Materials carry *meanings* through embodying traditional materials, methodologies, and rituals of construction as well as through the less tangible aspects of the uniqueness of place, program, and culture.

10 materials

Materials, both natural and artificial, retain traces of their origin, and they communicate intrinsic qualities that evoke associations and responses in their perceivers.

Materials are an architect's instruments. When a composer writes a piece of music, it makes a considerable difference if it is to be written for a solo piano, a string quartet, an orchestra, or a marching band. Similarly, an architect's choice of materials has a profound effect on both the form of the work and its reception by an audience.

A material's behavior bears witness to its interaction with a variety of both ephemeral and physical contexts while its properties inform its constructive processes: its fabrication, transformation, potential perforations, types of apertures, and the details of its interactions with other materials within a construction and its environment. Materials, both natural and artificial, retain traces of their origin, and they communicate intrinsic qualities that evoke associations and responses in their perceivers.

Characteristics

A material is often identified with its sensorial capabilities, which in turn inform how a space is perceived and how a surface performs.

Phenomenal

Intrinsic to each material are its physical attributes, which can perhaps best be described by a series of pairings—thick or thin, opaque or transparent, matte or reflective, dark or light. It is the qualities of these attributes that suggest meaningful associations with not only the program of a work, but also its perceptual experience. A wall made of glass might appear to dissolve the boundary between public and private, or inside and out, but it can also convey a crisp brittleness and a reflective hardness that suggests an atmospheric serenity. Of course, the manipulation of this very same material—tinting, screening, sandblasting, for example—can easily reverse these characteristics, and it is in exploiting these reversals that a material's capability to expand its programs and perceptions is often discovered.

(continued on page 94)

Overlooking Lake Lucerne in Meggen, Switzerland, stands Pius Church designed and built by Franz Füeg between 1964 and 1966. Here, marble, a typically opaque material, has been thinly cut to just over 1-inch (2.5 cm) thick to produce a surprising translucency, demonstrating a characteristic that is not normally associated with the material, but one that brings unexpected programmatic (stained glass windows) and perceptual (illumination) associations. The work exploits marble's potential as a material that can simultaneously demonstrate multiple characteristics: from the exterior, it is a cubic rock by day and a lantern by night.

Material and "De-Material" in the Architecture of Herzog & de Meuron

The Swiss firm of Jacques Herzog and Pierre de Meuron, has been based in Basel since 1978. While their designs favor basic, easily recognizable volumes (traditional house forms, simple boxes), their provocative and unfamiliar usage of materials has consistently altered our understandings of the role materials can play in an architectural work. Herzog and de Meuron consistently deprive materials of certain of their expected properties, leading the observer to experience aspects of the building's ambitions that would normally be obscured by the "grip" of the material's more familiar usage.

Herzog & de Meuron: Stone House; Tavole, Italy, 1985–88

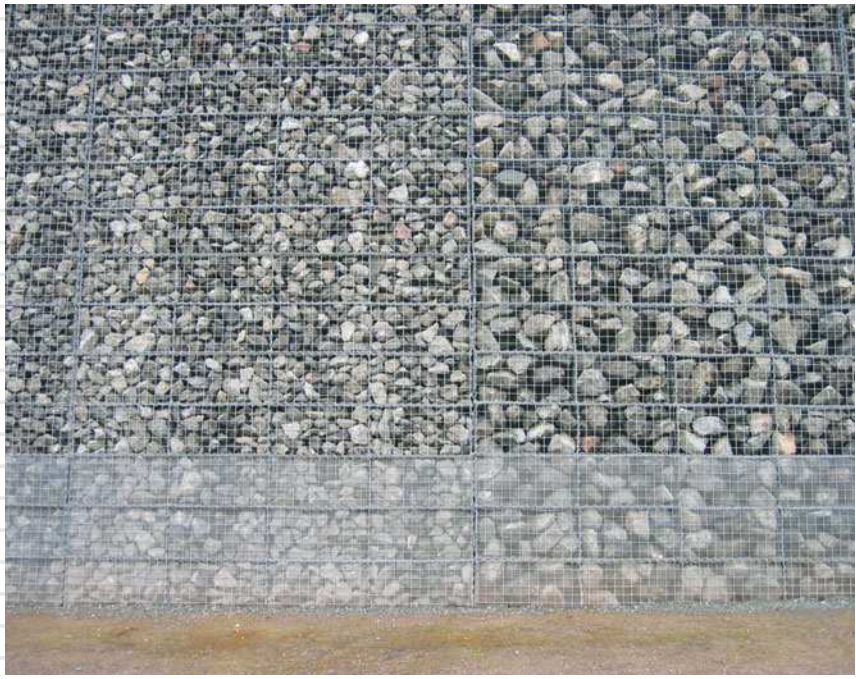
As is already clear in their first Ricola warehouse, it is very common for the "language" of materials to communicate through several modes of signification. The scale and detailing of the material not only suggests similar constructions, such as the wooden tobacco barns throughout the U.S. that fascinated Herzog, but the horizontal layering of panels reflects the horizontal layers of limestone immediately adjacent to the building. The use of materials can suggest a function: In this case, the dense storage of goods is represented in a building that looks as if it were, itself, a pile of stored wood. At the same time, the violation of some of the material's expected traits serves to signify a deeper sense of the building: The "wood" is actually cement panels; its "stacking" is accomplished through loose attachment to a frame; its "solidity" is actually highly permeable.

