Between Form and Material: the digital computability of indeterminate plaster behavior

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1. Introduction

Shapes can be represented, interpreted or structured in many ways. This indeterminacy in shape representation is a source of creativity and emergence in architectural design. The ephemeral quality, the divisibility of a shape to multiple parts, and various part-whole relationships are part of the creative process in design. These aspects, under the designer's actions, trigger emergence. Shape computation (Stiny, 2011) ideally addresses the phenomenological indeterminacy in calculation of visual matter and is a technical alternative to the symbolic representation that computers usually require for shapes.

In our studies, we extend shapes to a more general and physical world as we consider material interactions in design rather than just form related ones. The merit in making is not in the end product but in the process. Form is a *b*ecoming with the material instead of a *being* imposed on a material. Material makes the form, the space, the performance and the experience on which the shape is defined; exploration through making is what allows the shape, through material performance. This kind of emergence in shapes is not a result of the way the designer mentally creates the form but it is the result of the way s/he explores the potential of the material. The approach takes a phenomenological creative process and gives it a material existence. Interpreting from Deleuze's philosophy, DeLanda explains this relationship through *new materialism* (2009). New materialist philosophy suggests that materials are "morphogenetically charged" (DeLanda, 2009), which can and should alter the position of the designer with respect to material during design.

While emergence in material performance can be explored physically through making and interacting with the material, it is difficult to capture this experience especially in digitally supported models. This is mainly because the deterministic representations used in digital computation contradict the phenomenological indeterminacy in shape computation. Shape computation already employs rules that make the capturing of actions possible. It is especially significant to acknowledge that these rules are visual and incorporate experience as well. However, there is also a need to incorporate the material experience. To bridge the gap between the digital and the physical (as the extended version of the visual) explorations of emergence, the study, alluding to the notion of weights, proposes to incorporate information regarding material properties in shape rules. Forces that emerge due to material properties can be captured in digital implementations. In other words, instead of the geometry of the shape, forces that are active in the becoming of the shape are modeled. The assumption is that the shape emerges from the behavior of the material.

In order to explore the potentials of the proposed idea we focus on fluid behavior, and in particular of plaster. Plaster is a material that is dynamic and mobile which takes form under forces that act upon it. We set up a physical experiment to observe and document the behavior of plaster when it is first poured into an elastic mold. As the plaster takes shape against the elastic surface, we derive visual schemas with the aim of digitally representing the material behavior.

2. New Materialism and Becoming

Views on materials and matter in general took a new turn in the last century in relation to both advances in science and seminal issues in philosophy in terms of understanding natural phenomena and relating ourselves with these phenomena.

Turn of the 20th century brought a shift in science from the static "Cartesian-Newtonian understanding of matter" that "yields a conceptual and practical domination of nature" (Coole & Frost, 2010, p.8), towards a multidimensional (a four dimensional continuum of space and time) and curved understanding of space due to introduction of non-Euclidian geometries and Einstein's *theory of relativity* (Kolarevic, 2003a). In the Cartesian-Newtonian reference system, matter is defined as solid and rigid with Euclidian principles of form. However, with the concepts of dynamism that is brought about with multidimensionality and relativity we look for new ways of describing matter that is also dynamic. In the tangible world we get in contact with the surface of the matter so it is possible to understand its dynamicity through its surface. Hence the surface is crucial in understanding matter and its form (Cache, 1995), and Non-Euclidian description of the form deals with these kind of dynamic surfaces. These paradigm shifts alter the tools that designers use while describing their designs. Euclidian ways of describing forms rely on projections on coordinate axes that create an abstraction of forms at the very beginning that already breaks the ties with real matter. These descriptions are also discrete and transition from one form to another can be described by defining a new rule each time a change is occurred. On the other hand, non-Euclidian descriptions are smooth which rely on curvature. They eliminate external reference systems, abstractions of real forms, conceptualizations. These kind of descriptions let smooth changes between forms where infinitely many possible stoppages can occur in duration. These changes can be described as changes in the curvature of the surface.

