Capricious Concrete: On Plasticity in Material and Method

Things simply are not 'fit for their purpose.' At one time a flake of flint was fit for the purpose of surgery, and stainless steel is not fit for the purpose yet. Every thing we design and make is an improvisation, a lash-up, something inept and provisional. We live like castaways.

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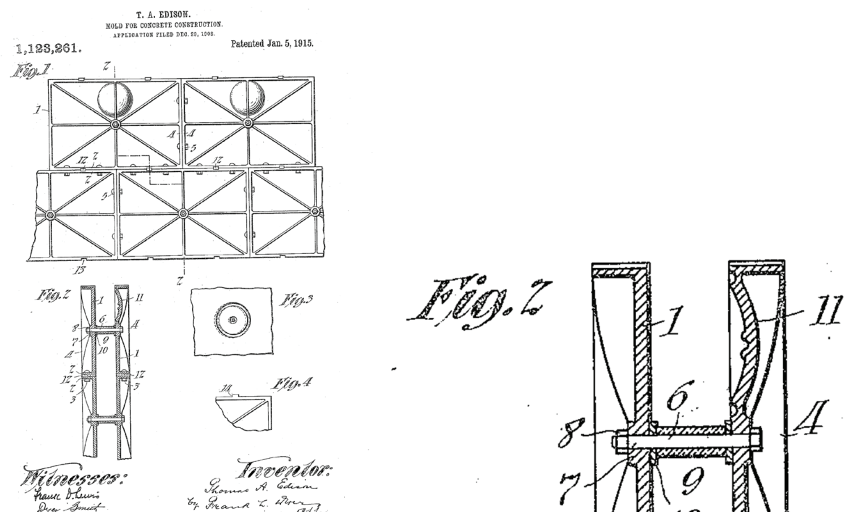
In a method displaying remarkable adaptability, a man at the turn of the last century built a seven-story reinforced concrete museum in less than a year with one horse and ten laborers. Concrete does not lend itself to speed. More significantly for this paper, concrete is rarely employed in architectural processes as flexible or adaptable—as plastic—as their material result might suggest. On the contrary, concrete construction often calls for greater attention to tolerances, specifications and construction sequence: that is, for greater control, than alternate materials and methods. Despite many of the claims made in the foment of early modern hyperbole, concrete construction is typically not a plastic affair. Every corner, gap, and detail must be drawn and calculated, measured and laid out, and built on site in formwork before the "plastic" material flows in to take its eventual shape. In this the most monolithic, most seemingly-sculptural of materials is in practice one of the least, often requiring more complex carpentry than similar forms executed in wood, and more intricate patterning of metal ties and connectors than similar structures made of metal. Concrete may be the most difficult material commonly used in contemporary construction; certainly, it is one of the hardest to predict.

Control is the question at the heart of what follows: How do our drawings, and the conversations that surround them like mayflies, set in motion a set of controlled activities which result in a (more or less) predicted-building; and to what degree does the explicit nature of that prediction—a representational activity which mimics, but is not equivalent to, depiction—foreclose on the collaborations and improvisations that may otherwise enrich architectural activity?

For the sake of brevity we will need to assume here a passing familiarity with contemporary architectural practice, in the United States and similar jurisdictions, and in that setting the way a typical set of construction or contract documents is created by a design team and interpreted by a contractor or builder. As it is practiced today, this is often called, in brief, the design-bid-build model, in which the architectural document has as its objective the complete foresight of all the variables of construction. That this is a pervasive and almost universally adopted method for the achievement of buildings "on time and on budget" is as much a legal requirement as it is a pragmatic solution to the problems of sourcing and managing the flows of material and expertise. It is not, however, invariably employed even today; and its advent is a recent historical phenomenon. As such, examples of alternative-construction methodologies more open—or given—to adaptive process may come either from contemporary artisanal or arts practice, or from moments prior to the hegemony of the design-bid-build process. Just such a moment occurred one hundred years ago in the countryside near Philadelphia, Pennsylvania, where the archeologist and collector Henry Chapman Mercer built a concrete house, workshop, and, finally, a museum.



