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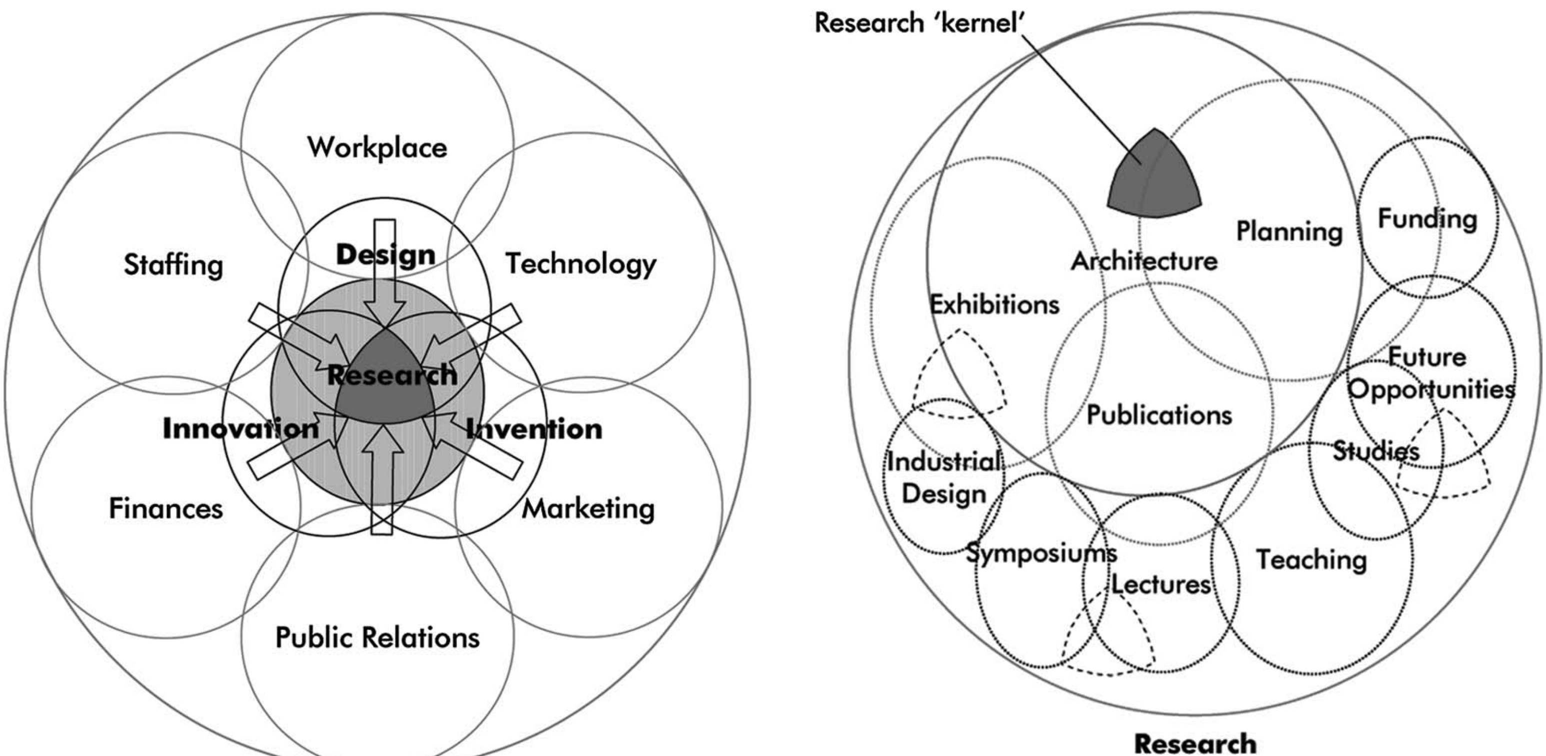
Research in Design

Planning Doing Monitoring Learning

To develop an ethical architecture that unifies the art of design with the science of performance; a research ethic is a necessary prerequisite.



