EARTHEN TECTONICS: A GRADUATE SEMINAR COURSE IN MATERIAL EXPERIMENTATION AND RAMMED EARTH FABRICATION

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ABSTRACT
This paper presents an interdisciplinary graduate research seminar investigating experimental earthen materials in landscape architecture. The course engaged Master of Architecture and Master of Landscape Architecture students in hands-on material exploration, iterative making, and site-based installation at a long-term ecological research reserve. The interplay between digital modeling with Rhinoceros, computer numerical control (CNC) carving, physical prototyping, and speculative hybrid representations formed a generative and exploratory design process. This fostered an experimental mentality that prioritized following emergent discoveries over achieving final products.

Through three overlapping sequenced projects, students built collective knowledge of traditional and experimental earthen materials, fabrication processes, and representation techniques. Making was positioned as a research method, emphasizing iteration, experimentation, and reflection, with material failure treated as a pedagogical opportunity. The seminar culminated in a small-scale installation where students designed and fabricated earthen modules for ecological performance—such as water capture and habitat creation—while anticipating material transformation over time.

Central to the course was the landscape framework of "change-over-time," viewing landscapes as dynamic systems, complemented by the intentional design for degradation, or "unmaking." Working with responsive earthen materials enabled students to engage deeply with temporal and ecological processes often addressed only abstractly in design education.

The outcomes highlight the pedagogical value of considering materials as active, temporal agents. Hands-on fabrication advanced students' understanding of materiality, temporality, and ecological performance, shifting design thinking toward adaptability and site-responsiveness. The course also revealed gaps in technical fabrication skills, underscoring the need to integrate making into curricula. While interdisciplinary collaboration enriched peer learning, it required targeted support to bridge disciplinary perspectives. This work contributes to discussions on hands-on pedagogy, material experimentation, and temporally responsive design in education.

Keywords
Material Hyperlocalism, Digital Fabrication, Earthen Materials, Design Build, Interdisciplinary Seminar

1 INTRODUCTION

This paper presents an interdisciplinary graduate research seminar investigating experimental earthen materials in landscape architecture. The seminar integrated digital fabrication techniques, material experimentation, site-based installation, and speculative representation within a landscape architectural framework. It builds upon prior research and teaching in the use of rammed earth, clay, and alternative bio-based materials, extending these investigations into hands-on, student-led design projects. The course sought to bridge disciplinary boundaries between architecture and landscape architecture, emphasizing material experimentation as a form of design research.

The seminar had four primary learning objectives:

- Introduce students to earthen materials, their contemporary applications, and their potential role in landscape architecture.
- Employ digital fabrication and making as iterative tools in the design process.
- Utilize both conventional and hybrid representational strategies to convey speculative landscape change-over-time.
- Design, fabricate, and install a site-specific intervention using earthen materials to manage, filter, or channel water.

This approach situates material exploration not as an ancillary activity but as central to design inquiry, allowing students to engage with ecological processes, construction realities, and the temporality of landscape systems.

1.1 The Potential of Earthen Materials in Landscape Architecture

Earthen materials have been used across cultures and geographies for millennia, combining local soils, clays, and sand with stabilizers. This includes chemical additives such as cement to bio-based materials such as straw, wool, or plant fibers, which improve workability and structural performance (Gallipoli et al., 2017). Unstabilized earthen materials, without cement, are infinitely recyclable and with low embodied carbon (Heringer et al., 2023). A less extractive and carbon-intensive alternative to conventional construction materials, earthen material assemblies offer measurable ecological and human health benefits, including reductions in climate change impacts by 20-80%, decreases in air acidification by 30-80%, and greater resistance to fungi and insects (Ben-Alon et al., 2019).

Despite these advantages, earthen materials remain underutilized in contemporary architectural and landscape practice. Many design and construction professionals lack familiarity with earthen materials, and concerns over durability, maintenance, and performance frequently drive reliance on chemical stabilizers, which increase embodied carbon and reduce recyclability (Ben-Alon et al., 2020; Heringer et al., 2023). Scholars have emphasized the importance of integrating earthen materials into design education to build both technical competence and creative fluency, highlighting the potential for these materials to support ecologically responsive design strategies.

Current scholarship primarily focuses on earthen material use in architecture, fine art, and material science, exploring methods to enhance material permanence, durability, or to generate complex geometric forms through digital fabrication (Laborel-Préneron et al., 2016; Elahi et al., 2020; Rael & San Fratello, 2018; Akemah et al., 2023). Landscape architecture, however, operates in environments where change, decay, and ecological processes are integral to design intent. By considering the temporal and dynamic qualities of materials, landscape architects can reframe earthen materials as an active participant in a living system, rather than a static medium. In this way, material experimentation becomes more than a technical exercise but a pedagogical tool for linking design inquiry with ecological processes, where moments of material failure and transformation are reframed as critical opportunities for student reflection and learning.

1.2 Pedagogical Gaps in Material-Based Learning

Although sustainability and ecological design are increasingly prominent topics in design education, hands-on, material-based pedagogy is often less emphasized. Studios frequently emphasize representation, site design, and large-scale system relationships, while providing few opportunities for engagement with materials. Without structured opportunities to physically manipulate, construct, and test materials, students may develop conceptual fluency without an understanding of practical material behavior.