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At the turn of the last century, reinforced concrete was a new technology, something only beginning to be adapted from factories and grain elevators for use in more traditional architectural contexts. It was (and may still be) one of the construction methods most prone to accident, and most designers who work with concrete do their best to eliminate the possibility of a whole catalogue of failures: blow-outs, bungholes, honeycombing, cracking, crazing, bellying, and so on. Some of the first experiments with concrete architecture were also some of the most absurd. Thomas Edison famously designed and prototyped a concrete house with cast-iron formwork that was so heavy, and so detailed, that it cost 25 times the sale price of its concrete result, and was used only a dozen times before being abandoned.[1] In these forms every detail—moldings, fireplaces, etc.—was created as part of the iron formwork, (figure 1) in order to enable the construction of the house in one single, continuous, pour.

Contrariwise, and contemporaneously, Mercer orchestrated his concrete pours in small batches, resulting in a myriad of striations and lines on the façade of his house, museum, and workshop (figure 2), an aesthetic effect prefiguring the material experiments with rammed-earth in the nineteen-nineties and aughts by architects such as Will Bruder and Rick Joy; or finding an echo at Peter Zumthor's Bruder Klaus Chapel. But the most avant-garde attribute of Mercer's architectural experiments had little to do with the buildings' material, style, or form. Mercer's forms were ad-hoc, with rooms added iteratively as domestice program or museum collection warranted. His stylistic intuitions were retrograde, owing as much to English estates and medieval castles as to anything relevant to the flowering of modern functionalist architecture that he preceded by only a handful of years. Even the choice of reinforced concrete may have had more to do with pragmatic considerations—Mercer cited fire resistance and durability among his driving concerns—than with a modern preoccupation with the new material as new material. Mercer worked with concrete as if it were not a new material at all, but rather as something with which he as intimately familiar, adapting to and accommodating its inaccuracies and idiosyncrasies as if the material were no more

Figure 1: Thomas Edison's patent for concrete formwork. Note, in the enlarged detail, item 11: a recess intended to create a relief pattern in the concrete. *Source: Edison's 1915 Patent:*

permanent than clay. (His only record of the design process, other than his ongoing and constantly evolving construction notebooks, was a model built first in clay and cast in plaster.)

If Mercer worked with concrete as if it were clay, this was only natural, given his occupation as owner of and primary designer for one of the most renowned ceramic tile producers of the early 20th century, the Moravian Pottery and Tileworks. I will argue in what follows that, far from being a series of impromptu and unplanned actions (as they are often interpreted), Mercer's method of construction was a distinct and strategic response to uncertainty; that this method may have had its origin in Mercer's longtime and daily association with the techniques of ceramic fabrication and kiln building; and that this method can only grow more relevant to future states and sites.

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Figure 2: Details of the façade of the Mercer Museum, Bucks County, Pennsylvania, USA. *Source: Author*

MERCER'S METHOD

In a passage from his notebooks, in which Mercer not only jotted ideas for room plans and tile designs, but which also contained reflections on the work, as well as digressions into history, philosophy, and the arts, Mercer described his peculiar techniques for concrete construction, first worked out in the construction of his house, refined in the building of the Moravian tile workshop, and streamlined in the construction of the museum:

> Several demolished buildings, followed by car loads of unplaned boards, furnished the wooden material for the forms. These consisted of partitions made by laying the boards horizontally, edge to edge one upon another, with battens nailed wherever convenient against their outer sides. Double lengths of wire were looped around and twisted upon the projecting ends of these battens as we proceeded to keep the forms from bulging. These forms were set vertically with a spirit level, and not by eye, as has been asserted. Where high winds deflected them or where they sagged or where mistakes were made the results were corrected after construction … The concrete was purposely not spaded inside the walls in the hope of making them more porous. Continued suggestions as to dampness, resulting in rheumatism, etc., caused us to cast large vertical holes by means of collapsible wooden boxes invented by me, stove pipes filled with dry sand, pulled upward as we proceeded, and even corn stalks wrapped in paper at intervals of a few feet throughout all the walls. The cornstalk plan was, however, a failure as the leaves flew in all directions into the forms and the wet stalks would not burn out of the holes. Angles in the very irregular chimneys, and the chimneys themselves, were cast upon wooden boxes or boards pounded, pried, or burnt out afterwards. … Owing to the color of the Jersey gravel, gray cement and bluish trap, the outer walls show soft gray-yellow with faint greenish reflections and, owing to the roughness of the forms, board welts, and porous spots not retouched, the texture is very rich as seen at a distance. In experimenting upon smoothing down these outer surfaces for weather protection with cement plaster, when a mason working upon a hanging platform did the work, we found that the plastering had been carried too far on the east upper wall of the tower and thereafter proceeded by retouching only the very porous spots.[2]

Mercer tells a story here of an implausibly makeshift construction process: forms were made from cast-offs, from pipes, even cornstalks. Boards were 'pounded, pried, or burnt out.' The mental picture is almost vaudevillian. But this ad-hoc process, he is careful to clarify, is not slap-dash: formwork, though rough in surface, was laid out plumb and square; a parge coat was applied where necessary to maintain a weathering surface, and not merely for visual effect. This last, however, may be as much a rhetorical claim as it is accurate description of the process—there is visual evidence of cosmetic parging throughout the structure, particularly on interior surfaces. (This is my own observation.)

It may be that Mercer's account is deliberately written to emphasize the manual and primitive attributes of his process, given his penchant for rescuing and elevating the undiscovered, unremarkable, and unrefined. (His museum collection was constituted primarily of the cast-offs and obsolete artifacts of early American industry.) Though what criticism there is on the subject tends to take Mercer's accounts of the building as a reliable and accurate description of the construction process, I would argue that Mercer is participating, here, in a narrative that was central to the arts and crafts movement (of which he considered himself a part) and which he would have heard from the source, Charles Eliot Norton, who at Harvard developed his distinctly American, and pragmatic, version of the Arts and Crafts program in the same years Mercer studied there.

Far from being a maverick or lone iconoclast, Mercer played an active part in the Arts and Crafts movement.[3] He was a member of the Boston Society of Arts and Crafts (founded by Norton and an influential body in the movement), and early on worked as the curator of American archaeology for the University of Pennsylvania museum. With Norton, he believed in the value of hand-craft in the face of the rapid modernization and industrialization of his time; but his was not merely a romantic fascination with the Medieval. Mercer stance was altogether more complicated, combining a pragmatic acceptance of industrial processes with a belief in the aesthetic value of variety and individual creative action. In his tileworks, for example, he made use of modern steam-powered pugmills and presses; but refused to employ a recently developed powdered clay die-pressed technique, despite its economy, because the resulting tiles were "oppressively mechanical."[4]

Given his friends and associations, Mercer probably had an iron in this particular fire: it seems likely he wanted his house to be seen as hand-made, as a full participant in the long trajectory of craft-knowledge, the "know-how" and "make-do", that he saw as a core part of American identity. In the exhibition catalogue for his museum, he wrote

> You may go down into Independence Hall in Philadelphia, and stand in the room in which the Declaration of Independence was signed and there look upon the portraits of the signers. But do you think you are any nearer the essence of the matter there than you are here when you realize that ten hundred thousand arms, seizing upon axes of this type, with an immense amount of labor and effort made it worth while to have a Declaration of Independence by cutting down one of the greatest forests in the North Temperate Zone?[5]

Leaving aside questions of motivation and returning to the construction methods that resulted from them, the process described above details a building growing piecemeal, day-by-day, in nearly impossible-to-anticipate variations upon the (minimal, though extant) plans that were developed at the project's outset. From floor to ceiling the walls of the building might vary as much as twelve inches;[6] from the tops of these walls vaulted ceilings would negotiate the span of four, five, or six-sided rooms, which might be smaller, or larger, than originally conceived.

