Sticking Together: Merging Techniques for a Holistic Building Materials Pedagogy

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Building materials pedagogy can be mapped to a spectrum of student engagement types. At one end, students take a hands-on approach, and instruction comes in the form of haptic epistemology. At the opposite end of the spectrum, students rely on digital tools and data sets, gaining an understanding of materials as agents in a global resource and climate regime.

The course described in this paper proposes a collapse of the spectrum, where haptic, local knowledge and data-driven, global knowledge come into alignment. It takes normative stick framing methods as a departure point for studying building envelopes. The banality of this type belies its broad impacts; the magnitude of its deployment positions it as an influential climate and resource agent. And its accessibility permits deeper study than with that of more complex types. A series of stick frame-based exercises conjugate physical/local and digital/global understandings of building materials.

INTRODUCTION – COMPETING DEMANDS

Emerging design professionals enter a discipline increasingly defined by complex, often conflicting social, economic, and ecological forces. In a more globalized, interconnected, aware world, these both grow in number and evolve in complexity, adding to the designer's millstone. Among these contributions is a renewed focus on building materials' intrinsic and extrinsic impacts, stemming from a convergence of factors: population and urban growth-fueled demand for building materials, increased scarcity of the same materials, and, positively, the successes of a decades-long focus on efficiencies in building operations, liberating a shift in attention. And, as 20th century history comes into clearer focus, the deleterious climate impacts wrought by profligate use of portland cement provides an acute example of building materials' gravity in design decision-making. Inasmuch as the construction of buildings, cities, and landscapes consumes a global plurality of materials, emerging designers' fluency in material stewardship and performance are of critical importance.

While global factors and the exigencies of climate change have increased the disciplines' focus on materials, there remains a parallel imperative to increase skill sets couched in digital tools. Both the NAAB and AIA call for expanded fluency in digital tools, with an emphasis on building performance simulation (BPS). The former lists Program Criteria where students should be enabled to leverage "advanced building performance...principles in their work" and Student Criteria based in "the ability to make design decisions" that integrate the "measurable outcomes of building performance" in architectural projects.[1] The AIA 2020 Climate Action Plan asks that architects become fluent in "data-driven storytelling" to leverage computational tools, i.e., simulation, towards high-efficiency architecture.[2] Where in the recent past these skills may have been limited to advanced study or specialization, they are now a codified sine qua non for baseline proficiency in the academy and in practice.

Figure 1. Consolidation of Digital and Physical Techniques

These simultaneous novel urgencies – demand for fluency in both materials decision-making and digital technologies – are joined by a third, long-standing pillar of architectural materials education: baseline understandings of types, assemblies, and tectonics. That said, the density of architectural education does not leave much potential for expansion; concentrated study in one realm comes at the expense of another. Competing demands threaten to push aspects of pedagogy and practice towards isolated specialization or, worse, disciplinary erosion towards dilettantism. The course examined in this paper posits that abrogation of either realm is avoided through merging or "sticking together" otherwise disparate modes (physical and digital), scales (detail to global), and contexts (social and technical) to build a more holistic understanding of materials and material performance.

WHAT IT IS / WHAT IT DOES

The required, mid-curriculum, Materials/Assemblies/ Construction course is themed by a central question pairing: what is it / what does it do? The parallel binary of these questions proposes a collapse of the normative building materials pedagogy spectrum of student engagement types. At one end, students take a hands-on approach, and instruction comes in the form of haptic epistemology. Students engage with physical materials through exercises and craft static drawings to demonstrate understandings of assembly and technics, i.e., what materials/ assemblies are. At the opposite end of the spectrum, students rely on digital tools and data sets, gaining an understanding of materials as agents in a global resource and climate regime, i.e., what materials/assemblies do. Projects, precedents, and other knowledge delivery methods span the spectrum, but the disparity of its poles generally requires that student understanding is biased to one end or the other. This fissure creates a dissonance in students' understanding of materials and the implications of their materials choices. Should a material be evaluated for its ability to be worked, assembled, and composed in an expressive form? Or should it be evaluated for its carbon implications, resource demands, and reciprocal landscapes? This choice may be extrapolated to broader, urgent issues demanding on an architect's focus: should they be concerned with the construction of high-quality, if simply composed, housing in their locality? or should they be concerned with their materials decisions' deleterious impacts on the global climate?