1. Research strategy, KieranTimberlake Associates LLP.

Architects tend to see most acts of design as unique. Site and program together give rise to circumstance. Circumstance inspires intention. Design organizes intention into instruction. Builders construct from what we instruct. And we all move on to the next set of circumstances and program, none the wiser. Architecture exists in a world where all we ever do is design and build prototypes, with little real reflection and informed improvement from one act of design to the next.

This view contrasts sharply with product design. Products are not fixed to place, and they are designed for replication, sometimes in vast quantities. Because of the intention to replicate, good products are subjected to a relentless cycle of improvement. This cycle begins with a plan, then moves to doing, monitoring, and learning—then, it repeats itself with an improved plan and more doing, monitoring, and learning—and so on. At its best, product design is an enduring flywheel that insists upon improving prior acts. It is a flywheel driven by criticism and reflection, underpinned by a research ethic that is not content to just plan and do but rather insists upon measuring performance and learning as the precursors to further planning and doing.

As educators of architects, we focus nearly all our efforts on the planning side of the flywheel. The bulk of our curriculum remains embedded in the nineteenth-century design studio where we plan, then we plan again and again, with little real growth in the quality and productivity of what we do either artistically or technically. While an

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ever-increasing number of schools have included the second part of the flywheel—building—in the curriculum, few schools of architecture teach research skills and fewer yet insist upon critical reflection and learning based upon research findings. In 2000, James Timberlake and I resolved that we were no longer going to teach design studio at the University of Pennsylvania. Instead, we began a design research laboratory that is now in its seventh year. One year later, with the impetus of an inaugural grant from the Latrobe Fellowship through the American Institute of Architecture College of Fellows, we reorganized our practice about a research core (Figure 1). This research core is a culture that we continue to nurture and build. It requires discipline and skill. The discipline is in the ceaseless inquiry about how we can do what we have just done better. The skill is in knowing how to frame questions and seek out measurable data that we can act upon to improve what we have done. We embrace an International Standards Organization (ISO)–certified process in our firm as one way to instill a research culture in our practice. ISO requires embedding reflection and learning into the process of planning and doing. Research is a central part of how we reflect and learn. Our research core is funded both internally through firm operations and externally through occasional corporate, foundation, and government grants. We have full-time staff dedicated to this enterprise. While our design research laboratory at Pennsylvania has been focused on speculative research with only occasional prototyping, the research efforts in our office are more broadly based, ranging from highly speculative projects to applied research that grows from our design commissions.

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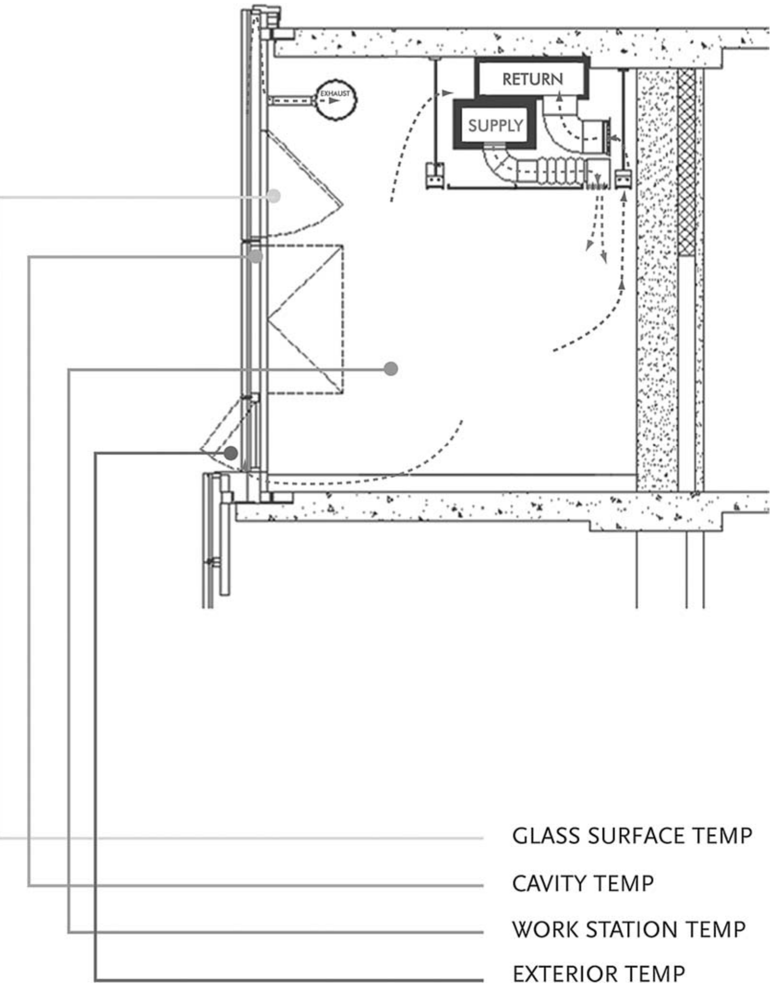
2. Curtain wall construction, Levine Hall, University of Pennsylvania. (KieranTimberlake Associates LLP.)



