

Elastic Boundaries

Biomorphic Structures and Algorithmic Material Intelligence in Deformation Casting

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THE FOREIGN FAMILIAR

Deformation casting relies on the inherent structural intelligence in elastic formwork to produce organic forms. When casting in elastic material, the weight and viscosity of the casting medium are critical elements in the pliable formwork's expansion to its final shape. Similar to how gravity acting on a hanging chain produces a catenary curve, the expansion of an elastic membrane charged with a casting substance converts the hydrostatic pressure within the volume into surface expansion resisted through tensile forces.¹ This creates an interaction in which pressure, expansion, and the resulting surface tensile forces are in balance, while the membrane, in its expansion, maintains a minimal surface to volume ratio. [fig. 1]



Figure 1. Photo: Scale prototypes with helical symmetry (2020)

When an elastic volume is filled with a liquid casting medium it expands towards a spherical or drop-like shape in accordance with the laws of energy conservation. Where traditional approaches to casting seek to control pressure within the volume by encasing the casting material in rigid materials that minimise deformation, elastic membrane casting actively embraces and relies on the deformation of the formwork. In this process, the practice and purpose of casting is relieved from its association with predictability, tight tolerances, and repeatable outcomes. Instead, deformation casting involves the practitioner in an intuitive process of controlling and restricting the elastic formwork's expansion subject to the internal hydrostatic pressure. Each cast's surface is a registration of the pressures and constrictions at play during its creation, and thus takes a portion of its meaning from the now of its creation.² To regulate this process, carefully designed formwork is used to disrupt the elastic volume's natural expansion toward spherical forms. This play between control and release, tuned through gravitational influence, reveals a plastic plurality that appears organic and evolved in nature.

The work presented at Kunsthall Aarhus deviates from preceding work with flexible moulds in fabric (Mark West, Ronnie Araya, Kenzo Unno) and inflated lightweight membranes (Heinz Isler, among others)³, in its use of formwork that is elastic. The shift from flexible to elastic membranes positions the practice in a precarious territory. The material elasticity prompts the work to embrace risk taking and open-ended experimentation in pursuit of outcomes that balance between vague predictability, surprise, and failure in search of discoveries that would not be reached through conscious or analytical approaches by themselves.⁴

The outcome and integrity of the cast elements are a consequence of the practice's algorithmic capacity to self-resolve in surprisingly constructive ways – a property Mark West described as "inherent structural intelligence"⁵ – as well as sculptural and structural considerations motivated by ideas of seeing the cast elements as zoomorphic and even anthropomorphic bodies evolved under a novel selective pressure. [fig. 2] The technique's capacity to subvert formal expectations is not limited to the sculptural casts: photographs of the formwork in various stages of construction are as important outcomes of the work as the tangible elements are. [fig. 3a,3b] The soft-bodied mammalian-like volumes of the cast figures are belied by an underlying helical symmetry – incompatible with mammalian bipedaled mirror symmetry – and the combination of irreconcilable traits which on their own display a strong internal consistency and evolutionary logic, produce in the same body a foreignness perhaps only available subconsciously to the spectator. [fig. 4]