The spectrum is collapsed by sticking together non-adjacent realms within, and its haptic, localized knowledge and data-driven, global knowledge poles come into clearer alignment. The inherent complexity of bringing together ostensibly incongruous knowledge sets demands a relatively simple subject matter. To that end, the course takes normative, American light wood framing, i.e., stick framing, methods as a departure point for studying building envelopes. The banality of this type belies its broad impacts; the sheer magnitude of its deployment positions it as an influential climate and resource agent. And its accessibility permits deeper study than with that of more complex, idiosyncratic envelope and structure types. To a lesser extent, another common typology in parking garages is deployed. In isolation, these quotidian typologies are not intellectually rich enough to sustain the curriculum, but their histories and ubiquity imbue them with enough cultural inertia to provide meaningful context for focused exercises around the conjugation of physical/digital, local/global, and social/technical understandings in building materials decision-making.

FIELD EXERCISES

Sticking together historical contexts, digital tools, contemporary semantics, and physical skills, the basic typological vehicle for the course objectives, stick framing, is investigated in a transdisciplinary deep dive. In-class lectures, weekend-based "Field Exercises", and a digital assignment converge to engender experiences and engage in methods that develop a rich, empathic understanding of this uniquely American system. An initial lecture series pairs the genealogy of stick framing – from its timber roots through the 19th-century advent of balloon framing – with the contemporary semantics used to describe typical parts in this system.[3] Following this, each of the subsequent three weeks is dedicated to the exploration of one variation on stick framing, with each week culminating in a Saturday Field Exercise.

In the first week, lecture content covers the post-war explosion in stick framing, where the confluence of a supercharged industrial complex and GI Bill-funded mortgage subsidies resulted in a proliferation of stick-framed "Levittowns" in the Eastern US.[4] On Saturday, one-third of the student body meets to construct a small, instructor-designed hut made with Normative Stick Framing methods not unlike those deployed at Levittowns. Their work is guided in part by QR-code stickers applied to every lumber member that indicate, through linking to an AR-ready digital model, where the member is intended to be installed.

In the second week, the Normative Framing structure is used as a physical demonstration before it is deconstructed. Lecture content covers the global historical contexts the precipitated the advent of Optimum Value Engineering, or Advanced Framing, including the 1973 Arab-Israeli War, the subsequent Oil Embargo, and the coordinated response of public/private entities to devise a low-energy-demand housing system.[5] On Saturday, another third of the class meets to frame a second structure, following

Figure 2. Mar Vista Frame Assembly

Figure 3. Completed Normative Stick Frame

the same digital methods and interior dimensions as the first, deploying Advanced Framing methods.

The third week marks the end of the Field Exercise-driven curriculum. The lecture content works in support of two parallel courses (Design Studio and Modern History) in describing the mid-century single family housing efforts developed by architect Gregory Ain.[6] Lecture content describes Ain's Mar Vista tract development in Los Angeles as a counter point to the production of Levittown. Where the latter stemmed from an overtly capitalistic, consumerist approach, the former was couched in socialist ideas of equitable access to affordable, quality housing aided in part by deployment of modular, replicable framing systems. Students construct a third structure based on the bespoke framing system developed by Ain.

Constructing and occupying these three stick framing methods/structures provides students with an expanded repertoire of experience and skills. Full-scale, collaborative framing introduces novel skills in construction that instill a level of empathy with framing professionals, regardless of the students' future deployment of the skill. On-site confusion is best stymied through precise use of technical semantics – often a hard-earned lesson.

Use of the parallel digital AR model begins to form the sinew between digital and physical methods. Comparison of the three structures makes clear their corporeal difference that might be otherwise occluded to the untrained eye. More importantly, the students internalize the notion that building materials and assemblies are not arbitrary creations but rather emerge from external, often unexpected, globalized forces.