The method of construction of Mercer's vaults is particularly notable. Mercer writes, "the vault forms were made of heaps of earth spread over piles of boxes and overlaid as before

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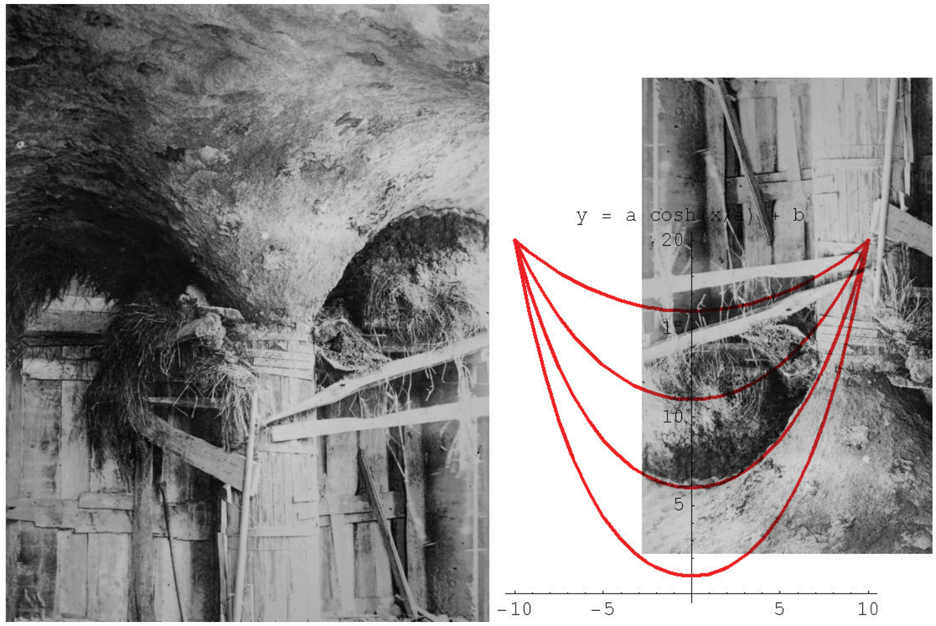


Figure 3: Partially disassembled formwork for a reinforced concrete vault at Mercer's house, with sand and soil still adhering to the surface of the concrete, the formwork not yet removed from column and walls; and a composite of the graph of the mathematical equation for catenary curves superimposed on the same, inverted, image. Note that the center-line of the column aligns with the base of the catenary, and the spring point of the arch is approximately one-third the distance to the apex, traditionally understood to be the ideal location for bracing a catenary arch[7]. *Sources: Bucks County Historical Society; Jim Swift, Northern Arizona University; Composite by author*

