

THE TECTONIC POTENTIALS OF CONCRETE

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Contemporary techniques for concrete casting in an architectural context are challenged by demands of increased individualization in our built environment, reduced waste generation and reductions in the use of resources. In recent years, new production technologies and strategies that break with the industrial paradigm of standardization have been put forward. This development is carried forward by computers and digital fabrication, but has yet to find its way into the production of building components. With regards to concrete casting, however, existing research do offer advancement towards an increased customization of casting moulds. The hypothesis of this research is that the techniques used in this research do not fully address the tectonic potentials of concrete which gives rise to the primary research question:

Is it possible to enhance existing or develop new concrete casting techniques which allows for individualization and resource optimization, while matching or enhancing the tectonic potentials found in existing, repetitive concrete casting techniques?

The research is comprised of two modes of inquiry: an *empirical study* of contemporary casting methods and subsequently six *case studies*, carried out as *research by design*. The empirical study is set forth to find tectonic implications and challenges in existing casting methods. These implications form the basis for the formulation of the case studies, the purpose of which is to assess tectonics potentials in existing casting techniques and develop novel ones. It is through an analysis of the empirical study and experimental case studies against a conceptual universe that conclusions are drawn and an answer to the research question is proposed. This conceptual universe is based on research into established writings concerning tectonic thinking. The ideas of German

Theorist Gottfried Semper are presented as a strategy for describing form as a result of materials and technical matter. Furthermore the idea of poetic construction is presented. Set forth by the English / American theorist Kenneth Frampton, the idea is that poetic construction is achievable though attention the properties of materials, structural logics and the craft of making. The thoughts of Marco Frascari which suggest a reading of *details* as a creator of meaning are introduced to be able to help establishing a progression in the case studies. Due to the narrow research focus on the *making* of concrete, an additional conceptual framework which emphasizes tectonics as a physical phenomenon is presented: The relationship between material, technique and form. Finally, a distinction was made between relationships surrounding mould making and the actual creation of geometric forms in concrete. The former was referred to as *mould tectonics*, the latter *concrete tectonics*.

A study of the concepts of *New Production Philosophy*, *Mass-Customization*, and *Digital Tectonics* is presented as a basis for investigating their use in concrete casting. Digital modeling and *simulation* as a mode of representation is presented as a means to contemplate both geometry and manufacturing processes at the same time.

In order to understand of the potentials and problems in the investigated techniques a distinguishing between addition, subtraction, and transformation (A-S-T) is proposed. Addition is found to be the most widely used principle in contemporary practice, where the addition of Euclidian geometrical elements make up rectangular casting moulds which present a geometric restriction to the inherent isotropy of concrete. *Subtraction*, on the other hand, is found to be the most widely used technique for casting complex and amorphous concrete. Current subtractive techniques are found to offer resource minimization but suffer from poor surface quality. *Transformation* is developed through casting in fabric which is found to contain a lack of precision which could become problematic when several fabric cast members are connected and in situations where fabric cast elements are to meet precise, rectilinear building components, such as windows and doors. This is addressed with the development of a novel casting technique using laser cutting and folding of large sheets of PETG plastic in which precision is maintained. The ability to reuse the PETG moulds makes the technique a zero waste production.

In general it was concluded that problems with existing techniques relate to production time, surface quality and precision and are caused by the use of mould fabrication technique and materials. These problems are addressed in the case studies. The case study research gives rise to the conclusion that the logics of the technique should be a determining factor

for the generation of form rather than a means to realize a preconceived form. This will reduce fabrication time and enhance a tectonic relationship insofar that the logic of technique becomes clearly expressed in the geometric form. Various design proposals are made to support this assumption.

The problem of poor surface quality of existing casting technique using Expanded Polystyrene (EPS) as a mould material leads to the finding that *casting* EPS under pressure against an adjustable membrane as opposed to *cutting* it, allows for amorphous concrete elements to be produced which have a high surface quality. This technique also dramatically shortens manufacturing time over existing techniques.

The successful design and construction of a research pavilion using the folded PETG plastic technique establishes that parametric and algorithmic computation support the generation of concrete structures which can respond to complex formational, material and contextual relationships. Provided these generative techniques are used in an iterative process, exploring boundaries rather than defining solutions. The Object Oriented design paradigm is found to support such development, allowing for structuring of code into 'classes' such as: concept, geometry and fabrication.

Based on an analysis of the empirical and case studies, four considerations essential to the mould tectonics are defined: *a simple process, amorphous form, complex form, surface quality* and *precision*. The mould materials examined are all found to possess more than two qualities at the expense of others, depending on the technique used. However, a single concrete casting material, given the use of the right technique that is able to address all these problems, has not been identified, neither in state-of-the-art nor in the case studies. It follows that due to today's demands for resource optimization and competitiveness it is unlikely a 'the one casting technique to end them all' can be found.

Finally it is concluded that in order to conceive tectonic forms in concrete, representational methods should be used which describe architecture as a result of its creation process. Not as a storyline rooted in formal or functional foci telling a story about arbitrary, non-existing steps that have been taken mentally to arrive at a form. Architecture that originates from such lines of thought naturally revolves around topics represented in that storyline, which are often purely spatial. This may be avoided by paying attention to the relationship between material and technique in the creation of the mould before turning to the geometrical form of the concrete construction. That is: the nature of the creation of the casting mould and the concrete elements should precede the development for construction and also influence architectural form.