In the Stone House in Tavole, Italy, the dry stone masonry walls at first suggest the other stone houses of the village, as well as the retaining walls that shore up much of the hill town. Thin concrete bands divide the walls, apparently mere traces of an organizing geometry that connects the house with its site. It appears to be a decorative touch, elaborated by the apparent absence of the concrete on the corners. In reality, the concrete *is* the structure, with smaller columns tucked within the corners. The dry masonry walls play no structural role, being instead exactly what they appear to be: a film of lightly stacked stones collected from the area. While the apparent lightness of the concrete leads us to believe that it has no structural value, the apparent massiveness of the stone suggests structure. The house leads us to question our material prejudices, referring to the traditional usage of materials while drawing us into new, unexpected impressions. A material seduction begins to occur.

Herzog & de Meuron: Ricola Warehouse; Laufen, Switzerland, 1987

Herzog and de Meuron's most recent work seems to employ more subtle modes of material manipulation: materials such as stone, metal, and concrete develop unexpected textures, and these fundamentally opaque materials join essentially transparent materials, such as glass and plastic, in beginning to assume a quality of translucency and reflection.

For example, the gabions that line the exterior walls of the Dominus Winery in Yountville, California, at first produce the image of a massively rusticated country wall. Gabions—wire mesh cages usually containing rough stones collected on-site—are traditionally used for retaining walls, most familiar for their usage in highway construction where their strength seems to be equated with their apparent solidity and opacity. At the winery, however, Herzog and de Meuron have used the gabions as an exterior cloak, filling the cages with varying sizes of rock and, occasionally, with no rock at all. From the interior, glass walls behind the gabions take advantage of the dappled light that filters through the stones. What is understood to be solid and opaque is instead permeable and translucent.



Herzog & de Meuron: Dominus Winery; Yountville, California, 1996–98

In the Laurenz Foundation art storage facility, the thick exterior surfaces of excavated earth panels with exposed pebbles propose a massiveness that protects its contents, both environmentally and in terms of security. Yet this massiveness is belied in several ways. A large, horizontal cut on two sides of the building is intentionally irregular, digitally derived and constructed to suggest enlarged pebblelike forms. Although this gash serves to demonstrate the wall's thickness, its horizontality simultaneously undoes the wall's mass. Then, as these apparently heavy walls make their way toward the street side, they seem to end abruptly, with a knife's-edge transition to a large, scaleless polygon of flat white surfaces that defy scale and deny material.

Subverting some of the traditional perceptions of a material lead to that material's perceived *de*-materialization, limiting a material's anticipated characteristics, while suggesting unexpected, previously unimagined traits that are often even opposite the initial impression. Herzog and de Meuron assume that material has no fundamental qualities, that "the quality lies in the work itself, where the material attains specific value that leaves bare materiality behind; ... [it] is no longer a purely representative means and therefore no longer restricted to the visible surface." Actually, in contemporary architecture, the immediately visible is perhaps the least reliable indication of a material's attributes, not only because of the capacity of certain materials to mime the traits of others, but also because a project's physical characteristics are usually surpassed by its conceptual values. The architecture of Herzog and de Meuron, however, proposes a sensuality that can be discovered only through a thoughtful encounter with the work. We find architecture's intangible values firmly rooted within our experience of materials.

Herzog & de Meuron: Laurenz Foundation Schaulager; Basel/Münchenstein, Switzerland, 1998–2003

Walls of scalelike glass shingles envelop an interior of cast concrete 'drawers' in Peter Zumthor's Kunstmuseum in Bregenz, Austria (1990–97). The contrasting materials produce an atmospheric dialogue that shifts between the reflective and translucent exterior lantern to the stark and cold of the concrete of the gallery spaces. The two are brought into focus as the light filters in through the plenum areas and the polished concrete galleries begin to glow.

