Post-Ductility
Metals in Architecture and Engineering
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Precious Industrial Metals
Paola Antonelli

Are metals really worth our while? Except for soft, warm, gentle, docile aluminum, is all the energy and the effort that it takes to shape them into architecture really worth it? What are we hoping for? Are metals and architecture only one step in the evolution of mankind, or are they here to stay? Are they where we are going to be in the future? Or, are we just waiting for the Boeing 787’s maiden voyage to be at last freed from metal and its tyranny, from the dry air and weird pressure that metal condemns us to? Are metals really necessary in this day and age?

In 1996, I worked on an exhibition at the Museum of Modern Art (MoMA) called Mutant Materials in Contemporary Design. The exhibition was divided into seven groups of materials. I have to confess that among all the sections—from glass, plastics, foams, ceramics, and even wood (the most traditional)—the metals section was the least interesting to work on. At that time, somehow—and structural engineer Guy Nordenson confirmed this hunch when I interviewed him for the exhibition catalogue—metals had not really been pushed toward their limits. Granted, it was 1996, the age of fibers and composites. Today, however, we hear that Werner Sobek is trying to engineer foam out of metal; he is trying to push it far beyond its physical limits. Though I hope that he will achieve this goal, so far metals in architecture have remained resistant to that kind of systemic innovation.

Aluminum, for instance, has a very distinct personality compared with other metals. Because it is so malleable and versatile, aluminum stands alone among metals in architecture and design. Seemingly humble, aluminum began as a very precious metal: witness the exquisite aluminum ring from the beginning of the nineteenth century, shaped to reproduce the dentures of a dead loved one.

Fig. 1 | Cast aluminum model of tooth, early nineteenth century (top)
Fig. 2 | Aluminum beverage can, ca. 1960 (bottom)

Fabricating the Pentagons Memorial
Keith Kaseman
An Old Glossary for the New Metallurgists
Ana Mijoclí

Ductility
Flows of metals describe geographical territories that have been controlled and contested throughout history. Not only can we think of these flows (economies of extraction, trade, exchange, etc.) as constitutive of material limits of metals, but material properties historically have also been territories controlled through advancements in technology and science. Once material limits and material territories begin to redefine one another, ductility also expands from a singular property of metals to a property of discursive and disciplinary definitions. Relying on this slippery collapse of material and discursive properties of metals, the glossary that follows revisits some of the oldest terms from the metallurgical lexicon in light of contemporary architectural practice. The main purpose of this glossary is not just to assess the capacity of antiquated terms that correspond to contemporary material or disciplinary processes but, more importantly, to highlight the coexistence of old and new in contemporary work as an important and historically specific characteristic of it.

The work and research of several design practices—The Living, KBAS, MOS, and John Fernández—frame many of the questions involving metals as a material with particular properties and architectural applications. From their own project descriptions, KBAS and Fernández have contributed to a conversation regarding the networks and economies of expertise. KBAS's Pentagon Memorial is repeatedly described in the context of the enormously complex and spatially dispersed network of people, materials, and knowledge that made it possible. The core of Fernández's work, which is the examination of the metabolism of material urban systems, involves an organized effort in re-extracting metals from the architecture of cities—what may be the most bountiful site of future ore deposits. Each of these practices can thus be seen in terms of territories that literally involve geography, exchange, and collective behaviors. On the other hand, The Living and MOS both tinker (or test) at the edge of material and design limits, invoking a territory of operation when that tinkering becomes a type of project. Similarly, on economy and network of expertise are meaningful only insofar as particularly valuable properties of a material are at their centers. Thus, it should come as no surprise that tests and hypotheses involving metal as an architectural material offered here ultimately reflect on the state of contemporary architectural practice in general.

This group's engagement with metals as a set of architectural materials, and their engagement with material reality in general, frame a number of issues particularly relevant to the contemporary practice of architecture: control, optimization, archaism, and radical scarcity. To call these architects metallurgists is in part a nod to the recognition that metallurgy received in Gilles Deleuze and Félix Guattari's shady, multiplied world of A Thousand Plateaus. Architecture's favorite philosophers of the 1980s described a world of continuous battle between the forces of stratification, stratification, and sedimentation and wild jumps, ingenious moves, and freeing agents, nearly always making their appearance in relationship to the forces of control that preceded them. Their model of constant takeover of the sedentary (e.g., state and bureaucratic apparatuses) by the nomadic (literally nomadic tribes), and vice versa, applied to large historical processes, to life in general, and to every form of creativity—whether they found proof of it in the life of plants, or in the life and work of great novelists, painters, and war strategists. But, characteristically exploding their own binaries, Deleuze and Guattari claim: "There are no nomadic or sedentary smiths." For these "materialists" philosophers, always interested in extracting abstract models from material evidence, metallurgy was a core metaphor for nonorganic life, and the metallurgists' position even more privileged than the nomads'. Neither nomads nor sedentaries, the metallurgists are able to deal with and contain both extremes. As Deleuze and Guattari set forth, "They are in themselves double: a hybrid, an alloy, a twin formation." Although this brief reading on the metallurgist will not do justice to the texts that inspire it, my use of the term metallurgist serves to call out a slippery hybridity, a condition relevant to a type of disciplinary ductility discernible in the projects and research of The Living, KBAS, MOS, and John Fernández.