In philosophy, Deleuze takes a different stand from his phenomenologist contemporaries and demonstrates that "there are a thousand plateaus, a multiplicity of positions from which different provisional constructions can be created" (Kolarevic, 2003b). While phenomenologists suggest that we create the world by cutting it out with concepts or with language, Deleuze suggests that world exists independently of our minds (DeLanda, 2009). However, DeLanda does not position Deleuze among classical materialists but coins the term *new materialism* for Deleuze's philosophy, which differentiates itself by getting rid of essences in materialism, thus from idealism and essentialism as well. Essences make generalizations and get in the way of capturing uniqueness of each situation, phenomena or becoming. DeLanda further continues to describe new materialism in terms of matter and says "matter is morphogenetically charged and that it has powers of morphogenesis of their own" (DeLanda, 2009). Coole and Frost (2010) similarly argue that "...materiality is more than 'mere' matter. It is an excess, force, vitality, relationality, or difference that renders matter active, self-creative, productive, unpredictable" (p. 9).

These contemporary positions shed light on the relation of the designer with material. Traditionally, designers create the concept of their designs through abstract representations and impose these concepts on materials, which are domesticated and become almost inert. However, like essences, concepts diminish the true being of the matter. They make it a generalization that is pertinent to any matter of the same kind. This inhibits emergence that can occur in becoming. On the other hand, designers can recognize that the matter is dynamic in the making of the form that is a continuous flux, mobility. Bergson describes reality as mobility, as things that are in the making not as things that are made (Bergson, 1912). Fixed concepts may be extracted by our thought from mobile reality but there are no means of reconstructing the mobility of the real with fixed concepts. Thus, designers benefit from interacting with real materials to make the form that is a becoming rather than a being.

3. Material Properties of Shapes

In shape computation, Stiny introduces the notion of weights to represent material qualities of shapes (Stiny, 1992, 2006). They often correspond to shape features such as color, tone, thickness, transparency, shading, texture, etc. These features can inform how rules can be applied and more importantly, which rules can be applied at a particular time. The inclusion of these features in the visual rules may provide answers to the common question "where do the rules come from?" (Stiny, 2011).

Following Stiny, we propose that physical forces resulting from material properties and in return influence the form can be the information captured as weights. In this study, we identify selected material properties that have direct impact on the formation of a shape and present an analysis of the relevant forces. In particular, we focus on forces that emerge when plaster is taking form. A similar investigation of how to schematize plaster behavior with shape and weight rules (Akküçük & Özkar, upcoming, 2013) describes a different setup for observing emerging shapes and focuses on how morphological transformations can be visualized in rules. Our focus is on identifying material forces as well as resulting shapes.

In order to observe the forces on the plaster, we create a controlled experiment. The experiment is set up with a mold which has static and dynamic parts. All four sides of the mold are rigid and the base is elastic. This physical set up limits form changes in the XY-plane only to allow for changes in the Z-axis for ease of observation. The fluid plaster in contact with the elastic part of the mold is prone to take form according to forces acting on it. To specify further characteristics of the behavior, we use rigid probes that limit movement of the elastic mold (Figure 1, Figure 2, Figure 3). We made the physical experiments by pouring plaster in the mold described and observed the duration of form taking from the time the liquid plaster is poured until it is cured to derive visual schemas (Figure 4). The whole process of each experiment is recorded on video. However, only the analyses of the changing sections of cured plaster are delivered here. But it should be noted that there are infinitely many possible sections from time 0 (staring condition) to time n (after plaster is cured in the mold).

After curing, the sections of the plaster are examined to derive visual schemas. We introduce weight algebras to represent the material properties as part of these visual schemas.

