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Materials Labs as a Collaborative Teaching Tool for Architects and Engineers

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ABSTRACT

The tectonic form and nature of innovative contemporary architecture is often the result of advances in material science. These advances are usually generated through increasingly integrated collaborations between interdisciplinary teams of architects and engineers.

In contrast, most universities have separate classes on materials for architecture and engineering students. These courses tend to be highly specialized for their respective disciplines: courses for architects tend to emphasize qualitative aspects of materials, while courses for engineers tend to emphasize the quantitative aspects. This specialization is somewhat justified, yet the result is that architecture and engineering students develop different languages to discuss the same topics, a potential impediment to future collaboration.

At California Polytechnic State University, steps have been taken to bridge this gap through the creation of a Materials Lab which is shared by all departments of a multidisciplinary college: architecture, architectural engineering, construction management, landscape architecture and city/regional planning. Although in its infancy, the Materials Lab is positioned to become an interdisciplinary teaching tool that enhances collaborative learning in three ways:

1. It is the common ground where design disciplines and the technical disciplines can share their respective approaches to materials.
2. It is the setting to explore methods and design tools that weave sensate and performance dimensions of material thinking into a single integrated fabric.
3. It is a place to experience first hand the visual, tactile and experiential aspects of materials, both traditional and new, that are the basis of the built environment.

This paper discusses the rationale and philosophy behind Cal Poly's Materials Lab which will have both physical and digital components. The discussion is framed with the understanding that a strong education in materials will improve the ability of students to become architects and engineers who respond collaboratively to contemporary needs and produce a more sustainable built environment.

INTRODUCTION

The future of architecture is being shaped by practices which are redefining the way buildings are designed and built. Practices such as Herzog and De Meuron, OMA, Gehry and Associates, Morphosis, Toyo Ito, KieranTimberlake and ShOP among others, are developing new modes of design and production while engaging materials in unprecedented ways. Not only do buildings by these architects look different, they are different. The new modes used to produce them employ a more synthetic work and information flow between interdisciplinary team members. And although relationships between architects, engineers, contractors, fabricators and material scientists have always been implicit in the architectural process, these relationships are becoming much more direct with less division of labor between disciplines. In part because of collaborative relationships, these architects are not only developing a deeper understanding of basic material properties and a pushing their limits for greater aesthetic and technical performance, they are also recognizing material advances in other fields and transforming them into innovative architectural strategies.

I. The New Design/Production Paradigm

> If you want to survive, you'll have to change. If you don't change, you're going to perish. It's as simple as that. You will not practice architecture if you're not up to speed with this. You will absolutely not practice architecture in ten years. I have no doubt about it.
>
> Thom Mayne in "Change or Perish" (2006: 5)

The redefinition of the process used to create architecture, as well as the shifts in the relationships between disciplines involved, is the focus of *Refabricating Architecture* by Stephen Kieran and James Timberlake. In it, they observe the integrat-

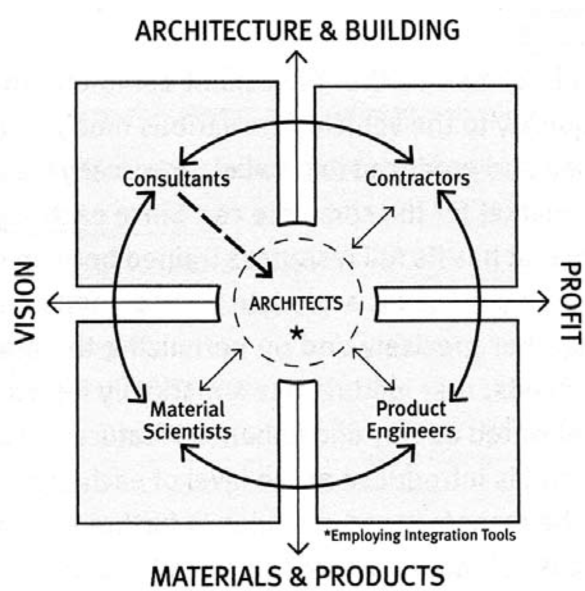

Fig. 1 Kieran and Timberlake's model of relationships is more integrated that the traditional model.

ed modes of production used to create complex objects such as automobiles and airplanes and assert that architecture should be designed and produced in a similar way (see fig. 1). They write, “The process of making is no longer entirely linear. Producers engage in design, and designers engage in production. Production becomes part of the design process by working with assemblers from the outset, designers picture how things are made, their sequence of assembly, and their joining systems. Materials scientists are drawn into direct conversation and problem-solving with engineers and even with designers. The intelligence of all relevant disciplines in used as a collective source of inspiration and constraint” (2004: 13).

