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Ramsgaard Thomsen, Mette; Tamke, Martin

Published in:
Communicating (by) Design 2009

Publication date:
2009

Document Version:
Publisher's PDF, also known as Version of record

Narratives of Making: thinking practice led research in architecture

Mette Ramsgard Thomsen[1], Martin Tamle[2]

[1]*CITA Centre for IT and Architecture, The Royal Danish Academy of Fine Arts, School of Architecture, Denmark*

[2]*CITA Centre for IT and Architecture, The Royal Danish Academy of Fine Arts, School of Architecture, Denmark*

http: //cita.karch.dk

[1]*mette.thomsen@karch.dk,* [2]*martin.tamke@karch.dk*

Abstract.

Practice led research methods investigate their line of inquiries from within a knowledge of doing. The practice is an incorporated skill set, a working method in which the practitioner is trained. The recent focus on practice led research method acknowledges practice as a means of gaining new knowledge. Efforts across the field of practice based research seek to develop means for engaging with issues such as critical assessment, comparability and evaluation. This paper presents research undertaken within the field of architecture. Through the presentation of two practice led research projects: Knitted Skins and Parawood our aim is to discuss the methodology by which these projects are developed and its particular referencing of architectural design practice.

Keywords. Practice based research; material evidence; design probes; material prototyping; demonstrator.

The practice of design: reflection in practice

Architectural practice is the practice of design. The skill of the architect is to develop and prioritise design criteria from a complex weave of interconnected concerns with multi-varied and often contradictive contexts into one distinct design proposal particular to its site, context and programme. Design is the means by which the architect poses a question and develops its dimensionality and solution. It is a reflective practice in which the making of evidence, the sketches, drawings, models, prototypes and tests, are a fundamental part of spatial invention. As such, architecture allies its media and a particular sense of craftsmanship to its intellectuality and its language.

In architecture reflection, assessment and evaluation takes place through making. Following Donald Schoen’s articulation of work practice as a reflective action, architectural practice takes place as a dual mode of reflecting on action and in action (Schoen 83). The process of moving between the exterior and the interior of making, creates a conversation between the dissective nature of analysis and critical assessment and the creative nature of proposition and result.

Architectural practice is shaped by this continual weaving between problem and solution. The understanding of the nature of its processes and their unfolding is complex and has in recent years gained much attention from the creative arts, design, architecture and engineering as well as from the fields of sociology, ethnography and systems design. Design process is often presented as one of refinement, where predefined problems are solved in respect to predefined knowledge sets. Here, the designer is seen to be presented with programme, formulate design criteria, develop design proposition, develop detailing and finally implement building. However, much attention has been given to the iterative nature of design and the cyclical movement between the inquiring and propositional. As summarised in Jan Capion’s introduction to architectural design process: “architectural/industrial design process grew up as a movement with its own identity during the early 70's very much as a reaction to the engineering model… opposing the view that solutions must be synthesised from exhaustive problem specifications" (Capion 04 p 16). As such the architectural design practice is established as solution focused, heuristic, empirical and intuitive (Young 97) continually shifting between a contraction and an expansion of the problem space, repeating actions with shifting focus evolving the design problem and its solution in one movement (Ziesel 81 p14).

Whereas the opposition between engineering as rational and architecture as intuitive is simplistic, architectural design practice is shaped by its facility to leap between problem spaces. Architecture as practice is characterised by being highly involved in many different, and often contradictory, levels of inquiry. The design proposal leaps between different modes of rationality relating its concerns with for instance the scale of the city, sociality, programme, construction, material and environment. Architectural practice is to construct meaningful relationships between these concerns, and allow the solution to "find its form" as a particular and unique answer. Rather than being general, architectural practice is always concerned with the specific. In this way architectural practice is concerned with a *wicked problem* which is creatively solved. Here, "information needed understand the problem depends on ones idea for solving it" (Rittel and Webber 73) and investigation, rather than concluding the project, propels new lines of inquiry. Problems are contextualised and solutions are not defined absolutely as true or false, but rather qualitatively as better or worse.

A material focus

The fact that the architectural problem is creatively tied to the particularities of a given context, whether conceptual or actual, and that its practice is held by the media of its invention creates a *material focus* for practice led architectural research. As framed by Stan Allen's discussion of the differences between the theories and practices of architecture, architecture is always touched by the embodied and the material. Allen revokes the perceived opposition between the uncontaminated realm of theory and the compromised realm of practice, instead positioning architecture as a place of multiple practices, some hermeneutic and critical, some material and transformative, but all touched by the particular and the site specific "…working in and among the world of things" (Allen 00 p21).