The lack of tactile engagement is especially noticeable with speculative and ecologically performative materials such as rammed earth, bio-based composites, or other regenerative material systems. These materials require iterative making, testing, and observation to understand their structural, ecological, and aesthetic capacities. Pedagogical structures that foreground such experimentation allow students to view materials as dynamic agents that directly engage landscape systems, rather than static forms that operate in a vacuum.

1.3 Landscape Change-Over-Time and Speculative Representation

The seminar integrated the conceptual framework of "change-over-time," which positions landscape processes as dynamic, layered, and continually evolving across multiple temporal and spatial scales (M'Closkey & VanDerSys, 2017). Within this, two scales of landscape architecture are described: the larger scale of site organization, territory, and connected ecological systems; and the smaller scale of materials, assemblies, and detailing. This approach situates design not as the production of static objects but as the orchestration of processes and interactions that unfold over time.

The course introduced the complementary concept of "unmaking," or the intentional incorporation of decay and disassembly into the design process (Song & Paulos, 2021). While conventional design often privileges permanence and durability, students were asked instead to imagine how processes of erosion, weathering, and decomposition might shape form, surface, and material assembly over time. Pairing "change-over-time" with "unmaking" challenged students to move beyond static notions of stability toward a design approach that embraced temporality, ephemerality, and transformation as productive and designed conditions.

Representation techniques played a central role in exploring these ideas. Rather than serving only as a means of illustrating final outcomes, drawings and visualizations were positioned as tools of design research. In this mode, projective drawings worked alongside physical making, quantitative testing, and technical documentation to anticipate and speculate on future conditions (Rossi-Mastracci, 2022). Students were encouraged to describe material and geometric configurations but also multiple potential scenarios of change, variations in performance, shifting environmental forces, and uncertain or unknown futures. Speculative drawings visualized ephemeral phenomena such as wind, precipitation, and flooding; seasonal cycles of vegetation growth and decay; and the long-term trajectories of climate change. In doing so, they became instruments for imagining design as a process unfolding through time.

1.4 Site Exploration: Cedar Creek Ecosystem Science Reserve

Cedar Creek Ecosystem Science Reserve is a 5,000-acre biological research site managed by the University of Minnesota in partnership with the Minnesota Academy of Science. Located roughly 45 minutes from the Twin Cities, the reserve encompasses a wide range of ecotones, including permanent marshes, ephemeral wetlands, lakes, prairies, hardwood forests, and bogs. This ecological diversity supports long-term investigations into the consequences of human-driven environmental change, with research programs addressing biodiversity loss, nitrogen deposition, elevated carbon dioxide, climate warming and altered precipitation regimes, invasive species, habitat fragmentation, and fire ecology (Cedar Creek Ecosystem Science Reserve). Cedar Creek is part of the NSF Long-Term Ecological Research (LTER) network that studies ecosystem processes across spatial and temporal scales.

Beyond its research functions, Cedar Creek actively engages with the public and students through K–12 programs, volunteer activities, and outreach initiatives. The author's collaboration with Assistant Director Caitlin Potter has expanded opportunities for design research and teaching, as Cedar Creek has become living laboratory, testing experimental materials in situ to observe their degradation, transformation, and interactions with ecological processes. These site-based investigations provide an invaluable pedagogical bridge between conceptual design, fabrication, and ecological observation, situating hands-on experimentation within a rigorous research context.

2 METHODS: SEMESTER-LONG SEMINAR COURSE

The interdisciplinary research seminar had 14 Master of Architecture (MArch) and Master of Landscape Architecture (MLA) students in the 2nd and 3rd years of their respective programs. This was the first offering of the seminar and one of the few interdisciplinary courses within the newly formed department that brought together the individual schools of Architecture, Landscape Architecture, and Interior Design (ALI). The course met twice weekly for 75 minutes, emphasizing in-class fabrication, iterative making, and peer learning, supplemented by presentations, discussions, and instructor-led technical lectures.

Three overlapping sequenced projects generated collective knowledge of earthen materials, fabrication processes, and experimental representation techniques.

- Part I: Material Testing + Developing a Shared Understanding
- Part II: Literature Review, Research + Alternative Material Development
- Part III: Fabrication, Speculation + Installation

Throughout all projects, making was positioned as a research method rather than a final production task. The course emphasized iteration, experimentation, and reflection, using failure and unexpected material behavior as pedagogical opportunities. Documentation captured the interplay between material composition, environmental forces, and landscape-scale outcomes, providing a foundation for both research and future teaching.

2.1 Part I: Material Testing + Developing a Shared Understanding

This assignment aimed for students to gain a deeper understanding of how variations in earthen material compositions, such as amount of clay and addition of cement, impacted workability, fabrication, and durability. It had three specific learning objectives:

- To learn the process of rammed earth fabrication, perfecting compaction amount, material consistency, and tamping techniques.
- To explore material differences in typical rammed earth compositions.
- To test how material composition impacts performance through a series of experimental “stress tests.”

Students began with the fundamentals of rammed earth construction. They built 4"x4"x5" modular wooden frames, learning precision measuring, cutting, fastening, and assembly techniques. Each student fabricated three samples each of three assigned material compositions, that included both stabilized with cement and unstabilized, resulting in nine total samples per student (Table 1). The list was derived from a literature review on rammed earth and earthen material compositions, where sources described proportions as ranges, such as 10%-20% sand, rather than a precise quantity (Gallipoli, et al., 2017).

Table 1. Assigned typical rammed earth material compositions.

