

# arcca

aicc design awards issue

08.3

architecture california  
the journal of the american institute of architects  
california council

Autobahn Motors, Belmont  
Peter Dodge, FAIA / EHDD

*Seismic Experience and Non-Prescriptive Design*

*Professional Relationships in Transition*

*Getting on the Same Page*

*Engineering Invention*

*Engineering Water: the Work of WET*

## *engineering + architecture*

*Engineers Are Square, Architects Are Spiral*

*Ralph Rapson and UC Santa Cruz*

*Clever Beyond Engines*

*The Other Academy Awards*



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arcCA, the journal of the American Institute of Architects California Council, is dedicated to exploring ideas, issues, and projects relevant to the practice of architecture in California. arcCA focuses quarterly editions on professional practice, the architect in the community, the AIACC Design Awards, and works/sectors.

arcCA

08.3

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Here we are in the midst of the election season, and it's so difficult to stay clear of partisan thoughts. But I shall try.

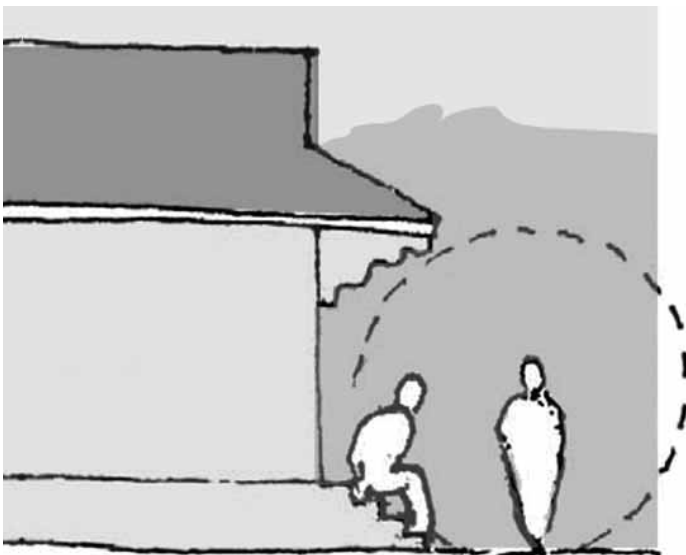
We're also in the midst of the hurricane season over in the Gulf. As I write, Gustav has come and gone, but hurricanes H, I, & J are lined up behind him. Meanwhile, the rebuilding of New Orleans from Katrina proceeds, though still neither smoothly nor evenly.

In the three years since the flood—yes, it has been that long—we have seen a few high-profile design responses to the disaster, all well-intentioned and some productive, while innumerable low-profile responses, largely volunteer-driven, have accomplished much of the actual rebuilding of people's homes.

The rebuilding of shelter is the first priority in the rebuilding of lives, but it is not the only priority, a fact particularly appreciated in the city that inspired the alternative ending to the old aphorism: "I used to complain that I had no shoes, until I met a man that had no . . . rhythm."

Yes, functionality is important, but ya gotta have style—in the nightclub sense of that word, not the architectural sense. Buildings don't have to be of a certain style, but they have to *behave* with style. Engage you, charm you, escort you home.

Here's a little sketch that suggests one way that traditional New Orleans buildings behave.



Whenever I see a new prototype proposed for a shotgun lot, I ask myself whether that dashed circle and the conversation going on in it can be transposed into it, whatever it looks like. (Note that the two people in the circle needn't belong to the same political party.)

For those of you who have work in New Orleans, or friends in New Orleans, or drinks waiting for you in New Orleans, here are a few resources:

—for more little sketches, [www.culvahouse.net/new-orleans/](http://www.culvahouse.net/new-orleans/)

—for streaming sounds from the Big Easy, [www.wwoz.org](http://www.wwoz.org)

—for inside tips from local architects, [www.studioedr.com](http://www.studioedr.com), click on

"lagniappe": and [www.studiowta.com](http://www.studiowta.com), click on "friends"

—for *Architecture School*, the new reality TV show produced at Tulane School of Architecture by Woodbury University (Burbank/San Diego) architecture professor Stan Bertheaud and directed by *Queer Eye for the Straight Guy* director Michael Selditch (also trained as an architect), [www.sundancechannel.com/architecture-school](http://www.sundancechannel.com/architecture-school)

On another (beach)front, Richard Neutra's Mariners Medical Arts Center in Newport Beach has been saved at least temporarily from the wrecking ball through the efforts of John Linnert, AIA, historian Barbara Lamprecht, and others. Read more in *The Architects Newspaper*, [http://www.archpaper.com/e-board\\_rev.asp?News\\_ID=2152](http://www.archpaper.com/e-board_rev.asp?News_ID=2152), and weigh in.