Architecture is in the most fundamental way about how ideas are embodied. This inherent focus on the material and the practice of making permeates architectural thinking, its concepts and its language. A traditional understanding of the architectural drawing as a language of communication, a means of representation is seeded with the knowledge of the skills and workmanship of making. To draw, or in other ways to make, the material evidences that are fundamental to the practice of architecture, is to interface with a knowledge of building technology. Architecture is shaped by its tools and the dimensionalities of its media. The flatness of the paper, the rectilinearity of the parallel rule and the set square dominate architectural practice, its intellectual traditions as well as its building. These tools correlate directly with the conditions for building. The set square implies the drag of gravity and the plumb line of the constructor; the parallel rule emphasises the cut of the horizon.

In our work we are concerned with the means by which architectural practice changes as new digital tools become ubiquitous in architectural making. As our tools change they challenge not only the production of architecture, its design and manufacture but also profoundly the thinking of architecture, its concepts and its language. Whereas the early development of computer aided design in the 1980's and

90's tools emulated the design traditions of architectural practice, replicating the flatness of the drafting board, it has also posited a new computational depth to architectural practice. As such, new digital design practice introduces computational thinking into making, bringing with it its underlying Boolean logic and its scripted fundamentals writing into a mathematical depth. The craftsmanship of drawing as a basis for architectural design practice is as such extended with a new language which incorporates the making of variable geometries shaped by logic iteration, loops and conditional deformation.

But digital tools also have a further consequence as its potential interfacing with the production of the built ruptures the traditional difference between the represented and the made. The contemporary development of solid interfaces with digital manufacturing tools such as CNC milling machines, laser cutter or 3D printing shifts the role of the drawing as a measured representation read by the builder, to a direct instruction to the machine. Here, the drawing, or the 3D model, becomes the direct handling of the tool, the pressing of the drill or the pointing of the saw.

These two trajectories, the mathematical and the crafting, present fundamental shifts to architectural practice. If design takes place across the skill of drawing, computational logic presents a new depth to its thinking. The way that the parametric and the variable queries the intellectual traditions of architecture suggests an expansion of territory within a formalist realm. At the same time, the link to crafting presents a new correlation between drawing and tool, to paraphrase Stan Allen, a new traffic between drawing and building, between geometry and construction, as a fundamental way to understand the integration of drawing practice into design work.

Material evidence and its differentiation

The presented research method understands the role of material evidence and its making as an integral part of architectural practice The evidence acts as material research inquiries by which the concepts, technologies and applications of the project can be tested and evaluated. In developing a strategy for investigation we have differentiated between three modes of material evidence. These modes allow us to query the role of evidence in respect to its position within the design process, and to develop means by which it can be critically assessed and evaluated.
The three different modes are:

- The design probe: a design-led investigation allowing speculative inquiry, theorisation and the setting out of design criteria
- The material prototype: a materially-led investigation allowing exploratory testing, of craft and material behaviour. The prototype answers and develops the design criteria of the design probe
- The demonstrator: an application-led investigation allowing interfacing with real world problems and constraints

These modes are seen as sequential and iterative building up the complexity of the architectural investigation while addressing different contexts of knowhow and application.

Project presentation

The following presentation of the two projects Knitted Walls and Para Wood describes the way in which the research inquiry uses the three different levels of material and develops their complexity and research enquiry. Both projects are developed within the context of CITA, Centre for IT and Architecture, and are framed by the larger research inquiry into how digital technologies change and challenge architecture design practice.

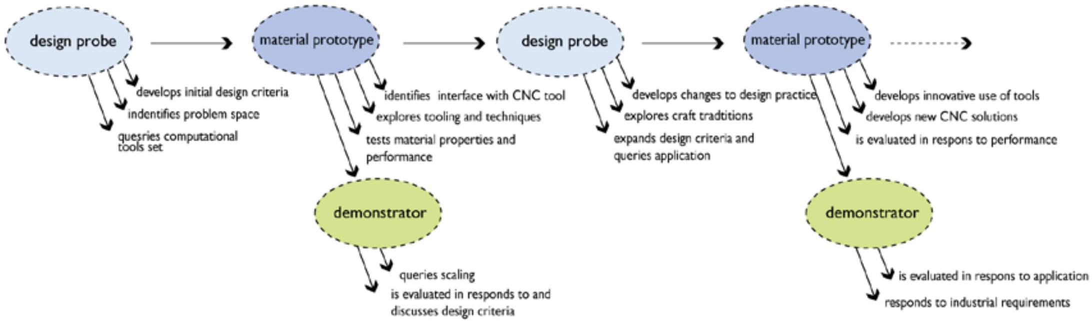

Figure 1
Diagram of sequence and role of material evidence.