Student names	Test #	Soil	Clay	Sand	Cement
Alexander, Emily, Valeria	01	60%	10%	30%	0%
Nash, Bradyn, Leah	02	60%	15%	25%	0%
Stephanie, Dan, Solomon	03	60%	20%	20%	0%
Addy, Kyle, Emily	04	40%	30%	30%	0%
Nash, Bradyn, Izzy	05	40%	40%	20%	0%
Valeria, Dan, Kyle	06	60%	10%	25%	5%
Alexander, Leah, Olivia	07	60%	15%	20%	5%
Olivia, Solomon, Nicole	08	60%	20%	15%	5%
Stephanie, Addy, Izzy	09	60%	10%	20%	10%
Emily, Addy, Kyle	10	40%	30%	20%	10%
Nash, Bradyn, Leah	11	60%	15%	15%	10%
Valeria, Solomon, Izzy	12	60%	20%	10%	10%
Alexander, Dan, Nicole	13	60%	10%	15%	15%
Stephanie, Dan, Nicole	14	60%	15%	10%	15%

Rammed earth requires time to cure before reaching full structural and material strength, where research indicated time frames between 30 and 90 days (Ghasemalizadeh & Toufigh, 2020). Students aimed for a minimum of 21 days, with 30 days preferred, for their samples to cure, then designed a series of "stress tests," or experiments, at varying time scales to evaluate compaction, curing behavior, and environmental resilience (Figure 1). At least one needed to extend over the course of the semester, such as leaving the material samples outside, misting with water every three days, or subjecting them to rapid freeze-thaw cycles using a freezer, to observe long-term impacts of snow, rain, and temperature on material properties, weathering, and durability. While a creative interpretation on a traditional lab experiment, students conducted each test with rigor, subjecting each sample to the same set of actions. Students documented their observations through diagrams, photography, and reflective writing, emphasizing iterative learning and understanding material behavior over time. Assigned readings included both conceptual and technical resources from material science, engineering, landscape architecture, architecture, and fabrication.

Figure 1. Sample experiment documentation. This student left samples outside over a period of 8 weeks to understand the impact of precipitation and freeze/thaw on material durability. Work found that the samples with a low percentage of clay and no cement degraded quickly. Student work.

2.2 Part II: Literature Review, Research + Alternative Material Development

This project used both traditional literature review and fabrication to investigate typical and experimental earthen material applications. The larger goal was to trigger ongoing research, thought, and creative investigations into using new, alternative, or non-traditional materials in the landscape. The assignment had four specific learning objectives:

- To learn about typical applications of earthen materials in Architecture and Landscape Architecture.
- To learn about experiments, products, and design work using alternative earthen material compositions.
- To design an alternative earthen material composition.
- To test small-scale material samples through experimental fabrication methods and stress tests.

Building on their hands-on material work of Part I, students conducted literature reviews on historical and contemporary uses of earthen materials in architecture and landscape architecture, including rammed earth, cob, compressed earthen blocks, and clay bricks. They also researched alternative materials incorporating bio-based fibers, waste products, or experimental fabrication techniques such as 3D printing, fabric formwork, and poured earth.

Each student designed an experimental material composition intended to support or encourage novel landscape processes, such as water collection, soil stabilization, vegetation growth, or habitat creation. Work spanned from using bubble wrap as formwork, integrating banana fibers as reinforcement (Figure 2), seeding compositions with mycelium spores, and layering harvested biomass between layers to mimic other construction techniques. Five small-scale samples of these compositions were fabricated, tested, and analyzed through stress experiments and iterative observation. Students documented formal and material variations with explanatory text, diagrams, and photographs, exploring potential interactions with landscape systems to place their materials in this larger context. Assigned readings included both conceptual and technical resources that formed the beginnings of their literature reviews.

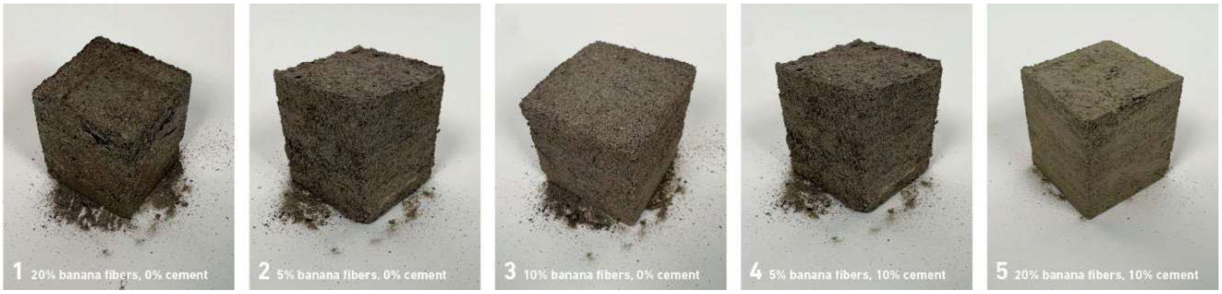

Figure 2. Five material samples reinforced with banana fibers, with cement content ranging from 0% to 10%. Mix proportions varied from 20% fibers (Sample 1) to 5% fibers (Sample 5). Student work.

2.3 Part III: Fabrication, Speculation + Installation

The final project synthesized conceptual knowledge, material experimentation, and technical fabrication taught in Parts I and II. It also introduced students to hybrid representation methods to visualize ideas of landscape change and relationships to larger systems. Part III had three learning objectives:

- To work in small groups to design and fabricate a series of cast earthen modules.
- To install modules at Cedar Creek Ecosystem Science Reserve
- To create a series of drawings that speculate on long-term landscape, material, or formal changes instigated by their installation.