Hoping that, by the time this Comment reaches your mailbox, Center City New Orleans will still be dry ground, I remain,

Yours faithfully,

Tim Culvahouse, FAIA, editor  
[tim@culvahouse.net](mailto:tim@culvahouse.net)

A correction: In "Proving...Ground: the Potential of Landscape Urbanism in California," *arcCA* 08.2, the authors of the LA River Revitalization Master Plan (p. 35, center column) and the Compton Creek Master Plan (labeled "LA River Open Space Network," caption, p. 33) were not accurately credited. The authors of the LA River Plan are Mia Lehrer + Associates, Civitas, Inc., and Wenk Associates; Mia Lehrer + Associates authored the Compton Creek Plan.

# Contributors



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I was the original Chair of the Editorial Board of *Architecture California Magazine* (now **arcCA**). Consequently I look at the publication with a little different interest from many.

I especially like the issue on Landscape Architecture (08.2), and I like the return to the use of more photographs. Architects are mostly graphically oriented, and we will always look carefully at the pictures first and then read if brought into the article, as you know. Many of us do not fully acknowledge the value of the space around our buildings unless we are old enough to be from the “Mid-Century Modern” days when we thought a lot about space and saw the building as essentially a negative form. The landscape presentations are excellent.

The format of the magazine is interesting (I should say “captivating”). I am glad that we have left the “all text” days behind. I am glad to see that Peter Dodge is still on the Board. His contributions have always been substantial.

Is there a reason why the AIA Orange County Chapter is not included on the Publisher’s page? All the information is so well organized and attractive, that I am not sure where it would be added. Also, it is so orderly that unless one were looking

for it, it would not be missed. I wonder what else is missing (the kind of comment that was common on the editorial board of the past)?

