Making Materials Matter[1]

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Fig. 1. Samples in the library show the various compositions of wood products.

INTRODUCTION

Simply put, the two issues weighing most heavily on the future of the built environment are sustainability and integrated practice. The education of architects, engineers, construction managers and all others involved in the creation of the built environment will have to change to make these two issues central to all curricula. Acknowledging the lengthy process of thoughtful curricular reform, this paper examines a program undertaken by faculty and students at California Polytechnic State University to use materials as an incremental measure to address these issues immediately.

Specifically, we created a new materials library intended to:

1. Promote an increased awareness of materials, especially in relation to sustainability, and

2. Provide a setting for collaboration between students of architecture, landscape architecture, construction management and engineering where a spirit of integrated practice can develop.

The first part of this paper examines the rationale behind using materials as a springboard to larger scale curricular reform; the second part discusses the creation and use of the Materials Library at Cal Poly.

MATERIALS AND THE ENVIRONMENT

To be effective at proposing a greener world, designers must be cognizant of the social and environmental impacts of building materials, new and traditional. It has been estimated that a greater number of new materials and products have been developed in the last twenty years than in the entire prior history of materials science. This results in a daunting task for educators and practitioners: how can we keep up with the myriad of new and green products which enter the market nearly every day and evaluate them for incorporation into our projects? The truth is many architects and educators have decided they can't keep up and resort to a reasonable and comfortable range materials that they know and understand.

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 materials. He writes, "Today, improving the environment requires a reconsideration of the contri-

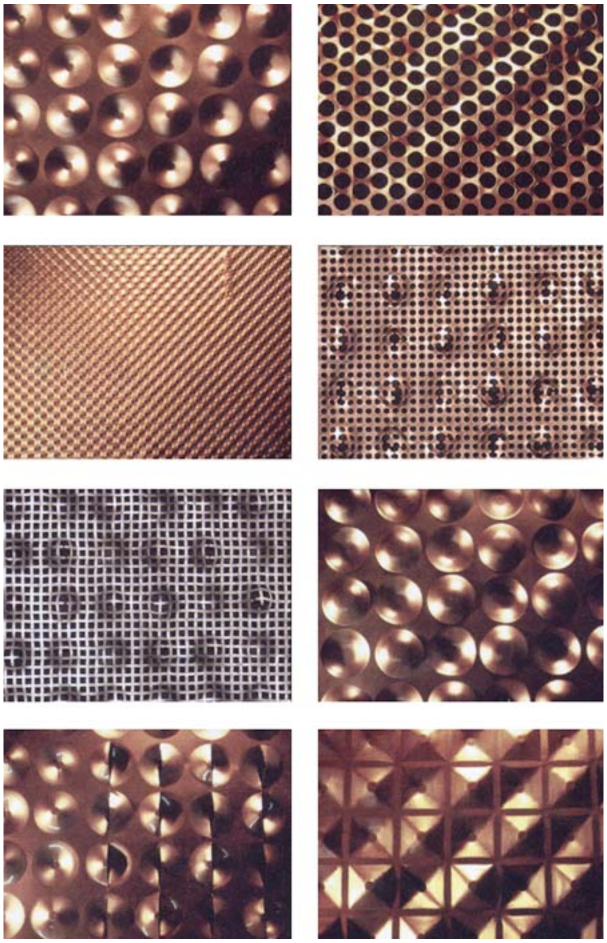

Fig. 2. Copper skin studies for the De Young Museum by Herzog and de Meuron.

bution 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 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".[2]

MATERIALS AS A FORM OF RESEARCH

The most interesting architects and engineers working today are not the least bit daunted by the burgeoning world of new materials. Comfortable with advances in technology and materials, they approach the reciprocity between them as the basis of material culture in general, and the built environment in particular. This 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. To engage these trends, designers must work with a steady hand and a willingness to research the intersection of new materials and their effective, sustainable incorporation into built works.

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 use of innovative materials. 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".[3]

Herzog's words underscore the two themes introduced at the beginning of this presentation. The first is that innovation need not come at the expense of environmental responsibility. The second theme is that other disciplines must be engaged if designers are to successfully engage new technologies and materials. This second theme is the basis of integrated practice.

THE VERGE OF INTEGRATED PRACTICE

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 integrated 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. 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

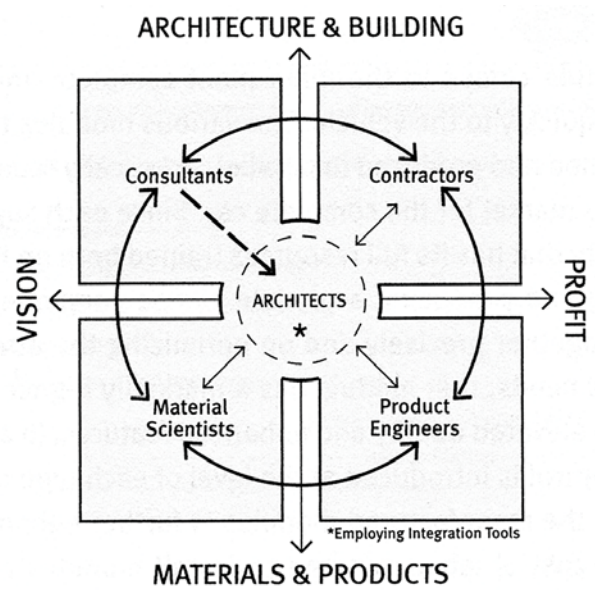

Fig. 3. Kieran and Timberlake argue for new design team relationships that bring architects closer to materials and those who develop them.

