Coding Open Rammed-Earth Systems: Preserving Sustainability in Earthen Architecture

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Contents

1 INTRODUCTION

"The history of building construction can be construed as a narrative of the inertia and momentum of two divergent construction logistics. One mode[, discussed above,] has very minimal historical inertia coupled with great current industrial momentum (the muli-layered assemblies of modernity.) The other has great historical, physical, and thermodynamic inertia that is coupled with minimal industrial momentum in the contemporary building industry/building science industry (more monolithic assemblies and masses). The former follows the short history of the twentieth century "rationalization" of construction, air-conditioning, factory production, lightweight envelopes, and, more recently, mass customization. The latter is a several-thousand-year history of accumulative knowledge and performance all but forgotten in the interesting yet hubristically selective amnesia of twentieth century architecture."

— Kiel Moe.
Convergence. 2013.

"Rammed-earth" / "pisé de terre" / "tapia" / "hāngtŭ" refers to an earthen building material formed by a particular mechanical process. Observably, rammed-earth forms are appearing around the U.S. with a breadth and depth previously unseen. They are visible east and west of the Rocky Mountains predominantly around academia, professional design, and building science/industry. Rammed-earth has archaeological, anonymous, and autochthonous roots in ancient China, Africa, the Middle East, Old Europe, and other regions globally. [2].

Rammed-earth's tectonic within the contemporary U.S. building culture is the subject of this thesis. The object of concern is the narrative/model for rammed-earth design and construction that has emerged since the latter part of the nineteenth century vis-à-vis rammed-earth's traditional construction logistic. The great current industrial momentum of the multi-layered assemblies of modernity; and the great historical, physical, and thermodynamic inertia of accumulative knowledge and performance.

"[T]he culture that once was slow-moving, and allowed ample time for adaptation, now changes so rapidly that adaptation cannot keep up with it. No sooner is adjustment of one kind begun than the culture takes a further turn and forces the adjustment in a new direction. No adjustment is ever finished. And the essential condition on the process — that it should in fact have time to reach its equilibrium — is violated. This has all actually happened. In our own civilization, the process of adaptation and selection which we have seen at work in the unselfconscious cultures has plainly disappeared."

— Christopher Alexander.
Notes on the Synthesis of Form. 1964.

1.1 The Model is the Message

Marshall McLuhan noted (*Understanding Media*, 1964), with respect to media/technology, that the medium is the message. The rammed-earth medium *qua* traditional rammed-earth conveys a perennial socio-technical desire for a durable, economical, and sustainable form of building. This is not an unseen desire in U.S. building history. In the late-eighteenth century, French architect François Cointereaux advocated rammed-earth architecture (residential and agricultural) to Thomas Jefferson to suit America's burgeoning rural economy; painted as "the economical building art of the ancients, perfected and made more universal[1]." During the Great Depression, rammed-earth briefly held the attention of the New Deal-era Resettlement Administration as an economical building alternative. During the 1960s and 1970s, rammed-earth attracted marginal interest from the environmental movements following the global recognition of adverse anthropogenic effects on the biosphere [1].

It is argued here that around this point in time (60s, 70s), the Second Law finally began to have its way with rammed-earth's inertial, coherent, and adaptable construction logistic. The environmentally-aware milieu raised rammed-earth into a technologically dependent world caught between (in binary terms) developmentalism and zero-growth[2]. The United Nations Department of Economic and Social Affairs (1964) output a disordering of rammed-earth called soil-cement.

> *"Provided that natural soil possesses a combination of certain characteristics, however, it can be subjected to the process known as 'stabilization'. The effect of adding a stabilizing agent like Portland cement, for instance, is not ony to enhance its best qualities but to impart to it other properties which soil alone does not possess."*
>
> — Augusto A. Enteiche G. Alexander.
> *Soil-Cement: Its Use in Building.* 1964.

> *"Contemporary stabilized rammed earth (SRE) draws upon traditional rammed earth (RE) methods and materials, often incorporating reinforcing steel and rigid insulation, enhancing the structural and energy performance of the walls while satisfying building codes. SRE structures are typically engineered by licensed Structural Engineers using the Concrete Building Code or the Masonry Building Code."*
>
> — Bly Windstorm and Arno Schmidt.
> *A Report of Contemporary Rammed-Earth Construction and Research in North America.* 2013.

Contemporary technologies such as cement-stabilized, pre-insulated, and pre-fabricated walls—innovations currently driven by standard fixations on insulation, energy efficiency, and mass-production—disorder the coherence between the industrially-unprocessed material and its formative methodology. Apart from historic preservation, for which there is no positive heritage of rammed-earth building in America to preserve, it is hypothesized herein that this coherence of local material with localized building methodology is the key to rammed-earth's veritable sustainability (physically and conceptually enduring for millenia, while concurrently sustaining its respective inhabitants).

> *"The history of building construction can be construed as a narrative of the inertia and momentum of two divergent construction logistics. One mode, discussed above, has very minimal historical inertia coupled with great current industrial momentum (the muli-layered assemblies of modernity.) The other has great historical, physical, and thermodynamic inertia that is coupled with minimal industrial momentum in the contemporary building industry/building science industry (more monolithic assemblies and masses). The former follows the short history of the twentieth century "rationalization" of construction, air-conditioning, factory production, lightweight envelopes, and, more recently, mass customization. The latter is a several-thousand-year history of accumulative knowledge and performance all but forgotten in the interesting yet hubristically selective amnesia of twentiety century architecture."*
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> — Kiel Moe.
> *Convergence.* 2013.