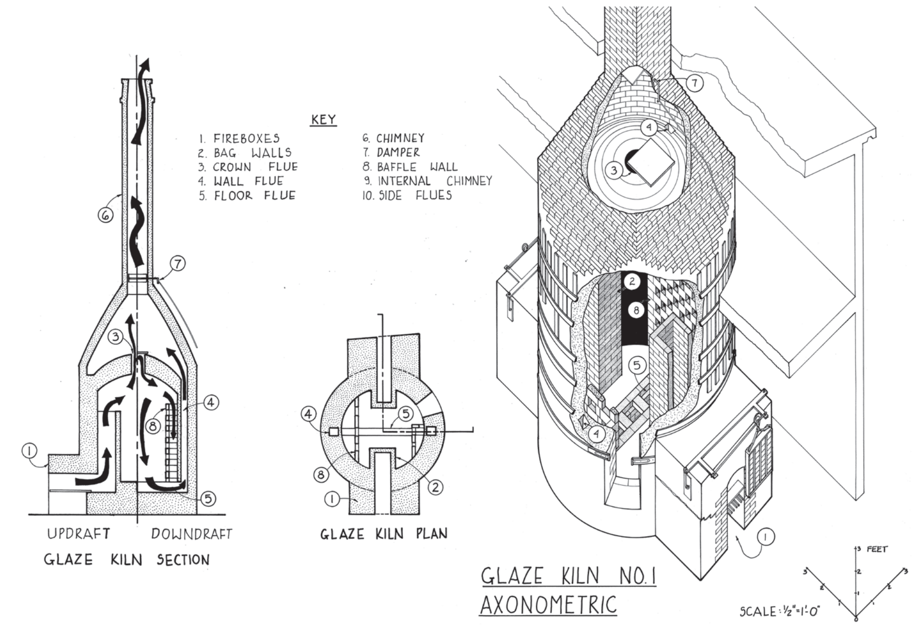
with sand producing a series of carefully graded mounds resting on the platforms." That is, a platform, custom-cut to the profile of the top of the walls, would be built on temporary legs (which would be pulled out later to remove the form.) On top of this platform earth was piled and sculpted to an approximate partial catenary arch. (figure 3) While the arches appear shallow, they are based on a structurally sophisticated system of mutually braced shallow catenaries. (Though some are so shallow, longitudinally, as to seem unlikely to function structurally as catenaries, and probably perform instead as reinforced concrete platforms.) This may seem an oddly, even improbably, modern structural solution; but in the context of ceramic kilns, the catenary arch has deep roots in both Asian and European traditions. The adaptation of the kiln-arch to the house and museum may simply have made good sense to Mercer as well as to his craftsmen, who were employed also in the tileworks.

ORIGINS IN KILNS

The suggestion of catenary structural thinking derived from traditions of kiln building is merely that: a suggestion, without any confirming testament to be found in Mercer's copious construction notebooks. The kilns built at the tileworks were brick, and so required the employment of masonry arches; but were bottle-kilns, and thus employed only partial catenaries, which required metal banding to brace their spring points. (Figure 4)

Interestingly, Mercer's first arches, in his house, are generally variations on low-slope bottle-shapes: columns are inserted to provide resting points for dome-type, crossing, or amorphous, rather barrel-type, vaults. In the pottery and museum, Mercer employed more barrel vaults, perhaps because of their greater simplicity, though Mercer was probably well aware that many traditional kilns used barrel catenaries, including tunnel-type kilns in Europe which go back to Roman times, as well as the Anagama-type kiln, which originated in Korea and was perfected in Japan by the 5th century. (Figure 5)

However, my interest here is not primarily in the adaptation of building technologies from one genre of construction to another. These are a natural part of the cross-fertilizations of tectonic knowledge; and yet they do not constitute the most adventitious of Mercer's contributions to the architectural process. It is not the shape of the arch, but the orchestration of its formwork, that stands as Mercer's most relevant contribution here: put simply, his process required no more infrastructure, occasioned no more complication, and thus entailed no more control, than was absolutely necessary to achieve its desired end. This is an economy of more than financial terms.



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The piling-up of cast-offs, clods of grass, and boxes, is a technique unlikely to be duplicated in contemporary concrete construction. Even were earth-formed-concrete to be specified, that specification would most likely be carried out using evenly-graded mineral soil and sand delivered to the site by a early-morning line of dump trucks, set in ordered and accessible piles for ready delivery to the building footprint. Later, perhaps another truck or trucks would come to haul away the dumpster or dumpsters of construction waste typically in evidence at the building site. Yet it is the cast-offs that are precisely the point here: immediately adjacent, ready-to-hand: they were, for Mercer, a resource rather than wastage; and he would have been trained in this way of thinking by both his scavenging for early-American tools and artifacts for his museum, as well as by the processes of recycling and reconditioning of clay, grog, and glaze materials which play a role in pottery operations of any size. (It should be noted that this kind of thinking is not entirely foreign to contemporary construction practice—there is a LEED credit (MRc3) specifically for the reuse of materials on site.)

