On Materials

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Design is the process by which abstract ideas assume concrete form and thus become active agents in human affairs. One of the critical parameters in any discussion of designed artifacts is material: what something is made of and how the material employed affects the form, function, and perception of the final design. In a broad sense, the story of materials, their discovery, and subsequent manipulation constitutes a significant thread in the history of civilizations, and often provides a common point of reference for cultural discourse in general. In the long view of history, the degree to which humans were able to exploit different materials has been taken as an indication of the level of technological sophistication achieved by different cultures. We speak of the Stone Age or the Bronze Age as readily identifiable chapters in the human story. In the more compact purview of the history of modernity, the advent of new materials generally is treated as one of the determining factors in the development of modern design. Beyond serving as an index of technological sophistication, different materials have acquired distinctive and widely shared cultural associations. If, for example, I identify a particular period as constituting a "Golden Age" in the history of a civilization, or describe a hero as having feet of clay, the reader understands the judgments expressed in such hoary phrases. The 1967 movie *The Graduate* provides a more recent example of this same phenomenon. When Benjamin Braddock—he is the fresh, young graduate of the movie's title—is offered career advice, the audience recognizes that an entire lifestyle has been devastatingly described with a single word: plastics.

As one moves from the realm of popular perception to the professional domain of design practice and the interdisciplinary field of design studies, the discussion of materials and materiality grows more complex. Materials, for example, can serve as a lens to focus insights derived from different disciplinary perspectives and methodologies. Design research—whether it is directed at the history of design, the refinement of design theory, or the advancement of design practice—often requires that the researcher pursue knowledge and insights embedded in different disciplines. The challenge of interdisciplinary work involves the integration of insights gained from exposure to different disciplinary perspectives. In terms of the argument I am developing here, the first step is to recognize the complex and frankly problematic nature of materiality in the modern era.

In 1956, the Reynolds Metals Company, one of the three major producers of aluminum in the United States, published a handsome two-volume survey of architectural uses for aluminum. *Aluminum in Modern Architecture* included a portfolio of recent buildings demonstrating architectural applications of aluminum, a technical section detailing the properties of the material, and a collection of interviews with twenty-seven architects and engineers in which they described their enthusiasm for aluminum's multiple applications in architectural design. One of the prominent voices included in this section belonged to Ludwig Mies van der Rohe. He began his discussion with a curious warning:

> The danger with aluminum is that you can do with it what you like; that it has no real limitations.[1]

I cite Mies van der Rohe as a way to begin my discussion of modern materials because he suggested that we understand the advent of new materials in the modern era as posing a new problem rather than providing a simple solution for whatever design opportunity is being considered. In constructing accounts of design in the modern era, we should be wary of deterministic approaches to the subject predicated on a positivist approach to history that suggests new materials naturally and inevitability generate new formal languages for design.

If Mies's warning represented an isolated position by an eccentric figure, we could dismiss it. However, he was not alone in registering a note of caution when discussing the brave new world of modern materials. In his 1940 treatise on industrial design *Design This Day: The Techniques of Order in the Machine Age,* Walter Dorwin Teague noted the epoch defining quality of modern materials. Today, he observed, designers are no longer limited to the catalog of materials available directly from nature:

> Our modern partnership between science and industry, with the great expansion of research laboratories and experimental stations through which it works, is able to meet our needs with reasonable promptness ... so that our repertoire of available resources is far more extensive than any possessed by designers heretofore.[2]

Teague went on to suggest that this partnership between science and industry presented designers with a challenging new context for professional practice, one they did not always handle well:

> These forces whose power we feel are not novel: they merely move more swiftly and so with greater impact, and they vary their direction more frequently, than they used to do. The peculiar difficulty of our position is that this interaction of forces is accelerated almost beyond our ability to keep pace with it in conscious mastery of our resources....

1 John Peter, *Aluminum in Modern Architecture* (Louisville, KY: Reynolds Metals Company, 1956), vol.2, 248.

2 Walter Dorwin Teague, *Design This Day: The Technique of Order in the Machine Age* (New York: Harcourt, Brace and Company, 1940), 68–69.