That this glossary of definitions is old and new simultaneously is of particular importance. The coexistence of the archaic and the digital in each of the four projects explored here is a symptom of a particularly contemporary condition of practicing architecture. The history and future are simultaneously present for us. The consensus is that we no longer inhabit the relatively simple modernist temporal paradigm in which forward was always equal to progress. Whether we call our contemporary moment "premodern" (Latour), "late style" (Eisenman via Said), or "altarmodern" (Bourriaud), instead of anguishing over the loss of clarity that was constitutive of modernism's narrative of progress, we may be better served today by concentrating on the computing power and intellectual agility that allow us to simulate our history and our future at the same time.

Mining
John Fernández's research on urban metabolism anticipates a world of radical scarcity in which a more or less benevolent species of architectural cannibalism is
imaginable. Fernández’s story starts like all good apocalyptic narratives, by invoking a time when the supply of metal from mines will be exhausted. But he quickly assures us that there is no reason to panic, or at least that there is enough reason to be hopeful given the amount of metals already embedded in our cities. Even though Fernández doesn’t specifically endorse this condition as a reality beyond his research, the radical scarcity of a finite material like metal would be a “game changer” for the discipline of architecture, literally and conceptually. Mining, reimagined as an extraction of ore from the new synthetic ground of dead cities and decayed structures, inevitably invites architects—whose task is fundamentally anticipatory—to reposition their conceptions of buildings within this retrospective paradigm. If urban metabolism were to transcend research and fulfill a dream not unlike that first forged in the utopian projects of 1950s Japanese Metabolism, it would involve an unprecedented amount of control and optimization of resources.

Melting Point
Control and optimization are at the core of the work produced by The Living, KBAS, and MOS. Enabled by new software, new levels of precision and versioning engage material realities, and often engage historically older techniques for shaping metal, MOS has perforated, sheeted, inflated, and stretched metal in their projects. When Hilary Sample, a partner at MOS, suggests that they “look at the resistance of materials—formless resistance—as a way to think about and frustrate architectural propositions,” she is both acknowledging the particular medial reality of metals and placing it within a disciplined description of MOS’s practice. Claiming repeatedly that they are interested in recuperating an avant-garde project, though not at the expense of the vast contemporary architectural intelligence, nor at the expense of the gritty, down-to-earth reality of architectural production and use, MOS dissolves an old definition of the architectural avant-garde in favor of a radically heteronomous, hybrid one—one which perhaps does not imagine a particular future as much as it culs it into existence by whatever means available. In their formal games, the material reality (of metals, plastic, or wood) “frustrates” the parametric formal research, just as their desire for certain effects (such as the chimney effect of passive cooling used in Afterparty, their project for the PS1/MoMA Young Architects Program) might inform other aspects of the research. Radical inclusionism or heteronomy are about a kind of discursive and disciplinary dirt. As is the case with metals, for which the inclusion of dirt and impurities lowers the melting point, by lowering the “melting point” of disciplinary definitions (of material limits, the avant-garde, or the medium), MOS rewires the connections to the history and the future of the field. It is in this sense, that we should understand the deliberate primitivism of Afterparty, or the 2007 PS1 entry Prehistoric Future. Both projects begin to augment author William Gibson’s often-cited notion that the future is already with us, just simply unevenly distributed, with its logical counterargument: history is always with us, just unevenly distributed.

Casting
The melting and pouring of 194 benches of KBAS’s Pentagon Memorial required a vast network of experts in load engineering, metal mixing, and casting. The number of people responsible for the production of the actual units of the memorial was in fact larger than the number of units that constitute the memorial. According to KBAS, the production of the Pentagon Memorial benches directly involved over two hundred people and indirectly over a thousand people. They initially projected five thousand pounds per unit, but through modeling, prototyping, and adjusting were able to reduce the unit weight to one thousand pounds. The KBAS team not only managed to convince their patrons of the aesthetic effect produced by a twinkling field of elongated benches, they supervised the master models of all components and information flows required for CNC fabrication of the molds. The Pentagon Memorial impressively closes the gap between architectural imagination and production, an achievement made possible in part through the sophistication of the digital models used in the process of designing and developing the project. Indeed, the economy of labor involved in closing that gap involved the Pentagon Memorial with an appropriate human energy, pointing to both its galvanizing program and to the deep pockets of its patrons. The robust network of experts, whose communication may indeed have been made possible via new digital tools (with the architect as the master of information flows), is also indicative of an unprecedented necessity for collaboration. The encounter between digital design processes and the most archaic method for shaping metals—casting—could be seen as another case of material properties frustrating the digital. In this project, the potential of new tools confronts an archaic material, shaping intelligence to produce a contemporary aesthetic whose task in the Pentagon Memorial is precisely to function as a link between future and past.

