall out in the discussion with developers and industry (Algreen-Petersen 2017). All together there is a risk that architects are being excluded, but also isolate themselves in dialogue with fellow architects that share similar ideas.

It is our observation that the challenge of fruitfully combining these two mutually dependent perspectives is reflected in Kenneth Frampton's motivation for his reintroduction of tectonic theory in architecture with his seminal publication; 'Studies in Tectonic Culture' in 1995. Here Frampton stated: *'Architects are confronted today by a crisis of value comparable to that experienced by Gottfried Semper in 1851, when he first realized the cultural depreciation that had already been effected through machine production and the substitution of materials, as this was then manifest in such processes as casting, molding, pressing, and electroplating. Over the last century and a half this cultural devaluation has greatly increased its scope, and its main effect has now shifted to the "spectacular" side of the economic cycle'* (Frampton 1995, p. 382). With this characterization of the contemporary architect as being faced with a 'crisis of value', Frampton points at how technologies driven by for example mechanical innovation or systems theory are challenging existing cultures in construction and architectural quality as e.g. refined detailing, spatial diversity or great sensuous experiences. Simultaneously, the application of tectonic thinking as a means for analysis allows Frampton to ascribe the value of iconic works by Kahn, Utzon, F.L. Wright, to a tectonic ingenuity that is neither an expression of a romantic denial, nor of blind trust in technology, but a critical balancing of the two related to a nuanced contextual understanding of architecture. Continuing this line of thought, it is our belief that the notion of 'tectonics' holds a strong potential as a critical theory and method when addressing the current environmental crisis and the present call for circular economy. This, as tectonics per se involves a fundamental commitment of architecture to its context and available resources widely understood as elaborated below.

2.1 *Tectonics as critical entrance to the question of ecological continuity?*

Throughout architectural history, the notion of 'tectonics' has been developed and applied as a critical means to position the discipline of architecture in its; societal-, technological-, local, global- and cultural context. The critical and methodological potential of tectonics in architecture can be traced back to early Greek descriptions, over the 1850's German reintroduction of the term, and into more recent repositions (Foged & Hvejsel 2018). The history of tectonic theories witness a continuous focus on the value and nature of the work of the architect related to the constructive use of resources at a particular point in time; antique, industrial, or digital. Defining this potential Gottfried Semper has provided us with a nuanced understanding of the meaning of the wall as a mutual interdependency of its value as; 'wand' and 'gewand' (Semper 1860, p. 227–231). Likewise, Eduard Sekler has pointed at critical tectonic thinking and decision making, as a core competency for the architect in increasing the experienced value of structure and construction (Sekler, 1965). Also, Marco Frascari has stated the potential effect of detailed tectonic decision upon the value of the architectural work as a whole (Frascari 1984). A potential that is cemented in Frampton's elaborate critical application of tectonic thinking in his review of architectural history and the subsequent analyses referred to above (Frampton 1995). This trajectory of research documents how tectonic thinking can be applied for analyzing the particular value of [iconic] works of architecture, by referring it to a critical utilization of the resources available in a given context that simultaneously opens a potential to employ this thinking methodologically in the general architectural practice, as 'Everyday Tectonics' as we have argued earlier (Beim & Hvejsel 2016). However, despite this critical and methodological potential, tectonics often remains associated with construction technology as such, or associated with certain (new) material conceptions in architecture such as in (Reiser & Umemoto 2006, Leach 2004). The scope of this paper is to show that the notion of tectonics in architecture holds a much broader potential. It is our argument, that tectonics is not to be misinterpreted as a separate area or aspect of architecture, but can be understood and developed as a general theory and critical means to arrive at a viable architecture that is committed to a given context. The recently published anthology 'Towards an Ecology of Tectonics' defines; *'the concept of buildings as parts tied together as a whole in a broader context*

of natural and cultural systems. This understanding feeds a new ethical dimension into tectonic practice that recognizes the correlation between the materials used, the ecosystems they form a part of and the resources we share as common members of the global community' (A. Beim, IN: Beim & Stylsvig (eds.) 2015, p. 12). This interpretation of ecological tectonic thinking outlines a series of potentials when associating tectonics with the current environmental crisis and economical call for circular practice outlined above. As stated by Webster the emerging possibilities of information technology are a central catalyst for a circular economy (Webster 2017, p. 35). However, he also makes it clear that the question of 'meaningful advancement and application of technology' represents an increasingly critical point, when stating: *'None of these IT-trends might make the flow of materials and energy more benign, in fact they could worsen the situation with more poorly designed products circulating ever more widely and quickly.'* (Webster 2017, p. 35). A similar concern is shared by Frampton in his observation that *'To the extent that architecture remains suspended between human self-realization and the maximizing thrust of technology, it must of necessity become engaged in discriminating among different states and conditions; above all perhaps among the durability of a thing, the instrumentality of equipment, and the worldliness of human institutions* (Frampton 1995, p. 23). In continuation hereof he presents tectonics as; '*a mode by which to express these different states and thereby as a means for accommodating, through inflection, the various conditions under which different things appear and sustain themselves.'* (Frampton 1995, p. 23). In the following, we set out to map the identified link between circular economy and tectonic thinking in architecture and to develop a framework for further maturation of this research field.