Knitted Skins

Knitted Skins investigates textiles as building material. With special focus on knitted fabrics, the project looks at how new interfaces between computer controlled textile fabrication and architectural drawing tools can allow for direct material specification.

Design probes

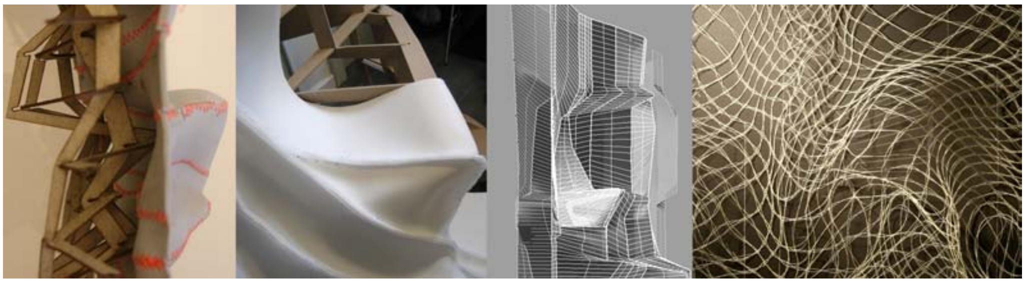

Figure 2
Examples of design probes in Knitted Skins

In Knitted Skins the design probes merge programmatic considerations with the development of tectonic solutions. In an initial workshop with key project partners, we developed a series of speculative scenarios of which two were taken to a further stage: the double programme of the dressing room and the bath room and the office separator. Both scenarios considered the making of a self supporting but non-structural interior wall. The thinking of their context allowed us to imagine aperture and openings, transitions between soft and hard, wet and dry, as well as invent their spatial extension and form, thereby generating design criteria for the research project. The design probes seek to respond to the design criteria developed in the scenarios. Solved as a series of digital and physical models, the design probes develop the ideas of scenarios into embodied proposition, thereby querying the spatial potential of their solving. The models are as such evaluative, allowing a first testing of the design criteria, while continually developing these and querying their intersection.

The design probes are at simultaneously technically probing. By developing the models using key software functions for unfolding the textile patterns and thinking the substructure, we were able to create a way of generating both from one defined surface. As such the design probes are also the place of the invention of a tool, a software based process by which the actual implementation of the design is solved.

The design probes were supported by a series of parallel probes questioning the potential of the substrate. The digital solutions that we developed were based on simple grid of compressive wood struts which allowed us to develop the complexity in form that we had defined through the scenarios. However, we were aware of the redundancy of the structure which is materially intensive and heavy weight. We carried out a workshop with the design group loop.ph in which we explored lace making as a way of developing a textile substructure. Here, we used extruded glass fibre rod (Antonelli 08) to create complex shaped membranes using the techniques self bracing structure in combination with the tensile material. In developing the design probes we assessed these as holding a greater complexity in respect the material usage and tectonic potential, but also that these were fundamentally hand crafted and therefore not able to be integrated into the architectural design process.