> But the Machine Age in its multitude of inventions has not only included our long repertoire of new materials, it has enormously increased the number and kind of things we can do with materials, old as well as new. It is not surprising that as a result we have fumbled very clumsily with many of our unfamiliar stuffs, while we ran wild in inept uses of those our forefathers understood so well.[3]

Publications like *Aluminum in Modern Architecture* and *Design This Day* are often described as self-promoting celebrations of individual designers, the design profession as a whole or specific industries. A close reading of this mid-twentieth century literature reveals, however, a significant maturation in design thinking compared to the prophetic but often technologically uninformed discussion of materials by designers generated earlier in the century. In 1924, for example, Mies van der Rohe could write confidently:

> Industrialization of the building trade is a question of material. Hence the demand for a new building material is the first prerequisite. Our technology must and will succeed in inventing a building material that can be manufactured technologically and utilized industrially. It will have to be a light material whose utilization does not merely permit but actually invites industrialization.[4]

A quarter century latter, and now fully immersed in a technologically sophisticated and industrialized building culture, Mies moderated his tone a bit and tempered his enthusiasm with a warning concerning the "danger" of materials characterized by seemingly limitless potential. In the comments by Teague and Mies cited here we see the emerging recognition among modern designers of a daunting new level of complexity that rendered traditional ways of thinking about the relationship between material and form increasingly outmoded.

Once we begin to listen to what designers like Teague and Mies van der Rohe were trying to tell us—that materials are not just a "given" to be incorporated in the designer's calculation but are part of the design problem—then the need to articulate a critical framework for the discussion of materials becomes obvious. Jeffrey Meikle opens his history of plastic with the following observation:

> Plastic itself, by its very nature, complicates efforts to think about it. Able to assume many degrees of shape, texture, hardness, density, resilience, or color, the myriad varieties are united only by a word—plastic—that has defied most attempts to promote specific trade names. What do we mean when we talk about plastic?[5]

3 Teague, *Design This Day*, 69–71.

4 Ludwig Mies van der Rohe, "Industrialized Building" (1924) reprinted in: Ulrich Conrads, *Programs and Manifestoes on Twentieth Century Architecture* (Cambridge, MA: MIT Press, 1970), 82.

5 Jeffrey Meikle, *American Plastic: A Cultural History* (New Brunswick, NJ: Rutgers University Press, 1995), 3.

In addition to my own work on aluminum,[6] in recent years, our understanding of the design history of materials has been enriched through the research of historians and curators like Gwenaël Delhumeau, Clive Edwards, Robert Friedel, Hans Joliet, Jeffrey Meikle, and Penny Sparke.[7] And, while not strictly speaking works of historical scholarship, the important contributions of Paolo Antonelli, Philip Ball and Ezio Manzini to the discussion of contemporary developments in materials technologies needs to be acknowledged here.[8] The fruit of all this scholarship is, I suggest, a new framework for the discussion of materials based on the triad: fabrication, application, and appreciation.

Fabrication deals with the initial stages in the life cycle of materials. It refers to the extraction, refining, and preparation of materials for initial use. In the case of aluminum, for example, fabrication involves extracting alumina from bauxite ore and reducing it to aluminum through a process of electrolysis. While in the case of plastics, fabrication involves calculating the particular molecular composition of the polymers to be employed. A historical discussion of fabrication involves tracing the scientific insights leading to the discovery of ways to produce new materials with specific properties. Discovery is followed by production and a discussion of fabrication also encompasses the growth of an industrial base technologically and financial able to produce the material in commercially significant amounts.

Application deals with transformation of materials into products. It involves the efforts of designers to match new materials to existing product needs, to develop new uses for novel materials and to impose a formal vocabulary on materials. This formal vocabulary can be imitative of other materials or emphasize properties and characteristics unique to the material in question. Mapping the various applications of new materials is familiar terrain for design historians because it traces the role of designers in the product development process. In my own work on the history of aluminum, for example, I have argued that designers enter the story to a significant extent when advances in metallurgy and production technologies (i.e. developments belonging to the story of fabrication) no longer are enough to sustain the growth of the aluminum industry. Furthermore, that the activity of design (understood as distinct from that of basic scientific research and production engineering) increases in importance as the competitive nature of the industry grows.

Appreciation deals with the reception of materials by the entire community of users who come into contact with whatever material is being studied. A history of appreciation traces the multiple and shifting response of different constituencies as they encounter artifacts endowed with a distinctive material identity. Just as a concern for the application of materials shifts the focus from scientists and engineers to designers, the turn from exploring application to appre-

6 Dennis Doordan, "Promoting Aluminum: Designers and the American Aluminum Industry," *Design Issues* 9:2 (Spring, 1993): 44–50; and "From Precious to Pervasive: Aluminum and Architecture," in Sarah Nichols, editor, *Aluminum by Design* (New York: Harry N.Abrams, 2000).