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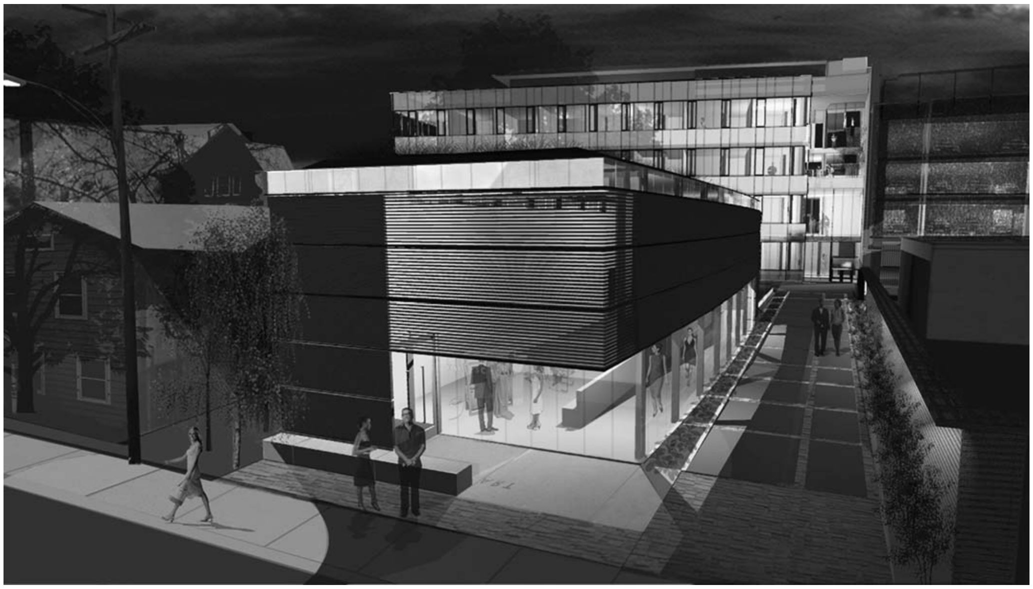
3. Monitoring device locations, Levine Hall. (KieranTimberlake Associates LLP.)