STICK-FRAMING INTERVENTIONS AT MAR VISTA

The social, historical, and technical context of Gregory Ain's Mar Vista neighborhood provides fertile ground for merging modes, scales, and contexts in studying building materials. Two exercises leverage this. In the more concise of the two, Growth, students are provided with an accurate framing model for a single home in the Mar Vista tract. A Grasshopper definition randomly locates two prismatic "growths" along the building's perimeter, representing the proposed interior volume for small annexes. The students' task is to digitally model and draw the two annexes such that they are constructed with Advanced Framing techniques and clad in an envelope system appropriate for a low-rise Los Angeles neighborhood. Ostensibly simplistic, this task challenges the students in multivalent ways. As a start, they must contend with the structural realities laid bare by the parametric

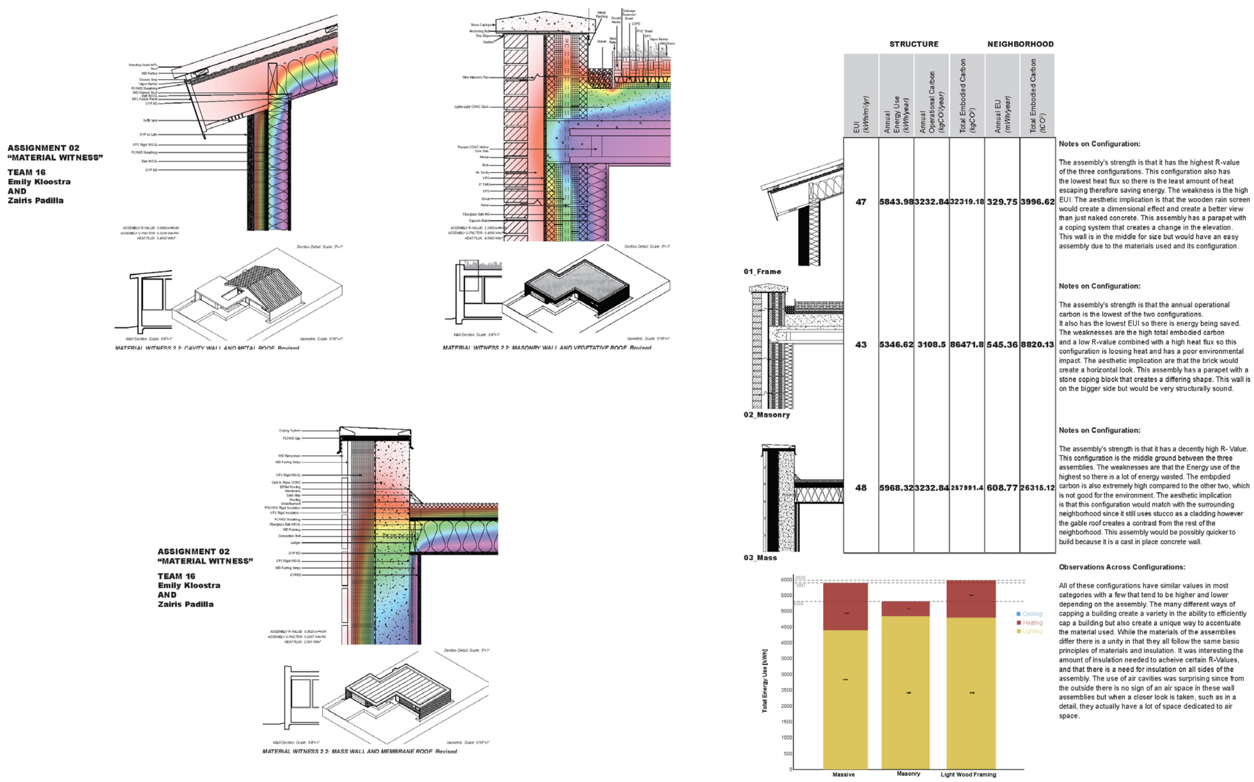

Figure 4. Material Assembly permutations coupled with Carbon and Energy Impacts

growths' removal of existing framing members. Following this, their re-framing operation requires the marriage of a bespoke, historic method with a more contemporary method. Here again, this is not just a hybrid of technics but a marriage of singular moments in socioeconomic history. The complexity is exacerbated by the need to integrate a contemporary cladding scheme with the existing, historic stucco. As a reference, students access and study the full-scale, Mar Vista-style framed structure completed as part of the Field Exercises. At a minimum, the presence of this structure establishes a level of rigor in the work – every framing member must be accounted for and negotiated. An ulterior motive for this project is to develop initial digital skills through detail drawings, the accuracy of which are validated by the physical structure.

