THERMALLY ACTIVE SURFACES IN ARCHITECTURE: 2008 RFP & 2009 UPJOHN RESEARCH GRANTS

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This body of research focuses on the new role of thermally active surfaces in architecture in our work towards low-to-no energy consumption buildings. In this transformation of energy and building practices, the thermal conditioning of a building is decoupled from the ventilation system by using the mass of the building itself as the thermal system rather than air. This method of heat transfer is physiologically and thermodynamically optimal. It also reinvests the fabric of the building itself with a more a poignant role: the structure is also the primary mechanical system. As energy and construction strategy, it yields a cascading set of advantages for the building design and construction industry: radically lower energy consumption, more durable buildings, more healthy buildings, and more integrated building systems and design teams. As such, thermally active surfaces are central to multiple aspects of sustainability.

The Upjohn grant has significantly accelerated the production of the first book manuscript that combines parallel strains of research related to thermally active surfaces: the documentation and illustration of the physiological and thermodynamic basis of thermally active surfaces, the elucidation of changes and amendments to professional practice and the building industry implied with this technique, ten case studies that focus on the illustration/documentation on the systems, performance, and constructability of each project of these case studies. This report summarizes the book and its organization that documents the multi-faceted strains of research on thermally active surfaces.

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Thermally Active Surfaces Research and Documentation

The 2008 RFP & 2009 Upjohn Research Grants have significantly accelerated the research and production of the first book manuscript on the topic of *Thermally Active Surfaces in Architecture*. The intent of this book is to document the basis and efficacy of heating, cooling, and building with thermally active surfaces. In this transformation of energy and building practices, the thermal conditioning of a building is decoupled from the ventilation system by using the mass of the building itself as the thermal system; a paradigm of water, rather than air, as the primary medium of heat channeling and transfer. This method of heat transfer is physiologically and thermodynamically optimal. It also reinvests the fabric of the building itself with a more a poignant role: the structure is also the primary mechanical system. As the basis of energy and construction strategies, it yields a cascading set of advantages for the building design and construction industry: radically lower energy consumption, more durable buildings, more healthy buildings, and more integrated building systems and design teams (Figure1). An important aspect of thermally active surfaces is that they are low-tech yet high performance and are thus equally applicable in the developed and developing worlds. As such, thermally active surfaces are central to multiple aspects of sustainability.

The book is designed to explain this technique to architects, engineers, contractors, and clients. The book combines parallel strains of research related to thermally active surfaces: the documentation and illustration of the physiological and thermodynamic basis of thermally active surfaces, the elucidation of changes and amendments to professional practice and the building industry implied with this technique, ten case studies that focus on the illustration/documentation of the systems, performance, and constructability of each project of these case studies.

Figure 1: As a method of heat transfer, thermally active surfaces offer advantages for the building design and construction industry, including more integrated building systems and design teams. [Source: Geoff McDonell, P.E.]

The first section of the book contrasts the parallel histories of thermally active surfaces and air conditioning. These histories explain the material, social, marketing, and technical unfolding of building technology in the twentieth century as a means to explain why we build the way we do and why that will change in the new century. The next section of the book covers the physiological and thermodynamic basis of thermally active surfaces. This section is designed for engineers and architects to grasp the logic and advantages of this technique. This section also includes a chapter on the de-fragmentation of buildings and design practice inherent in building with thermally active surfaces.

The formal potential inherent in thermally active surface systems constitutes another chapter. Thermally active surfaces engage the body in new ways: sensation and performance on physiological levels as we establish new relationships between body, space, building fabric, and energy. Non-visual ornament and thermodynamic figuration are outcomes of thermally active surface that stand to transform our assumption of what and how buildings are composed. The final section covers a series of contemporary case studies that demonstrate the efficacy of this technique. The project list currently includes Zumthor's Kunsthaus in Bregenz, SANAA's Zollverein School of Management, Steven Holl's Linked Hybrid in Beijing, Peter Rose's Kripalu Housing, Dreiner's Sudwestmettal office in Heilbronn as well as The Fred Kaiser Building in Vancouver, amongst other projects. A multifarious approach to architectural research was critical to this research project and is critical in today's context of integrated design.

Thermally Active Surface Strategies and Research

As architecture often rushes towards technologically rich—if not often technologically determined— research and practices, a more patient study of its own disciplinary assumptions and habits is a source of potent transformation. As neurologist Kurt Goldstein wrote, "there is greater revelation in pathological phenomena."[1] In the case of architecture's thermal milieus, study of air-based techniques reveals oversights and problems that, through study, indicate alternate pathways to its own panacea. The conditions and conditioning of the dominant, convective approaches to thermal comfort in buildings are endemic to a range of problems in contemporary buildings from energy performance and indoor air-quality to durability and the increasing complexity of contemporary construction. By re-evaluating existing techniques—and the overlooked principles in their historical development and repeated implementation—a pathway for the reorientation of building science and systems emerges.