Students worked in interdisciplinary groups to design and fabricate site-specific earthen modules to be installed at Cedar Creek Ecosystem Science Reserve. Students used Rhinoceros 8.0 (Robert McNeel & Associates) to design modules that could tile together and fabricated a portion (2’x2’ minimum) of a larger tiled design. Modules were fabricated through computer numerical control (CNC) carving a mold or negative of their designed module out of K-60 pottery plaster, wood, high-density foam, or MDF. Each group created a series of drawings to speculate on change-over-time of their installation at Cedar Creek Ecosystem Science Reserve in plan, section, detail, and perspective. Students considered multiple scales and times, including landscape, geologic, and hydrologic, with each drawing working in concert to elaborate on their project beyond simply the smaller portion that was constructed and installed. The research goal of this final assignment was to not design or consider these modules as “static” but rather as active agents in the landscape that change, adapt, or generate novel processes over time, asking students how this can be choreographed through formal variations and material characteristics.

Students in the *Generative Wall* group (Figure 3) began with the design concept of “a structural wall that does (something).” This group designed four unique unstabilized modules that, when stacked, created a wall with continuous interior voids. Their speculative drawings described material degradation over time, highlighting how the voids could channel and collect water, creating pools in some areas while encouraging decay in others. Other student-produced drawings described alternate configurations, including how additional built modules could expand to divide space, adapt to different site conditions and topographies, and provide more expansive habitat for emergent vegetation, insects, and animals.

This group chose a location within the demonstration prairie for installation. Shortly after installation, a spider was observed exploring the unintentional cracks and crevices formed during the fabrication process. A large bull snake found its way into the wall to bask in the sun momentarily. While it was their intention to create a modular wall that supported both humans and non-humans, students were pleasantly surprised how quickly the installation became inhabited.

Students in the *Water Tectonics* group (Figure 4) were interested in two unique sloping modules that could manipulate, shed, and collect site water. Their speculative drawings imagined change over time at multiple scales, including envisioning the modules as a large-scale topographic intervention could begin to modify existing and create new hydrological systems.

They fabricated four modules, two of each form in stabilized and unstabilized material compositions to test how the different material compositions and forms interacted with both permanent and ephemeral water on site. Both compositions contained high levels of clay to facilitate plant growth and improve durability. Two were installed in a part of the marsh with permanent water, where the other two were installed in an area that infrequently flooded.

The final group, Froggy Town: Experimental Habitat for the Cope's Gray Tree Frog (Figure 5) aimed to provide habitat for the Cope's Gray Tree frog, a common species in northern Minnesota, throughout their lifecycle. A group of six, each student designed a unique module with different geometries, functions, time scales, material assemblies, and orientations, and installed them into a star-like form around a tree adjacent to the marsh. Both module form and material composition were designed with landscape performance in mind; for example, creating a grooved and channeled module composed of a high clay mixture to reduce infiltration and encourage pooling. Speculative drawings projected short- and long-term impacts, including water collection, emergent and seeded vegetation growth, mycelium establishment, material decay, and habitat creation for both the treefrogs and other species.

After ramming, some blocks had non-rammed earth components added, such as mycelium spores or a stick-and-twine shelter to catch leaves and create covered shelter. During installation, moss, leaf matter, soil, and other found organic materials were placed on and in between the modules to facilitate both habitat creation and encourage embedded seeds and mycelium spores to grow.