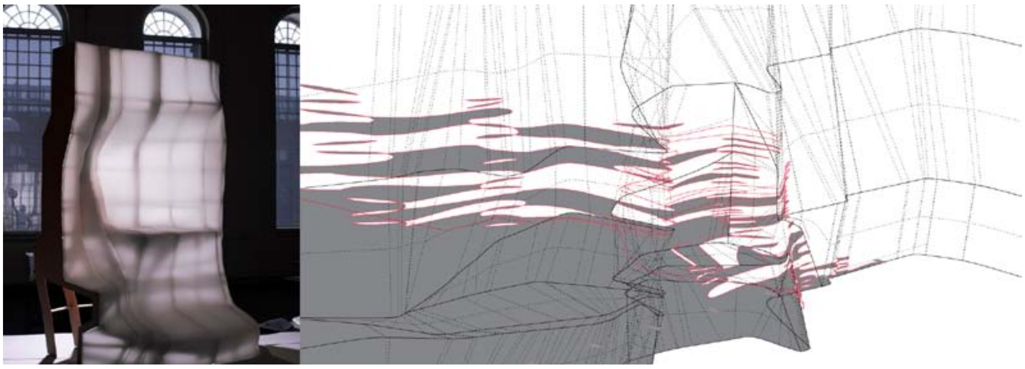

Figure 3
Knitted Skins demonstrator

Material prototype

The design probes allowed us to develop criteria for a first set of material prototypes. These were developed in collaboration with Manchester University, School of Materials and employ the CAD CAM knitting technology on which the fabric is developed. The material prototypes allow us to query the making of the material, and the means by which we can control it specification and performance. Taking point of departure in the spacer fabric developed by Manchester, we developed two sets of prototypes based on nylon and polyethylene spacer fabrics. A series of these prototypes investigated the forming, seaming and the detailing of the material by which it can be fitted and mounted on the wood substructure. Here we developed knitting patterns and a way of striating the material to allow for greater flex around the curvatures of the wall, thereby making the material perform specifically for its context. In a second set of prototypes we explored the embedding of conductive fibre allowing us to pass electricity through the material so as to integrate light panels or heating. Finally a third series of prototypes explored the potential of consolidation through heat treatment and resin, testing how the fabric itself could become self supportive. The material prototypes are evaluated in respect to the technology that they probe. As full scale investigations they allow direct experience of the technologies involved in CAD CAM knitting while simultaneously generating material for evaluation. As such the tests are assessed in respect to the potential for form making, the solidity and discreetness of seams and assemblage, the structural integrity of the consolidation methods.

Demonstrator

The demonstrator was developed for the public exhibition Digital Practice at Meldahls Smedie at theThe Royal Danish Academy. The aim for the demonstrator is to test the design solution and its technologies in a full scale experiment and to communicate the potential of the technology to an audience. The Knitted Skins demonstrator explores the relationship between substructure and skin. We used a prefabricated fabric allowing us to explore the shaping of the material as well as its relationship to the substructure. The making of the demonstrator allowed us to verify that the relationship between the skin and structure is in perfect fit. Through the making of the demonstrator we developed techniques for seaming large scale and multiple layer textiles as well as integrating ties by which the textile was bound to the wood structure. We learnt that the technique by which the frame work of the wood substructure was developed was marked by an imprecision across the length of the wall which necessitated on-site adjustment.

Parawood

Parawood examines the link between parametric design, mass customisation and traditional woodcraft techniques in a digital fabrication environment. The project takes point of departure in the real-world design scheme for the façade of a multi-story parking lot.

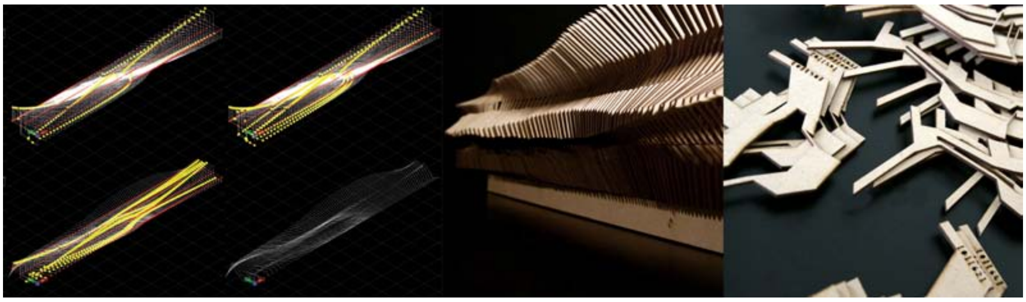

Figure 4
Examples of design probes in Parawood

Design Probe

Based on knowledge about the joining of wood beams a proposal was developed for a façade made of shaped wood beams that create shifts in transparency and relief. The first design probe develops a simple parametric, which allows a varying amount of beams, changes in the placement of kinks and overall flow. The probes were developed as parametric 3D models allowing a numeric control of the design. The parametric model allowed a continual assessment of given external parameters such as distance to neighbouring buildings and amount of opening. The model is therefore also a tool for evaluation. The customized parametric setup used, introduces an understanding of the designer as toolmaker, a novel approach to digital construction tools (Kolarevic 04). In a second series of design probes we furthered these investigations by developing a series of physical models. The models are understood as sequential, building up the complexity and composition of the design scheme. By using self-made and in-house tools we were able to emulate the relationship between design and fabrication dramatically intensified the communication and feedback between these processes. This allowed us a more exploratory inquiry emphasising the emergence of unforeseen effects and spatial qualities. Through the making of the prototypes we developed an understanding for the relationship between design complexity and spatial ambition, the amount of degrees of freedom the system embodied and the necessity for simplicity to enable overview and control. The design probes thereby enabled an individual design language to emerged.

