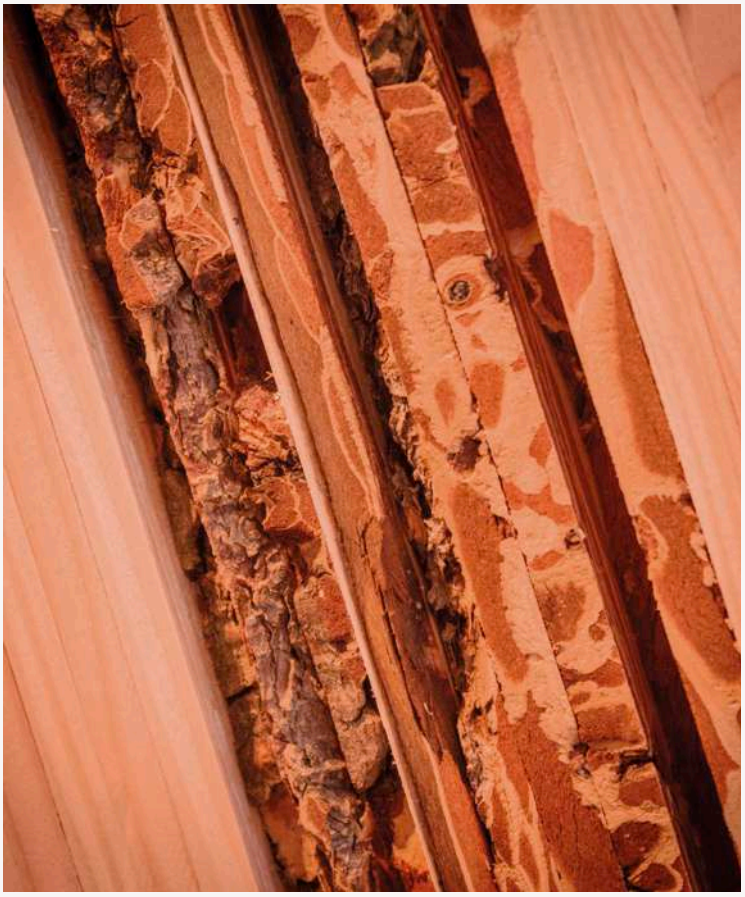
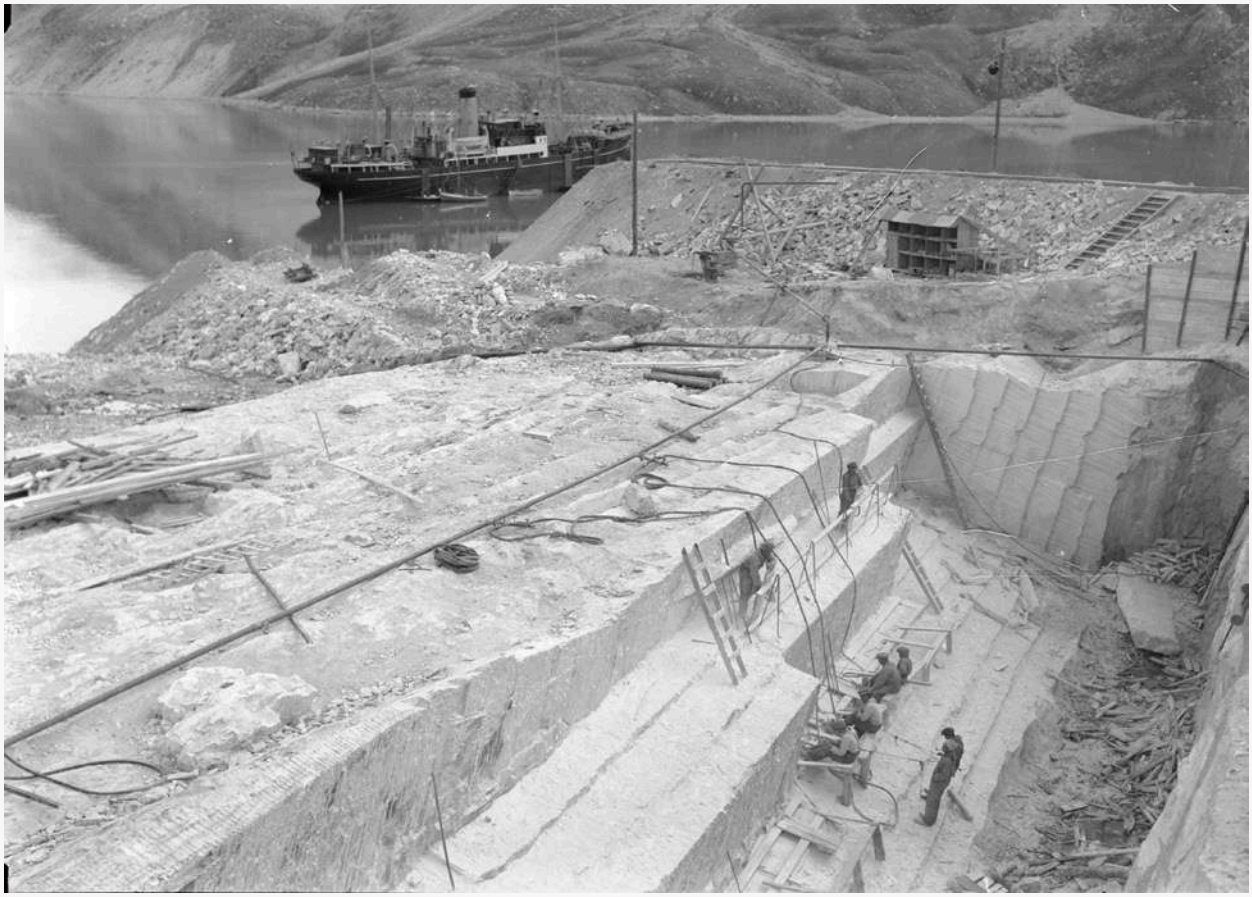
IMAGINARIES ON MATTER:
TOOLS, MATERIALS, ORIGINS



Thomas Bo Jensen, Carolina Dayer
and Jonathan Foote (editors)



Imaginaries on Matter – Tools, Materials, Origins promotes an innovative architectural research agenda that connects historical-cultural written research with digitally led material explorations. The common thread is the notion of the material imagination, disclosed in the reverie, or material daydream, which challenges overly pragmatic or unreflective material choices within current architectural practice. In bonding our imagination directly with matter while also confronting new technologies, this book promotes strategies by which architects' and builders' future relations with materials can stay rooted within the deeper concerns of cultural meaning.