With this in mind, it is probably fair to propose that it is not lack of opportunity, not even lack of know-how; but rather a lack of comfort with the appearance of mess and disorder, that prevents otherwise enterprising designers and builders from employing methods like Mercer's. This is not merely a cosmetic problem: disorder, here, stands for every sort of failure of predictive capacity. This is the future earth architecture stands to inherit: a rising tide of economic and ecological uncertainty, and thus, undoubtedly, of increasingly frequent failures of prediction and control. Architecture may address itself to these problems by attempting to create "better," more accurate, more predictive drawings. (Much innovation in the field today seems to be driven by this very goal.) Or it may seek an altogether different relationship to the orchestrations of materials, infrastructures, and human craft, for which the drawing, however detailed, acts merely as sheet music or storyboard.

ON PLASTICITY

Architectural drawings and narratives are, by nature, descriptive of incomplete or wholly nonexistent reality; they articulate a strategy for action, never completely explicated, by which these nonexistent realities might come to be; they are not 'mere' fictions; yet they participate in the temporality of fictional constructions: abridged, itinerant, and fragmentary. These are a particular kind of fiction, akin to what the 19th century philosopher Hans Vaihinger labeled 'heuristic fictions': that is, they assert the truth of the nonexistent for pragmatic ends. But all architectural representations are not equally heuristic.

Figure 4: Bottle Kiln at the Moravian Tileworks (not printed to scale). *Source: Historic American Engineering Record (Library of Congress)*

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Communications in architecture may be more or less pragmatic—that is, related to the building of buildings rather than the judgment of them. An architectural drawing may bear more or less correspondence to possible-real (artifactual) outcomes. But it makes little sense to talk about the 'truth' of architectural drawings, as their subject is, typically, a future state. They are projective, and where a pictorial depiction might be evaluated on the accuracy of its resemblance, with a projective drawing it makes more sense to talk about the reliability of its projection, since 'accuracy' is a property the architectural drawing is incapable of possessing (and odd things result when it is placed above all other criterias.) This becomes a relevant question when we think about the way architectural drawings set in motion the processes they enable.

Doubt is corrosive. When an architectural project fails, when the commitment of intention and resources to a possible future peters out or is diverted to some other end; when we go 'back to the drawing board' it is not the result of inaccuracy but of unreliability: the cause may be blamed on unforeseen costs or regulatory requirements or changes in scope or site or clientele; but these are symptoms of an underlying transformation in the relationship between the architectural drawing and the particular future it projects. The architectural drawing, when it fails, fails through irrelevance rather than inaccuracy, and occasions, rather than rejection, neglect.[8]

Imagine an architect acting more like an FDM machine (fusion deposition modeling, a type of 3-d printer) than like the maker of "blue-prints": that is, he (or she, a thought Mercer might have had trouble encompassing) shuttles back and forth across the site, registering the layers deposited the day before, and directs a fresh layer of construction to be added. This sounds, I am sure, absurd; yet it is a relatively accurate depiction of the motion Mercer made across his job site, day by day. Mercer knew approximately, but not (dimensionally) exactly what he would find. Having made a complete circuit of the footprint of his museum, placing small, hand-mixed batches of concrete, he would arrive back at the level at which he had started a few weeks previously, and the concrete would be cured enough for the forms to be removed, and reused. Then the next layer would begin. The cycle of constuction and the cycle of material maturation were matched, and allowed for an economy inaccessible to a more methodical, controlled (only seemingly, I would argue), approach.

Mercer set some large decisions is play early on in the building process (material/structural choice, perimeter footprint) but left others until the activity of construction and the logic of individual room layout required their determination (interior partitions, window bucks, vault spans and shapes, stairs, landings). Mercer's action might be described as flowing from a short and economical rule-set—a heuristic—which, when posed the question of a particular,

Figure 5: 18th century tunnel kiln outside Bradford, England; Contemporary Anagama kiln. *Sources: Peter Hughes Photography; Hambridge Center for the Arts, Georgia*

undecided, construction detail, responded with an internally consistent answer. This is not to say that Mercer was not whimsical in his decision-making; but rather that whimsy, and strategy, may be afforded by the same device; and that we would do well to assume the sophistication of the latter, rather than dismiss a project for the apparent frivolity of the former. This sort of sympathy is the hallmark of an adaptive mindset.