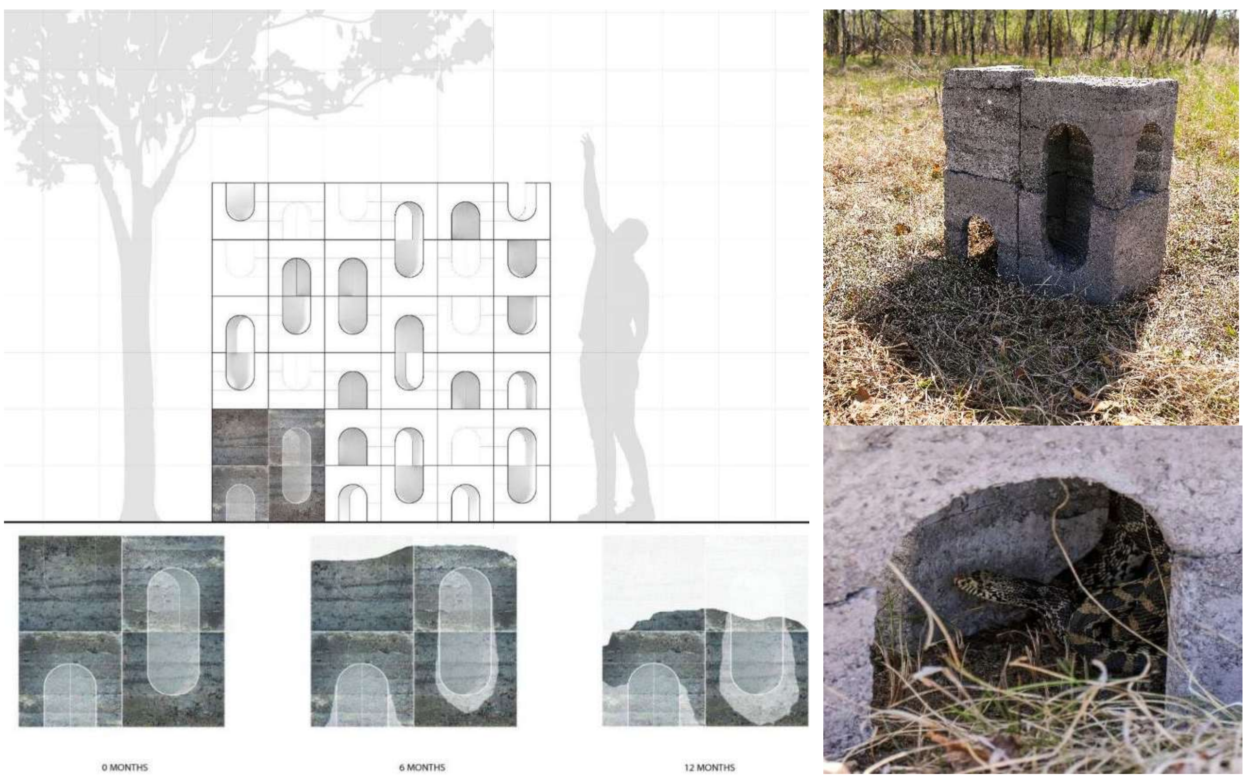

Figure 3. Speculative drawings and installation photographs for *Generative Wall*. Student work.

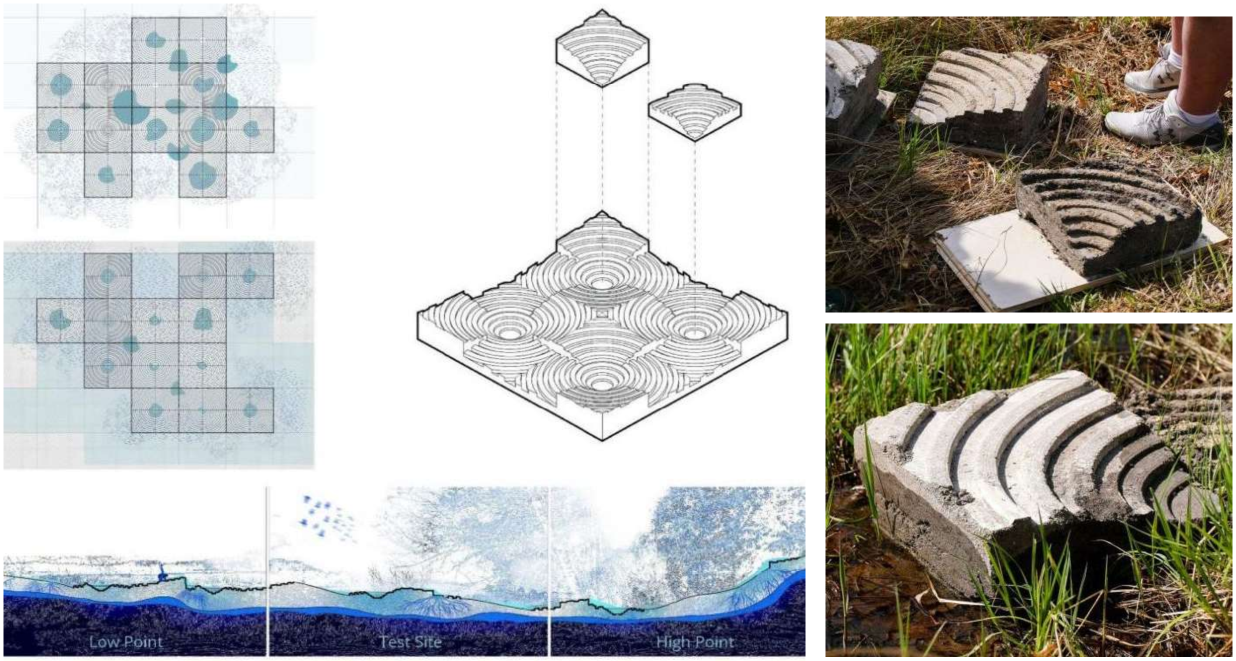

Figure 4. Speculative drawings and installation photographs for *Water Tectonics*. Student work.