The book is edited by Thomas Bo Jensen, Carolina Dayer and Jonathan Foote

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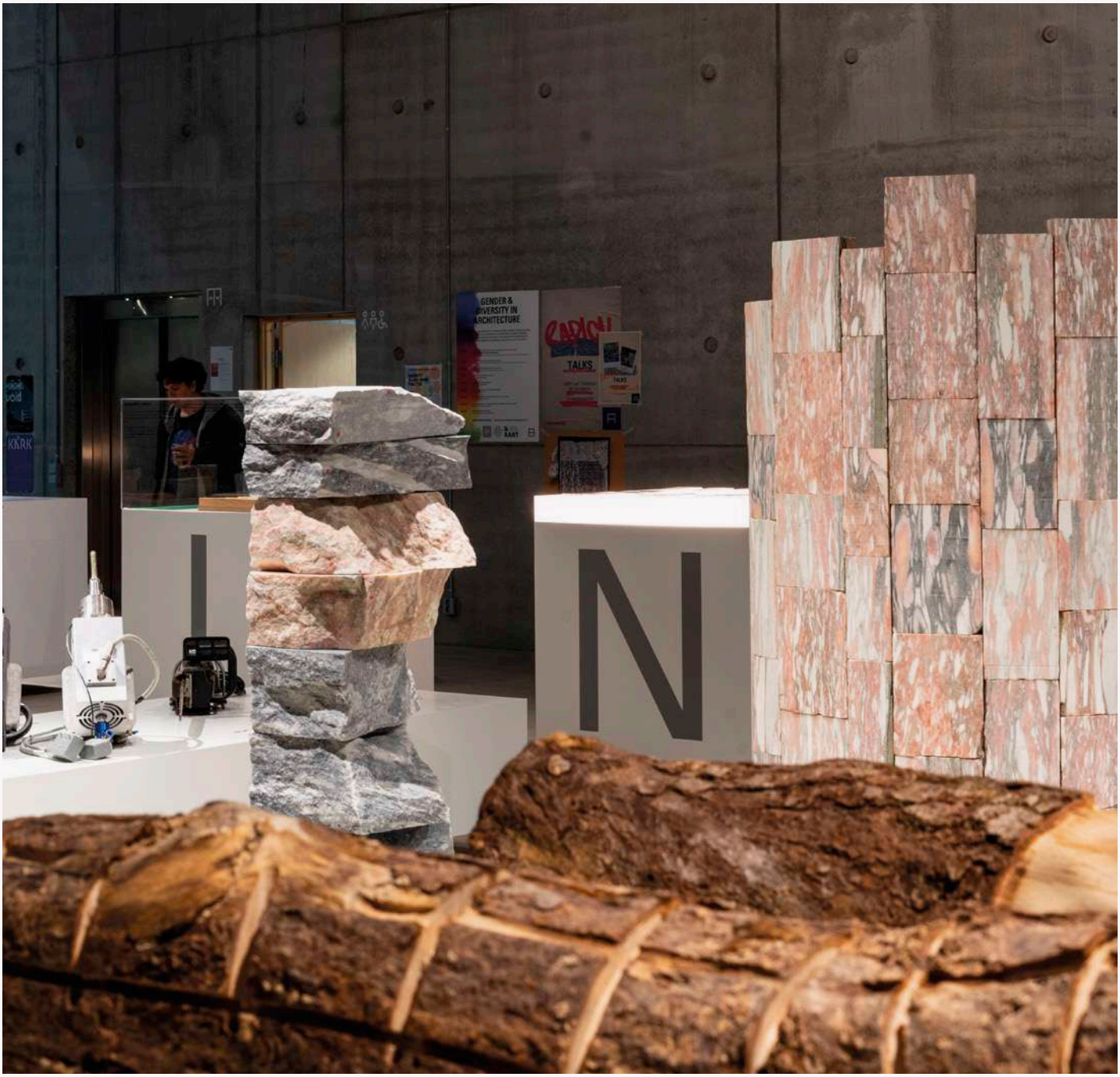
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Table of contents

Secret Sky, Alibi Studio, Hume, Michigan 2021. Slicing a passageway through an existing barn to allow the sky to enter. Photo by Catie Newell.

It is necessary to mark the greater from the lesser truth: namely the larger and more liberal idea of nature from the comparatively narrow and confined; namely that which addresses itself to the imagination from that which is solely addressed to the eye.

J.M.W. Turner[1]

This book builds on the concern that contemporary architecture has by and large lost touch with the physicality of materials. The supply chain of building materials is dominated by manufacturing interests, and norms and standards are defined by the industry. Modern architects navigate in a narrow field, where the choice of materials is limited to colours and a fixed set of prefabricated product lines. Under the credo "faster and cheaper", one building after the other appears overnight, leaving one to wonder whether the choice and processing of the materials have been considered in depth.

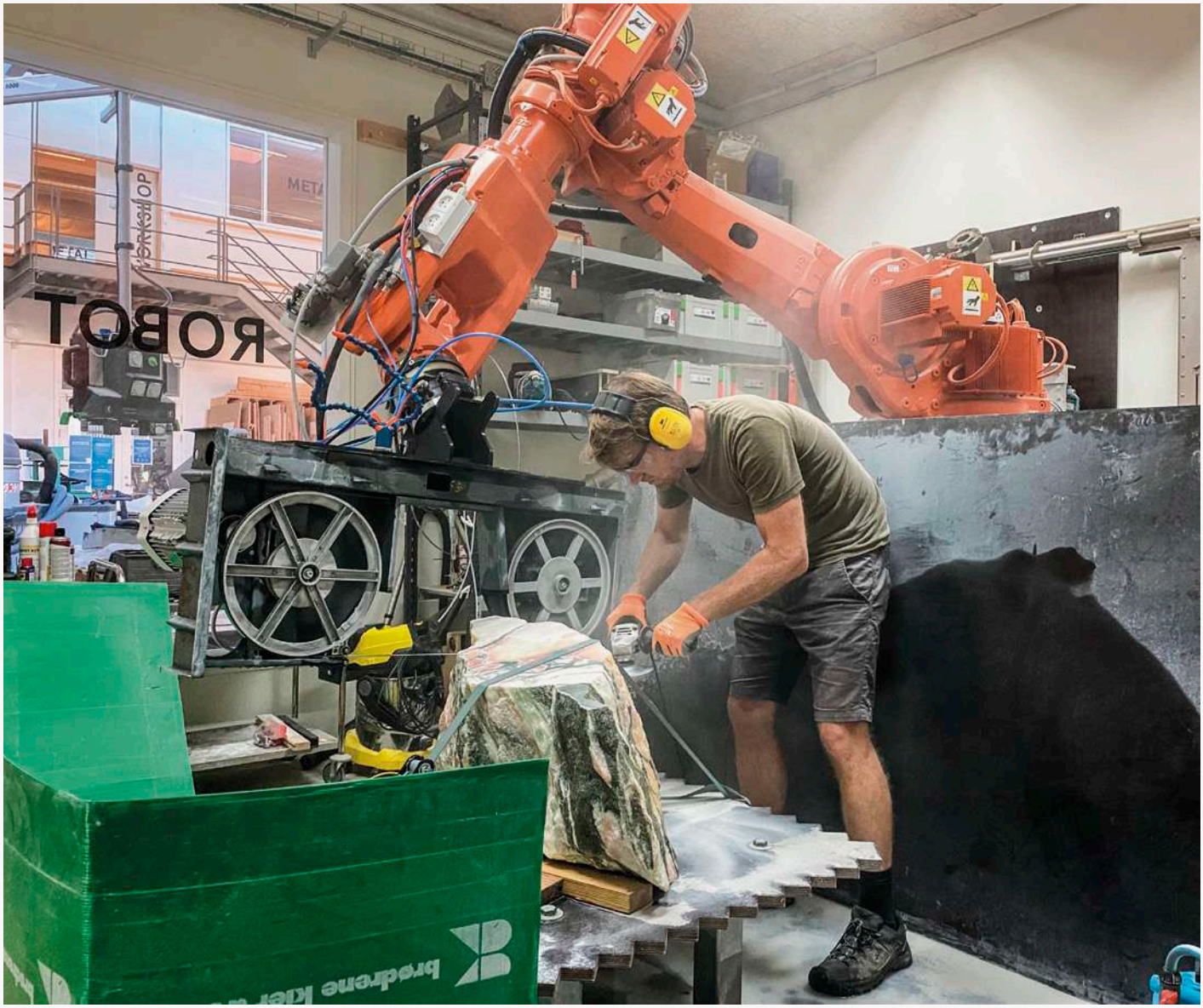
We believe that human beings share a personal and collective "material imagination", but that the sense of materiality and its connection to our everyday lives is underexposed in contemporary architecture and missing from the current field of digitally motivated materials research. We share a concern that much of today's mainstream architecture lacks material depth and that too much material research remains disconnected from the broader implications of cultural meaning.

Over the past 15–20 years, a new preoccupation with the physical material's deeper natural and cultural implications has emerged. Not only in architecture but also in many other creative fields, we find a renewed interest in a more profound reading of and engagement with the tactile world. Scholars, artists and architects have rediscovered philosophers such as Henri Bergson and Maurice Merleau-Ponty, whose early ideas about our mind and body's deeper imaginative and sensory connections with the physical surroundings have been confirmed by neuro-scientists and cognitive psychologists.[2] This has given new impetus to more far-reaching thinkers like the chemist and philosopher Gaston Bachelard, whose many books about *poetic imagination* and the deeper associative implications of materials form the primary philosophical inspiration for this book, centred around Bachelard's key concept *material imagination*.

Parallel to this tendency in material philosophy, we have seen a vibrant development within computation and digital technology, and thus also a strong growth of experimental material research under headlines such as "digital fabrication", "digital craft" and "digital materiality". Advanced digital tools such as 3D scanning and robotics have revealed potential for reaching a deeper understanding of materials' capacities and use. This has led to new perspectives on better utilization of waste material, for instance, and on drawing out hitherto unknown capacities of natural materials or revitalizing the art of profiling and ornamentation. Most of these enquiries are, however, purely technologically driven, with little weight given to historical, cultural or haptically anchored agendas.

1 Eric Shanes, *The Life and Masterworks of J.M.W. Turner* (Parkstone International, 2008), 23.

2 See for example Christopher Bardt, *Material and Mind* (Cambridge, MA: MIT Press, 2019), 20–28; Juhani Pallasmaa, *The Thinking Hand: Existential and Embodied Wisdom in Architecture* (London: Wiley, 2009), 11–22.