Read with this sort of sympathy, Mercer's discovery of a highly economical set of architectural improvisations—understood as ad-hoc heuristics—models the present-day transformation of design thinking from the myth of perfect knowledge (a 19th century artifact if ever there was) to a more nuanced, nimble, and adaptable practice. However conditions change, whatever the demands placed on architectural prediction, it is ultimately the ability to adapt to and encompass change that preserves the reliability of the architectural narrator. (And, conversely, it is often the reliability gained by past success which permits the most remarkable flights of architectural fancy.) The maintenance of reliability need not be achieved by top-down, all-encompassing knowledge, or even the pretense thereof. Instead, we might try something both more humble and more happenstance, more yet-to-be-determined. And to be sure, we may have to be there, amid the burr of rotohammers and the clatter of nail guns, insisting on the consistent decisions our heuristic plans propose. The future archiect might do well to invest in a good pair of boots.

Architectural representation is not often grouped with scat singing or the subtle permutations of the tea bowl; yet it is, like these more esoteric and individual art forms, a pursuit improved by long practice; by iterative and reflective process; and by the support of a diverse and collaborative creative community. With these structures and supports, the activity of the architect, like that of the jazz vocalist or the raku potter, may take on a free and gestural quality rarely equaled by a more deliberate and predictable process. Improvisation is also evident in the deliberate lacunae by which an architect leaves room for the work of associated disciplines, or for his or her own projected (future) activity—that grey area where "construction observation" may become a more active participation in the process, and where the capriciousness of concrete and the lack of delineation make room for happy accident.

ENDNOTES

The epigraph is from David Pye's *The Nature and Aesthetics of Design*. New York: Van Nostrand Reinhold, 1978, 14

1. "Edison's System of Concrete Houses." *Scientific American* (1845-1908) XCVII., (Nov 16, 1907): 356. See also his original patents: Edison, Thomas. 1915. Patent: "Mold For Concrete Construction." United States: US 1123261 A; and Edison, Thomas. 1915. Patent: "Process of constructing concrete buildings." United States: US 1219272 A.

2. Mercer, Henry C. "The Building of Fonthill, at Doylestown Pennsylvania, in 1908, 1909, and 1910." *Bucks County Historical Society Papers*, vol. 6: 321-31.

3. Conn, Steven. *Museums and American Intellectual Life: 1876–1926*. Chicago [u.a.]: Univ. of Chicago: 1998, 177.

4. Moravian Pottery And Tile Works Haer No. Pa-107. Historic American Engineering Record. HABS/HAER. America's Industrial Heritage Project. Washington, D.C.: National Park Service, U.S. Dept. of the Interior: 17.5.

5. Mercer, H. Chapman. *Tools of the nation maker: A descriptive catalogue of objects in the museum of the Historical Society of Bucks County, Pennsylvania*. Doylestown, Pa.: Printed for the Society at the office of the Bucks County Intelligencer, 1897.

6. Eichenberger, Kurt Frederick. *Design and construction techniques of an American vernacular architect : the work of Dr. Henry Chapman Mercer.* Master Thesis, Massachusetts Institute of Technology. Dept. of Architecture. Cambridge: DSpace MIT. (Publication 09343398-MIT.): 1982, 105.

7. Harris, Samuel Y. *Building pathology: deterioration, diagnostics, and intervention*. New York, NY [u.a.]: Wiley: 2001, 261.

8. I am indebted here to Frank Kermode's use of the term neglect in the context of his landmark study of narrativity, see: Kermode, Frank. *The Sense of an Ending Studies in the Theory of Fiction*. New York: Oxford University Press: 2000 (1967), 40.