**Joe Woollett, AIA**  
**Orange**

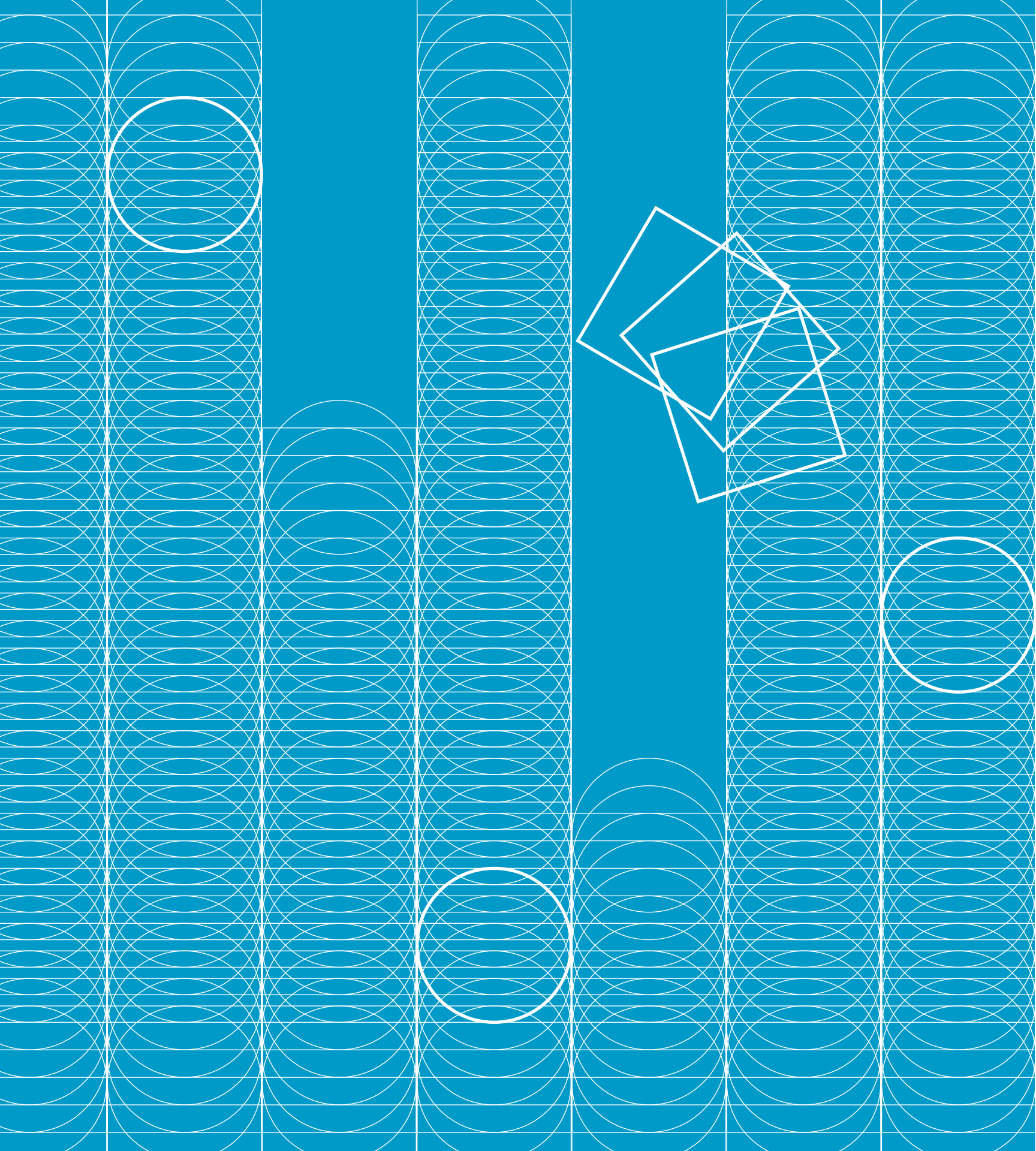
*[Editor’s note: We have corrected the omission of the Orange County Chapter. Peter Dodge, FAIA, is not still on the board, but rather back on the board.]*

The insightful comments I read in “The View...” (**arcCA** 08.2) were far more illuminating than those expressed on the TV talk show “The View.” While a few opinions were a tad plaintive and defensive, overall there was a scintillating range of pointed observations that gave ample reason for further contemplation.

While I attended three schools of architecture, I received my M. Arch. from the University of Oregon’s School of Architecture & Allied Arts (AAA), the “allied arts” being landscape architecture and interior architecture. In reality, while taking nothing away from the programs, there was nothing at all “allied” about the three disciplines. Even though the trio were housed in

the same building, each could have been on a different planet, because, at least while I was in school, there was no interaction at all among the students and faculty. Thus, I am not at all surprised that such a chasm exists between architects and landscape architects. Among my sole practitioner colleagues in the (primarily) residential business, the association with a landscape architect is practically unheard of.

**Miltiades Mandros**  
**Oakland**



# Square Wheels or Round?

Professional Relationships in Transition

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Charles F. Bloszies, AIA

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Architects are creative, but egotistical, flaky, and self-promoting. Engineers are thorough, but inflexible, stubborn, and socially awkward. Do these stereotypes that architects and engineers have of one another accurately represent the two professional cultures, which are viewed from the outside as highly collaborative? To a certain degree, they do.

I have wrestled with this question for a long time, since I am both an architect and an engineer. My opinion was first formed over thirty years ago, when I taught structures to architects at the University of Pennsylvania. Every term the class grades fit the bell curve perfectly—at one end of the continuum, a few students had no engineering aptitude or interest whatsoever, and at the other end a small number had a firm grasp of engineering concepts as well as an avid interest. All had the potential of becoming excellent architects.

One student was exceptionally curious about how engineering principles affected architectural form, investigating this issue by interviewing the structural engineers who were consultants for the most famous New York architects at that time. He was disappointed to learn that this question was of little interest to them. They were unanimous in their view that the role of the engineer was to serve the architect. I have come to believe that views on engineering (and engineers) vary widely among architects, while views on architecture (and architects) are rather narrow among engineers.