Alchemy
Through a set of directed-tests and a number of lab accidents, several families of shape memory alloys (SMA) were developed over the latter course of the twentieth century. A little bit of electrical current, exposure to heat, or exposure to the effects of a magnetic field make some alloys “remember” an earlier configuration
of atoms. The architects who make a glass membrane breathe with the use of SMAs are treading in unknown, or previously undescribed territory. The Living explain their project as one of constantly redefining a design territory appropriate for the issue at stake. With the constant redefinition of their territory of operation, material limits are challenged in every project. Fascinated by rules of thumb, The Living precisely seeks out design territories that don’t yet have commonsensical solutions. Instead of frustrating their formal propositions by the old definitions of material, the testing (the only rule of thumb that The Living subscribes to) seems to frustrate the materials they work with. The two types of testing described by David Benjamin of The Living—the multiobjective optimization software and the full-scale physical test—clearly operate on different registers, but they are productive only in tandem. In the hands of The Living, both of these lines of inquiry, a highly computational method and a direct physical test, inhabit a particular retro-aesthetic of an alchemist’s lab. Just like video footage of materials at their limits, the numbers and formulas read to the postwar research at some “mucky” lab at MIT, if not to the middle ages and the quest to turn metals into gold or to Dr. Frankenstein’s lab (consider “The Living” as a name), if the group’s “archival” footage showing a low-tech hammer on a piece of metal, or their installation rendering aesthetic of the local pollution levels of your air and water, simulate a narrative link to a historical era characterized by a more naive desire to control organic and nonorganic life, they also suggest the emerging forces seeking to capitalize on such control. Although their aesthetic traffics in both nostalgia and legitimation, it also announces The Living as the inheritors and the possible contemporary corrective to that naivété simultaneously.

2 | Ibid. 475.

Pliability

Hilary Sample

Pliability negotiates the relationship between flexibility and resistance. Being pliable suggests the potential of a material to be unyielding; this differentiates metals from other materials. No material seemingly bridges greater extremes. When thinking about the architectural properties of metals, words like “soft,” “mutable,” “receptive,” and “ephemeral” may not immediately come to mind. However, recent projects have proven that metal is capable of transcending its well-known conventional properties when engaged by a pliable architecture—an architecture that applies pressure to the soft spots of received ideas in an effort to produce alternative design methodologies. One needs fantasy and science to work with metals.

In the midst of comparing the tasks of building and weaving, Amin Albers introduced the term “pliability” to contemporary architecture in the mid-1990s. If architecture is conceived of as grounded, fixed, and permanent, then producing textiles, producing pliability, is its antithesis. Albers pointed to the role of textiles as the enclosing skin placed over the structure of the nomadic tent. This recalls Gottfried Semper’s concept of Bekleidung (dressing), a practice that celebrates the application of covering and, more important, that was dismissed by the form-follows-function arguments for visible, undressed structure favored by the modernist polemists of the early twentieth century. Despite the modernist rejection of pliable coverings, Albers argued that building and weaving are fundamentally similar: they both involve the joining of disparate parts that retain their individual identities. However, Albers suggested that the techniques of fabrication that were developing in her time—in both architecture and textiles—were leading toward a “fusion” of these parts “as opposed to linkage.” In other words, new means of making introduced new possibilities, or outcomes, that were not tied to mere surface nor to mere structure. This fusion resonates even more today as the surface versus structure debate has reached expiration. As our projects attest, skin can become frame and, likewise, structure can become surface, while the whole ensemble is challenged to perform structurally, environmentally, and sensorially.

If anything, the emerging manipulability of metal has produced a tendency toward spectacle not unlike the novelty of plastics over half a century ago. Upon discovering the transformative means of its production, Roland Barthes notably described plastic as “a spectacle to be deciphered: the very spectacle of its end-products.” He continued, “At the site of each terminal form (suitcase, brush, car body, toy, fabric, tub, basin or paper) resulting from the extreme pliability of the productive process, the consumer understands plastic only as a ‘shaped...
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