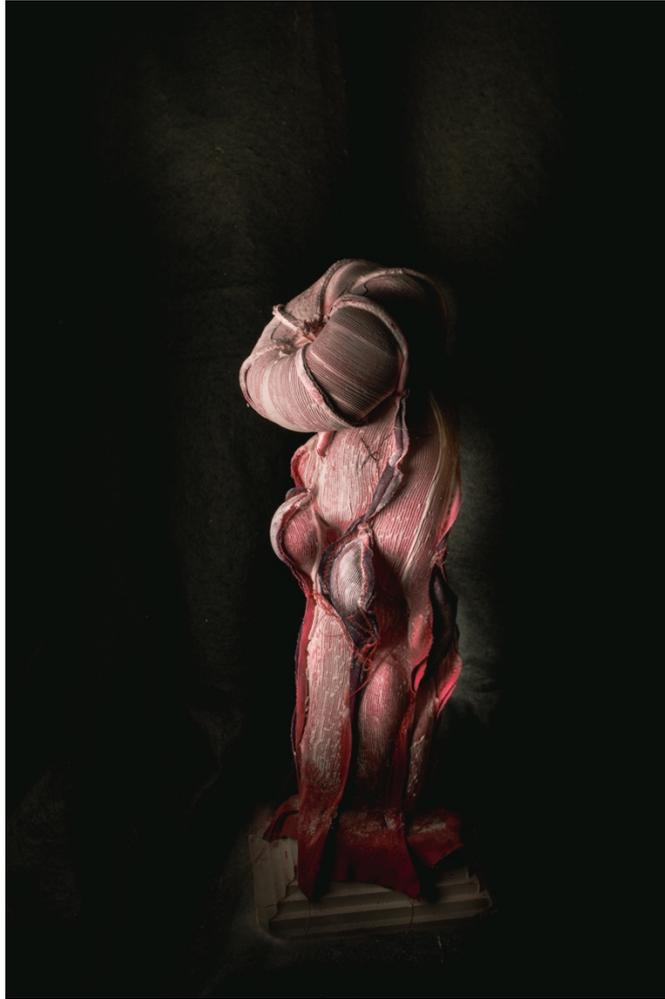
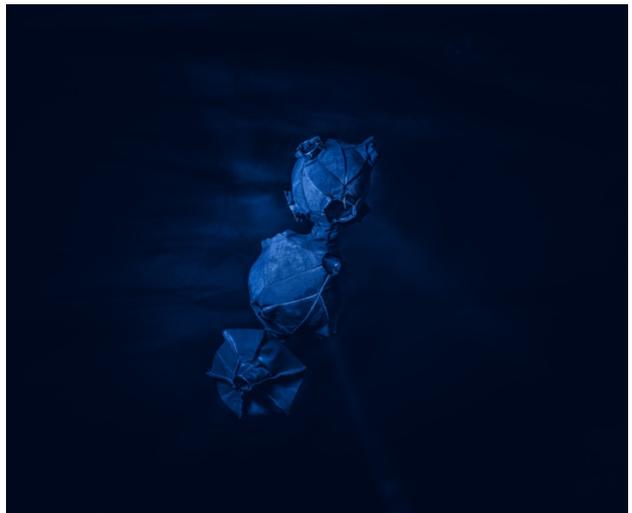


Figure 2. Photo: Scale prototype (2019)



Figures 3a and 3b. Photo: Formwork during production (2020)



Figure 4. Photo: Detail from cast element (2012)

ARCHITECTURE'S YOKE

Much of the work involved with the production of space and the built environment happens through techniques and approaches where precision and prediction are foundational. Even if chance and uncertainty have been essential to the conception phase and early design process, by the time a design reaches the modelling phase and construction drawings are produced, aleatory elements are treated as suspicious influences that undermine uniformity and clarity as guarantors of efficiency and predictability. In the building process there is little room for aleatory reliances. They run contrary to the fetishization of precision architects have developed as a compensatory strategy to deal with their separation from the realised architectural object itself.⁶ Strategies of interpretation, indeterminacy, and chance are oppositions to the finite and static nature necessary to the built environment.⁷ The radical acknowledgment “[...] that architecture – as distinct from building – is always that which is represented [...]”⁸ explains the insistence, indeed the obsession, with precision and certainty of outcome in the translation from drawing and model into built reality. This has caused the media architecture is conceived through to labour under a yoke of representational uniformity and rigidity, substantially different from how the drawing, the model, and the maquette have been released from their representational and naturalistic responsibility in aligned artistic fields.⁹