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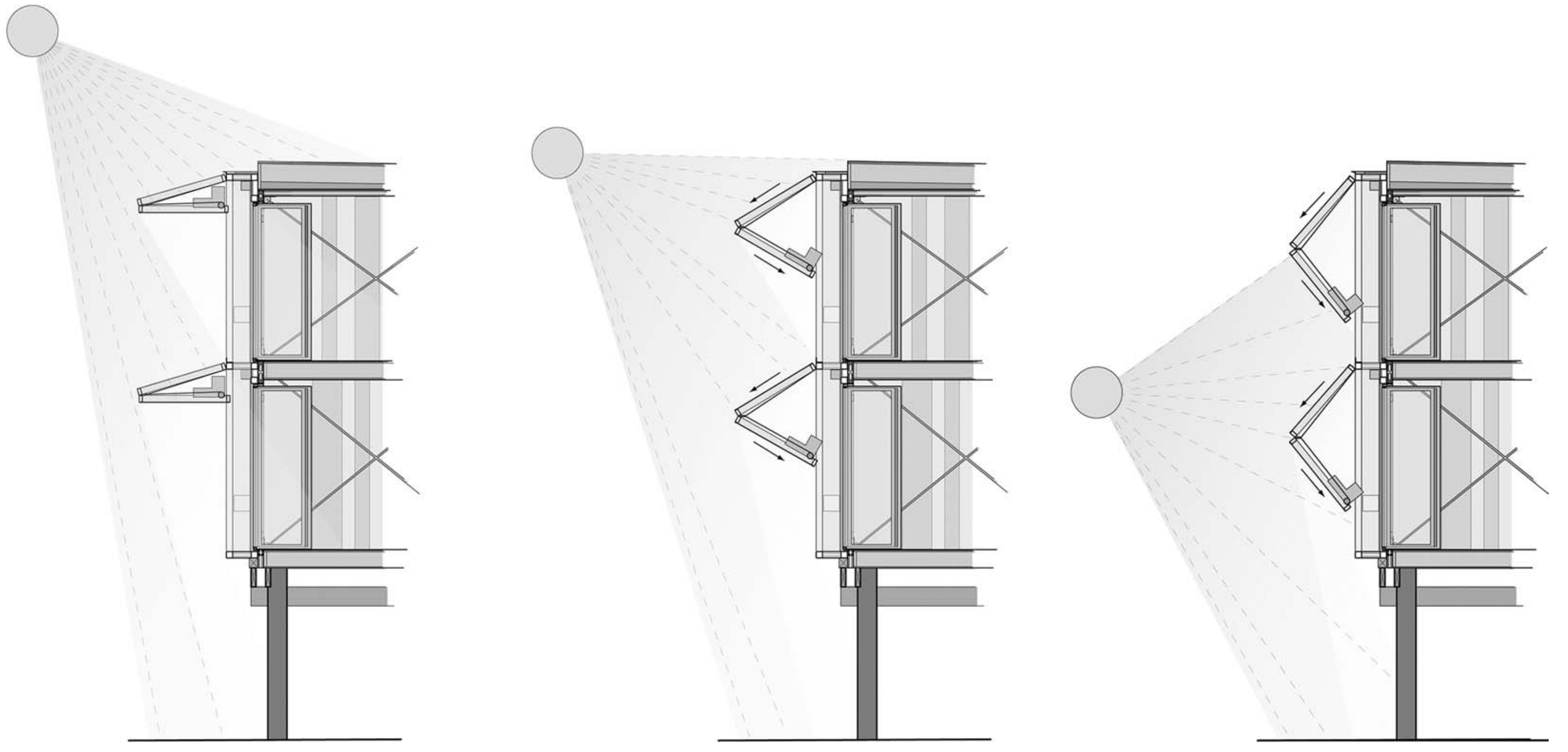
4. View, Sculpture Building, Yale University. (KieranTimberlake Associates LLP.)

5. Monitoring devices, Sculpture Building. (KieranTimberlake Associates LLP.)

A recent series of glass building envelopes provides a window into our evolving effort to establish a deeply engrained research ethic as part of the design process at KieranTimberlake Associates. There are many reasons why large areas of glazing are increasingly employed not only in our work but also in that of many other architects. Environmental factors including daylight and view into and out of buildings are important but they need to be balanced against overall energy use and carbon footprint. Given how important environmental obligations are to architecture, it is alarming how little performance-based research exists on these systems. While we and other architects, engineers, and university-based researchers can and do develop virtual performance models to test our designs, there is little actual verification of those projections after construction. If we are to have a truly performance-based architecture that addresses environmental issues in a verifiable way, then we need to introduce monitoring into our practice. We have an ethical obligation as architects to own the consequences of what we design. We can no longer just complete the project and walk away, exhausted from the effort, looking forward to the next opportunity. Our obligation is to reflect and look back, monitoring, researching, and learning from what we have just done so that we can move forward, however incrementally, aspiring toward a cycle of continuous improvement derived from a performance-based design ethic and aesthetic.