The study avoids defining too specific shape rules in order not to achieve deterministic results. Instead, labels and weights are defined to represent the features and forces that allow the shapes to emerge. Labels specify where the probes are placed along the elastic mold (Figure 5). Weights specify the actual weight of the plaster as a force that is exerted on the elastic mold (Figure 6). Although weight forces are distributed along the section, the places of the weights indicate centers of mass where curve changes direction between probes or probes and ends of the elastic mold. While defining a visual rule for the placement of weights we actually assign an abstract weight function to them. The function for the weight of the plaster is affected by two parameters: 1) quantity of the plaster, 2) viscosity of the plaster. Defining the place of weights with regard to probes is part of the process. As seen in Figure 4 sections change based on the place and number of probes. Probes play a role in how weights divide.

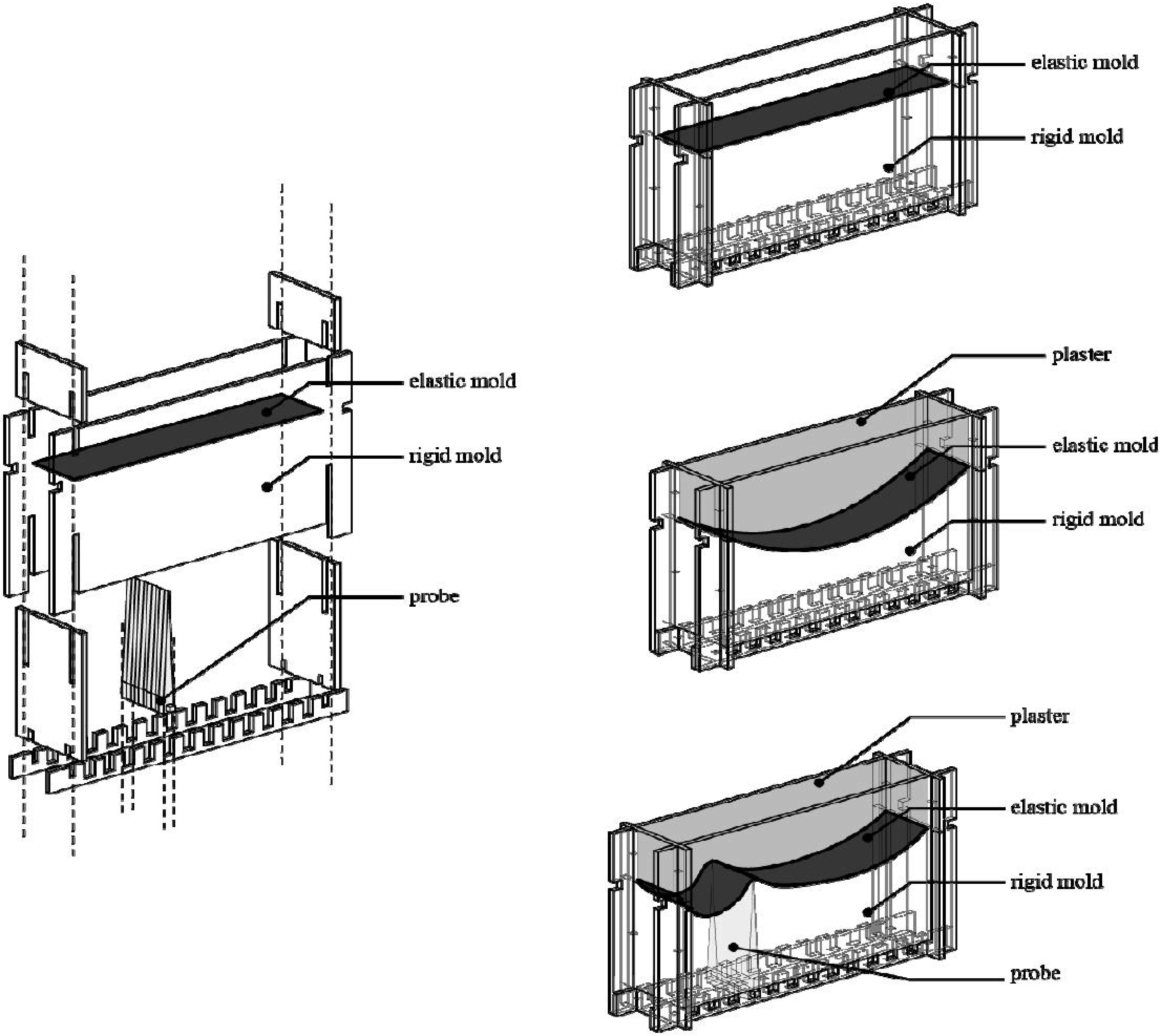

Figure 1: Diagram of the assembly of mold for the physical model (on the left), form in becoming when plaster is poured in the mold (on the right)