The division between representation and realisation¹⁰ is mirrored in the division between architect and builder, between designer and labourer, whereby the work of the mind remains detached from the work of the hand. There are good and rational reasons for this division, not least the scale,

complexity, and compartmentalisation of knowledge required to construct buildings. Add to this the status of drawings as legal documents that impart accountability among the many professions involved in the process, and the emphasis on precision and predictable outcomes appear beyond reproach. In this understanding the need for a uniform reading of drawings is reflected in the full-scale construction techniques, which are selected, curated, and adapted to ensure a similar kind of predictability. But if experimental approaches that allow for unforeseen outcomes are valued in the conception phase of architecture – as essential catalysts for discovery not accessible through reason alone – they may also play a role in the realisation process. In this way, expansion casting functions both as a hands-on construction technique and as a conceptual vehicle for propelling the unpredictability of the technique into the construction phase. This introduces a collapse, where idea and technique are intertwined and persist beyond representation into actuation. For Jonathan Hill, this collapse provided access to a special mode of operation in which an idea and its materialization could dissolve into one another: “Particular pleasure and creative tension exists where representation and analogue overlap – drawing the building and building the drawing. One feeding the other.”¹¹ Robin Evans’ emphasis of “[...] the peculiar disadvantage under which architects labour, never working directly with the object of their thoughts, always working at it through some intervening medium [...]”¹² is a diagnosis of the field's fundamental tension and simultaneously unveils its greatest epistemic potential. The uneasiness in the division between representation and realisation, maquette and building, control and indeterminacy, becomes available with a particular legibility in deformation casting.

THE COST OF RIGIDITY

The active interplay of formwork and casting material in deformation casting is fundamentally different from traditional casting practices. In traditional casting, formwork is typically stiffened and dimensioned to prevent deformation that would otherwise arise from the hydrostatic pressure inside the form. A rigid and stable formwork is essential in achieving reproducible elements with predictable tolerances. It is also one of the reasons why the cast elements that shape our spaces and buildings are often orthogonal and prismatic. Another consequence of working with rigid formwork is its relative structural inefficiency. An inefficacy that arises when sheet material is used to prevent deflection caused by forces acting perpendicular to the plane of the formwork, and thus seek to counteract the hydrostatic pressure from liquid concrete through a combination of tension and compression. This produces a dual stress state where few materials perform well. Resisting forces

by resisting bending is a relatively material-intensive load condition, that allows only a limited portion of the cross-section to contribute to the load-bearing capacity, while the outer zones absorb the majority of the load. This is why planar formwork often requires significant substantial bracing beyond the sheet material that is in direct contact with the liquid casting material.

DEFORMATION AS STRUCTURAL STRATEGY

A membrane, in contrast to rigid formwork, expands under liquid pressure and resists pressure primarily through tensile forces. This happens because the fluid pressure is distributed continuously across the membrane's surface, avoiding point loads, and because the membrane does not resist the applied forces through bending, but accommodates them by deforming into an equilibrium geometry governed primarily by tensile (single) stress state. This commitment to tensile resistance – as opposed to the combined bending and axial stresses to which plate materials in traditional formwork are subject – enables efficient material use when combined with a membranous material characterized by high tensile strength, such as silicone or textile.

Membrane casting relinquishes reproducibility, metric precision, and predictability in exchange for a surprisingly intricate, organic formal language. The interplay of the forces in the casting process embeds themselves with a direct immediacy in the outcome. The exchange between compressive and tensile forces is particularly evident in the surface articulation, where the membrane's expansion can be read directly from the deformation of the surface texture. Often the most pronounced displacement of the surface is seen at the base, where tensile counter forces are greatest. A unique aspect of the reciprocity between formwork and its liquid content is the degree to which each element contains a visual archaeology of the forces at play during its creation. Expansion cast elements are imbued with the history of their coming into being, a history that remains legible in the hardened force patterns of each element. [fig. 5]

BEYOND THE SPHERE – CORSETS AND COMPACTOS

In deformation casting, the liquid casting material is shaped and constrained by the surrounding membrane, which responds through expansion and deformation. In a simplified model one might say that elastic membranes generally expand toward a spherical or drop-like form when they distend. This is because the interaction between gravitational forces, expansion, and the resulting tensile forces in the membrane surface seek a balance in which the membrane maintains a minimal surface relative to volume, and this minimal surface is spherical or droplet-shaped.