Thom Mayne of Morphosis graduated from architecture school in 1969. For the first thirty years of his career he practiced as he was taught: using a traditional process with clear distinctions between creative and technical efforts. Ten years ago he computerized his office and ever since has followed new visualization, communication and fabrication technologies as they first emerged, then converged. His incorporation of these technologies into the working culture of his office transformed their approach to architecture. About the process used for the recently completed GSA Building in San Francisco Mayne observes, “We did no two-dimensional drawings for this project. Three-dimensional models provided continuity from the initial concept to construction documents. The design model connects directly with the Permasteelisa Group, which continued through the design process, blurring the line between the architect and the sub-contractor. The model feeds directly into prototyping; and finally, into the fabrication and assembly of the construction. This environment is no longer linear. It allows us to continually move back and forth between micro and macro.” To hear Mayne tell it, the future is here and it is both demanding and liberating: “The tools we now utilize simplify potentialities and make them logical, allowing us to produce spaces that even ten year ago would have been difficult to conceive, much less build. Our conceptual thinking is increasingly embedding tectonic, constructional, and material design parameters. Less emphasis in the traditional sense—styling, let’s say—and more emphasis on making” (2006: 3).

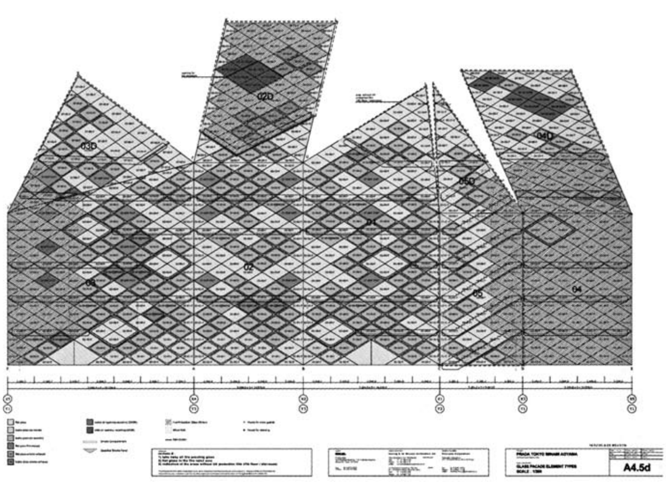

Fig. 2 Herzog and De Meuron’s drawing of the skin of the Tokyo Prada Store. It’s two-dimensional, but why?

II. The New Materiality

How will materiality respond to the infinite transformational processes of digital production? Internalization, invisibility, and speed of transformation demand from architects a nuanced understanding of materials and fabrication techniques, because production of materials and fabrication of building components will soon be simultaneous.

Toshiko Mori in *Immaterial/Ultramaterial* (2002: XV)

The reciprocal relationship between technology and materials is the basis of material culture in general, and the built environment in particular. During the same period that technology has been transforming modes of design and production, a new awareness of traditional and new materials has emerged. The surging interest in materiality is stimulated by two trends: the appropriation of materials developed for other fields by architecture, and a growing concern for resource management and material ecology.

Jacques Herzog and Pierre de Meuron are known as architects who approach their buildings as a form of research, with much of their creative energy being focused on the crafting of innovative materials (see fig. 2 and 3). Herzog has written, “We look for materials that are as intelligent, as virtuoso, as complex as natural phenomena, materials that not only tickle the retina of the astonished art critic, but that are really efficient and appeal to all of our senses. This is a strategy that gives us the freedom to reinvent architecture with each new project rather than consolidating our style. It also means we are constantly intensifying our research into and with materials and surfaces sometimes alone and sometimes in collaboration with various manufacturers, laboratories, with artists and even with biologists” (2001: 24).

Herzog’s words connote two important themes. The first is one that has been repeated throughout this paper: to successfully engage new technologies and materials, architects must engage other disciplines. The second theme is that innovation need not come at the expense of environmental responsibility.