The machine and the body, interacting on a block of “Norwegian Rose” marble from Fauske, Norway.

With this emergence of great passion for both digital technology and material philosophy, we have observed a void between the two areas which to this day seems quite unexplored on the international research scene. Material research within the fields of architecture is generally separated into technologically focused environments, with an inclination towards natural science, and milieus oriented around cultural history that subscribe to the humanities. Borrowing an analogy from the British philosopher Philip Goff, who has traced this division between quantifiable science and the more intangible cognition belonging to humanities back to Galileo, we can look at a set of chess pieces.[3] People playing chess are interested in what the pieces do, what moves you can make and which pieces you can take. They study the rules and practise tactics over and over again to be able to win. But if you are someone who collects rare chess pieces, then you are interested in the character of the pieces. You are interested in the worth of matter, whether it be ebony, ivory, marble, alabaster or rare metal. You are interested

3 Dagbladet Information, “Langsomme samtaler med Rune Lykkeberg”, interview with Philip Goff, 14 April 2021.

in what it is, rather than what it does. According to Goff, we are about to enter "the second Copernican revolution", where we slowly realize that nature and matter have their own intrinsic consciousness, no less important than our own. It will put us in a totally new relationship with our surroundings and with the matter we use to build our world. This "consciousness" has a memory that can tell us about the slow evolution of nature and the deep time of geology, and with its tactility, smell and taste it has the ability to affect us from childhood and go on moving us throughout our lives.

In the research laboratory at the Aarhus School of Architecture entitled Technology, Building Culture and Habitation, we have brought together the chess players with those collecting rare chess pieces. Bridging architectural history and theory with material studies, technology and digital fabrication has invigorated researchers from the two areas to combine their interests and attract new researchers with cross-disciplinary interests. This book, which concludes a four-year grant research project entitled "Material Imagination – reconnecting with the matter of architecture", is a result of this fruitful encounter. The project is supported by three sub-projects exploring the materials of wood, marble and concrete for architectural purposes. These formable materials – two of them natural, one of them composite – have been studied through three different prisms: Tools, Materials and Origins.

The book is organized into four main parts: an introduction to the concept of material imagination seen from various angles, followed by three sections that unfold the materials of wood, marble and concrete in relation to the three conceptual prisms of tools, materials and origins just mentioned. In between the main parts there are three intermezzos with interviews and reflections around the theme of the book, from the perspectives of eight contemporary architecture practices situated in different contexts, all of them deeply engaged in material properties and expressions.

Looking closer at the conceptual prisms, *tools* has served to unveil particular material capacities for our eyes and our sensing bodies. They have been the key to studying the structural composition of the materials, and to getting as close as possible to their interiority. Tools are the precondition for human civilization; they carry the germ to the Anthropocene. Tools enable us to shape matter into desired objects, but they also inspire us to shape things that could not have been imagined without the tool. Tools feed our imagination, memories and associations layered in "the massive background of our bodies", to quote Merleau-Ponty.[4] "Tools awaken in us a need to act *against* something hard", Bachelard added, but they also "enable us to experience instantaneous time, prolonged time, rhythmic time, corrosive time, unhurried time".[5] Spending endless hours watching the diamond saw cutting thin slices of Greenland's Maarmorilik marble to study its translucency definitely torments our sense of time, just as the delicate pouring and petrifying process of concrete formwork demands extensive patience. To the relativity of time we can add the function of sound. When the tool carves its way through the solid material, like a spindle cutter through marble or oak, the slight

4 Maurice Merleau-Ponty, *Phénoménologie de la perception* (Paris: Éditions Gallimard, 1945), 117. Original quote: "le fond massif du corps".

5 Gaston Bachelard, *Earth and Reveries of Will: An Essay on the Imagination of Matter* (Dallas, TX: The Dallas Institute Publications, 2002), 27, 39.

disturbances of the monotonous sound will warn you if the material's resistance is getting in the way. As a messenger between the tool and the material, the sound becomes a guide for our curious search; the subtle snap of the marble block, pierced with wedges, tells us that shortly it will fracture into two and reveal its inner secrets. All of these sensory impressions are part of the interplay between tool, material, body and mind. As the project unfolded, we realized we needed to construct our own additional tools to be able to achieve the material effects we were looking for. The home-made, improvised tools allowed for a deeper level of engagement with the hidden life of the materials. They became our extended hands, ears and eyes, just as the sixteenth-century French architect Philibert de l'Orme's image of the ideal architect was equipped with four hands, three eyes, and winged feet, as we learn from Paul Emmons' essay "Being in Touch".

The second prism, *materials*, deals with the material "as found" in its pure and immediate presence – "as found" meant in the sense of "encountered", since, as Theodor Adorno stated in his *Aesthetic Theory*, no material can escape history, and even new materials carry the burden of history.[6] When presented with a standard-shape clay brick, you're not just looking at a cuboid block – a myriad of associations confront your mind that draw from personal memories and cultural history. These associations are usually positive, because of the brick's human scale and warm colours. Likewise, through its smell, texture and softness, a simple block of wood won't leave you untouched by memories and associations of an affirmative kind. In contrast, and quite paradoxically, as pointed out by Adrian Forty in his essay "Love and Loathing among the Stones", the world's most common material, the once wondrous concrete, has gradually slipped down the material hierarchy due to the unfortunate memories and cultural associations that have accumulated in the solid grey substance. But dark memories can of course also invade valued materials, as we learn from Catie Newell's essay "Material Lives". Her rebuilding of one of the many historic wood buildings that fell victim to arson during the decline of Detroit tells gloomy stories about a material that has been "ghosted" in a haunted urban setting.

Our material interest is not only bound to experiences and associations triggered by the mere presence of the material. The inner cellular structure of a tiny splinter of wood, for instance, which in a 3D microscopic recording forms a complex organic fabric, shows a structural world beyond our imagination. What seems to be repetitive chains of similar components appear on closer inspection to be uniquely shaped elements, hinged together one onto the next as an additive structure. This is of course not new knowledge, but we tend to forget that along with the exterior aesthetics there is a deeply entangled, inner structural world of wisdom and immense beauty. Even in the seemingly lifeless aggregates of concrete, as in the sharply cut shapes of the sand grain's quartz crystals or the flowering calcite minerals of lime, we recognize a secret world of nature's own ingenious architecture. Remarkably, these are the same calcite minerals that under tremendous pressure for millions of years form the basis of marble, whose surfaces tend

6 Theodor W. Adorno, *Aesthetic Theory* (Minneapolis: University of Minnesota Press, 2020).

The concrete pump aided by human hands feeding a constant supply of semi-fluid concrete into its rotating auger

to captivate architects and other dreamers. What secrets are hidden inside of such surfaces when we consider the incredible depths of nature?

The third prism, *origins*, has several points of departure. When we speak of the origin of building materials, we normally talk about the quarries where the stones have been broken, or the gravel pit, limestone pit or clay pit where the components for bricks and concrete have been excavated, or the forest as the typical origin of wood. But manmade materials like bricks and concrete also point to their production facilities, such as factories and kilns, as their place of origin. To these two notions of material origin we can add a third and much deeper point, namely the geological origin of the materials. Before it is quarried, a block of Greenlandic Maarmorilik marble has existed as one of the oldest rocks in the earth's crust, subject to nearly two billion years of tectonic drift and metamorphosis. The early calcite-based lifeforms, the densification through immense pressure, folding and heat, and a slow northward journey, are all part of its embedded material memory. The

cultural memory, which begins the day it is named, quarried, transported, shaped into building components, mounted on a building, looked at, touched, smelled, and perhaps disputed for years, is just a tiny phase of its deep history. Concrete, for its part, is more difficult to determine. Its origin is alienated, its memory blurred, but inside the indefinite grey mass there is a no less deep memory of eroded mountains, corals, shellfish and fossils. These are the hidden stories, which human beings treat with the utmost ignorance and disregard.

Any basic building material like wood, brick, metal, glass, concrete, granite or marble – they all leave traces in the landscapes they are extracted from. A gravel pit, clay pit, steel mine or granite quarry will eventually be turned into nature again when taken out of use, but the holes and traces will always remain as memorials in the landscape. In her pioneering book *Reciprocal Landscapes*, the landscape architect Jane Hutton points precisely to this situation when she follows different building materials that have shaped New York back to their place of origin. Every material is related to transformations elsewhere; they create "paired landscapes", effecting social, economic and environmental circumstances in both places.[7] To this we may add that material transformations affect several places, when we think of composite materials like concrete or plastic. The awareness of this fact is essential to this book.