Figure 5. Photo: Scale prototype with internal cavity (2020)



Figure 6. Photo: Inflation of elastic membrane (2019)

In this understanding of casting, a balloon inflated with air also constitutes a form of expansion casting. The skin of the balloon is the membrane and the gaseous agent inside it provides the mould of its form. [fig. 6] While the balloon's initial shape is spherical or drop-like, the elegant material calculation is soon complicated by pressing the balloon from both sides until the pressure points meet, and a torus or donut shape is created. Adding additional localized constrictors further manipulate the membrane's expansion and quickly leads to a surprising formal intricacy that would require extensive computation and explicit definition to register in an explicitly defined Cartesian system.¹³ [fig. 7]



Figure 7. Photo: Test of elastic membrane with unfolding pattern corset (2025)

When the membrane's expansion is constrained, for example by surrounding it with an exterior jacket, the membrane redirects the forces and expands through openings in the constraining elements. In Figure 8, the local deformations of the figure reveal a formal complexity that preserves the fluid character of the casting material. The governing element – that which prevents the elastic container from expanding into a spherical form – acts like a corset, allowing excess material to swell out and overflow its edges. An alternative to the encapsulating corset is the application of isolated elements that produce localized deformation. These are called *compactos* and function similar to a concrete anchor that prevents deflection. [fig. 9]



Figure 8. Photo: 3-part compacto (2023)



Figure 9. Photo: Scale prototype with elastic membrane and corset (2020)

AN ANALOGUE ALGORITHM

Deformation casting provides an alternative to the prismatic forms that follows from contemporary approaches to formwork and casting. It interjects a different approach to form finding and design: a way of working where the outcome is simultaneously unreliable, in the sense that the result is foreseeable only within a broader frame of manifestations – and processual in a way where the

designer's ability to influence the casting process becomes severely limited as soon as the loading of the formwork (with liquid concrete) begins. In this way, expansion casting is analogous to an algorithm. It takes as input the membrane, its constrictors, and the heavy liquid casting material, combines these with the practitioner's actions while filling the membrane, and gradually resolves how the resulting forces interact, producing the final form.

In expansion casting the relationship between idea and technique is largely dictated by the capacity, perhaps the will, of the technique and the material itself. The lack of predictability and the formal indeterminacy point toward a design process in which control and intention are replaced by an openness to discovery. The work does not merely proceed with an acceptance of the risk of error and collapse, but assumes that the balance between experimental failure and potential for discovery are mutually dependent. [fig.10]