7 Gwenaël Delhumeau, *L'invention du béton armé. Hennebique, 1890–1914* (Paris: Editions Nomra, 1999); Clive Edwards, "Aluminum Furniture, 1886–1986. The Changing Applications and Receptions of a Modern Material," *Journal of Design History* 14 (3): 207–225; Robert Friedel, "Some Matter of Substance," in *History from Things: Essays on Material Culture,* edited by Steven Lubber and W. David Kingly, (Washington D.C.: Smithsonian Institution Press, 1993); Hans Joliet, *Aluminum: die ersten hundert Jahre* (Düsseldorf: VDI Verlag, 1988); Sarah Nichols, editor, *Aluminum by Design* (New York: Harry N. Abrams, 2000); Penny Sparke, editor, *The Plastics Age: From Modernity to Post-Modernity* (London: Victoria and Albert Publications, 1990).

8 Paola Antonelli, *Mutant Materials in Contemporary Design* (New York: Museum of Modern Art, 1995); Philip Ball, *Made to Measure. New Materials for the 21st Century* (Princeton, NJ: Princeton University Press, 1997); Ezio Manzini, *The Material of Invention* (Cambridge, MA: MIT Press, 1989).

ciation shifts the focus again, this time from designers to consumers and those critics, commentators, and trends setters who shape the cultural understanding of materials.

At this point, some refinement of a framework based on this triad of terms is necessary because a simple listing of the terms fabrication, application, and appreciation suggests they exist as discrete categories separate from each other chronologically as well as in terms of the "cast of characters" involved at each stage and the language each cast uses to discuss its respective domain of activity. In working with these terms, however, researchers soon recognize areas of overlap between these terms and the role of feedback loops within the sequence fabrication, application, and appreciation. Designers, a group I have identified as key players in the discussion of the application of materials for example, routinely respond to feedback from consumers. In the same way, the type of basic research and development activities characteristic of the fabrication phase of the material story often involves input from constituencies located in later stages of the material life cycle. The critical terms described here are serviceable to the degree they can clarify the type of questions researcher should ask and suggest the type of sources to be consulted in pursuit of answers. Interdisciplinary research is complex and the interpretive framework proposed here brings into sharp relief what stage in the life cycle of materials is under review at any moment in the research process.

A second clarification involves the concept of time. It is not my intention to specify in a restrictive manner the temporal dimension of these terms. Any attempt to discuss the appreciation of aluminum, for example, must take into account the shifting perceptions of this material as it evolves from a precious material in the nineteenth century to a pervasive one in the twentieth century. The rapidity of social and technological change and the fluidity of cultural meaning are recognized as characteristic features of the modern era. In the modern era, discussions of *what* must always be coupled with an appreciation of *when* in order to capture the fine details as well as the big picture in terms of the story of materials in the modern era.

A third clarification involves the place of natural materials in the critical schema presented here. The Teague passage cited above reminds us that the catalog of materials available to designers has expanded dramatically in the modern era. But the arrival of new alloys, polymers and laminates did not mean the disappearance of traditional natural materials. Substitute *cultivation* for the term *fabrication* and the schema works just as well for materials like cotton, bamboo or oak as it does for aluminum and plastic.[9]

In 1992, Richard Buchanan published an article in this journal entitled "Wicked Problems in Design Thinking." In it, Buchanan introduced a conceptual tool he called the "doctrine of placements." He used the concept of placements, which he described as broad

9 See, for example, Nancy Moore Bess, *Bamboo in Japan* (Tokyo: Kodansha International Ltd., 2001).

areas of particular types of design activities, as a way to explore the nature of invention in design activity. He observed that the conceptual repositioning of a design problem from one place to another often sparked innovative solutions. In an attempt to refine the concept of placement he distinguished it from the more familiar concept of category.

> Categories have fixed meanings that are accepted within the framework of a theory or a philosophy, and serve as the basis for analyzing what already exists. Placements have boundaries to shape and constrain meaning, but are not rigidly fixed and determinate. The boundary of a placement gives a context or orientation to thinking, but the application to a specific situation can generate a new perception of that situation and, hence, a new possibility to be tested.[10]

Buchanan is concerned here with design practice. If, however, we substitute research for design practice and consider my terms *fabrication, application,* and *appreciation* as designations for the different "placements" of research emphasis the scope and applicability of the doctrine of placements expands substantially. Hopefully, the critical framework outlined here will transform, what Walter Dorwin Teague characterized as our "peculiar difficulty" into a greater opportunity to treat the discussion of materials with the same sophistication we bring to other aspects of design discourse.

10 Richard Buchanan, "Wicked Problems in Design Thinking," *Design Issues* 8:2 (Spring 1992):10.