7 Jane Hutton, *Reciprocal Landscapes: Stories of Material Movements* (London: Routledge, 2020).

Between a Forceful and Restful Encounter with Materials: *Reveries of Will and Repose in Bachelard's Material Imagination*

Thomas Bo Jensen

In the midst of the gloomiest period in Europe's history, in 1942, Gaston Bachelard first formulated his concept of "material imagination" (*l'imagination matérielle*). He did so in the second volume of a series of books about the four elements: fire, water, air and earth – in English known as *Water and Dreams: An Essay on the Imagination of Matter*.[1] Initially, Bachelard makes a sharp distinction between a *formal imagination*, which designates what we understand with our acquired knowledge when we engage with materials, and a *material imagination*, which denotes the immediate associations evoked in the individual through the close encounter with those materials. Before our formal knowledge comes into play, there is a subconscious layer of poetic imagination, triggered by childhood memories or undefined tactile and sensual daydreams, which colours and drives our creative imagination: "Besides images of form, there are […] images that stem *directly from matter*. The eye assigns them names, but only the hand truly knows them." The level of openness to this dimension, with all its poetic and wild paths, defines the depth of the creative mind, Bachelard claims.[2]

In this context, it is important to highlight another key concept connected to the material imagination, the French notion of *rêverie*. In English, *reverie* is most often translated as "daydream", but in Bachelard's perspective it also refers to an active world of dreams between conscious and unconscious, or a form of meditative, intuitive thinking that is carried out without causal explanatory models known from the poetic and artistic work process. The poetic reveries bring you in contact with deeper layers of imagination, which tend to be overshadowed by our formal knowledge if these – our "oneiric guide" – are not held open. In the introduction to *Earth and Reveries of Will*, Bachelard's call for poetic reveries is elaborated even further:

> The existence of a fundamentally creative imagination is out of the question: a rich imaginative recombination can only result from one's having seen a great deal. The Counsel *to see well*, at the base of the culture of realism, easily outweighs my own paradoxical advice *to dream well*, to remain faithful to the oneiric archetypes deeply rooted in the human unconscious.[3]

Having completed three volumes on the elements of *fire*, *water* and *air* in 1943, Gaston Bachelard continued his material imagination research in the fourth and final element, *earth*. This essay concentrates on the element earth, since this is where Bachelard offers the strongest focus on tools and physical materials. During the course of his studies on earth, Bachelard realised that he needed to separate his enquiry into two volumes: one dealing with *extroversion* or *extrovert imagination*, and another with *introversion* or *introvert imagination*. In the first book on extroversion, he deals with "reveries which invite us to act upon matter".[4] Whether it is through kneading with the bare

1 Gaston Bachelard, *Water and Dreams: An Essay on the Imagination of Matter* (Dallas, TX: The Pegasus Foundation – Dallas Institute of Humanities and Culture Publications, 1983). Original title: *L'Eau et les rêves: essai sur l'imagination de la matière* (Paris: Librairie José Corti, 1942).

2 Bachelard, *Water and Dreams*, 1–2.

3 Gaston Bachelard, *Earth and Reveries of Will: An Essay on the Imagination of Matter* (Dallas, TX: The Dallas Institute Publications, 2002), 2. Original title: *La Terre et les rêveries de la volonté: essai sur l'imagination de la matière* (Paris: Librairie José Corti, 1947).

4 Bachelard, *Earth and Reveries of Will*, 7.

Your work reflects consideration of the materials and structural principles employed. Are you also seeking new ways of producing architecture through digital fabrication technology, in projects such as the Ratatosk Pavilion, for instance?

SHS: Yes, definitely. The Ratatosk Pavilion [at the V&A Museum] was a small but significant project that influenced our approach towards many of the projects that were to follow. We started off reliving our childhood memories of playing and climbing in trees and wanted to express this joyous feeling in the pavilion. The pavilion was inspired by a cave-like or hollow tree, which is, in fact, made of several hollow trees. We discovered that pollarded ash trees grow with a hollow centre, and we based the design around this concept by opening up ten of these hollow trees and using them to create a new curious play space. For us, the Ratatosk was also a significant project in terms of utilizing and exploring digital tools.

At the time of the project, the workflows and software available for technologies such as 3D scanning and CNC fabrication were not as straightforward as they have become now. We started by excavating the ten chosen ash trees, including their roots, cutting them in half and 3D scanning them with a scanning machine borrowed from the oil industry. We then used the scans to digitally 3D-model the trees to start working on the complex geometries and decide and specify how the CNC machine would mill the trees. The project demonstrated to us the difficulty of connecting different digital software and platforms that immediately becomes necessary when working with nonlinear geometries. Back then, we tested multiple formats and combinations and eventually found the workflow that let us complete the pavilion's construction. This process took place alongside continual analogue testing through methods that included hand sketches, drawing and physical modelling with miniature trees, an essential method to make design decisions. As architects and designers, we became aware that digital tools have vital new possibilities but also challenges and peculiarities that influence and form the design process. In the end, the project demonstrates how trees can be transformed and processed, playfully capitalizing on the many different parts and structures they have and their own intrinsic organic growth forms.

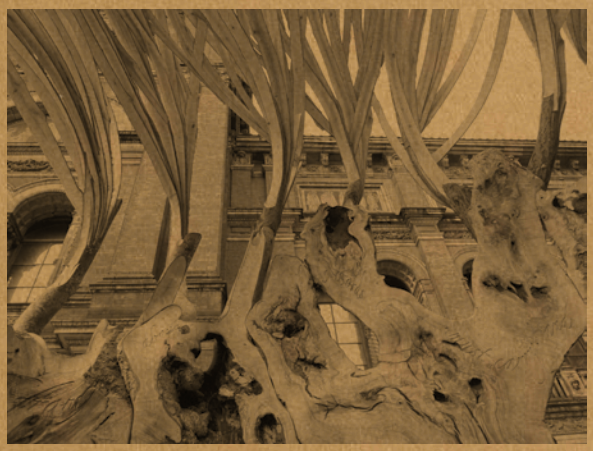
The Ratatosk Pavilion has an unusual and enigmatic mode of expression, and it has a powerful tactile character. How do you consider the tactile dimension of materials in your projects?

SHS: The sensory experience of the materials plays an essential role in all of our projects. In Ratatosk we experimented with contrasting degrees of processing the wood, keeping the rough bark on the outside and milling the trunks on the inside to a very soft and smooth surface. Such contrasting appearances and haptic qualities of the same material engage the senses and create a distinct and very direct aesthetic experience.

In a similar way, our housing project Vindmøllebakken [in Stavanger] uses a wood-based modular construction system; the exposed nature of the material allows users to directly experience the natural timber surface inside their living spaces. The growth patterns of the wood are clearly visible,

creating a reminder about nature and its lifecycles. The surface has a softness, with a subtle texture that gives a very comfortable acoustic quality. At the same time, its robustness, durability and adaptability allow people to reconfigure their internal walls and spatial arrangements as their needs change over time. The overall effect of this natural timber material palette contributes to creating a calm and warm atmosphere that invites the users to occupy and inhabit the spaces.

Many of your projects show new ways of using wood as an important factor in architectural expression. Does wood play a special role in your approach to architectural design?



Ratatosk Pavilion, Helen & Hard (2010). Photo by Helen & Hard.

Ratatosk Pavilion, CNC milling, Helen & Hard (2010). Photo by Helen & Hard.