In three projects developed over the past few years, we have introduced the process of monitoring what we have planned and built. Most glass curtain walls suffer from both temperature discomfort for occupants along their perimeter and high energy use to overcome this discomfort. At Levine Hall, a research and teaching facility for the School of Engineering at the University of Pennsylvania, we employed the first active curtain wall in the United States (Figure 2). This wall is glazed with an exterior insulated glass unit (IGU) and an interior glazed panel set about four inches from the exterior glazing. The chamber between these panels is the return air plenum for the building, drawing air in at its base and extracting air out at the ceiling through ductwork into remote air handlers. Because the space between the glass layers is filled with air drawn out of the building interior, the interior glazed surface temperature is similar to the desired interior temperature. Despite the seemingly obvious advantages of this system, little performance monitoring existed. Ali Malkawi, the director of the T.C. Chan Center at the University of Pennsylvania School of Design, introduced monitoring devices to measure temperature and air flow (Figure 3). The results of this monitoring verify the comfort of the interior spaces in a variety of environmental con-



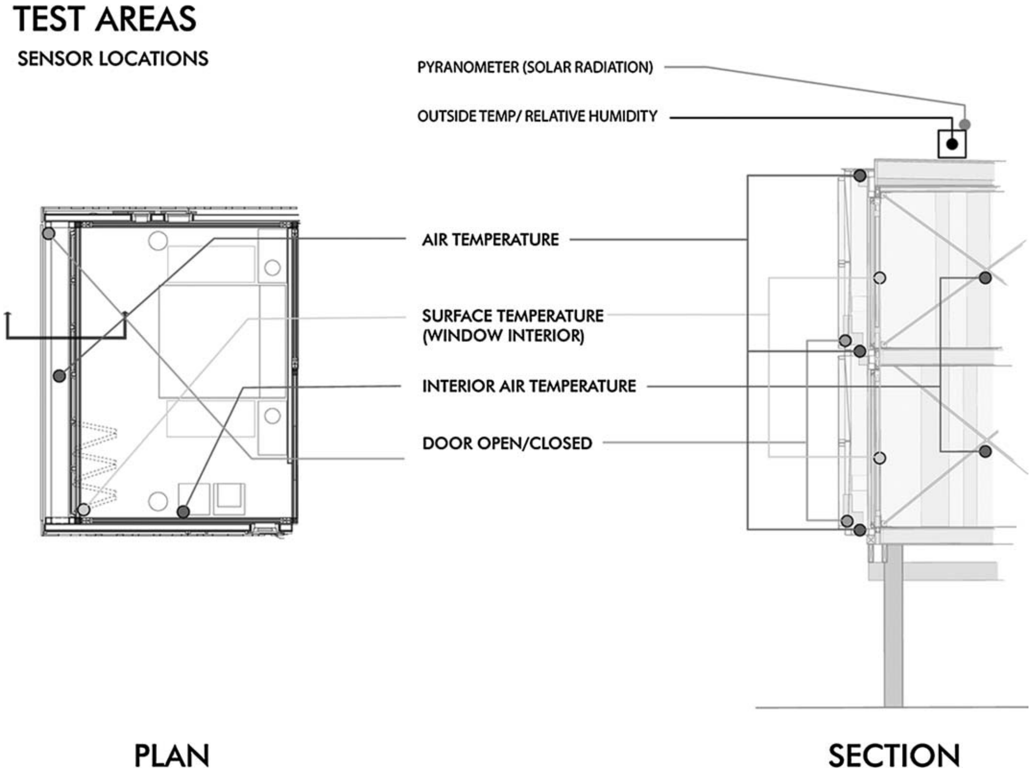
6. From left, west wall positioning at noon, mid-afternoon, and early evening, Loblolly House. (KieranTimberlake Associates LLP.)

ditions. Data produced by these monitoring devices show that temperatures adjacent to the window and at the work surface remain close to seventy-two degrees despite the drop in exterior temperatures. This occurs because the temperature differential between the cavity and the room is negligible, damping conductive heat loss across the interior layer of glass. A further benefit of the active wall system is that the surface temperature of the window remains close to the room temperature for the same reasons, minimizing radiative heat loss from the body to the cold glass as often happens even with facades constructed using insulated glazing units.