The walls of the Kunstmuseum in Vaduz, Liechtenstein, by the Swiss architects Morger and Degelo, with Christian Kerez (1997–2000) are of cast concrete, and it is the sanding of their exterior surfaces that reveals its composition: basalt, nearby Rhine river gravel, and black cement. The result is a highly polished surface that reflects the surrounding buildings, connecting the building with both its built and geological contexts.

Textural

Materials can develop textures through their installation, manipulation, finish, and wear. These textures have significant impact not only on a material's durability, penetrability, and usage, but also on the distinctness of space and surface. If cast concrete is highly polished, it can virtually disappear as it reflects the environment surrounding it. Or its normally hard, inelastic surface can be softened through the imprint of the traces of its forming. Or if it is subdivided into individual blocks, it can be stacked into a porous screen. The texture of a material can determine the sharpness or blur of a shadow, can suggest the finite or infinite impressions of a space, and can tempt or inhibit the tactile engagement of a surface.

Acoustic

Materials can be acoustically hard or soft; they can cause echoes or muffle voices. An acoustically reverberant space can appear to be exaggerated in its vacancy or in the grandness of its scale. A space that is acoustically absorbent can be perceived as more intimate, more comfortable. The materials of a floor or path can make our steps seem stealthy or monumental, modest or emphatic, unobtrusive or processional. The acoustic traits of materials can inspire associations related to memories, perceptions, and even other arts such as film or music.

Permeability

The way a building can weep or breathe is an important and even necessary aspect of the selection of materials. The permeability of materials—especially those used in the exterior membranes of a building—can keep a structure and its components dry or humid, hot or cold, fresh or musty, even light or dark. As a result, a material's degree of permeability has a direct relationship to all of the above material characteristics.

Behaviors

It would be a mistake, however, to consider the nature of materials as being permanent and unchangeable. An understanding of the behaviors of materials not only plays an important part in protecting the integrity of a construction and ensuring the quality of life of those within, but it can also contribute significantly to the aesthetic qualities of a building.

Texture *is* the material of Heatherwick Studio's Seed Cathedral built for the 2010 Shanghai Expo. While the primary structure is a wooden box, 60,000 clear acrylic rods intersect its surfaces, blurring the boundaries between building and sky. 250,000 seeds are embedded into the tip of the rods, which are illuminated by day as the sun shines through and, at night, by light sources embedded in each rod. The swaying of the rods in the breeze is a material expression of its program: the seeds growing into a field of wheat.

Herzog and de Meuron's Ricola-Europe production and storage hall built in Mulhouse, France (1992-93), is a concrete box with a northern face that opens up as if to expose the strips of polycarbonate panels at its entry façade. The building's drainage has been intentionally choreographed to spill down its matte concrete surfaces and it is these newly striated surfaces that enable the concrete to take on the characteristics of the adjacent polycarbonate façade. This intentional engagement and registration of temporal aspects of the environment allows these unrelated surfaces to be brought into material conversation, temporarily transforming the concrete volume into a glistening crystal.

Responsiveness

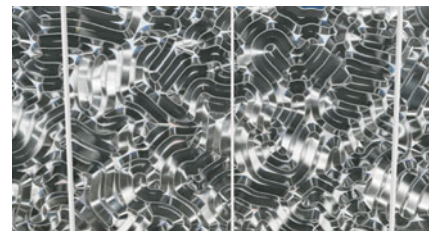
Very few materials are entirely static. Most respond in a direct way to the stresses of gravity, heat, cold, moisture, and so on, albeit in varying degrees. Some of these responses can be permanent, as with cracking or erosion, while others can be cyclical, as with expansion and contraction or flexing and straightening. Recognizing these behaviors, not only at a material's various scales and dimensions but the *interaction* of these behaviors among different materials, is critical in accommodating these inevitable transformative behaviors.

Weather, or the inevitability of transformation

All materials have a lifespan, but how a material transforms over time is unique to its composition and to its interaction with a specific weather and environment. It is important to understand that the end of the construction process is but the beginning of a course of weathering and entropy, most of which can be anticipated. At the very least, most materials change color or texture when wet. However, some materials are much more reactive, with transformations that can be quite pronounced, as in the case of copper as it changes from reddish brown to green, with weathering steel as it oxidizes to an earthen rust, or with cedar as it weathers from a reddish brown to gray. Less predictable is the staining and eventual erosion of more resistive surfaces that allow initially untainted materials to slowly fade into their surrounding context, to return to the earth. Mohsen Mostafavi and David Leatherbarrow speculate on the *intentional* deterioration of a funeral chapel, "... used deliberately as a device for marking and infecting the purity of the new building surface, ... as the possibility for showing the life of the building in time." (Mostafavi and Leatherbarrow, page 103.) Anticipating such material transformations is a significant aspect of the design process.

