Realizing High-Performance Energy Design in Hospital Buildings: Integrated Project Teams, Change, and the Effects of Strong Constraints

Research Problem Purpose: Given the continuing demands on the AEC industry for wholesale energy reduction and decarbonization, this study probes the social context of institutional constraints that might be working against improvements in building energy design. Using the analytical strengths of structuration theory, we focused on the changes to structural constraints in integrated project team practices that contributed to realizing significant energy reductions in building operation. This research method expanded the understanding of energy design practices of AEC integrated project teams beyond what we call *key indicators*, where topical categories of practice and project team factors like "communication" and "integration" are used as the units of analysis. Initially applying grounded theory analysis to search for patterns, this study applied a second analysis using structuration theory to view the holistic social context of project practices where AEC integrated project teams make energy design decisions. To do this, we looked at the patterns and interactions of social constraints at the meso and macro levels affecting energy design decisions made during project work.

In AEC project teams, *social context* refers to the socially situated interaction among individuals, their practice habits, organizational frameworks, and institutional structures that together shape and sustain collaborative activities (Alexiou & Zamenopoulos, 2008; Cicmil et al., 2006). Early scholarly work investigating the problems of energy design and the energy performance gap (Bordass et al., 2004; Menezes et al., 2012; de Wilde, 2014) emphasized the social context of AEC practices. These social issues included problems like the struggles over energy design decisions between engineers, energy modelers, and architects (Bazjanac, 2008; Grinberg & Rendek, 2013); the gap between what architects and engineers wanted and expected out of building performance simulation tools (Aksamija, 2010; Attia et al., 2012; Punjabi, 2005); and the fundamentally different knowledge and design process paradigms being integrated in energy design collaborations between architects and engineers (AIA, 2012; Bleil de Souza, 2012; Schlueter & Thesseling, 2009). While previous research into AEC integrated project teams has investigated specific issues as key indicators of successful integration—as in "communication" (Manata et al., 2022), "goal alignment" (Sparkling, 2018), "trust" (Pishdad-Borzorgi & Beliveau, 2016) and the like—studies using systematic social theories to assess the effects of larger institutional constraints on these activities are much less common. This lack is somewhat perplexing in that, over the past two decades, key indicators for AEC integrated project team and IPD research have consistently moved away from a rationalist-functionalist view of project delivery toward "soft" skill issues in collaborative work that are highly influenced by social context (Baiden et al., 2006; Franz & Olopade, 2024; Ibrahim et al., 2013).

To overcome these methodological problems, we employed structuration theory as an analytic tool to connect action to structural constraints in a way that could reveal what changes led to energy design outcomes and provide explanations for the improvements observed in hospital energy performance. This study aimed to find patterns in the practice changes of project teams that successfully achieved reduced energy consumption in hospitals. By doing so, the study illustrated how change operates as a vehicle for improved building design outcomes as well as provides a more accessible operationalization of structuration theory for AEC industry researchers.

Research Methodology and Approach: The study is based on qualitative case studies of seven U.S. hospital projects completed between 2009 and 2014 that achieved substantial reductions in energy consumption in operation. Recognizing that hospital facilities represent some of the most energy intensive buildings in the commercial building stock, the project owners and design teams would be considered early adopters of high-performance energy design in the U.S. hospital market. All projects were operational at the time of study which enabled comparison between predicted and operational energy performance. By achieving an energy performance goal that was substantively different than normative hospital project outcomes, these projects could be expected to exhibit some kind of pattern of change in practice activities, structural constraints, or both.

Primary data collection consisted of retrospective interviews (Sosniak, 2006) conducted shortly after the hospitals were constructed and operational. Interviews included architects, engineers, energy modelers, sustainability consultants, owner's representatives, and facilities management staff who led or were a major part of the energy design work. The interviews were designed to elicit both descriptive narratives of project processes and reflective interpretations of decision-making, project variables and constraints, and practice changes. Interview prompts encouraged participants to discuss how particular project conditions shaped their actions, how competing constraints were prioritized, and where the energy design process led to practice changes. Follow-up technical interviews gathered benchmark data on building systems used for the energy design of each hospital building.

Data analysis proceeded in two phases. The first phase employed inductive thematic analysis to identify commonly cited variables associated with successful energy design outcomes. This phase produced a set of "key variables for success," which included boundary spanners, access to data, clear goals, project champions, quality energy modeling, and trust from experience. These initial results identified successful energy design indicators through a number of topical practice characteristics familiar to an AEC industry audience. Since these key variables did not necessarily reveal a consistent pattern in how these projects—similar in building typology and project delivery through integrated project teams—may have achieved their energy design goals, a second phase of analysis reframed the data using structuration theory (Giddens, 1984; Stones, 2005) as an explanatory framework (Feldman & Orlikowski, 2011:1241). This phase focused on identifying meso- and macro-level constraints that repeatedly appeared in participant narratives as shaping or directing energy design practices. Interview data were recoded to identify explicit, implicit, and implied constraints influencing project work. Through structuration analysis, patterns emerged showing how certain constraints were consistently prioritized over others. These particular constraints were seen to have modified practices consistently across the integrated project team such that energy goals were ultimately achieved.