Although it has been estimated that more new materials and products have been developed in the last twenty years than in the prior history of materials science, designers must be cognizant of the social and environmental impacts of all materials, new and traditional. In *Material Architecture*, John Fernandez underscores the impact of architecture on the environment and the increased burden of responsibility assumed by the architect when employing new new materials. He writes, “Today, improving the environment requires a reconsideration of the contribution of materials in the process. One such issue is the relationship between the production and consumption of materials and the service lifetime of buildings. Yet, buildings do constitute an enormous store of materials used in construction—primarily due to their long lives. Understanding and designing within an organized ecology of the built environment, and not just for a single project’s needs, requires more information about the material flows for construction. Therefore, the ecology of the built environment becomes one aspect of the study of materials for buildings” (2006: 6).

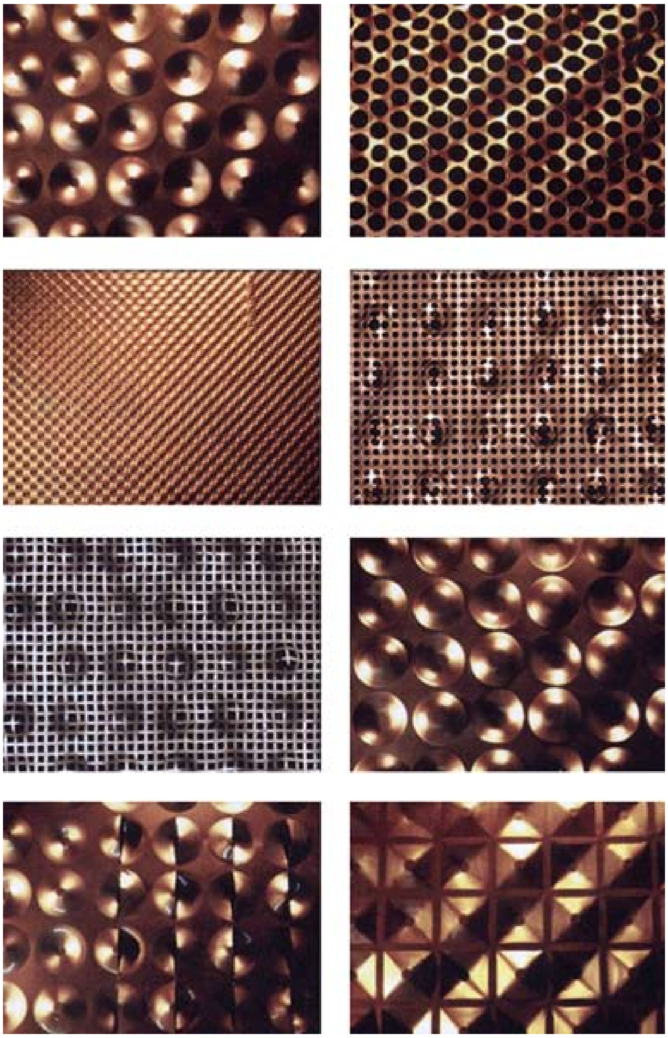

Fig. 3 Herzog and De Meuron's studies for the copper skin of the De Young Museum.

III. The Responsibility of Architectural Education

Changes in the profession of architecture inevitably place pressure on architectural education. It is acknowledged that education must meet the needs of the profession. But education's most important role is to shape the trajectory of exploration after graduation, thus contributing to the future of the profession.

Renee Cheng in "Suggestions for Integrative Education" (2006:2)

The question is not whether architectural education has a responsibility to respond to these changes in the profession. The vexing question is how. A compelling argument can be made that a complete and radical rethinking of architectural education is necessary. Daniel S. Friedman makes such an argument in his essay "Architectural Education and Practice on the Verge" in which he asks, "What would happen if each architecture school dismantled not just its current curriculum, but also its entire instructional apparatus? What would happen if schools recombined the elements of instruction based on a hybrid model—newly formulated around shifting topics, repertoires, vocabularies, skills, and sequences, in dialogue with changing requirements and conditions for practice, driven by new critical methodologies, commensurate with emerging technology? What would happen if schools acknowledged design as an epistemology more so that a skill; reoriented the development of individual expertise to the ethos of the team; expanded studio as the laboratory for all academic activity in architecture; renounced the jury in favor of 'rounds' (on the medical school model); and elevated building technology, engineering, construction economics, and professional practiced to the same cultural status as visual composition?" (2006:6)

Recognizing both the validity of Friedman's questions and the overwhelming scope of a complete reformulation of architectural education, the Department of Architecture at California Polytechnic State University looked at its program and formulated some questions of its own, more modest in scope, designed to frame immediate changes to how architecture is taught. How can we create an environment that encourages and inculcates a spirit of collaboration between disciplines, now critical to the contemporary practice or architecture? What other types of active learning spaces, besides the studio environment, can inspire the engagement of materials to a higher degree and generate research into materiality?