Simon Ungers's T-House, Wilton, New York, built in 1992, is a project that blurs the boundaries between architecture and sculpture. Its fundamental geometry and the relentless use of weathering steel suppress all detail and scale, reinforcing the notion of the building as a sculpture. Steel is also used as a functional material capable of accommodating the extreme cantilevers of the raised library block. The house's dimensions are determined by its mode of transportation: It was constructed off-site in a factory, brought to its site on eighteen-wheelers, and assembled *in situ*. Over time, the steel has rusted to a dark brown, its weathered surfaces merging with the forested landscape.

Through the use of thin-film photovoltaic textiles, KVA's 2007 Soft House transforms the prosaic curtain into an energy-harvesting textile that can generate and distribute up to 16,000 watts of renewable electrical power. Translucent, movable curtains convert sunlight into energy throughout the day while facilitating changing spatial configurations. Parametric design software developed for the Soft House project allows the homeowner to customize the energy density of the textiles according to need and guides the relationship of building form to site: Technological invention produces the spatial experience.



Inspired by homeostasis in biological systems (a system that regulates its internal environment and tends to maintain a stable, constant condition of properties such as temperature) Decker Yeadon's Homeostatic Façade System regulates a building's climate by responding to environmental conditions. It does so by using a simple actuator, or artificial muscle, to transfer electric energy directly into mechanical work. The façade's silver-coated ribbons automatically deform in response to heat, increasing their surface area and thereby preventing thermal gain and reducing energy consumption.

Smart materials

Smart materials are materials that are designed to actively perform, whose shape or properties change in response to an external stimulus. Michelle Addington explains that smart materials design *behaviors*, with the actual materials being secondary to the effect that they produce. These behaviors are programmed into the material's composition and when activated (by for example temperature, moisture, electricity, or stress) the material's functionality is transformed, allowing it to perform in or adapt to a particular set of circumstances. The use of smart materials alters our understanding of materials from being static elements that are meant to withstand one or more predetermined environments to being animate substances that have the potential to engage continuously changing environments and are fully capable of reconciling the body with its cultural and physical environments.

Similarly, *nanotechnologies* provide us with the ability to manipulate material at its atomic and molecular scales. The material scientist Michael Cima speaks of simultaneous fabrications in which multiple programs are embedded within a single material structure. Like a hearty stew, various predetermined material properties (such as transparency, acoustic properties, strength, warmth, and illumination) might be layered into the 'process of their fabrication,' introducing an interactive programmatic complexity to a single composite material. These nanocomposite materials not only improve material strength and performance, but recent exciting research reveals a potential for introducing multifunctionality into singular building surfaces.

David Adjaye's Genesis pavilion installed at the Design Miami 2011 fair is constructed of hundreds of equally dimensioned wooden timbers. Floors, walls, and ceilings are created out of the same material increment, and it is the manipulation of the spacing between these planks that allows for the various programs of sheltering, structuring, entering, framing, viewing, screening, and reposing.

Bamboo is highly regarded for both its material behavior and sustainable properties. Its usage is directly related to the method by which it is processed. Its stems can be bundled, cut, split, flattened, twisted, woven, and laminated, each process lending itself to a unique constructional process. Simon Velez's "Church without Religion" in Cartagena, Colombia, exploits bamboo as structural armature, a framelike lattice of bamboo rods that tethers the building to its site.

Yet a temporary church in Yogyakarta, Indonesia, (right) demonstrates a decidedly alternative application. Here, the architect Eugenius Pradipto transforms bamboo into a series of flattened shingles that wraps the church's structural framework. In both of these examples, bamboo is alternatively exploited as both structural framework and porous skin.

Constructive Processes

Constructive processes are often a function of a material's properties and of their intrinsic dimensional standards and limits, which can, in turn, greatly influence its usage and how it might be detailed. These processes are equally a function of the location of the project (ease of accessibility, the expertise of those building it) and affordability.