Architecture has as much to gain from a reflexive evaluation of its own eternally recurrent procedures and techniques—its received and repeated knowledge—as it does from leaping its disciplinary bounds for borrowed agendas or new softwares, techniques, or technologies. German sociologist Ulrich Beck has described such an approach as reflexive modernization: "a radicalization of modernity, which breaks up the premises and contours of industrial society and open paths to another modernity."[2] Reflexive modes that place the increasingly relevant material and energy practices of our techniques at the center of architectural production and formation stand to more strategically advance architecture's practices. Stan Allen has called for "a notion of practice flexible enough to engage the complexity of the real, yet sufficiently secure in its own technical and conceptual basis to go beyond the simple reflection of the real as given…a rigorous forward movement, capable of producing new concepts out of the hard logic of architecture's working procedures."[3] When contrasted with the machine mentality cul-de-sac of so-called "new" or "emerging" technologies, a reflexive, if not iconoclastic, approach to disciplinary procedure is no less creative, radical, or adventurous, as the questioning of basic assumptions and tactics must always be. In this case, an interrogatory, reflexive mode of research yields an approach to our current techniques that retires the discipline's thermodynamic and physiological acquiescence in favor of enriched thermodynamic imagination capable of advancing architecture's standing preoccupation with form in our current resource-constricted context. By burrowing into unconsidered disciplinary assumptions, the research on hydronic, thermally active surfaces creates multiple possibilities for architecture. Such engenderment is crucial not only to our current fiduciary responsibilities but more importantly will be fundamental to the achievement of the integrated ecological, economic, social, cultural, technical, thermodynamic, and formal performances that can make architecture so rich. Today, architecture must escape its self-imposed twin constraints of technological inertia and technological acquiescence with sufficient escape velocity to imagine technique anew, for its own techniques are the architecture of sustainability.