3 DISCUSSION: CIRCULAR TECTONICS?

The critical review of the state-of-the-art of circular architecture (research as well as experiments) presented above has revealed a possible pitfall when translating circular principles into specific design strategies such as DfD in architecture. The architects risk to step outside of their specific field of knowledge ending up excluding viable societal and cultural dimensions in the understanding and 'calculation' of architectural value. The pitfall shows as a narrow materialistic or capitalistic valuation of system thinking in building components exemplified above. While the narrow approach may make these components technically suitable for disassembly and reuse, they may at the same time risk to fail. This by not embedding the fundamental contextual dependency of architecture in the system and thereby compromising their spatial robustness over time.
In this paper we have outlined a potential to apply tectonic thinking as a driver for transition to circular economy from an architectural point of view. It is defined as a central means to establish a critical framework for gathering, evaluating, and synthesizing ideas about ecological continuity, that feed into a circular architectural practice. If this hypothesis holds true, tectonic thinking can be applied to translate principles of circular economy from an architectural point of view, without falling into the above mentioned pitfalls.

3.1 *Circular tectonic synthesis of disassembly principles and spatial robustness?*

The overall considerations that frame the general movement towards circular thinking are rooted in actions to protect the environment - manifested in the slogan; '*reduce, reuse*, and *recycle'*. This attention was forwarded by American environmental movements in the early 1970'ies, which later led to the organization of EPA - the United States Environmental Protection Agency (EPA 2018). In Frampton's critical understanding of tectonics it can be translated into; '*a mode by which to express these different states and thereby as a means for accommodating, through inflection, the various conditions under which different things appear and sustain themselves.'* (Frampton 1995, p. 23). Therefore *Reduce, Reuse, Recycle* may not only concern CO2 footprints and costs understood through technical measures, the three points should also imply alternative answers to the design of architectural spaces. Spaces that allow for reducing the increasing number and monotony of especially housing and office spaces through an advanced form of 'spatial ecology' that

exist across the daily use and across generations in time. In addition to in-depth knowledge about the construction system as such, this implies inflection of building industries and policies.

This reading of the core principles for a circular economy positions the architectural task in a tectonic synthesis of the present call for system thinking in for example disassembly principles and lifecycle analyses paired with the core knowledge about the un-calculable cultural and societal potential of spatial robustness in architecture: At one end of the spectrum the architectural icon, e.g. a cultural building with a considerable budget and significant urban role, is positioned. Jørn Utzon's Sydney Opera is a critical case in this end of the spectrum. The design and building process was long, complicated, filled with drama, involving interdisciplinary collaboration and disagreements. The Sydney Opera was anything but cheap, yet it has become the key signifier not only forming Sydney's identity as urban landscape, but also the identity of Australia as a continent of the modern world, due to its contextual viability as urban architectural form. What sort of demands for ecological continuity must be raised at this end of the spectrum?

At the other end of the spectrum we have everyday architecture. It could be social housing in the outskirts of a major city where an industry- and developer's financial approach easily will reduce the project to a 'constructed system' as such. What demands for ecological continuity must be raised at this end of the spectrum? Will it be sufficient to design for disassembly or can spatial robustness akin to those that characterize iconic projects be developed through specific architectural knowledge?

The challenge in changing our conception of growth lies at the center of circular economic thinking, and it is central when entering this synthesis between disassembly principles and spatial robustness. We need to aid a shift from a narrow materialist/capitalist understanding to a broader definition of growth related to 'society wide benefits' (Ellen MacArthur 2018). The recent report from the Danish Association of Architectural Firms entitled 'Architect – Document the value that you create' address this challenge (Sattrup (ed.) 2018). The report visualizes how the cost of the architectural idea represents a 'small gear' that drives others gears that increase in cost and size; representing design, construction, and operation and finally a much larger potential surplus value. Hence, the quality of the architectural idea is crucial to be able to release this surplus value. In this regard tectonic thinking represents a potential to strengthen the viability of the idea by referring it to the means applied in its construction.

4 PERSPECTIVE

In perspective, Richard Wesley and David Leatherbarrow's characterization of Ian McHarg's; 'Design with Nature' seems to mirror the challenges inherent in the transition to a circular economy from an architectural perspective as they have been outlined above. The research of McHarg led him to the conclusion that designing with nature requires inventory of all sectors in a given region. Wesley and Leatherbarrow observe; *'Yet still another premise was required for these studies: that "physical, biological, and social phenomena [could] be represented as values"* (McHarg 1969, p. 24)*. He didn't define this last term, but given what he wrote elsewhere in the book, it would seem incorrect to assume they included cultural or historical matters, especially if understood anthropocentrically. Closer to his understanding and aim is the use if the term in mathematics: the* value *of an unknown in question for example'* (Wesley & Leatherbarrow 2018, p. 5). Following this line of thought, it is our conclusion that whereas this account of value must address and be applicable to other disciplines and fields of knowledge, architects always will have the responsibility to enter the question of value based on the premises of architecture itself. Hence, as contextual spatial construction. For architectural practice this implies focal attention to the challenge of; How to construct ecological *continuity* in our understanding and development of architectural value towards a circular economy? And herein; that of outlining adequate means, relations, and strategies in this process. Tectonic thinking in architectural practice does not offer a quick fix to the complexity of this challenge, but as discussed above, it opens a potential to qualify our actions that calls for further research.

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