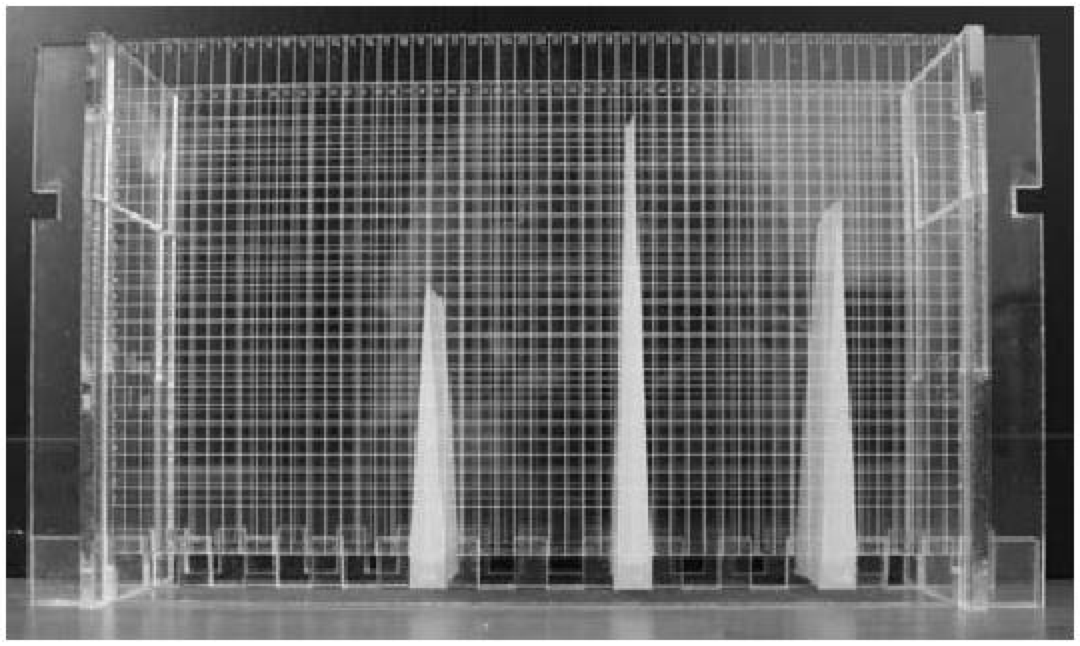

Figure 2: Laser vut rigid mold

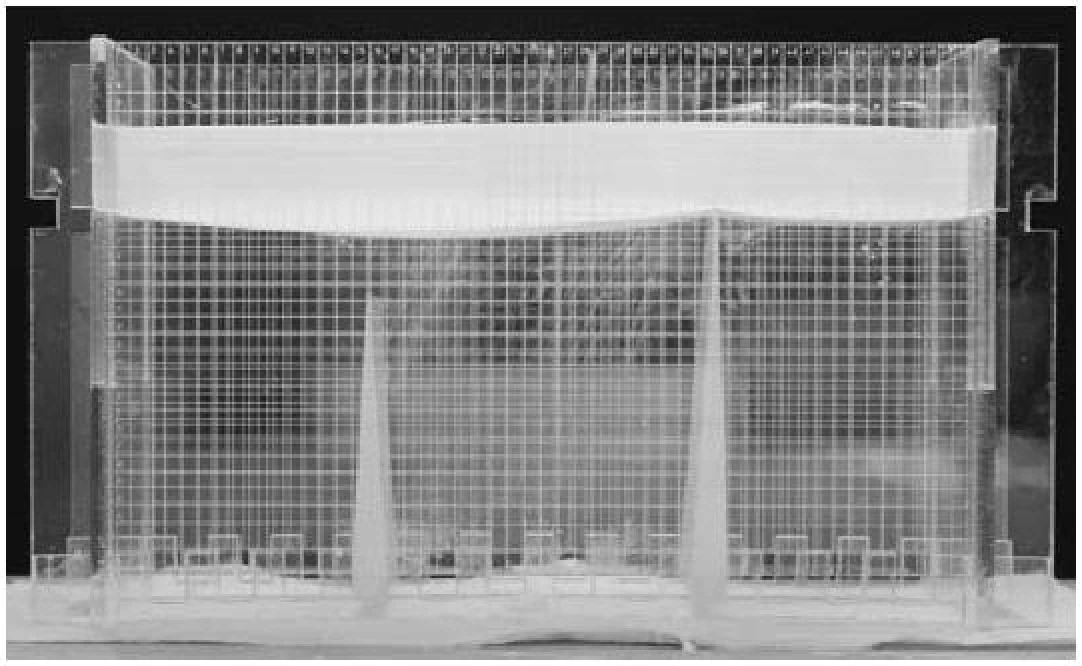

Figure 3: Laser vut rigid mold with elastic base