Material Prototype

The design probes were developed into a series of prototypes investigating the link between an intuitive drawing process and its subsequent manufacture using large scale CNC tooling, creating direct physical manifestation through a digital design chain (Scheurer 05). Using HSB CAD, the software by which the CNC wood joining machinery is controlled, we develop a series of digital models investigating the joint types by which the structure could be constructed. Here, a bespoke solver-algorithm was developed to enable the negotiation between conflicting parameters enabling complexity in the design. The prototypes allowed us to gain knowledge about the machines, materials and joints constraints, gathered from the former stages, communication and test runs with the project partners.

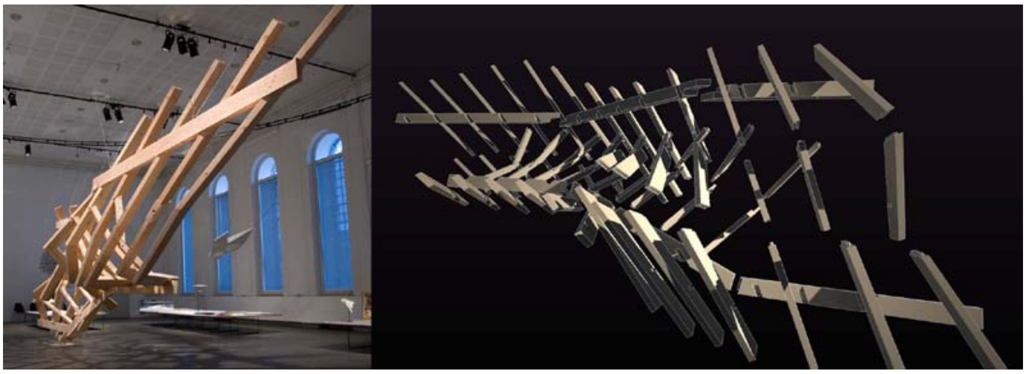

Figure 5
Parawood demonstrator

Demonstrator

The Parawood demonstrator was developed for the Digital Practice exhibition. The aim for the demonstrator was to show case how digital design chains can be used in building. The demonstrator embodies the project's knowledge about design, fabrication and assembly, as well as further concerns such as structure, weight, distributed production and especially the need to communicate and interact with external fabricator and assemblers.

The design probes developed complexity through the merging of multiple parameters. In the demonstrator this complexity was achieved through a sophisticated secondary level of diagonal connectors introduced to stiffen the structure. To develop the second beam we created an algorithm that analysed the structure and altered local geometry in order to place the joints strategically. This would have been extremely labour intensive to solve manually but by developing bespoke interfaces between drawing and construction we were able to solve these globally.

The fabrication of the demonstrator allowed us to develop and verify a digital chain from design to fabrication as well as test the precision these interfaces, the making of joints and their assembly. By engaging directly with the software as well as the machinery we were able to develop self-registering wood joint which through their shape and position allow easy plug in assembly otherwise not common to complex geometry architecture (Shelden 2002). In the end the assembly of the completely customised beams took 4 hours by 5 unskilled builders and assembly of the complex structure worked out well due to the self registering joints.

Conclusions

The presented method renders the role of material evidence and their correlation explicit. By differentiating between the design probe, the material prototype and the demonstrator, our aim is to engage with the material focus in architectural practice while simultaneously developing an awareness of the different means by which this practice holds means for its own internalised practice of assessment and evaluation.

Acknowledgements

The projects are developed through collaboration with a network of academic and industry partners. Knitted Skins is developed in collaboration with University of Brighton, and University of Manchester. The project was further supported by Hobbs Construction and Heathcoat Ltd. Parawood takes point of departure in the commission for the ZOB project, a collaboration between Blunck + Morgen Architects, CITA and WTM engineers Hamburg. Parawood is developed in collaboration with industry partners hsb-Systems, Bentley Systems, Hundegger Machinebau, and Douglas A/S as well as consultancy from DTU, Taasinge Trae and PreCon A/S.

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