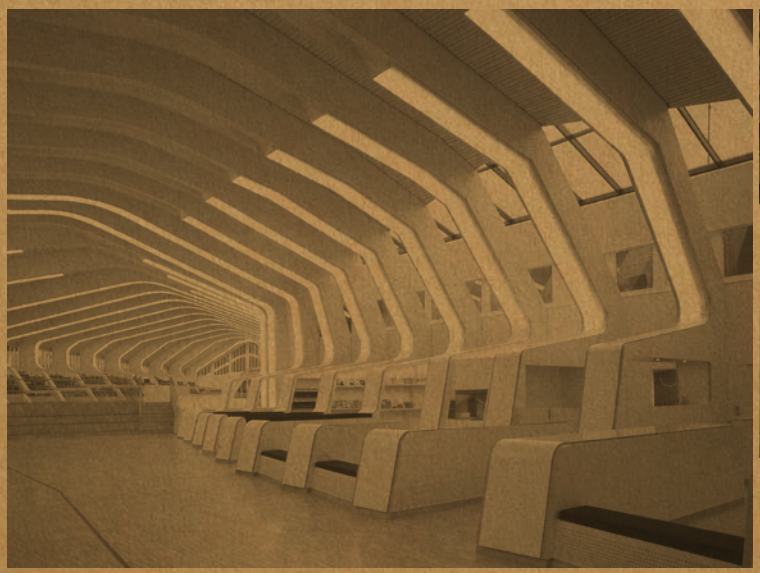
RK: Yes, the wide range of opportunities that comes with using wood plays an essential role throughout our practice, starting from the initial conceptualization of a project. We are fascinated by wood, first and foremost for its tectonic potential as a construction material. An iterative workflow is necessary for us to find a spatial organization that is optimal for practical use, a geometry with experiential qualities, and a coherent timber construction. We often use parametric modelling for this form-finding and optimization, but these methods are always accompanied by an inherent “thinking with timber” and a knowledge that spans from the available raw material to the machine and tools used during processing through to the methods and details of construction. We are very interested in how natural timber can be used in more settings and in new ways. For instance, we find it very inspiring to see the extremely refined culture of boatbuilding with wood that is still alive, especially along the Norwegian west coast. It is interesting to see how different wood species and parts of the tree are used in different applications and the large variety of accompanying tools and methods that have been developed for processing the material.

Of course, there is also huge potential for making architecture more sustainable by using wood as the main construction material. We carefully consider the role that the timber will play in the overall construction and try to come up with the most sensible solution that avoids waste and benefits from the specific properties of the material. To achieve this, we work closely with

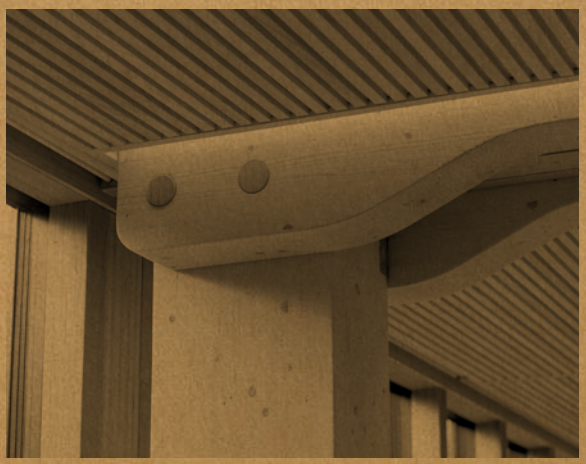
skilled engineers such as Hermann Blumer to integrate structural principles and architectural design intent. In this process, we seek logical construction methods and prioritize certain parts of the architecture where we can allow more advanced forms of expression. This is, for example, the case in the Bjergsted Financial Park [in Stavanger], where we have a greater concentration of curved Glulam beams in the central shared spaces than in the more regular office areas.

In the Bjergsted Financial Park project, the wood definitely contributes to the atmosphere of the building. Was it the client's idea to use wood when the project was initiated?

SHS: Actually, the overall ambition for the building was that it should be as sustainable as possible. It was then, through the discussion of many considerations, that we managed to persuade the client to commit to a timber building. Timber construction might be more expensive if you only look at the initial material cost, but when you also consider the efficiency and precision during the construction process, timber is able to compete with more standard materials such as concrete. We also find it interesting that, if you consider and plan how the materials are handled during the construction process, it is often perfectly acceptable to leave the surfaces of the timber structures exposed. The unique materiality of the timber can therefore contribute to the internal atmosphere of the architecture without the need for further cladding, which often arises with concrete or steel constructions. The thermal and acoustic conditions of interior spaces with exposed timber are also often more pleasant to live and work in, as they are better at regulating heat, humidity and noise than some other building materials, such as concrete. The beautiful and unique natural quality of timber can also positively influence the craftsmen producing and installing the construction elements and thus increase commitment to the work.



Vennesla Library, Helen & Hard (2011). Photo by Erieta Attali



Financial Park, Helen & Hard (2019). Photo by Sindre Elligsen

It appears that you are using the chosen construction principles to become part of the architectural identity in many of your projects.

RK: Yes, the timber structure and its individual members, connections and joints are often the driving force behind the architectural design, embodying both the conceptual and practical considerations at the core of the architecture – it's like a musical score, in which all other building elements have to play along. In the Financial Park project, we have developed a joint that involves layers of beech wood, which on the one hand creates a beautiful construction detail but also reduces the amount of steel in the joint, thereby becoming a more sustainable solution. Generally, we see structure and material as elements that are integrated throughout the architectural expression and run through the duration of the design process from the beginning to the point of arrival at a holistic and successfully built architecture.

The Ratatosk Pavilion indicates that you are occupied with the origins of materials, specifically wood. How do you see the connection between the forest and wood as a construction material?

SHS: The Ratatosk is a playful installation that conveys our reflection and memories of exploring the forest and being deep in nature. We find it very inspiring to work on small-scale projects where this connection can be expressed directly in the architecture. One example is the Woodnest project [at Odda, on the Hardanger Fjord] which is, in fact, a treehouse built of wood and supported above the ground around a living tree trunk. Another project, again similar in scale and which focuses on the users' direct experience of the materiality of the architecture, is the Tyrvefjøra rest stop [also on Hardanger Fjord]. Here we actually used less digital technology than for Ratatosk, as the structural concept for the architecture makes direct use of the existing structural properties that are inherent in a tree. We have kept the root and the tree trunk connected and intact and designed a construction that is comprised of whole trees, sometimes placed upside down, letting the roots create a canopy that supports the formwork for a cast concrete roof. Here, it is very easy to identify and recognize the material in its original state but also to experience how it can be re-imagined and re-invented.

You are the leader of the transdisciplinary research group at KieranTimberlake. How does the group approach a material's wants and desires?

BF: As a practice, we've grown to situate our materials imagination in a core principle: materials flow continuously. This principle is not abstract, nor is it outside of an architect's domain. Materials, or more specifically building materials, are not simply products that we specify. Instead, architects enrich their imagination and ethical obligations by incorporating materials extraction, processing, and recovery knowledge into the design process. After a decade of working on Tally®, this core principle augments our approach to specifying and detailing materials. However, people, businesses and countries make materials flow. As materials flow continuously, what are the impacts on people and communities? Who is impacted by our materials' imagination?

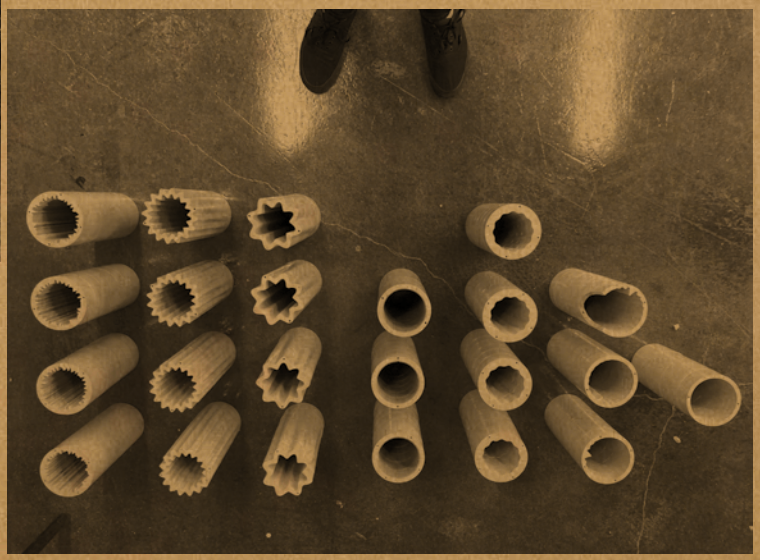
But your question also speaks to the organization of our practice. Our research group members are embedded in architecture's day-to-day practice. They are also people profoundly committed to original projects that elevate our understanding of what architecture can be. Our research group reflects KieranTimberlake's longstanding commitment to practice-based research. We aim to expand the knowledge and agency of designers and the overall value of architecture for clients and communities. I joined KieranTimberlake in 2008 to evolve the firm's research practice and form a dedicated transdisciplinary research group. Our group's structure reflects our belief that if we converge knowledge and methods we can see new and better design opportunities with positive outcomes for the built environment. We approach materials research through our transdisciplinary lens.

