Visibility of Research in Design Practice Current and Future Trends

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ABSTRACT: This paper discusses the current trends in research coming from practice, particularly focusing on the research efforts of Perkins+Will Building Technology Laboratory (Tech Lab). We discuss the processes, types of research questions, selection of appropriate research methods, and applications of results in design projects. We demonstrate these aspects by examining a specific research project as a case study, focusing on the facade energy performance and daylight analysis. Then we discuss the forming of a new non-profit research organization, AREA Research, which was initiated from the existing design practice and the current research activities. The primary objective of this entity is to allow collaborative research efforts between design firms, research laboratories, universities and other research organizations that concentrate on the research relating to the built environment, which may or may not be directly driven by a specific architectural or design project. We discuss the objectives, vision and mission of AREA Research, as well as its organization. These new types of collaborative efforts are aimed to increase visibility of research relating to the built environment, as well as the application of research results in practice.

KEYWORDS: research in practice, innovation, building technology, design

INTRODUCTION

Research in architecture and design is not a new phenomenon. Gradual technological changes, such as new materials, construction techniques and design representations, have accelerated the need for research over time within design disciplines. Today, research is more important than ever and it has become an integral component in the design practice.

Over the past two decades, research in design and architecture has diversified and now often involves interdisciplinary approaches. Topics are wide-ranging, encompassing advanced materials, building technologies, environmental and energy concerns, design computation, automation in construction, design delivery methods, project management and economics. The practical value of this knowledge is enhanced by a new direction, where research originates in practice. Research questions, methods and results must be closely related to architectural/design projects, design processes and services.

This paper examines current and future trends in research coming from architectural and design practice. It first reviews activities and research conducted at Tech Lab, and presents a specific research study as an example of research questions, methods, results, and implementation in architectural projects. Then we discuss the formation and organization of a new non-profit research organization, AREA Research, whose primary objective is to bridge the gap between academic and practice-based research activities, and allow collaborative efforts to address research needs relating to the built environment.

1.0 RESEARCH IN PRACTICE: BUILDING TECHNOLOGY LABORATORY (TECH LAB)

Tech Lab was initiated in 2008 as a research entity within Perkins+Will to enhance project designs through dedicated research. Tech Lab's research agenda focuses on advanced building technologies, materials, sustainability, high-performance buildings, renewable energy sources and computational design. Tech Lab monitors developments in building systems, materials, and information technology; reviews and analyzes emerging technologies that can have a direct impact on the course of architectural design, and investigates building systems and technologies that can significantly improve the value, quality and performance of architectural projects.

Examples of Tech Lab's research projects are:

- Performance and life cycle cost analysis for building integrated photovoltaics

- Performance of double skin walls
- Renewable energy systems optimization
- Advanced thermal comfort modeling
- Parametric modeling and design
- Thermal analysis of exterior wall assemblies
- High-performance building envelopes
- Selection on renewable energy sources.

Primary research methods include simulations and computational modeling, which are used to investigate different design scenarios and strategies. Typical research process involves: 1) determination of research objectives and questions based on the needs of specific architectural/design projects; 2) identification of appropriate research methods; 3) identification of the timeline, schedule and research procedures; 4) execution of the study; and 5) dissemination and implementation of research results. Besides implementation of research results on architectural and design projects, sharing and dissemination of findings with the larger architectural and design community is a key aspect of Tech Lab's objectives. Publications of research data and methods, analysis processes and results benefits the entire industry, therefore, research studies and results are shared through Tech Lab Annual Reports, shown in Figure 1.

Figure 1: Dissemination of research results through Tech Lab Annual Reports. Source: (Aksamija 2010, Aksamija 2011, Aksamija 2012)

For example, Tech Lab Annual Report 2009 includes studies such as building envelope performance analysis and daylight optimization, life-cycle cost analysis of building-integrated photovoltaic system, building envelope studies and daylight analysis, relationships between thermal comfort and outdoor design elements, study of facade options and building integrated photovoltaics, and a feasibility study for stand-alone self-powered exterior signage lighting system (Aksamija, 2010). Tech Lab Annual Report 2010 includes facade energy studies, photovoltaic system energy performance and cost analysis studies, curtain wall heat transfer analysis, and exterior wall thermal transfer study (Aksamija, 2011). Tech Lab Annual Report 2011 includes studies relating to high-performance building facade, dew point analysis of a typical exterior wall assembly, hygrothermal analysis of exterior walls, and facade energy performance and daylight analysis studies (Aksamija, 2012). These reports also include selected white papers that are written on building technology topics, as well as published research articles and research reports.

The next section reviews a specific case to illustrate research processes and methods in more detail.

2.0. CASE STUDY: FAÇADE ENERGY PERFORMANCE AND DAYLIGHT ANALYSIS

2.1. Façade Design and Energy Performance

The purpose of the study was to investigate high-performance curtain wall facade design options for a commercial building, located in Boston. The study considered different facade orientations of the building, and different design strategies for improving energy performance and occupants' comfort.