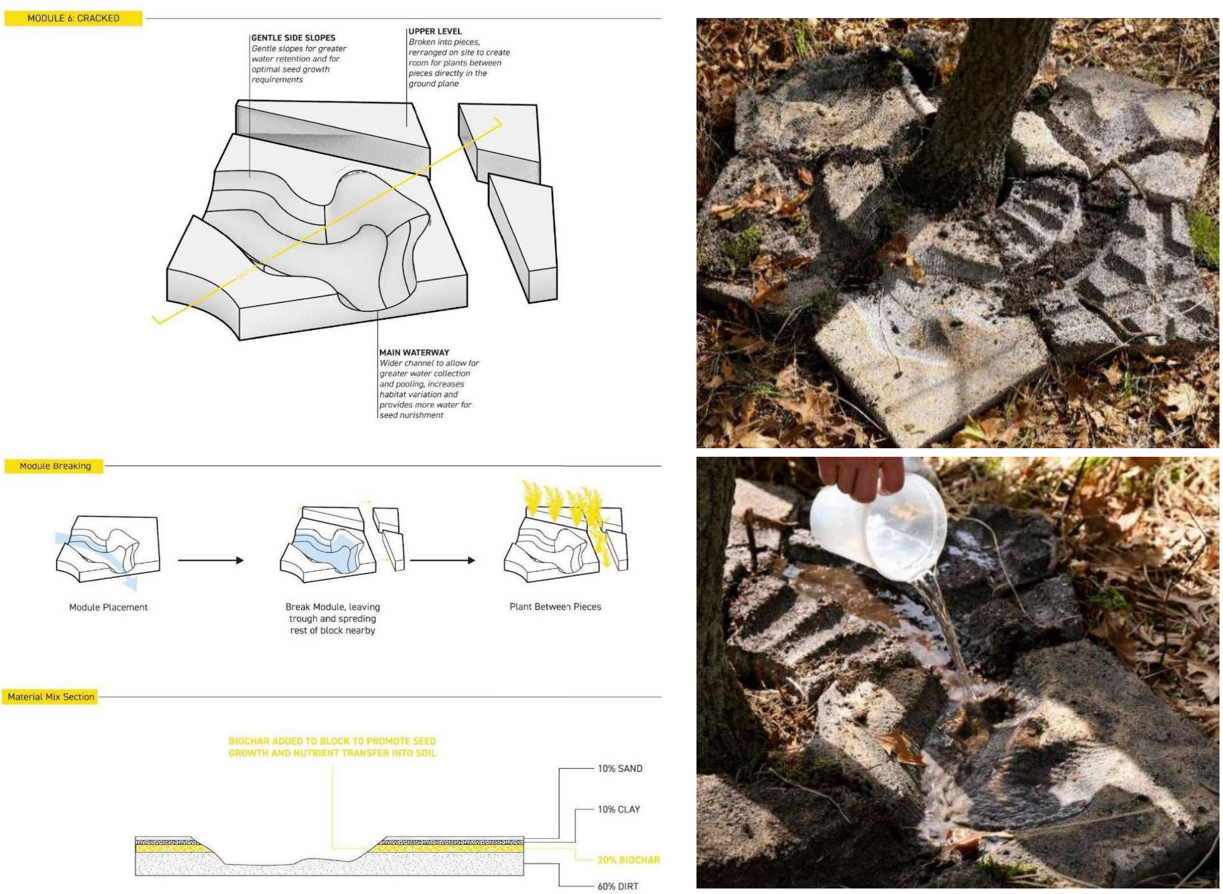

Figure 5. Speculative drawings and installation photographs for *Froggy Town*. Student work.

3 RESULTS

3.1 Materials and Fabrication Processes

Outcomes of this course were limited by student inexperience, who had little or no background in fabrication or woodworking. None had prior exposure to RhinoCAM, CNC milling, or rammed earth, which meant a significant portion of the semester was devoted to building basic competence. This work builds on scholarship in design-build pedagogy that emphasizes the value of hands-on engagement with materials while also highlighting the challenges of balancing conceptual ambition with technical execution in landscape education (Canizaro, 2012). While the course created valuable learning opportunities, it also revealed how gaps in fabrication training can limit the depth of material exploration. Future iterations of the course will need to place greater emphasis on technical skill-building early in the process to better support experimentation.

Part I revealed a steep learning curve: inaccurate molds, uneven compaction, and inconsistent material mixtures led to fragile or failed blocks. Some students achieved well-compacted blocks with appropriate soil-to-water ratios, while others repeatedly produced mixtures that cracked or collapsed. Observing these outcomes reinforced lessons in precision, iterative making, and the sensitivity of earthen materials to small variations in material composition (Ghasemalizadeh et al., 2020).

Part III introduced plaster casting and CNC milling, which presented challenges. Students were tasked with casting plaster blocks for CNC milling, but the process, surprisingly, proved difficult for many. The *Water Tectonics* group, for example, mistakenly purchased Plaster of Paris instead of the specified K60 Plaster, and they also struggled with consistent plaster-to-water ratios. Their blocks cured unevenly, were brittle, and too soft for precise milling. The resulting milled blocks failed to capture the intricacies of intended designs, and poor rammed earth fabrication processes compounded, resulting in imprecise, brittle, and overall poor-quality final modules. On site, even the stabilized modules degraded rapidly, emphasizing the importance of understanding the specific relationship between intent, fabrication precision, and material performance in design research and practice (Figure 6a).

The *Generative Wall* group pursued a more ambitious exploration of form and structure, but their design revealed limitations when fabricated. Their modules incorporated thin leg-like supports attached to heavier block masses, which introduced stress points that consistently failed during demolding, drying, or transport. They hypothesized that differential drying rates between thin and thick sections accelerated cracking and created weak points and attempted to re-attach the legs with an earthen material mixture. By the first site visit, much of the wall had collapsed, though the larger blocks persisted longer and weathered closer to the intended design intent (Figure 6b).

(a)

(b)

Figure 6. Fabrication failures: (a) modules by the Water Tectonics group disintegrated rapidly due to improper fabrication; (b) the Generative Wall collapsed as its form was structurally unsound. Student work.

These outcomes point to the importance of scaffolding technical instruction in courses that integrate material research and site-based fabrication. Without a foundation in mixing, compaction, and formwork construction, design ambitions outpaced technical execution. Embedding skill-building earlier in the curriculum could lay a stronger foundation for experimentation, while also positioning material practices as a productive site of inquiry in landscape pedagogy and research (Brown & Camilli, 2023).