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”.[4]

The future of architecture is currently being shaped by practices such as Kieran Timberlake’s and Herzog and De Meuron’s. They, along with others such as OMA, Gehry and Associates, Toyo Ito, SHoP, Morphosis and 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.

Take for example Thom Mayne of Morphosis who 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”.[5]

To hear Mayne tell it, the future is here and it is both demanding and liberating. He writes, “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”.[6]

THE RESPONSIBILITY AND RESPONSE OF EDUCATORS

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 when 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 practice to the same cultural status as visual composition?"[7]

Recognizing both the validity of Friedman's questions and the overwhelming scope of a complete reformulation of architectural education, the Department of Architecture at Cal Poly 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 the ethics of sustainability and inculcates a spirit of collaboration between disciplines, now critical to the contemporary practice of 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?

THE MATERIALS LIBRARY AT CAL POLY

The Architecture Department at Cal Poly 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 includes architectural engineering, construction management, landscape architecture and city planning. Sadly, this inclusion of all the design and construction disciplines in one college has not 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, while courses for engineers tend to emphasize the quantitative over the qualitative. 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.

In *Materials for Design*, Mike Ashby and Kara Johnson observe that, "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 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".[8] Although they are addressing the difference between industrial designers and engineers, their observations can easily be expanded to include architects.

In 2006, the Architecture Department initiated a Materials Library 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, students in the college are already using it both as an active learning tool and for interdisciplinary collaboration.

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. Although Materials ConneXion is a privately owned and profitable business (underscoring the surging interest in materials), its model of providing both physical space (for

Fig. 4. Samples in the library expose students in various disciplines to the dizzying range of polymers and composites.

samples and exhibits), as well as a complete internet-based database provided us with a viable construct to use as a point of departure.[9]

THE PHYSICAL COMPONENT OF THE LIBRARY

The physical space of the Materials Library is extremely important to our mission of educating students about materials 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 Materials Library very carefully, choosing a ‘neutral’ location unassociated with any particular discipline in the college so that all students can share it. 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. Roughly two-thirds of the 1200 square foot Materials Library is comprised of shelving for the physical sample collection; the remainder 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 these holdings to 2500. Since it is impossible to have a physical sample of every 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

Fig. 5. The space is comprised of a materials sample collection, a space for classes to meet and an area for exhibitions on materials/products.

the design possibilities that open up when a designer or engineer engages a new material for the first (or fiftieth) time. A browsing collection offers serendipity: students may begin by looking for a specific material but leave the Library with two or three other materials in hand for future projects. Although we are constantly revisiting our decision, the collection was organized by classifying materials according to the CSI Masterformat, the general specifications format most commonly used in the US. Eventually we may move away from a system that classifies materials by application and towards a system that classifies materials by properties. This will encourage students to think beyond narrow applications and consider materials for their form, aesthetic and technical performance, and fabrication method.

Included in the physical component of the Lab is an 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 is somewhat analogous to a studio space, but in this case it is shared by 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.

Despite its infancy, the physical collection is now being integrated into courses on materials. Second-year architecture courses require students to visit the Library both individually and as part of a group to examine materials after they are discussed in lecture. Students from landscape architecture, architectural engineering and construction management will soon do the same. New projects are being formulated to take advantage of this new teaching and research tool.

THE DIGITAL COMPONENT OF THE LIBRARY

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 Library 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 facilitating checkout and inventory of samples. More importantly, it will interface with two important stages of student design projects: ideation and development. At the early stage of a project students can use the database to browse broad ranges of materials; as with the physical collection, serendipity factors into the browsing activity as cross-links allow students encounter unexpected materials. At later stages of design projects, students will use the database to access performance characteristics of the materials they've selected.

In both of these scenarios, the digital database is meant to interface with the physical collection as students move back and forth between the two different, but related learning experiences. The database allows materials in the collection to be searched and studied from any computer, thus 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. In the future when Building Information Models are more widely used by students, the database will provide an important resource.

CONCLUSION

At Cal Poly we recognize the necessity to reformulate architectural education in response to the ecological and technological changes that are transforming practice. While curricular reform may require years, we saw the opportunity to take advantage of the multidisciplinary nature of our college and use materials as a means to make immediate, incremental changes in the culture of our school. With the creation of Materials Library and courses that integrate its use we hope to promote increased awareness of sustainability and integrated practice. Although in its infancy, the Materials Library 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

ENDNOTES

1. "Material Matters" is borrowed from a number of sources. It is the title of a book by Geiser and Commoner which argues for a sustainable materials policy (MIT Press, 2001), the title of a trade show of cutting-edge materials organized by the Materials ConneXion, and the name of a non-profit organization that provides low-cost building materials to other non-profits involved in community revitalization or affordable housing projects.

2. John Fernandez, Material Architecture (Oxford: Architectural Press, 2006), 6.

3. Jacques Herzog, from his acceptance address for the Pritzker Architecture Prize (Los Angeles: Jensen and Walker, 2001), 24.

4. Stephen Kieran and James Timberlake, Refabricating Architecture (New York, McGraw-Hill, 2004), 13.

5. Thom Mayne, "Change or Perish" in the Report on Integrated Practice (Washington, DC: American Institute of Architects, 2006), 3.

6. Ibid.

7. Daniel Friedman, "Architectural Education and Practice on the Verge" in the Report on Integrated Practice (Washington, DC: American Institute of Architects, 2006), 6.

8. Mike Ashby and Kara Johnson, Materials and Design (Oxford: Elsevier Butterworth-Heinemann, 2002), 3.

9. The idea behind Material ConneXion and a catalog of some of their collection may be found in the book Material ConneXion by George Beylerian, Andrew Dent and Anita Moryadas, (New York: John Wiley and Sons, 2005).