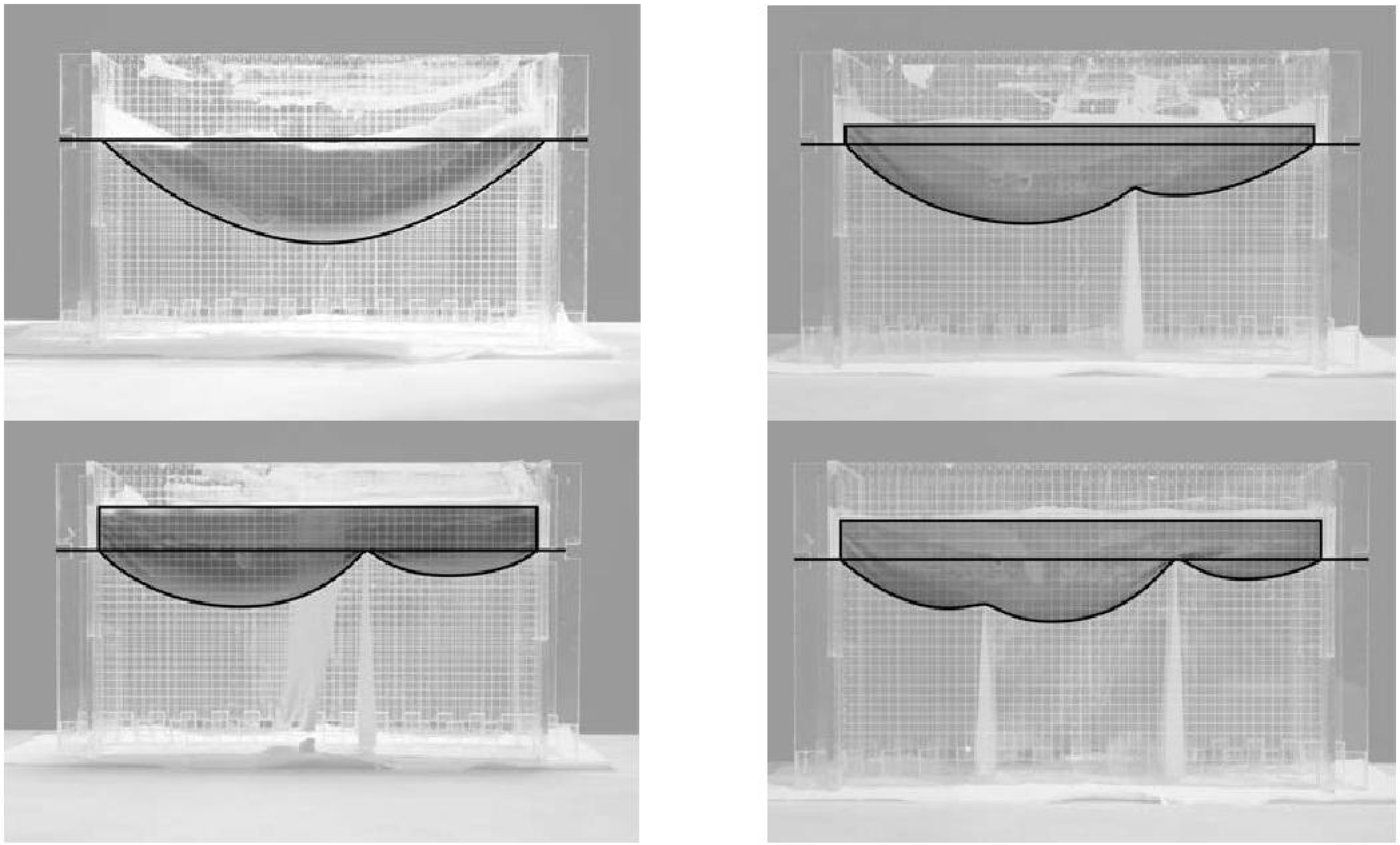

Figure 4: Rendered areas of observed changes in the sections for four experiments