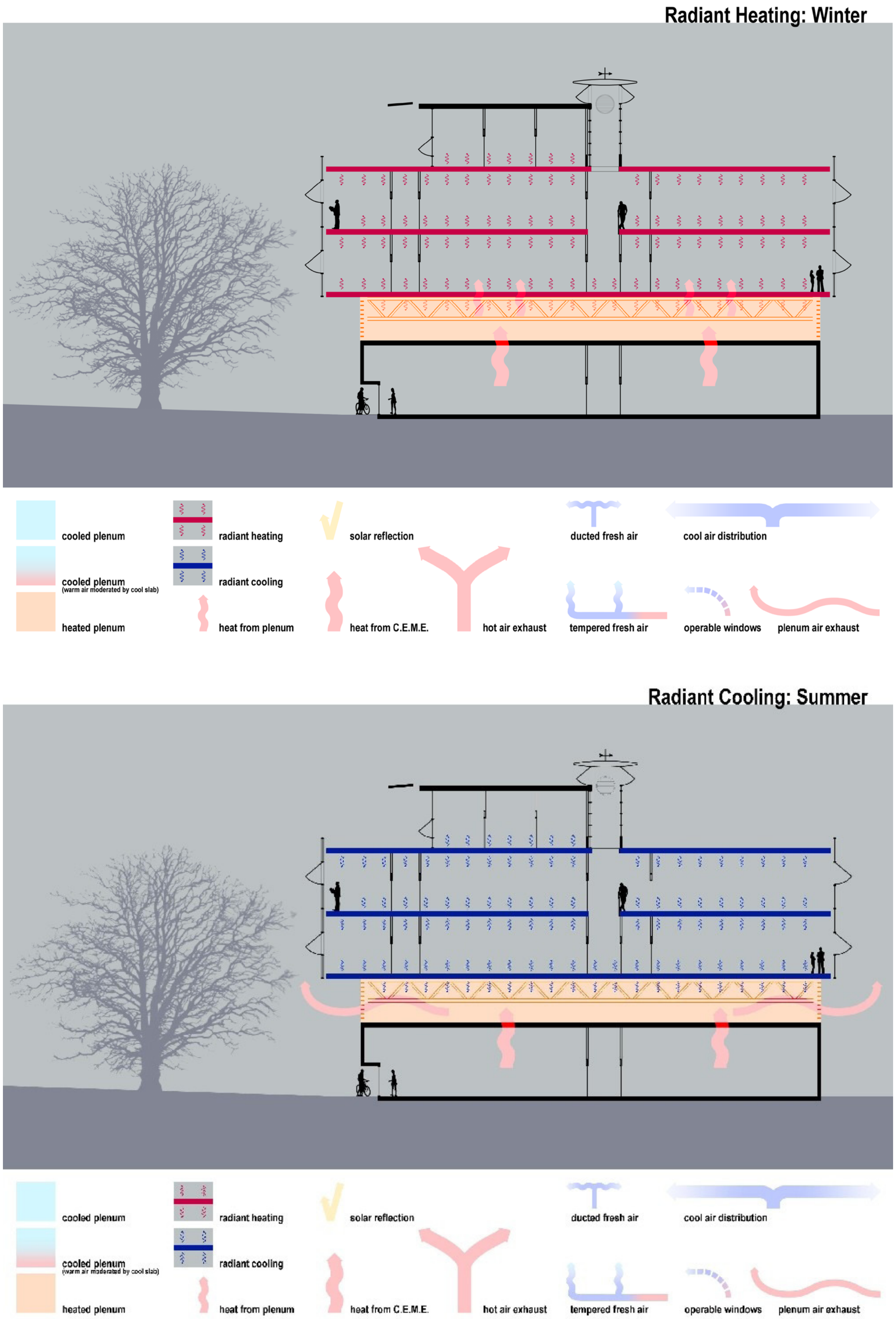

Figure 2: Thermally active surface strategies utilize a low-air temperature approach to heating, that can facilitate zoning and reduce operating costs. [Source: Geoff McDonell, P.E.]

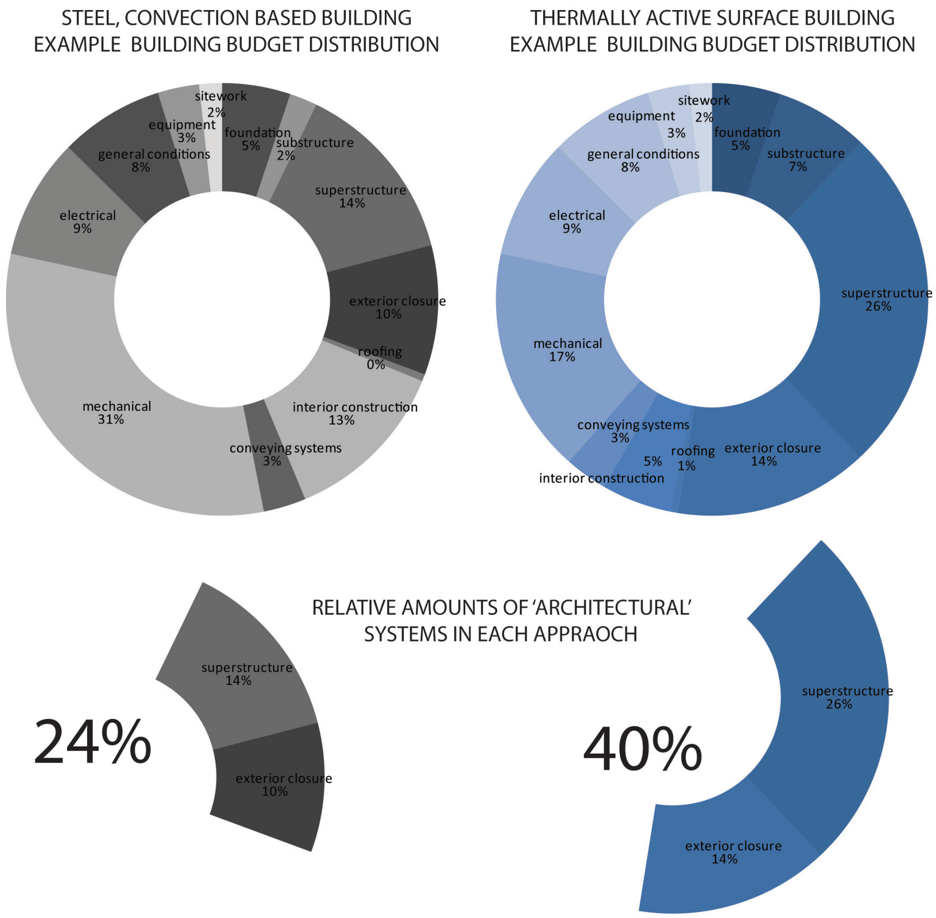

Figure 3: Architects can invest more design time and budget in the building envelope using thermally active surface strategies.

Thermally Active Surface Strategies Beyond Research

This research applies directly to three areas beyond the AIA funded project: subsequent research, teaching and lecturing, and, through consulting practice, applying the research knowledge in practice. Related aspects of the research associated with the Upjohn and RFP grants led to a parallel research project that I am working on at the American Academy in Rome that deals with the thermally active surfaces of ancient building typologies such as the Roman Baths. The research also deals with related topics focused, like the thermally active surface research, on the reasons and arguments for building lower-technology, higher-performance buildings.