In their simplicity, replicability, and immanent genuineness, the Mar Vista homes provide a canvas for sticking together the complex realms of envelope design, heat transfer simulation, and greenhouse gas emissions. In this second Mar Vista-based exercise, Material Witness, students work across multiple scales to holistically evaluate the veracity of the materials decision-making. In a first step, students develop three unique wall types, three unique roof types, and three permutations of their integration. Working at a detail scale, they hand-calculate thermal resistivity values for each wall and roof. To better understand heat transfer and potentials for thermal bridging at the wall-roof intersection, students simulate the developed detail in THERM, a DOE-developed 2D heat transfer software. After mitigating weaknesses revealed by the simulation, students model the revised roof/wall schemes for the entire single-family structure. With this in place, students develop illustrative graphics to visualize the schemes' aesthetic impacts and ClimateStudio-based Thermal Model simulations to establish comparative Energy Use Intensity (EUI), Operational Carbon, and Embodied Carbon metrics. In a final step, the Thermal Model metrics are extrapolated to the entirety of the Ain-designed neighborhood, numbering some 70 homes.

Where the Field Exercises and Growth assignment focused on digital/physical modes and social/technical contexts, Material Witness challenges students to make meaningful connections in their decision-making across scales. At the detail scale, the THERM simulations provide unambiguous feedback on the impact of material and assembly strategies in sensible, if synesthetic, ways. At the global scale, ClimateStudio-derived Carbon metrics situate their decision-making within the global discourse of climate change. That said, the witnessed impacts at the neighborhood scale are perhaps the most impactful. Here, the energy and carbon implications are not governed by inherited material properties nor the processes of their formation; they are instead the direct, calculable result of decisions made firmly within the designer's purview. Having studied Ain, students are equipped to empathize with his position, and they have an unforgivingly clear comparison of the impacts stemming from their decisions. This may engender the right balance of empowerment and humility needed to make such decisions.

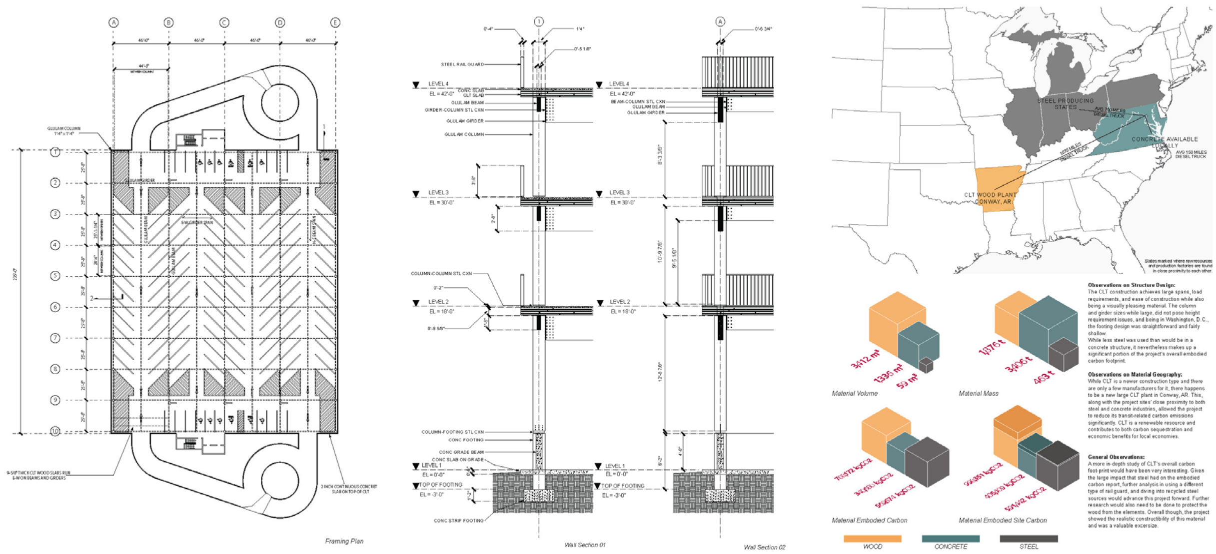

Figure 5. Structural Design meets Material Geography

MATERIAL CAPACITIES AND GEOGRAPHIES

Though it provides an effective vehicle for studying the various realms of building materials pedagogy, stick framing is too limited in its size and mass to access all critical aspects of study. For Seeing Things, the similarly pervasive parking garage typology is deployed. The project's premise is that a parking garage design process is half complete, where the vertical circulation and parking layouts are established, leaving only the design of vertical and horizontal structure. Each student is prescribed a project location (a city) and a structural type such that no two students have the same combination. The relatively low floor-floor heights are set, and the parking layout it immutable. These constraints imply that the design challenge is based in strategically locating vertical structure to not interrupt parking operations and sizing horizontal members such that adequate head height is maintained. At the base, footings must be designed per the prescribed above-grade system, and footings depth must acknowledge local frost depth.