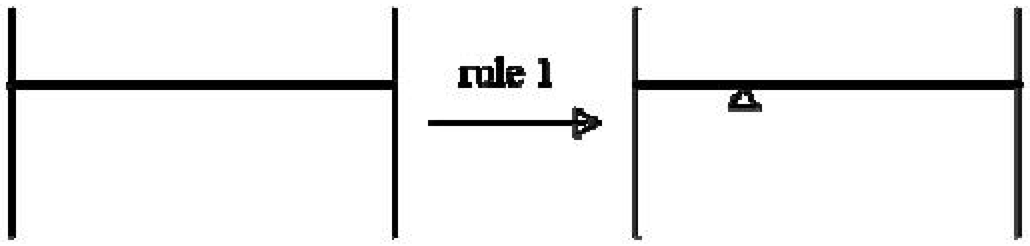

Figure 5: Rule 1 - insertion of probe label

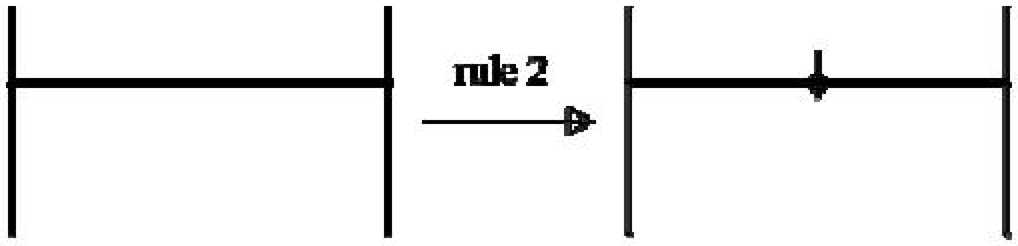

Figure 6: Rule 2 - indicator of material weight

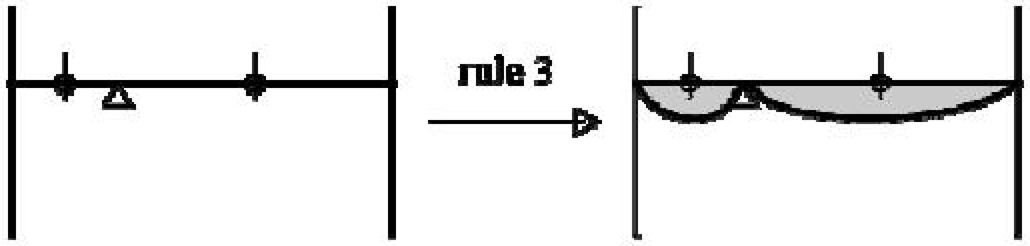

Figure 7: Rule 3 - Changing section according to applied forces

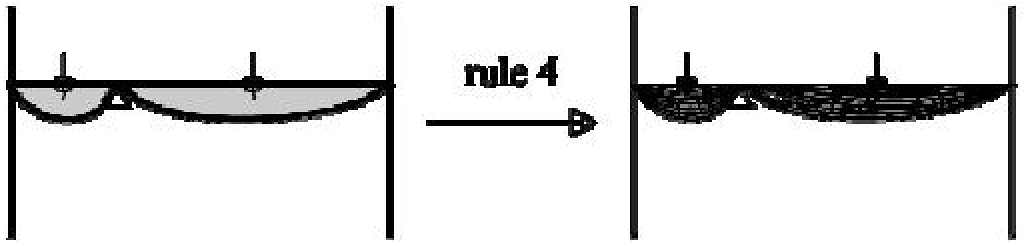

Figure 8: Rule 4 - Deriving possible sections in becoming

Additionally, we define an observation rule that renders the changing area when the plaster is poured in the mold until it is cured (Figure 7), as well as a derivation rule that shows the possible sections that emerge when plaster is taking form, i.e. possible stops in the duration of becoming (Figure 8). The derivation rule shows that there are infinitely many sections that the designer can choose from while pouring the plaster in the mold by stopping to pour more material. The process of applying the rules is shown as a continuous visual computation (Figure 9).

The section of the poured plaster that is in contact with the elastic mold with regard to label, weight, observation and derivation rules are analyzed in order to gather information about how the section can be interpreted so that it can be translated to the digital medium. The analysis follows the use of extremas and inflection points as topographical features as introduced by Cache (1995). As in non-Euclidian geometry, variations on the surface can be explained through curvature. It is observed in the section that there emerge extrema points due to labels and weights. These extrema points are where the curve changes direction. Labels create maximum extremas and weights create minimum extremas. There occur second order emergences along the section of the plaster, which are the inflection points. Inflection points are zero curvature points where curvature of a curve or surface changes direction (Figure 10).