One recent example of a thermally active surface approach in practice is a proposal for a pair of office buildings in downtown Denver. In addition to the typical constraints that determine much market-driven office space in North America, this pair of office buildings (about 100,000 square feet each) was limited to sixty-five feet in height due to a landmarked Beauxs-Arts structure next door. Thus competing, air-based proposals were limited to four stories. By decoupling the thermal loads of the buildings from its ventilation loads, the thermally active surface approach by a Denver architecture office, however, was able to insert another level of office space by altering the floor-to-floor height, removing most of the ducts and other equipment that typically occupies increasingly thick ceiling and floor plenums. Further, as rooftop units were not at option in this historically sensitive context, the architects also opened up considerable floor space by removing fan rooms and duct chases. Taken together, these leasable gains significantly transformed the developer's pro forma. For instance, the building envelope budget was calculated as a percentage of the leasable floor space.

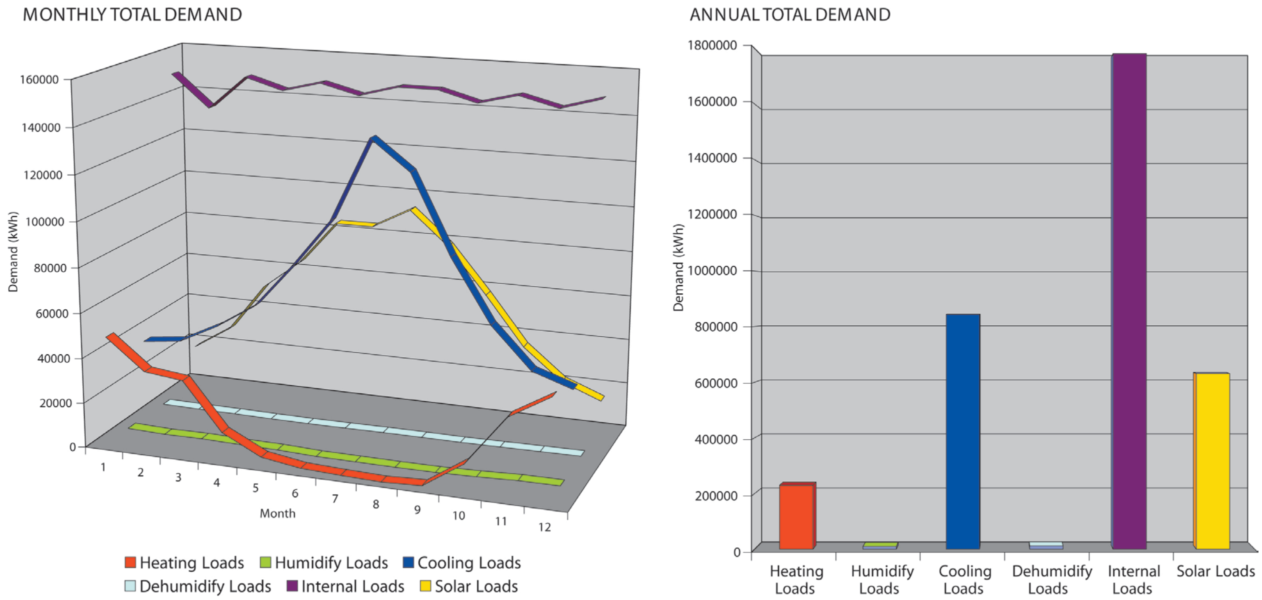

Figure 4: Reduced loads in a building using thermally active surface strategies. [Source: Geoff McDonell, P.E.]

With the extra level of leasable space, the architects can invest more design time and budget in the building envelope, a key effort in thermally active surface strategies (Figure 3). Further, budget otherwise spent on ducts and drop ceilings was redirected towards a more robust precast concrete thermally active surface structure with an exposed plaster ceiling. The thermally active surface strategies are optimal for the developer in terms of maintaining unleased office space because such systems utilize a low-air temperature approach to heating, thus saving operating costs for the owner and because it can so easily be zoned (Figure 2). When these multiple advantages are conflated with less energy consumption, greater human comfort, and consequently great office productivity, the thermally active surface approach gained momentum in this case (Figure 4).

[1] Kurt Goldstein, *The Organism.* (New York: Zone Books, 1995) p 29.

[2] Ulrich Beck, “The Reinvention of Politics: Towards a Theory of Reflexive Modernization” in Ulrich Beck, Anthony Giddes, and Scott Lash eds., Reflexive Modernization: politics, Tradition, and Aesthetics in the Modern Social Order, (Stanford university Press: Stanford, California, 1994) p 3.

[3] Stan Allen, “Practice versus Project” in *Practice: Architecture Technique, and Representation.* (Amsterdam: G + B Arts International, 2000). P. XVI.