IV. A Materials Lab at Cal Poly

Architecture heightens the issues brought about by the adoption of new technologies for in contrast to many other fields in which the material choice 'serves' the problem at hand, materials and architecture have been inextricably linked throughout their history.

Addington and Schodek in *Smart Materials* (2005:2)

The Architecture Department at California Polytechnic State University, or Cal Poly as its called, has the fortunate circumstance of being in a college that includes most of the disciplines mentioned as team members by Thom Mayne and Jacques Herzog. Along with architecture, the College of Architecture and Environmental Design (CAED) includes architectural engineering, construction management, landscape architecture and city/regional planning. However, the close physical proximity and shared subject matter between departments hasn't translated into integration; disciplines within the college still suffer from insularity and students in architecture, for instance, have very little interaction with those in engineering.

As with most architecture programs, students at Cal Poly have separate classes from engineers even for those subjects held closely in common such as materials. On one hand, this is expected and desirable, for it allows classes to be highly specialized for their respective disciplines: courses for architects tend to emphasize qualitative over quantitative aspects of materials (see fig. 4), while courses for engineers tend to emphasize the quantitative over the qualitative (see fig. 5). To some extent, the specialization of these courses is justified, yet the result is that architecture and engineering students develop different languages to discuss the same topics, a potential impediment to future collaboration. Ashby and Johnson, observe in *Materials for Design*, "Bridging the gap in information and methods is not simple. The technical terms used by engineers are not the normal language of industrial designers –indeed they may find them meaningless. Industrial designers, on the other hand, express their ideas and describe materials in ways that to the engineer, sometimes seem bewilderingly vague and qualitative. The first step in bridging the gap is to explore how each group 'uses' materials and the nature of the

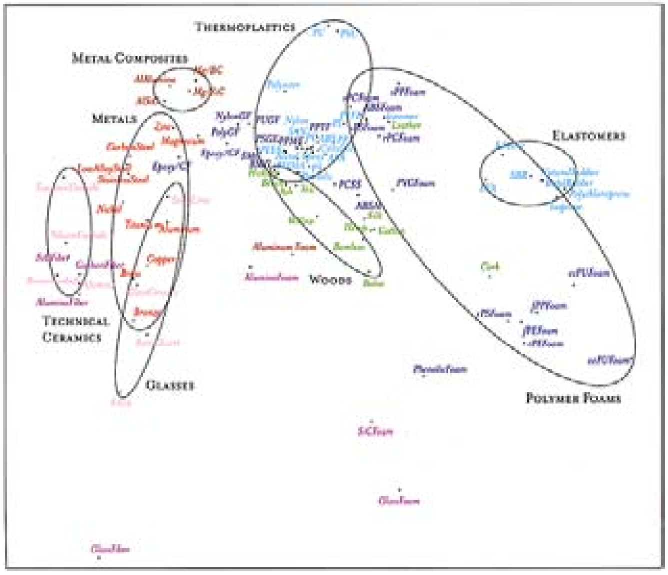

Fig. 4 Ashby and Johnson's depiction of the aesthetic qualities of materials.

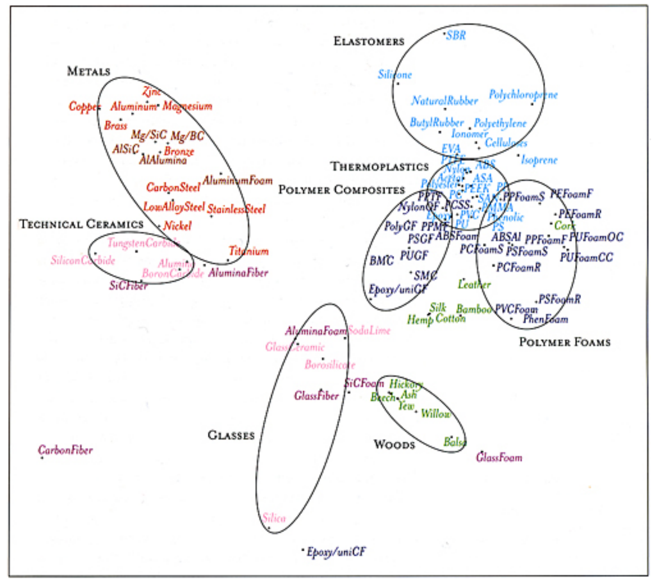

Fig. 5 Ashby and Johnson's depiction of the mechanical qualities of materials.

information about materials that each requires. The second is to explore methods, and, ultimately design tools that weave the two strands of thinking into an integrated fabric" (2002:3). Although they are addressing the difference between industrial designers and engineers, their observations can easily be expanded to include architects.