[1] `http://archive.is/yWexi`
[2] `http://archive.is/sOf7w`

2 AN ARCHITECTURAL THEORY ABOUT THERMODYNAMICS AND A THERMODYNAMICAL THEORY ABOUT ARCHITECTURES

2.1 An Architectural Agenda for Energy

Architect/builder/author/professor Kiel Moe has authored a number of texts and a number of buildings in and around the past decade that cogently and convergently embody a novel theory about building(s) and energy. “An Architectural Agenda for Energy”, the subtitle of *Convergence*, describes a “more totalizing” conjunction of building systems with the subtle yet opportunistic complexities of energy typically siloed off to engineering and applied science. In this way, the Agenda predicates healthier building dynamics (more durable and effective flows of matter/energy), in turn, predicating healthier inhabitants (re: Sick Building Syndrome, Building Related Illness) and healthier ecosystems (holistic environmental accounting) [3]. The Agenda and its network of references form an ideal system with which rammed-earth's contemporary presence may be bridged to its sustainable history. This section is dedicated to fitting rammed-earth design and building further into the Agenda, hopefully with minimal gain in conceptual entropy from Professor Moe's work. At once, the Agenda reflects latent, useful properties of the rammed-earth material and method as well as the terrifically complicated, complicating mega-structure of building rammed-earth currently finds itself in.

Professor Moe explicitly references rammed-earth at least twice. Once, in the Building Lecture Series at the University of Virginia[3], in the context of rammed-earth as a thermally massive building material. Capillary to this vein, Professor Moe discusses the material quantities thermal effusivity (e) and thermal diffusivity (α) contributing to a more wholesome understanding of building materials as thermally transient, interactive, qualitative systems rather than scientifically ideal systems forever operating in the steady-state mode. Second, Professor Moe references rammed-earth as a case study in *Convergence*: the Granturismo Earth and Stone project in southern Portugal. Initially a reforestation initiative funded by the European Union, the project entailed ten rammed-earth and stone structures in the inner Algarve region suited for tourism and recreation. In this remote area, the locally-sourced property of rammed-earth proved to be critical for design, construction, economic, and ecological reasons. Furthermore, the Algarve does possess a positive heritage in rammed-earth building and Granturismo was an opportunity to “[make] the history of the Algarve material culture apparent while [the material selection reinvests] in the labor and skill connected to that material.” [3]

In the next three subsections, rammed-earth codes, performance, and energetics are drawn around the Architectural Agenda for Energy. The ultimate motivation for doing so is founded in the fact that the Agenda values the historical inertia of rammed-earth with its contemporary potential in a profoundly integrated manner. Ostensibly, no other theory of building draws across disciplinary boundaries (engineering, physics, architecture, ecology, history, economics. . .) nor across scales (“From the Molecular to the Territorial”[4]) so applicably.

At a high level, the socio-technical, building codification is regarded as a great challenge and a great opportunity to preserve traditional rammed-earth. At an intermediate level, material and thermal performances of rammed-earth are considered in light of standard building envelopes. At a third level, the quantum and the global simultaneously, quantities and qualities of energy are considered as they pertain to the design and construction of rammed-earth buildings.

[3]`http://archive.is/u9TKf`
[4]`http://archive.is/7lXIB`

2.1.1 Rammed-Earth Codes

2.1.2 Rammed-Earth Performance

2.1.3 Rammed-Earth Energetics

2.2 Constructal Design

“The pyramid and the quarry grow at the same time. If the pyramid is a positive architecture (y ¿ 0), the quarry is its negative. Such positive-negative pairs are everywhere in history and geography, even though modern advances in transportation technology tend to obscure them ”

“Pyramids and ant hills are like the dried beds of rivers, cracked mud, and dendritic crystals (snowflakes): They are traces (fossils) of the optimized flow configurations that once existed. The universal phenomenon is the generation of flow architecture, and the principle is the constructal law: **For a flow system to persist in time (to survive), its configuration must change such that it provides eas** [author’s emphasis] In a flow system, easier access means less thermodynamic imperfection (friction, flow resistances, drops, shocks) for what flows through the river basin or the animal. The optimal distribution of these numerous and highly diverse imperfections is the flow architecture itself (lung, river basin, blood vascularization, atmospheric circulation, etc.). . . In the making of a pyramid, the constructal law calls for the expenditure of minimum work. This principle delivers the *location* and *shape* of the edifice.”

In the same way, rammed-earth structures are traces of animal collectives that have known to expend work to converge a particular soil gradation from local soilscape to site (area to point), compose a workable mixture

3 BOURNE-AGAIN SHELLS: COMPUTATION IN BUILDING

3.1 Open-Source Architecture

3.2 Flux.io

References

[1] Jennifer Lynn Carpenter. *Dirt Cheap: The Gardendale Experiment and Rammed Earth Home Construction in the United States.* 2010.

[2] Anthony F. Merrill. *The Rammed Earth House.* Harper and Brothers, 1947.

[3] Kiel Moe. *Convergence. An Architectural Agenda for Energy.* Routledge, 2013.