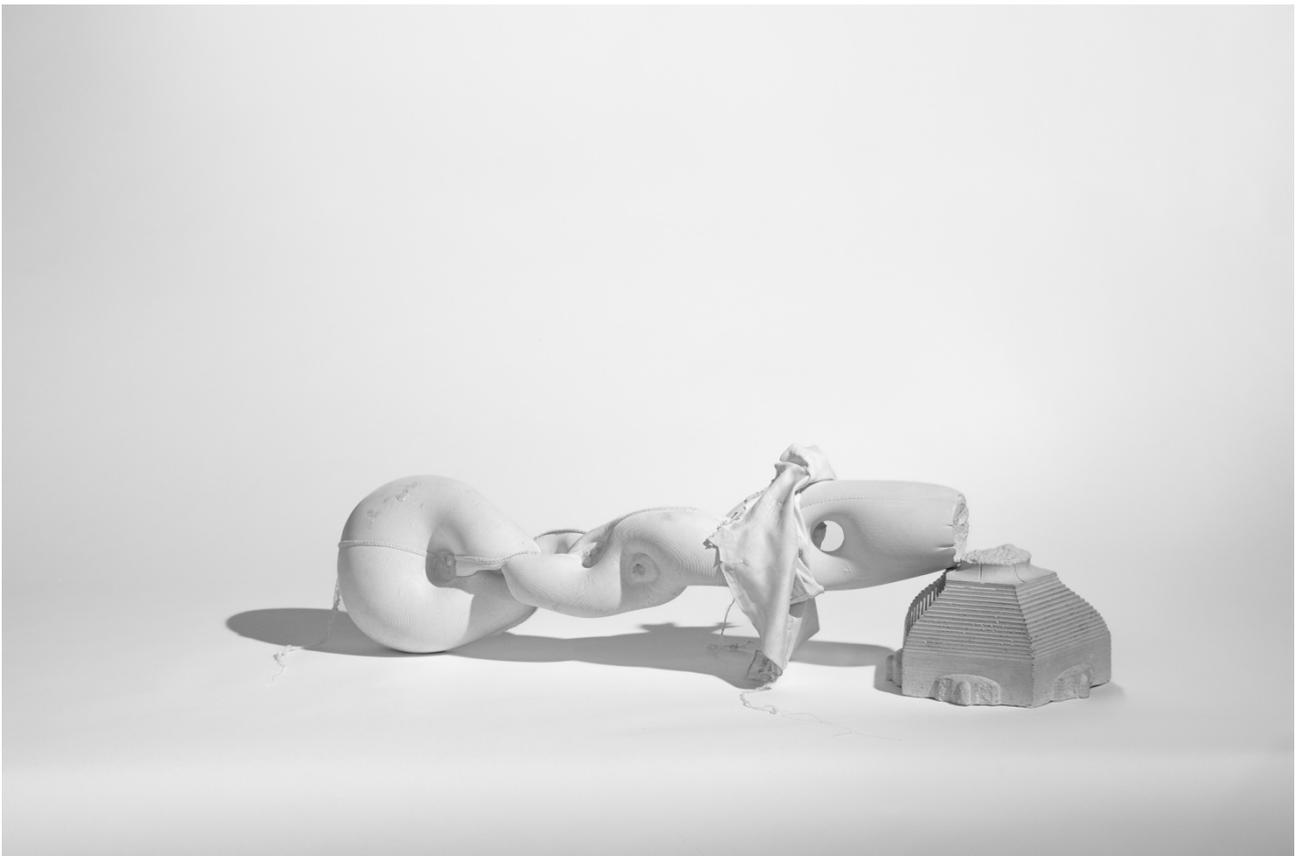


Figure 10. Photo: Scale prototype failure (2023)

CONTAMINATION AND IRRITATION

The practice of deformation casting occupies a territory where purpose, function, and content remain open and unresolved. The artefacts derive part of their meaning from the moment of their creation while retaining an indeterminacy. The inherent unpredictability of the casting process positions the practitioner as an obligate force – necessary to advance the process, yet not fully in control of its outcome. The practitioner becomes more of a catalyst than a controlling agent. As the work progresses, the initially neutral understanding of the technique and production method is gradually contaminated by a meaning-producing photographic examination, through which the process itself becomes an active contributor to its meaning. In this context, indeterminacy is not a by-product but a condition of the work: a state in which uncertainty and ambiguity become productive forces for investigation.

The work has an affinity for the indeterminate condition. Here, ideas are allowed to be turned over and challenged, rather than being fixed to predictable outcomes. This aligns with Chard's proposal to pursue a way of working that actively generates "[...] the sort of irritation that would incite conscious adjustments."¹⁴ Chard reminds us that technical frustrations are not merely obstacles to be resolved; they are invitations to reflection and wonder.