Manufacturing Methods

The dimensional limits of a material are either determined by its natural state or imposed on it by the manufacturing processes used to transform a material from its natural state into a useful building material. This link between origin and application can be exploited in projects where a material's dimensional increment, either in its natural state or as manufactured, is consistently registered while accommodating a variety of programmatic and environmental concerns. For example, the densification or expansion of a particular dimensional increment can alter a surface membrane's porosity or provide the logic for the operation of its apertures.

Manufacturing processes not only inform a material's dimension but can also demonstrate a unique characteristic or behavior. For example, a quarried block of granite can be cut into monolithic blocks or sliced into thin slabs—the one producing the effect of a massive wall while the other, a thin membrane. The exploitation and exaggeration of these processes can be a powerful tool in the development of an architectural concept.

Massimiliano Fuksas's Museum of Graffiti in Niaux, France, completed in 1993, is located in an extreme site on the side of a hill and at the mouth of a subterranean passage that leads to prehistoric cave paintings dating from 11,000 BCE. The difficulties of access required the on-site assembly of steel components that had been precariously transported up a small access road. Not only does the rusting of the weathering steel components protect the structure and minimize the necessity for maintenance, but their apparent weightlessness is suggestive of the delicacy of the cave drawings to which the pavilion provides access. The line of the cave drawing is conceptually extended out to the face of the mountain, erupting into a three-dimensional expression of the two-dimensional drawings deep within the mountain.

Assembly

Site access, methods of transportation, and builders' expertise can further inform material choices. Transportation and site access can limit the dimension of materials that can be delivered to a site, which will then either require on-site assembly of smaller components (that have been fabricated elsewhere) or demand on-site fabrication. In these extreme sites, an understanding of local or traditional construction practices can inform material choices and construction processes.

Detail/Jointure

Materials undergo various degrees of change as they react to environmental conditions (gravity, temperature, erosion, and pollution) or as they react to other materials (corrosion and staining). Strategies for addressing these changes are often demonstrated at the intersections between adjoining materials. For example, each material responds to temperature variations by exhibiting a unique range of expansion and shrinking behaviors. As one material meets another, these behavioral differences must be acknowledged either through not letting the two materials touch, as in a "reveal" (a small gap left between the materials), by allowing the materials to overlap so that they can move independently or by inserting a third material that can mediate two materials' distinct behaviors.

Differences in dimensional precision between materials that are fabricated using precise tools (as in steel fabrication or wood cabinetry, for example) versus those that are fabricated on-site using less controllable technologies (as with poured-in-place concrete) can also be accommodated by a reveal, or by introducing a third material that can accommodate the differences between the two (for example by inserting a piece of cork between a precisely milled wood and a rougher concrete surface).

The glass panels that enclose Sverre Fehn's 1973 Hamar (Norway) Bispegaard Museum float slightly away from the thick exterior stone walls of the existing barn. This detail negotiates the distinct dimensional differences between the manufactured crisp glass edges and the fluctuating stone profile, while permitting some of the weather into those parts of the museum where controlled climate might be dangerous to the artifacts. The detail also reinforces the primary concept of the project, that of a series of material and historical layers.

Chamber music was written to be performed in intimate spaces, often made of wood. The interior of the Sala Suggia in OMA's Casa da Musica in Porto, Portugal, 2005, though of another scale, refers to that tradition and the resonant qualities of a wooden music box.

Indices

Materials carry *meanings* through embodying traditional materials, methodologies, and rituals of construction as well as through the less tangible aspects of the uniqueness of place, program, and culture.

Site

A material often operates as an index to a particular site. The use of wood from a local forest not only inextricably links the work to its immediate physical context but to those projects that share a similar material source. The ways in which materials are connected to each other can further reiterate a context by referring to traditional building techniques.

Program

Often, the performance requirements of a particular function will motivate material selection. A wood railing carries with it material warmth that is smooth to the touch, or a stone staircase will withstand centuries of wear.

Cultural

Materials often carry symbolic expectations, as in a granite tomb or a marble city hall or a wood cabin. Granite implies eternity, marble alludes to grandeur, and wood to a natural primitiveness. It does not necessarily mean that all tombs should be granite, but it is important to be aware that traditional associations exist, and they may be unique to each culture in which a work might be situated.

Blocks of locally hewn granite form the cubic mass of Ensamble Studio's Musical Studies Center in Santiago de Compostela, Spain, built in 2002. The hydraulic drilling techniques related to the stone's extraction are expressed and celebrated on its surfaces, transforming a prosaic and unremarkable constructive detail into an essential ornamental motif. The material is converted into a didactic tool, an index to a fast-disappearing quarrying technology.