Energy modeling using EnergyPlus software was performed to investigate different design options for each relative orientation, and these following design scenarios:

- **East orientation (Facade type 1, which encloses a two-story atrium**):
    - Base case: Fully glazed curtain wall with low-e air insulated glazing
    - Option 1: Fully glazed curtain wall with low-e fritted air insulated glazing (frit pattern covering 50 percent of the vision area)
    - Option 2: Fully glazed curtain wall with low-e fritted air insulated glazing (frit pattern covering 50 percent of the vision area), and 1.5 ft deep exterior shading elements (vertical fins) spaced 2.5 ft apart
- **East orientation (Facade type 2, enclosing one-story interior space)**:
    - Base case: Curtain wall with low-e air insulated glazing unit and 2.5 ft high spandrel with approximate thermal resistance of 17 h-ft^2-F/Btu (window-to-wall ratio 70 percent)
    - Option 1: Similar to base case, with added 1.5 ft exterior vertical fins spaced 2.5 ft apart
    - Option 2: Similar to base case, with frit pattern covering 50 percent of the vision area
- **South orientation**:
    - Base case: Curtain wall with low-e air insulated glazing unit (window-to-wall ratio 95 percent), seen in Figure 2
    - Option 1: Curtain wall with low-e air insulated glazing unit and 2.5 ft high spandrel with approximate thermal resistance of 17 h-ft^2-F/Btu (window-to-wall ratio 85 percent)
    - Option 2: Curtain wall with low-e air insulated glazing unit, horizontal overhang (3 ft deep) and an interior light-shelf, and horizontal shading elements (0.5 ft wide fins spaced 1 ft apart below the overhang, and 2 ft above the overhang), as seen in Figure 2
- **West orientation**:
    - Base case: Curtain wall with low-e air insulated glazing unit (window-to-wall ratio 95 percent)
    - Option 1: Curtain wall with low-e air insulated glazing unit and 1.5 ft deep vertical fins spaced 2.5 ft apart
    - Option 2: Curtain wall with low-e air insulated glazing unit, horizontal overhang (3 ft deep) and an interior light-shelf (also 3 ft deep), and horizontal shading elements (0.5 ft wide fins spaced 1 ft apart below the overhang, and 2 ft above the overhang), identical to south facade option 2.

Figure 2: Comparison of solar radiation for south-oriented façade (Base case and Option 1). Source: (Aksamija 2012)

Properties of the glazing units are listed in Table 1, and all three scenarios considered thermally broken aluminum mullions.

Table 1: Properties of the glazing units.

Glass properties	Base case	Options 1 and 2 (fritted glass)
U-value (Btu/h-ft^2-F)	0.29	0.29
SHGC	0.38	0.26
Visual transmittance	0.70	0.48

Annual energy consumption, thermal comfort and daylight levels were investigated for all options. Figure 3 shows summary results for energy consumption for all building orientations and design options, while Figure 4 shows comparison of average annual daylight levels in interior spaces. The results indicated that Options 2 would be the best design scenarios for all four orientations for improving energy performance.

Figure 3: Comparison of energy consumption for all design scenarios. Source: (Aksamija 2012)

Figure 4: Comparison of daylight levels for all design scenarios. Source: (Aksamija 2012)

2.2. Daylight Analysis

Daylight simulations using Radiance software were performed to investigate availability of natural light reaching the interior space. Since it was found that the best-performing design scenarios for the south and west orientations include horizontal overhang, horizontal shading elements and a light-shelf for reducing energy consumption, these design options have been used to study availability of natural light. They were compared to two other design options:

- Base case: flat south-west facade
- Option 1: serrated south-west facade without any shading elements or light-shelves
- Option 2: serrated south-west facade with a 3 ft deep horizontal overhang, horizontal shading elements (0.5 ft wide fins spaced 1 ft apart below the overhang, and 2 ft above the overhang) and 3 ft deep interior light-shelf.

Daylight analysis was performed for September 21 at noon, with sunny sky conditions. Since this facade adjoins two-story interior space, the purpose of the analysis was to compare daylight levels on both levels. Specifically, light redirecting mechanisms for the office space located on the second floor were investigated, since this space is located approximately 20 ft from the facade, and is separated from the atrium by a glass partition wall. These different options are shown in Figure 5, as well as the daylight simulation results.

Figure 5: Design options and daylight levels. Source: (Aksamija 2012)

Generally, highest daylight levels for the first floor would be present for the base case scenario; however, this option is the worst from energy performance perspective. Comparison between options 2 and 3 shows that option 3 would provide more daylight, since the shading elements and a light-shelf would redirect light within the interior space. For the second floor, daylight levels are comparable for both options, although the actual values are higher for the base case scenario. Since option 2 is the best performing design scenario in terms of energy performance, the addition of light-shelves would balance the effects of shading elements on the availability of natural light. Tables 2 and 3 show detailed results of the daylight analysis.

Table 2: Daylight analysis results (first floor, September 21 at noon).