At Yale University, we are now completing construction of a new Sculpture Building for the School of Art (Figure 4). The vision lights at all four floors, each eight foot eight inches high, are triple glazed with low-*E* glass. The five foot four inch–high spandrels, including a three and one-half foot–high sill, are double glazed and have a third glazed layer composed of translucent aerogel in a fiberglass panel. Although still translucent, this portion of the curtain wall has an *R* value in excess of twenty, significantly increasing the overall thermal performance of the building envelope. The south and parts of the east facade also incorporate a louvered shading system that reduces solar loads through the vision light and improves lighting conditions in spaces designed for artists and architects. Owing to concerns over heat buildup in the cavity between the clear glazing and the aerogel panels, our research team introduced monitoring devices into the wall assembly (Figure 5). The goal was to determine if the cavity space between the IGU and the aerogel panel required ventilation. To this end, two adjacent panels on the east and south walls are being monitored, one being vented to the interior and the other remaining sealed. The preliminary data suggest that the heat buildup does not exceed the material tolerances of the fiberglass and will not compromise the integrity of the translucent panels in either the vented or the unvented configuration—although the vented configuration does not reach as high an internal temperature as the unvented. The data also suggest that the size of the ventilation apertures (which are essentially just holes drilled in the upper and lower angle stops that secure the translucent panels) is too small to allow for enough air circulation between the cavity and the interior to maintain a temperature equilibrium. Further monitoring and testing will continue throughout the first year of occupancy to determine if cavity temperatures can be maintained at appropriate levels throughout the year.

At the same time, these data suggested a further line of development for this curtain wall system. Even on extremely cold days in February with outside temperatures in the low teens, the heat in the cavity approaches 140 degrees during the day on the south facade. However obvious this information now seems, its existence suggests the potential to use this double-layer system as a solar thermal heating device. Why leave this free very warm air outside the building envelope on such a cold day when it could provide significant passive solar heating if we could introduce it to the building interior? Conversely, on very warm summer days, how might we vent air in this cavity back to the exterior rather that wrap the structure in a heated thermal blanket? The presence of the performance-monitoring information has spurred a new line of inquiry by our research team toward an even higher performing solution. Planning and doing are moni-tored. From the monitoring, we gain insight into a new line of inquiry. We learn from the research and move forward toward even more beautiful and high-performing solutions.

Last, we have just completed a new home on the eastern shore of Maryland. The west elevation of this home faces the Chesapeake Bay and is glazed. To take advantage of the prevailing offshore breeze and the extraordinary site, we developed the home so the entire west wall opens through



7. Monitoring device locations, Loblolly House. (KieranTimberlake Associates LLP.)

accordion-style glass doors that fold against the end walls (Figure 6). In essence, the entire house can become a porch, extending the range of natural ventilation well beyond that of conventional structures. To secure the home in bad weather and to provide an adjustable solar shading system, however, we developed a second layer to this facade. The second layer is a lateral bifolding polycarbonate clad hanger door. It provides protection against excessive wind, and when lowered in the winter months, it introduces a thermal pocket against the glazed western wall. To study the performance of this operable double wall, we introduced temperature and motion sensors to the assembly (Figure 7). We measured and continue to measure temperature inside the cavity and the room against exterior temperature, taking into account the position of bifold hanger doors. The preliminary results suggest a temperature differential during the day that is up to 30 percent warmer in the cavity than the outside air, reducing conductive losses and maintaining higher surface temperatures on the glazed portions of the interior folding doors. Obviously, the system is dependent on incident solar radiation and does not offer significant insulating capabilities on cloudy days. Since the facade faces west and receives radiation in the afternoon on sunny days, however, this temperature differential persists into the evening after the sun has gone down, even though the cavity is open at the base and the polycarbonate and ungasketed hanger door has little insulating value. These data suggest further lines of development, including separating the open two-story cavity into two single-story cavities to enhance the thermal stacking effect and introducing thermal mass into the cavity to store heat for the evening hours. In addition, we will experiment with drawing heated air out of the top of this cavity into the house interior, using the facade as a type of Trombe wall.

Research brings science to our art. Responses to place and program provide intuition to guide form. Research provides information and insight that enhances the performance of our intuitions. Architectural education rightly focuses on develop-ing design intuition. To move the art of architecture forward, however, we need to supplement intuition with science. Research skills need to be brought to the center of the architectural curriculum, providing the basis for a cycle of continuous reflection, learning, and improvement. We need a deep research ethic to guide the art of intuition.