The first half of Seeing Things is an exercise in rigor and graphic clarity; students must design and represent the structure unambiguously. The second half, though, is a departure from this mode of design and the site entirely. Students are asked to develop a material geography to assess the atmospheric and geospatial impacts of the structural material system. They identify the materials used, quantify them by mass, identify regional primary and secondary manufacturers, identify modes of transit and their fuels use per ton-mile, and, using tools like ClimateStudio and the Embodied Carbon in Construction Calculator (EC3) , develop estimates for embodied carbon, including transit emissions. As with Material Witness, this exercise connected the students' work across scales and elucidates the impacts on climates and landscapes outside the project site.

CONCLUSION / DISCUSSION

The purpose of these course activities is to empower students with building materials understandings and skill sets matched to the demands of contemporary practice. Synergistic combinations of otherwise disparate realms and knowledge sets helps to build the intellectual scaffolding for the broad set of challenges these emerging designers will face. The course leverages the cultural inertia of quotidian typologies, i.e., stick framing and parking garages, to liberate more robust, critical thinking about the broad impacts of material performance and the digital skills requisite in mitigating them.

A potential weakness in the approach lies in exercises largely dependent on predetermined design forms. The course instructor provides, for example, a model of the Mar Vista home, a predetermined size for the Growth interventions, and a model of a parking garage, among other resources. While this permits the students to engage in the task of studying the impacts of materials decision-making, it does not allow them to fully realize the real time impacts of their decisions. This was a conscious motivation in the course given the limited amount of time available. In the future, this might be reconfigured such that there are fewer exercises and greater possibility for the students to cultivate feedback more specific to their own work – not the work that's been provided for them. Alternatively, the principles of the course could be shifted into a studio model with greater time and credit allotted to it, permitting a broader, deeper study of materials decision-making, and its concomitant impacts.

Another pitfall may lie in exercise content heavily reliant on Building Performance Simulation tools. While those tools are becoming increasingly robust, their inherent ambiguities and occlusions present the possibility of conflating precision with accuracy. Their persuasiveness may incentivize uncreative dependency on the tools while, per Fernández-Galiano, "abusing the concept or exhausting the instruments"[8], or, per Moe, yoking students to "thermodynamic quackery"[9]. That said, inasmuch as the tools are used on a strictly comparative basis, their feedback can be couched in terms of decision and not prescriptions for design.

ENDNOTES

1. NAAB. (2020). 2020 Conditions and procedures. National Architecture Accreditation Board (NAAB). Retrieved September 20, 2020, from https://www.naab.org/accreditation/program-resources/current-conditions-and-procedures/
2. "The AIA 2020 Climate Action Plan ." Climate Action Plan: The Climate Imperative . The American Institute of Architects, July 2020. The American Institute of Architects. https://www.aia.org/resources/6307290-climate-action-plan.
3. Giedion, S. (Sigfried). Space, Time and Architecture : the Growth of a New Tradition. Cambridge: Harvard University Press, 1944, 281-284.
4. "What Is Levittown?: Planopedia." Planetizen. Accessed September 5, 2023. https://www.planetizen.com/definition/levittown.
5. "Advanced House Framing." Energy.gov. Accessed September 5, 2023. https://www.energy.gov/energysaver/advanced-house-framing.
6. Denzer, Anthony, and Thomas S. Hines. Gregory Ain: The Modern Home as social commentary. Rizzoli, 2008.
7. "Embodied Carbon in Construction Calculator (EC3)." Carbon Leadership Forum, April 29, 2023. https://carbonleadershipforum.org/ec3-tool/.
8. Fernández-Galiano Luis. Fire and Memory: on Architecture and Energy. Cambridge, MA: MIT Press, 2000
9. Moe, Kiel. Convergence: an Architectural Agenda for Energy. London: Routledge, 2013.