We incorporate materials science, computation, sculpture, thermodynamics, anthropology, industrial ecology and architecture expertise. Some of our newest members have backgrounds in supply chain equity, climate adaptation and resilience. The fields that have and will continue to shape our approach to materials research make a long list! Projects such as SmartWrap™ (2003) (fig. 1), the US Embassy in London (2017) and North Campus Housing at the University of Washington Seattle (2019) exemplify this approach. But we must be deliberate when forming inter- or transdisciplinary teams. For instance, when creating the research group, we wrote a job description for someone trained in materials engineering to join us – and that happened. Then we started looking for people who worked at larger scales, hoping to have people trained in urban ecology or industrial ecology join us – and that happened too. Over time, we've learned the power of orienting our materials work to a range of spatial and temporal scales and new knowledge domains.

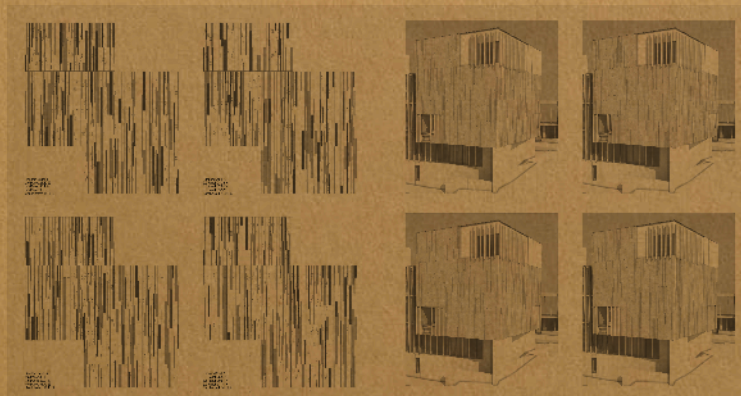
There is ample evidence in the broader design research community that our materials imagination expands when we bring together people with a range of understandings of and perspectives on materials. I believe that collaboration fosters insight, new opportunities and materials–methods empathy. Our research group describes the sparks that fly from knowledge convergence as "wait, what?" moments. I could go on at length about the day-to-day moments when working this way has led to new directions in our work!

[Fig. 1] SmartWrap Pavilion, Cooper-Hewitt National Design Museum, New York City, KieranTimberlake Associates (2003). Photo by Barry Halkin.

[Fig. 2] Listening to the note a ceramic cylinder can make during the Architectural Ceramics Assembly Workshop (2019). Photo by KieranTimberlake Associates and Christopher Connock.

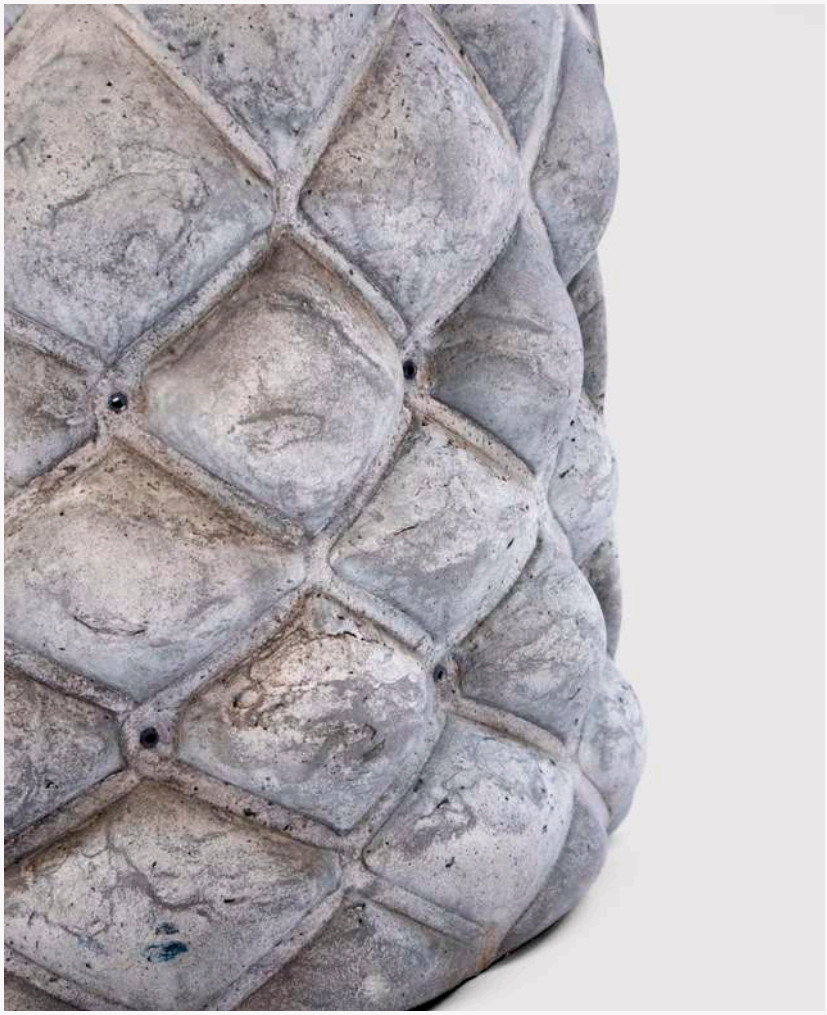


[Fig. 3] Ceramic cylinders produced during the Architectural Ceramics Assembly Workshop (2019). Photo by KieranTimberlake Associates and Christopher Connock.

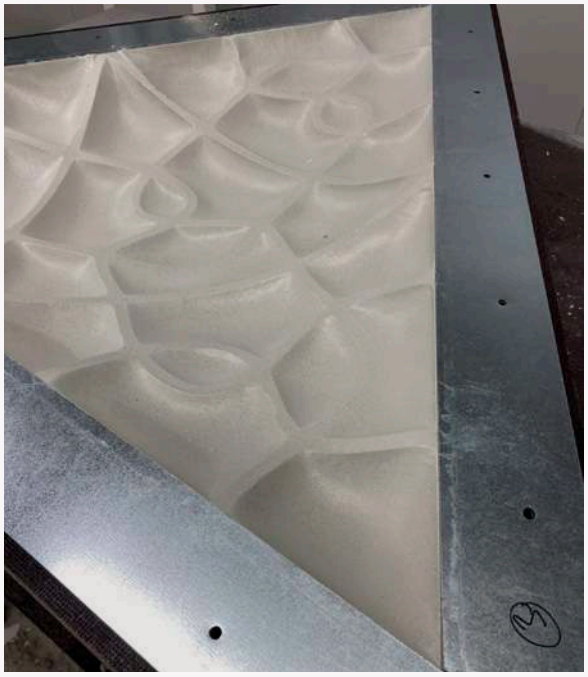


[Fig. 4] Parametric studies for board-formed concrete panels of the Pendleton West complex, Wellesley College, Wellesley, Massachusetts, KieranTimberlake Associates (2017). Illustration by KieranTimberlake Associates.

[Fig. 5] Board-formed concrete mockups of the Pendleton West complex, Wellesley College, Wellesley, Massachusetts, KieranTimberlake Associates (2017). Photo by KieranTimberlake Associates.



[Fig. 34] An elevation view from the other side showing how the form transition from the bottom to the top produces a stable structure. Photo by the author.
[Fig. 35] Closeup of the bottom part of the prototype. Photo by the author.
[Fig. 36] Detail from concrete surface. In the bottom of the openings the concrete has forced the clamps apart and pushed through. Photo by the author.