3.2 Pedagogy

Student responses, collected through the University of Minnesota's Student Rating of Teaching (SRT) survey, reflected a strong interest in fabrication and alternative materials, affirming the value of hands-on making within a landscape architectural curriculum. As shown in Table 2, students consistently noted that the course deepened their understanding of subject matter while also creating space for exploration. The course structure, which combined open-ended inquiry with a scaffolded sequence of assignments, was recognized as a strength because it encouraged experimentation while still guiding students through material and fabrication processes. This aligns with broader research on design-build pedagogy, where experiential learning fosters both conceptual engagement and technical proficiency (Brown & Camilli, 2023).

Table 2. Student evaluation responses collected through the University of Minnesota's Student Rating of Teaching (SRT) survey.

Course Items		
I have a deeper understanding of the subject matter as a result of this course.	5.50	6.00
I would recommend this course to other students.	5.75	6.00
My interest in the subject matter was stimulated by this course.	5.50	6.00
The activities in this course supported my learning.	6.00	6.00
The amount of effort needed to be successful in this course is reasonable.	5.75	6.00
Instructional technology employed in this course was effective.	5.75	6.00
Open ended responses		
Offered a hands-on learning approach that helped immensely with grasping the concepts of rammed earth and its various compositions.		
Left the class very open ended and allowed students to explore topics that they were passionate about.		
Provided helpful feedback when needed and allowed for a lot of hands-on work time.		

Despite these successes, several constraints limited the depth of learning. Space limitations in the shared woodshop required students and instructors to use an area that had to be fully cleaned at the end of each class session. This logistical hurdle added extensive preparation and take-down time to every meeting, cutting into already short 75-minute sessions. Both students and instructors recommended a dedicated fabrication space, paired with longer class sessions, to enable more immersive and continuous work, aligning better with the iterative nature of making and testing in material research. Several students suggested reducing the number of assignments to allow deeper focus on Parts I and II, giving more time to explore material properties and speculating on potential ecological interactions before the final installation. This shift would allow students to fully connect conceptual exploration with technical rigor, reinforcing the pedagogical value of making as a mode of inquiry.

The course also demonstrated that hands-on material experimentation strengthened the conceptual learning. Students developed a critical understanding of temporality, change-over-time, and ecological performance through tactile engagement with materials. Failures, cracking, and unexpected degradation became pedagogical opportunities, challenging assumptions about permanence and durability while reinforcing the value of iteration. Future versions of this course would develop a specific survey tailored to the unique format and learning objectives, distributing to the students at the beginning, middle, and end of the semester to demonstrate the connection of hands-on making with inquiry. By providing the survey multiple points during the semester, outcomes and technical skills could be tracked including familiarity with fabrication tools and processes, comprehension of course's conceptual framing, vocabulary around rammed earth fabrication and change-over-time, and view on traditional landscape architectural materials, earthen materials, and experimental bio-based materials.

3.3 Interdisciplinary Collaboration and Peer Learning

The interdisciplinary structure of the seminar was a distinct pedagogical strength, as one of the few curricular opportunities to bring together students from both the Master of Landscape Architecture (MLA) and Master of Architecture (MArch) programs. This facilitated peer-to-peer learning and fostered meaningful connections across academic cohorts. Interdisciplinary collaboration was intentionally embedded across all project phases to encourage collaborative workflows and conversations throughout the semester. One successful example occurred at the beginning of Part III, where the class collectively brainstormed a range of potential project ideas then self-sorted into groups based on their interests, rather than by discipline, resulting in three interdisciplinary teams (Figure 7).

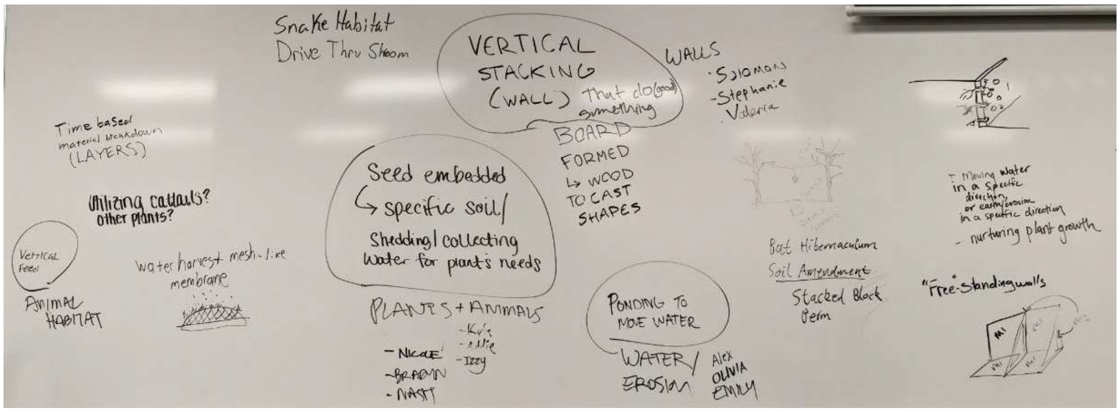

Figure 7. Part III in-class brainstorming session. Students first generated a range of potential intervention ideas, then consolidated similar ideas around themes, and finally self-sorted into working groups based on individual interests. Photo by the author.