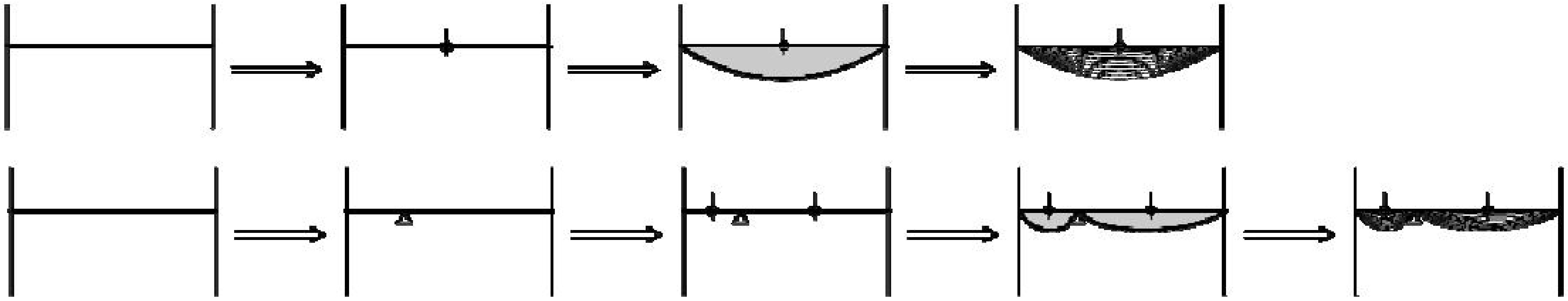

Figure 9: Two possible applications of rules in the process

While labels show the placement of the restrictions in the digital model, weights include the information of where each center of mass is along the section as well as parameters of mass and viscosity. The analysis of the physical model shows that the digital section should also follow the limits of labels (maximum extremas) and weights (minimum extremas). It is then possible to initiate a *digital becoming* with a digitally constructed initial section. The becoming can be documented in relation to the observation rule. There will then be infinitely many possible sections in the process, one or many of whom can be selected by the designer as in the derivation rule.

4. Conclusion

The study addresses two issues: 1) the contradiction between deterministic computation and phenomenological indeterminacy and 2) the conventional use of materials in architecture that tells materials to be forms. As we propose shape computation to address the first issue, we observe forms as becoming with non-Euclidian descriptions rather than as being in a Cartesian-Newtonian reference system in a continuous processing of