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Notes

- 1 Olga Popovich Larsen, *Conceptual Structural Design* (ICE Publishing/Thomas Telford Limited, 2023), 89-90.
- 2 Mark West, *The Fabric Formwork Book: Methods for Building New Architectural and Structural Forms in Concrete* (London: Taylor & Francis, 2016), 4.
- 3 Casting in flexible formwork can be traced back to around 1900 (See Veenendal in West, *The Fabric Formwork Book*, 18) with several independent rediscoveries and reinventions into current day. Relevant to the present work are structural thin-shell engineers of the 1950s and onwards, such as Heinz Isler, with their focus on pneumatic formwork (See John Chilton and Heinz Isler, *Heinz Isler: The Engineer's Contribution to Contemporary Architecture* (London: Thomas Telford, 2000), 34–35), as well as a renaissance in the 2000s propelled by the architect Mark West's focus on fabric formwork's capacity to produce building components that combine analogue form finding and organic sculptural form in concrete structural elements.
- 4 Nat Chard, *Drawing Indeterminate Architecture: Indeterminate Drawings of Architecture* (Berlin: Springer, 2005), 10.
- 5 West, *The Fabric Formwork Book*, 40.
- 6 "Precision fetishized effectively substitutes the absence of the architectural object itself—or, more specifically, the absence of direct, physical relations with the materialization of the object, the absent act of consumption *in* and *with* matter" Francesca Hughes, *The Architecture of Error: Matter, Measure, and the Misadventures of Precision* (MIT Press, 2014), 41.
- 7 "My other resistance to relying on interpretation is that once it is resolved it tends to be static, at least for the interpreter, that the life of the drawing ends with the interpretation." Chard, *Drawing Indeterminate Architecture*, 35
- 8 Perhaps rarely acknowledged outside of academia and criticism: "There's a strong argument, probably even a historical one, that architecture – as distinct from building – is always that which is represented, and particularly that which is represented in the media aimed at architects. Architectural drawing evolved for description, not for construction." Kester Rattenbury, *This Is Not Architecture* (Routledge, 2002), xxii
- 9 Similar to how Pablo Picasso speaks of how "Photography has arrived at the point where it is capable of liberating painting from all literature, from the anecdote, and even from the subject. In any case, a certain aspect of the subject now belongs to the domain of photography. So shouldn't painters profit from their newly acquired liberty, and make use of it to do other things?" Brassai, *Conversations with Picasso*, trans. Jane Marie Todd, illustrated reprint, *Studies in Communication, Media, and Public Opinion* (University of Chicago Press, 2002)
- 10 "[...] drawing was the only part of the process of the building production over which the architects retained absolute and exclusive control; it was (and continues to be) the principal material object that the architects themselves produced." Adrian Forty, *Words and Buildings - A vocabulary of Modern Architecture* (Thames & Hudson, 2000), 31
- 11 Jonathan Hill, "Building the Drawing," *Architectural Design* 75, no. 4 (2006): 13–21 (John Wiley & Sons).
- 12 "[...] the peculiar disadvantage under which architects labour, never working directly with the object of their thoughts, always working at it through some intervening medium, almost always drawing, while painters and sculptors, who might spend some time on the preliminary sketches and maquettes, all ended up working on the thing itself which, naturally, absorbed most of their attention and effort." Robin Evans, *Translation from Drawing to Building and Other Essays*. (Janet Evans and Architectural Association, 1997), 156
- 13 This distinction is parallel to the difference between a form that emerges from a few simple parameters and one that requires brute-force calculation, where every point is explicitly defined. In computational terms, it would resemble the contrast between a NURBS-defined surface and a mesh representation.
- 14 Chard, *Drawing Indeterminate Architecture*, 3

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BIO:

Frederik Petersen, PhD, cand.arch., investigates the interplay between technique, concept, and meaning within architecture's exploratory practices. His research combines experimental and speculative methodologies, with a particular emphasis on the role of drawing and photography in the conception, documentation, and dissemination of architectural ideas. His photographic work explores the interplay of naturalistic representation and reality in scientific and fantastical contexts, with focus on illusionistic constructs such as the natural history habitat diorama and the faith-based tableaux.