In the *Froggy Town* project, for example, each student was responsible for designing a unique modular unit, with the group collectively determining a consistent set of design parameters including overall dimensions, shape, edge height, and material thickness. This ensured the modules would tile correctly, ensuring cohesion in the final installation. During the fabrication phase, the students developed an efficient assembly-line production strategy to pour the plaster forms, mix material compositions, and participate in the ramming process for each module, allowing all to contribute equitably to the entire fabrication process. This collaborative method reinforced the importance of shared decision-making, iterative problem-solving, and co-authorship.

Despite the strengths of this interdisciplinary structure, challenges emerged in the comprehension of the course's conceptual framing. The seminar's central theme of "landscape change-over-time" is foundational within the MLA curriculum but largely unfamiliar to MArch students. To address this, additional lectures, targeted readings, and in-class discussions were required to build foundational knowledge and support their engagement. Moreover, most MArch students had limited prior experience designing with landscape systems, earthen and landscape materials, or across spatial and temporal scales. Future iterations of this course might dedicate more time to building foundational knowledge and creating space for interdisciplinary conversation around the course's larger, more complex conceptual and theoretical frameworks.

This identified gap has since informed broader curricular developments in the ALI Department, including the design of joint Landscape Architecture and Architecture studios, seminars, and lecture-based courses. These offerings seek to cultivate a shared design vocabulary, support collaborative methodologies, and strengthen interdisciplinary competencies among graduate students. Future iterations of the seminar will benefit from this evolving pedagogical infrastructure, enabling deeper engagement with complex systems-based thinking that is critical in contemporary design practice.

4 SUGGESTED AREAS FOR FUTURE RESEARCH AND TEACHING

This case study highlights several key themes for future research and pedagogical development, particularly in the integration of hands-on making into design education. Physical making provides an important supplement to digital drawing and design, as students engage directly with materials and must consider texture, tactility, craft, and the process of assembly. Students can test the limits of specific materials, gaining an in-depth understanding of their properties such as grain, texture, and how these materials break under stress (Christenson, 2016). This hands-on experience fosters a deeper appreciation of materiality, not simply as a theoretical concept, but as a tangible, and integral aspect of the design process. Future research could explore the educational benefits of incorporating more hands-on making into the curriculum; for example, how the approach might impact long-term learning outcomes in design education and professional practice. Surveys conducted pre- and post-course could measure these impacts, tracking students' progress and assessing the transfer of skills into their remaining design education and into their early careers (Crowther & Briant, 2021).

The experimental stress tests conducted within the course also provide venues for further inquiry, particularly in relation to rigor and assessment within an educational context. Such tests offer students the opportunity to evaluate the performance of their designs in real-world conditions, allowing them to revise and adapt their projects based on actual outcomes. This element of experiential learning is rare within design education, where many projects are speculative in nature. Understanding implications of design decisions such as material failure or unexpected performance outcomes can significantly inform the iterative design process. Additionally, it raises important questions about how students engage with failure and learn to adapt in the face of real-world constraints.

Beyond pedagogical considerations, these findings also suggest future research trajectories, particularly in exploring the relationship between material performance and large-scale landscape systems. Expanding the scope of experimental stress tests and integrating additional fabrication methods, such as 3D printing and alternative bio-based materials, could provide valuable insights into the intersection of materiality, fabrication, form, and performance. This research and teaching could contribute to broader discussions on sustainability and resource efficiency in design, highlighting how material choice and fabrication processes influence both environmental impact and long-term performance. Integrating these experimental methods into teaching and practice could further inform how landscape architects approach materiality, from conceptualization to implementation, in both academic and professional contexts.

5 CONCLUSION

Research seminars offer unique opportunities for design exploration and experimentation that extend beyond the boundaries of traditional studio settings. These courses provide fertile ground for interdisciplinary collaboration, as elective courses often offer greater flexibility than core curriculum courses and allow for the exploration of alternative topics, novel working methods, and expanded learning objectives. The curriculum for *Earthen Tectonics* was designed to both teach students specific fabrication skills and foundational knowledge about earthen materials in the built environment while simultaneously allowing flexibility for creative exploration and self-directed learning. The goal was to foster an experimental mentality, explicitly giving students space to follow emergent and unexpected discoveries from making processes rather than working towards a fixed “end point” or previously determined outcomes. This mentality was particularly apparent in “Part II - Literature Review, Research + Alternative Material Development,” where students explored a wide range of ideas spanning from iterations on traditional construction methods to the incorporation of experimental waste materials. The breadth of topics reflects the course's commitment to experimentation and rejection of prescribed outcomes.

Outcomes from this seminar underscore the growing interest in material experimentation and potential for expanding earthen material use in landscape architectural contexts. These materials, by nature, undergo change and degradation over time, offering students opportunities to engage with complex conceptual and theoretical questions central to our discipline, including landscape change-over-time, speculative representations, and projecting alternative futures. By directly engaging with material testing, iteration, and physical making, students were able to develop a more nuanced understanding of the environmental impact of their design decisions. This approach provided an alternative way to visualize and understand the long-term impacts of design on landscapes, an aspect of design education often limited by the speculative nature of typical projects, bridging theoretical exploration and practical application.

The broader implications of this course suggest valuable directions for future research and educational practice. Expanding the use of alternative, sustainable materials in design education could deepen students' engagement with pressing environmental issues. Similarly, future seminars and research could further investigate how experimental material methods intersect with large-scale landscape systems and environmental processes. Pedagogical experiments such as this one not only prepare students with technical and conceptual skills but also contribute to the evolving discourse on sustainability and resilience in Landscape Architecture.

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