plaster. We use the real physical material properties of shapes as something to calculate with in order to achieve indeterminacy in digital implementations of shape computations. We particularly identify forces and show how they can be incorporated as relevant information in shape rules. This establishes a basis for future studies on defining such properties as weights in shape computation and eventually on defining algebras for operating with these weight values in parallel to shape computation.

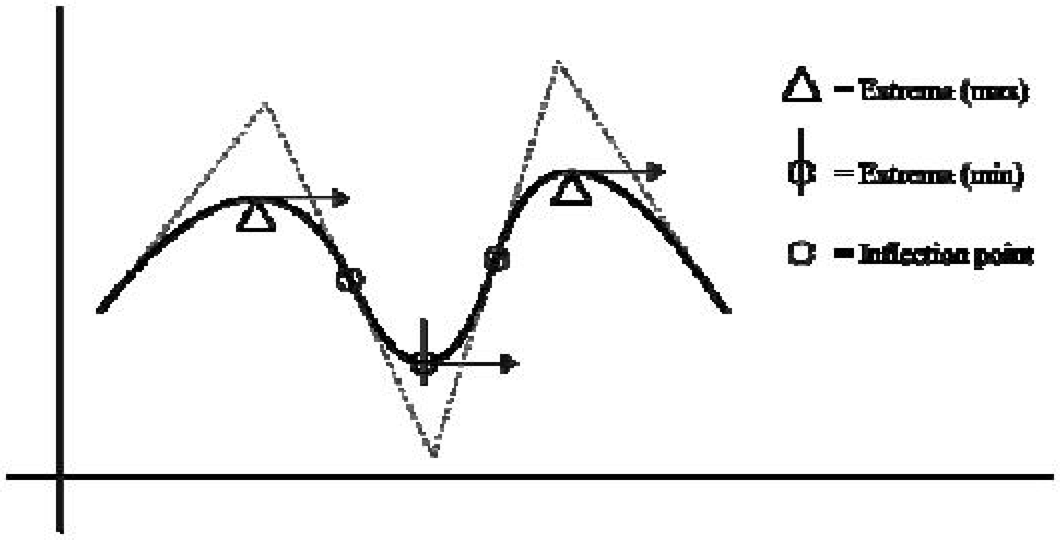

Figure 10: Analysis of the section for digital implementation

Weight algebras in shapes have previously been studied for properties such as color, thickness, tone, etc. Our study is unique in that it focuses on forces effective in material performance as weight attributes in shapes. Not only does it strengthen the connection of material aspects of design and computation, it also holds potential to contribute to the answer to where rules come from in shape computation. The answer is crucial since computer implementations also seek to answer the same question to be able to formulate a computable yet indeterminate problem.

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