Distance from curtain wall	**3 feet**	**6 feet**	**9 feet**	**12 feet**	**15 feet**	**18 feet**	**21 feet**	**24 feet**	**27 feet**	**30 feet**
Daylight levels Base case (footcandles)	170	164	149	136	121	90	85	78	73	70
Daylight levels Option 1 (footcandles)	170	160	133	118	101	80	57	38	30	20
Daylight levels Option 2 (footcandles)	180	173	147	132	118	96	72	55	49	45

Table 3: Daylight analysis results (second floor, September 21 at noon)

Distance from curtain wall	**24 feet**	**27 feet**	**30 feet**	**33 feet**	**36 feet**	**39 feet**	**42 feet**	**45 feet**	**48 feet**	**51 feet**
Daylight levels Base case (footcandles)	150	142	120	103	76	63	58	54	52	48
Daylight levels Option 1 (footcandles)	131	102	80	70	58	52	46	44	42	40

This case study illustrates how research process can be beneficial for design decision-making. Having these results and quantifiable data allowed the design team to make informed decisions regarding the facade treatment for this specific project, as well as daylight harvesting strategies. At the same time, documenting results and sharing research processes, objectives and results is beneficial for the design community at large since these results can also be applied to other similar projects or design problems. Besides project-specific research, there is also a need for broader research spectrum that addresses all of the different aspects relating to the design of built environments, which may not necessarily relate to only a specific project. These types of research projects are often long-term, and may require substantial involvement from different disciplines, collaboration and investments.

3.0. NEED FOR COLLABORATIVE RESEARCH IN PRACTICE: AREA RESEARCH

In November of 2011, Perkins+Will launched a new nonprofit organization, AREA Research, for the purpose of advancing design through dedicated research. The objective for this organization is to become a platform that connects the design professions, academia, and research institutions, supporting innovative research that results in a higher-quality built environment, and by extension, the lives of the inhabitants of those environments. The mission is to align the long-range research capabilities of academic, and research institutions with the practical, project-based knowledge of the design professions.

The name AREA translates this mission into four actions that include advancing knowledge about the built environment and its design through the pursuit of collaborative research funded by a diverse range of third party sources. Further, the aim is to research innovative solutions that lead to technically sound, ecologically rich, healthy and livable buildings and communities, expand the research networks by partnering with industry leaders and research collaborators to undertake research pursuits and apply outcomes of the research to real world projects, demonstrating practical and tangible applications of the results.

Two primary conditions drove the formation of this company. First is the growing need for research institutes and other organizations to team with professional partners that represent the potential practical application of their research. Second is the need of design professions for a venue to investigate issues that are not project-specific, but longer duration efforts. Founded to address both demands, the true potential of AREA Research lies in its ability to bridge basic and applied research.

As a venue for partnerships, this organization will become a conduit for bringing the information garnered in the research process to the broader design professions, as well as others who might benefit from this valuable information as well as pushing data from professional sources back to the research community. Over time, it will translate both basic research into applications, and raw data into manageable knowledge. By facilitating the functional use of basic research, AREA Research will expand the impact of research on the built environment.

In terms of functional capacity, AREA Research is an independent 501(c)(3) nonprofit organization operating parallel to Perkins+Will. As a nonprofit organization, AREA Research allows Perkins+Will to engage in basic research, and further, partner with research institutions on any number of research projects. AREA Research is simply the next stage in developing Perkins+Will's current research efforts. The organization's initial focus is on HEALTH, SUSTAINABILITY, ENERGY, TECHNOLOGY, and CITIES, with the goal of expanding these research channels in the future (Figure 6). Further, AREA Research is a support mechanism for the pursuit of research partnerships and funding. By being flexible and offering various models for structuring projects, AREA Research is organized to take advantage of opportunities as they arise.

Figure 6: AREA Research and its channels.

Projects can be structured within AREA Research in a number of ways, but ultimately there are three fundamental models, as seen in Figure 7:

1. Externally funded projects in which AREA Research is a supporting member of a larger team, typically with a research institution as the lead. In this scenario, AREA Research would be providing specific services for the lead institution.
2. Externally funded projects with AREA Research as the lead. These projects may or may not have associated partners. If there are associated partners, AREA Research acts as the principal participant, and all funding runs through AREA Research.
3. Small, unfunded or internally funded projects.

Figure 7: Methods for organizing research projects.

These partnership arrangements are meant to allow AREA Research to facilitate stronger relationships between basic research and applied research, combining the value of sustained research with project-specific data and expertise. To do this, the organization provides research services and partnership support to research institutions, corporations, foundations, and other entities engaged in basic research.

AREA Research is guided by a multi-disciplinary committee of Perkins+Will leadership, each with specific expertise tied to the research channels. As the governing body for AREA Research, the Committee includes channel directors and coordinators from each of the respective channels who provide leadership and direct operations across channels.

CONCLUSION

This paper examined the current and future trends in architectural and design research, reviewing activities of a practice-based research laboratory, as well as formation of a new non-profit research organization aimed to allow collaborative research between academic institutions and design practice. We discussed Tech Lab's activities as an example of research coming from practice, and we illustrated with a specific case study how research questions, methods and results are implemented on architectural projects. We also discussed the need to grow collaborative efforts between practice, academic and research institutions to progress knowledge, and we presented the objectives and focus of a non-profit research organization that was specifically formed to address that need. These collaborative efforts are aimed to increase visibility, as well as application of research relating to the built environment.

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