Key Findings: In all of the hospital cases, we identified integrated project team practice changes that led to improved energy design outcomes. These changes involved a pattern of resistant project variables and meso- and macro-level forces that we called *strong constraints*. Strong constraints were structural forces that were prioritized over other competing constraints with enough consistency that they repeatedly guided energy design decisions as well as integrated the decision process more consistently across project teams. These constraints also lead to other team integration improvements in areas like communication. We observed that early-adopter hospital projects in which significant energy reduction was a performance goal often assumed—and at times deliberately embraced—strong constraints as a necessary means of directing and changing practice activity. Our findings suggest that following AEC integrated project team activities as they are seen within larger structural constraints provides a more accurate explanation for why particular practice activities appear improved. The analytical framework of structuration offers a particularly compelling lens on how projects unfold and evolve through change dynamics.

Strong constraints were of two types: 1) *resistant project variables* from meso-level project design factors, and 2) *exogenous forces* from macro-level institutional structures. Where present in a hospital project, both of these forms of strong constraints were seen to have had notable and repeated influences over energy design actions across the AEC project team. Examples of *resistant project variables* would be particularly constrained site conditions, the selection of a novel building technology, or a new or difficult operational goal essential to the client. All of these resistant project variables were internal to the design problem itself even if they were decisions initially made by the project team. Although these variables originated within the project, their resistance to negotiation gave them a force comparable to institutionalized external constraints. Alternately, *exogenous forces* involved the classic macro-level institutional structures like building codes and regulations, engineering design standards, or the positive hospital market attributes of environmental responsibility. Following from structuration theory (Barley & Tolbert, 1997:102), exogenous forces are classic examples of institutional structure in that they are imposed from outside of the project boundaries, they are disassociated from who or what caused them to be, and therefore they appear factual and unyielding in a way that other project variables do not. Across the cases, strong constraints functioned as organizing forces that reshaped project team practices. By collectively prioritizing these constraints, teams reconfigured normative practice structures including traditional disciplinary boundaries, conventional sequences of design decision-making, and normative project leadership and decision-making authority. Importantly, strong constraints did not eliminate agency; instead, they reflexively redirected agency toward coordinated action aligned with the established energy performance goals.

The energy design processes for two hospital projects were developed from the interview data in the form of vignettes. These stories showed that when sustainability certification requirements or novel mechanical systems were established and managed as non-negotiable constraints, project teams intensified collaboration, elevated the role of energy modeling as shared evidence, and expanded communication across disciplines. Improvements in communication, trust, and integration emerged as consequences of navigating these constraints rather than as outcomes of explicit managerial interventions. Participants described these improvements as atypical relative to their normative project experiences, yet attributed them to the demands imposed by the prioritized constraints rather than to formal team-building strategies.

Implications: Our findings suggest that strong constraints function not merely as guides for design decisions, but also as organizing mechanisms that play a role in the improved integration of a project team. Through the reflexive agency of individual and collective decision making, the consistent prioritization of one strong structural constraint over competing ones appears to reduce the inherent complexity of coordination in demanding design processes. In this way, as design actions are bounded and directed by strong constraints, building design decisions tend to become more synthetic across the project. We posit that strong constraints may be a characteristic of building projects where success depends on significant departures from normative AEC practices. As a broader contribution to studies of improved team integration, our findings show that examining AEC project work as it operates within—and is shaped by—larger structural constraints provides a more precise and accurate explanation for why particular collaborative practices appear improved. This suggests that attributes commonly seen as key performance indicators in AEC research—such as integration, communication, and trust—may be better understood as emergent properties of deeper structural dynamics rather than as independent drivers of success.

Conceptually, the study demonstrates the explanatory value of structuration theory for understanding how change occurs in project-based organizations. By tracing the recursive relationship between agency and structure, structuration analysis can reveal how ambitious energy performance goals can be realized when project teams engage with constraints that reorganize practices. Methodologically, the study offers an operationalization of structuration theory that complements indicator-based approaches commonly used in AEC research. For practice, the findings suggest that intentionally embracing strong constraints—such as ambitious performance goals, externally validated standards, or resistant design variables—may offer an effective pathway to realizing high-performance goals. More broadly, the study underscores the importance of managing AEC project work within an awareness of its full social and institutional context when seeking improvements in design outcomes.