In 2006, the Cal Poly Architecture Department initiated a Materials Lab that we believe has the potential to become a setting for information gathering and innovation, the measures suggested by Ashby and Johnson as necessary to bridge the gap between designers and engineers. And although the Lab is still in the early stages of development, it is already being used both as a active learning tool and for interdisciplinary collaboration by students in the college.

The Lab is modeled on the Materials Connexion, a materials service created by George Beylerian which is self-billed as the largest global resource of new materials (2005). Although Materials Connexion is a privately-owned and profitable business (underscoring the surging interest in materials), its model of providing both physical space (for samples and exhibits), as well as a complete internet-based database provided us with a viable construct to use as a point of departure.

A. The Physical Component

The physical component of the Materials Lab is extremely imporant to our mission of educating students about mateials in an interactive environment. It is, after all, the most likely place for students to innovate and collaborate in a hands-on fashion.

We located the space very carefully, choosing a 'neutral' location unassociated with any particular discipline in the college so that it can be shared by all. We chose to assume half the space in the College's Media Resource Center, a facility that maintains an image collection, a reference library and a small book/ periodical collection adjunct to the main library (the space became available when slide images were converted to digital resources). Roughly two-thirds of the 1200 square foot Lab is comprised of shelving for the physical sample collection. The remander of the space is used as a meeting area for groups and classes and an exhibition area.

The sample collection is a work in progress. Currently we hold about 500 samples with plans to expand those holdings to 2500. Since it is impossible to have a physical sample of every known material, the emphasis of the collection is on new materials, green materials and smart materials. We encourage students browse the collection, touch and smell the samples, feel their weight and tactility, see their transparency/opacity, and consider the design possibilities that open up when a designer or engineer engages a new material for the first (or fiftieth) time.

Depite its infancy, the physical collection is now integrated into courses on materials. Second-year architecture courses require students to visit the Lab individually and as part of a group to examine materials after they are discussed in lecture. Students from landscape architecture, architectural engineeering and construction management will soon do the same.

Included in the physical component of the Lab is a active learning area for groups and individuals to meet and examine materials. This is considered the 'think tank" component of the space, and it is designed to be flexible enough for individual research, class meetings and presentations by manufacturers. The area includes large, movable tables where materials can be laid out and classes can gather around. This space has a strong relationship to a studio space, but in this case it is shared by all students, of every discipline, in the college.

Also included in this area is an exhibition area. Here, exhibits of all types can be created: materials can be pulled from the collection and given special prominence, juxtapositions can be created across materials classifications, and new materials or products can be highlighted. This area, like the active learning area, was designed to be flexible in anticipation of exhibits we've yet to imagine.

A. The Digital Component

Materials are physical and cultural artifacts that are loaded with information of many types, some understandable through empirical means and others only through intellectual engagement. Where is its place of origin? What is the history of its use? What are its performance characteristics? What are the economics of its production? What are the life cycle implications of its use?

A component of the Lab that is interrelated to the physical component is a searchable database. Data entries will be created for each material sample in the collection, and this information will be linked back to the physical sample with a barcode. This will serve the obvious purpose of faciliting checkout and inventory of samples. At some point in the future when Building Information Models are more widely used by students, the database will provide an important resource. Most importantly, it the database will allow the materials in the collection to be searched and studied from any computer, supplementing the hand-on experience of the physical sample with information that allows the student to understand the place of a particular material in the large context of an increasingly complex material culture.

CONCLUSION

At Cal Poly we understand the necessity to reformulate architectural education in response to the technological and material changes which are transforming practice.While curricular reform may require years, we saw the opportunity to take advantage of the multidisciplinary nature of our college and create a Materials Lab. Although in its infancy, the Materials Lab is positioned to become an active teaching tool that provides students with a way to access to the burgeoning world of new materials while also encouraging collaborations between disciplines.

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