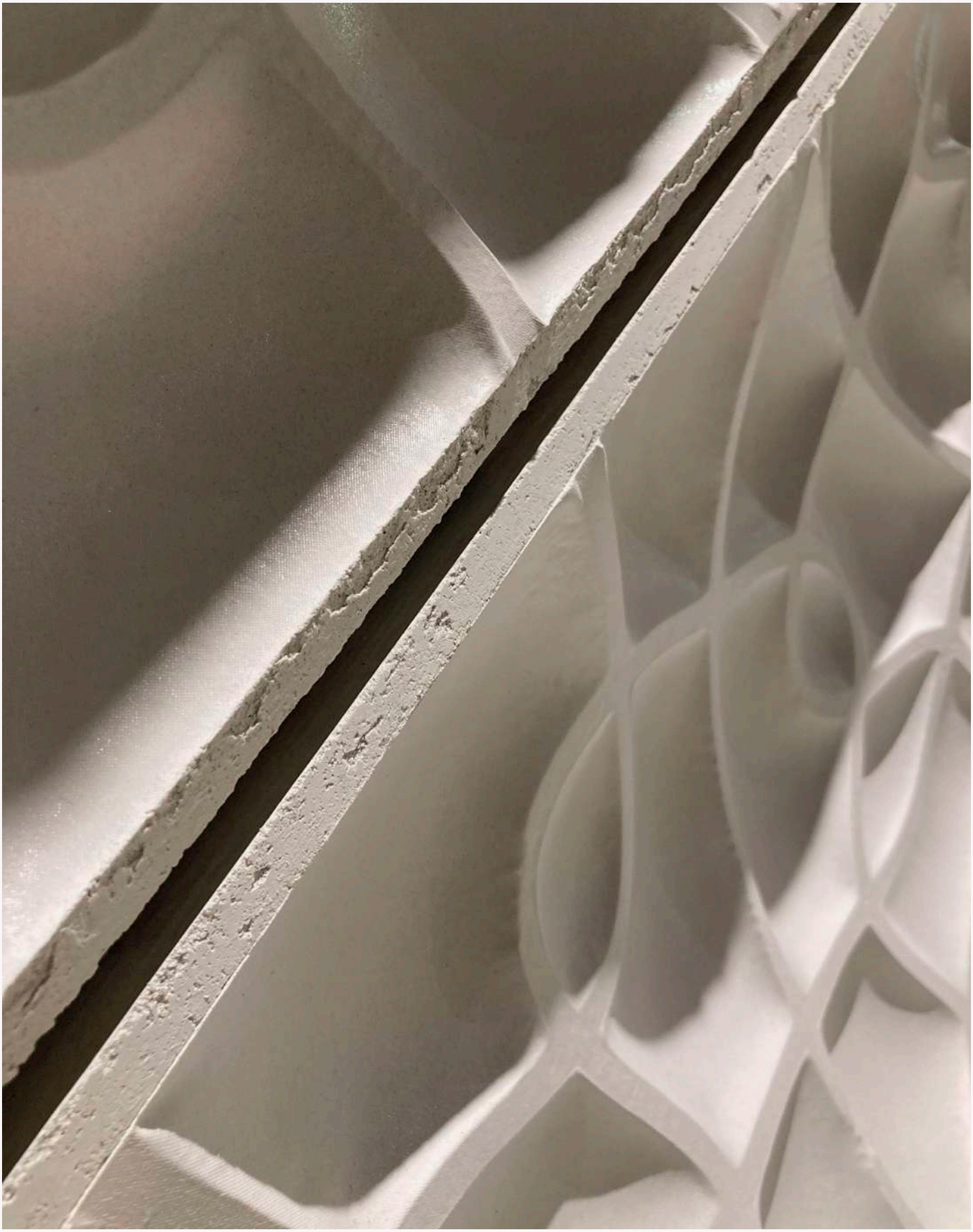
[Fig. 37] A view inside the "negative" mould where the sand has maintained its gravity-induced form during the casting process. Photo by the author.
[Fig. 38] The mould before casting. Formed by sand and flipped upside-down, the smooth fabric sits securely inside a form-ply frame. Photo by the author.
[Fig. 39] The concrete form and finish during demoulding. Photo by the author.
[Fig. 40] Three-part prototype assembly of concave GFRC panels. Photo by the author.

Case IV: The inverted rationale

A fourth experimental trajectory separates the concrete's constituent parts and benefits from their individual material capacities: the aggregate's considerable density and the cement's rapid petrification.[47] Distributed onto a fabric braced with 3D-printed thermoplastics, the dense aggregate forces bulges to form, comparable to the concrete casting principle outlined in the previous section. As it is secured inside the shuttering and turned over, the sand does not redistribute but maintains the form achieved earlier by gravity. This "inverted" shuttering supports a thin structure of glass-fibre reinforced concrete (GFRC) sprayed from above. In this mass, Portland cement interlocks short strands of glass fibres, creating a lightweight and rigid cast with ample compressive and tensile strength (figs. 37–41).

The "inverted" casting principle and specimens supplement the other experimental contributions as an analytical exercise distinguishing between concrete's artificial and natural expressions. Separated from the natural component of aggregate and bound with another synthetic material (glass), the cement assumes a truly artificial character. The lightweight

47 Ibid., 379–386.



GFRC is an industrial composite material with equally composite and optimized performance.

[Fig. 41] Detail of three-part prototype assembly of concave GFRC panels. Photo by the author.

The four elements

This essay has followed concrete's constituent parts in their interactions with the elements at different points during their lifetime – and how these interactions collectively form a rich material history around an otherwise omnipresent industrial commodity. Section I traced the geological origins of concrete's constituent ingredients, guided to the Danish subsurface by water and ice. To the degree that the specific aggregate features affect the character of the concrete, the cast expresses a unique history of these geological migrations. Separated from silt through millennia of erosion, the aggregate particles reassemble in concrete, embedded in the artificial residue of cement. Section II dove deep inside the earth to find the minerals and mechanisms that define various historical variations of cement. The section tied cement's adhesive capacity – or chemically induced ability to petrify – to its violent rebirth and mineral transmutation inside the scorching kiln. Section III offered an intimate account of how the coarse fluid mass encounters the mould and how this encounter might become a nexus for carefully choreographed material negotiations.

Finally, Section IV presented a range of physical experiments that explore this interface between concrete and mould. Each experiment navigates a precarious balance between control and collapse as the fluid concrete mass confronts nuances in a digitally manufactured mould. In each physical experiment, the material choreography is reactionary and instant. The membrane's most important feature is not its ability to contain but its ability to deform – to react. The auxetic perforation pattern is not a control deficiency; it is what allows the membrane to react as the concrete forces it apart. As the concrete settles and awaits its rapid petrification, the choreography allows the immense density and fluid dynamics to actively negotiate the final form. Reverberating its violent beginnings, the concrete pushes and strains against its confines in a final act of defiance.

While the individual casts cannot embody the manifold layers of material memories explored throughout the essay, they each express a tension within concrete. The experiments highlight some of the concrete's paradoxical features as they probe the fluid concrete and its transition into a solid mass. Some experiments bring forth the delicate balance between density and fluidity, while others offer material nuances between concrete and container. Emphasizing the concrete's fluid past, the petrified specimens expose some of the mass's interior friction, accentuating the multiple layers of liquid memories.

Postscript: Architecture Silently Understood

David Leatherbarrow

The veneration of matter: what could be worthier of the spirit? Whereas the spirit venerating spirit …?
Francis Ponge

If there ever was a time when materials *didn't* matter to architects in their design work and theory, it is certainly not today. This book joins step with the increasing number of studies that see the building's material reality as the site and soil of both productive creativity and rich experience – dethroning shape and style. Obviously important in this new arrangement are the work's physical aspects, but no less significant are corresponding dimensions of our mental and emotional lives. At stake in this turn is more than a re-estimation of neglected concerns in design and experience; it is rather the repudiation of long-standing assumptions, and a wholesale reconceptualization of basic premises.

Well-known recent titles provide a preliminary indication of the shift in thinking that is now underway: *Vibrant Matter*, *Materials Matter*, *Material and Mind*, *Material Transfers*, *Materials and Meaning in Modern Architecture*, *The Material of Invention*, among many others. The truisms that are being vigorously challenged include assumptions about the nature of materials, the distinction between form and matter, the passivity of architectural materials, and their poverty of expression in the absence of artificial formation. Rejecting these notions, *Imaginaries on Matter* enters into conversation with wood, stone and concrete, lending an ear to their family ties, personal histories, predispositions, desires and potentials.

The book's title is attractive but also arresting in three ways. First, the "imaginaries" it contains are not *of* matter but *on* it. Suggested here, I think, is a thesis about the decisive importance of imagination in both architectural discourse and design, not only skill and knowledge. Second is the proposition that ideas and images can be found *within* materials, not only used to shape and form them. And third, that we should concern ourselves with *matter*, as if it were somehow different from materials. Might it be that in that very difference – matter vs. materials – *imaginaries* in both discourse and design find their place?

Matter vs. materials … How do they differ, and what would such a difference mean for creative thought and project making? Etymological kinship suggests differences are only apparent (Latin *mater* [mother]→ Latin *materia*→ Late Latin *materialis*/Old French *matiere*→ Old French *materiel/matere*→ English *material/matter*), and conventional usage in and outside architecture is hardly promising because the words are often used interchangeably. Considering usage more closely, however, it is fair to say that we tend to think that matter is more general and inclusive. The word indicates anything that occupies space. Usage in modern science suggests that matter when measured is mass, another widely inclusive category of phenomena. Materials, on the other hand, seem to be more specific, each possessed of distinguishing attributes or properties. The

distinction recedes once again when we remember that both are commonly thought to be *substantial*, which is to say are capable of *subsisting* through change. A sharper version of the question is this: what might it mean to say that materials are types or kinds of matter?

Four observations about matter can be gathered from this book's chapters and interviews: matter is sensible for the body and mind, it is animate, also relational, and articulate. Let me elaborate:

> The first key point is the non-separability of substantial and spiritual things in matter. Rendered negatively, this observation means that matter is no longer thought to comprise an order of being entirely separate from that of the thinking and feeling body. In the teeming world of primary experience and creative thought, ideas, emotions, memories and desires emerge and recede in all physical things. Decades ago, the American poet William Carlos Williams argued for the importance of seeing ideas in things. The imaginaries in this book elaborate that premise and its significance for architecture.
>
> The second important observation is that matter should not be thought of as inert and passive. Though we tend to say matter has potency, it is more correct to say it *is* potency, which means force and power are unknown in its absence. Matter's powers take two forms. It can be seen in capacities for passive resistance – steel's resistance against tension's pull, or stone's stand against loads that press themselves upon it; and it can be seen in its active powers of growth and formation – as in embryos or seeds, or more specifically in floors, roofs and walls that reveal "the golden stain of time" when weathered. Matter in this sense is not only a capacity for resistance, but an agency of image making, possessed of intrinsic forces of change.
>
> Thirdly, giving due consideration to matter helps us grasp the mutuality or kinship of things. One might say that terms like icy steel, chalky stone, or velvety timber are merely metaphorical. The studies in this book suggest, however, the reverse is equally true: that steel and stone *as such* (construction materials in the conventional sense) are second-order phenomena, abstracted from a network of more basic or ancient relationships, kinship ties, that antecede the objects known in instrumental operations and analytical thought.
>
> Lastly, the imaginaries set out on the pages of this book have an ear for *the voice of things*. Gaston Bachelard is a good guide here. A fellow traveller whose title I've just invoked is Francis Ponge. In his case, a life in poetry was dedicated to "taking the side of things", releasing them from the constraints and solitude of objectivity, being attentive to their expressions, and taking the time to listen to what they have to say. Things have names, perhaps

> they are inseparable from them, but they also possess dimensions of sense that are linguistically unclaimed. Images disclose this manner of content, but also expressive are colours, textures, scents and weights. Reversing our vantage may make this clear: as they convey thought and emotions, human and animal voices have texture, also weight (or thinness), and a world of other qualities we associate with things. Were those qualities or dimensions of embodiment absent, communications and expressions would never reach their targets.

The first pages of this book present photographs of materials, tools, and evidences of people at work. Words on pages come later – the table of contents, chapters and interviews. A hierarchy of concerns is implied, also a sequence of different kinds of sense. Again, Ponge is helpful: "it is less a matter of truth than the integrity of the mind, and less the integrity of the mind than that of the whole man … Given the singular power of words, the absolute power of the established order, only one attitude is possible: taking the side of things all the way." In this book's layout and arguments, we see ways of restoring matter to its proper role and place in architecture: formative and native, also strangely familiar and silently understood.

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Tools, Materials, Origins
Editors: Thomas Bo Jensen, Carolina Dayer, Jonathan Foote

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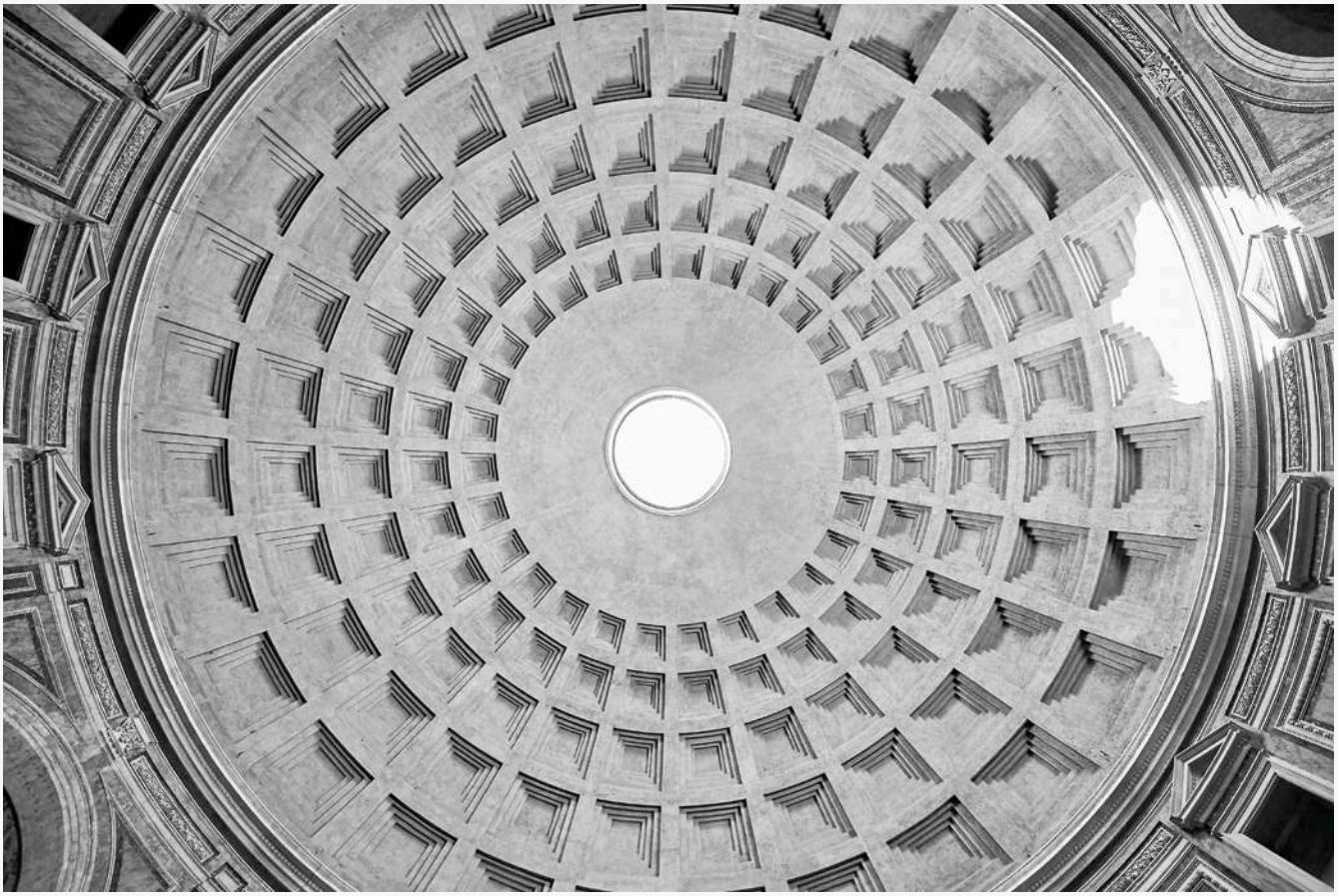

Imaginaries on Matter – Tools, Materials, Origins promotes an innovative architectural research agenda that connects historical-cultural written research with digitally led material explorations. The common thread is the notion of the material imagination, disclosed in the reverie, or material daydream, which challenges overly pragmatic or unreflective material choices within current architectural practice. In bonding our imagination directly with matter while also confronting new technologies, this book promotes strategies by which architects' and builders' future relations with materials can stay rooted within the deeper concerns of cultural meaning.

The book is edited by Thomas Bo Jensen, Carolina Dayer and Jonathan Foote

If there ever was a time when materials *didn't* matter to architects in their design work and theory, it is certainly not today. This book joins step with the increasing number of studies that see the building's material reality as the site and soil of both productive creativity and rich experience – dethroning shape and style. In its layout and arguments, we see ways of restoring matter to its proper role and place in architecture: formative and native, also strangely familiar and silently understood.

David Leatherbarrow, Professor Emeritus, University of Pennsylvania

While contemporary architectural writing overflows with talk of materiality, surprisingly little of it engages with actual materials – their resistance, their affordance, and the imagination they fuel. This book is a rare exception, exploring the richness and complexity of materials and our dealings with them.

Mari Hvattum, Professor of Architecture, The Oslo School of Architecture and Design

This enthralling collection of essays takes the reader on an extraordinary quest through materiality and matter, inviting us to discover a perceptually rich form of bold and substantial architectures in marble, timber, concrete. The juxtaposition of theory, research, archival illustrations, creative works and cutting-edge technologies such as robotics and advanced fabrication creates a mesmerizing fusion of past and present. These material imaginations firmly anchor us in the world, igniting our dreams and inspiring us to explore the boundless possibilities of materials with joy and fascination.

Dagmar Reinhardt, Associate Professor of Architecture, The University of Sydney

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