This variation in viewpoint can perhaps explain why, in some cases, architects and engineers collectively produce work that clearly shows how their disciplines have informed each other. It can also explain the frustration and bitterness some architects have toward engineers and vice versa. Have these dynamics existed historically, and will they persist into the future?

In the past, the measure of good architecture was taken as a mixture of “commodity, firmness and delight”; engineering principles (firmness) significantly influenced built form. The parabolic arch and flying buttress were based on engineering principles discovered by trial and



Louis Kahn once said something to the effect that a sculptor may sculpt square wheels on a cannon to express the futility of war, but an architect must use round wheels. Architects are not particularly interested in round wheels today.

error, which led to daring forms in Gothic times. The development of steel technology and vertical transportation allowed tall buildings to be built. Notwithstanding their stereotypical characteristics, architects and engineers depended on each other to produce excellent work. Innovations in firmness led to delight.

Firmness, however, is no longer a precedent for delight. Louis Kahn once said something to the effect that a sculptor may sculpt square wheels on a cannon to express the futility of war, but an architect must use round wheels. Architects are not particularly interested in round wheels today. Gravity-defying shapes are appearing all over the world. Commodity, too, has in some cases been decoupled from delight, resulting in a function-free, often provocative architectural vocabulary. The reason these decouplings are possible is another engineering innovation: the computer. It is now possible to model mathematically just about any shape an architect can imagine. The limits of the architect's imagination itself are being advanced with the help of the computer, too.

Engineering is still serving architecture, but the collaboration is a bit different. As long as the architect has left enough *poché* for the

engineer's structure, ductwork, pipes, and wires to inhabit, technical constraints no longer exist. Buildings thought impossible ten years ago are now safely built.

The force of gravity is, however, the same now as it was in Gothic times, and the principles of engineering to resist gravity, wind, and earthquakes are *a priori* truths. The ingenuity of the engineer, still serving architecture, is now used to create amazing yet inefficient buildings that not everyone can afford. Only "starchitects" are able to do aesthetically innovative architecture, while the journeyman architect is subject to value engineering as cost control becomes more difficult in the face of rising material and labor costs. Can this trend possibly persist?

In some parts of the world, yes. The gap between rich and poor will likely continue to grow, and the wealthy will continue to consume conspicuously. Competition for the tallest and most highly differentiated buildings will provide demand for architects to dream up structures of pure delight. Engineers will continue to serve architecture and will help figure out how to build these stimulating edifices.

Elsewhere, the now almost mainstream

desire for sustainable architecture may recouple both firmness and commodity with delight, demanding more interdependence between architect and engineer. Sustainable design gives a new meaning to "less is more," and a truly sustainable design will need input from various perspectives to succeed. Professional stereotypes need not change, but the future may lead to a paradigm shift concerning how buildings are designed. In fact, one could argue that architects need to maintain their traditional role as purveyors of delight, since early attempts at integrated, sustainable design seemed to completely sacrifice delight for commodity and firmness. Solar paneled roofs "need not look like castoffs from the space program," as William McDonough pointed out in *Cradle to Cradle*.

One scenario is a shift to a highly collaborative process led by the architect, with input from various engineers at the inception of the basic design concept. Many design firms employ a process like this already, but I would speculate that few are architectural design practices. Although large A/E companies employ both architects and engineers, true integration of talent is probably rare, in

part due to the variation in viewpoints architects have of engineers and *vice versa*.

Another scenario could develop for economic reasons. Almost every man-made object we encounter daily is mass-produced, with one notable exception: buildings, especially large buildings. Although a building is an assemblage of many prefabricated components, each building is unique, lacking the refinements that make airplanes or cars, for example, more efficiently produced as lessons are learned from a prototype. Like cars and airplanes, beautiful buildings could be created that are much more sustainable than buildings we currently construct, and they could cost less, too. In this scenario, the roles of the architect and the engineer would certainly change. Production and fabrication engineering, for example, would wield a large influence on formal expression, traditionally the architect's purview.

Mass production of large buildings would be objectionable to many, of course, and could lead to a more banal visual environment than anyone could tolerate. In fact, it has already happened. Eight of the twenty-five tallest buildings in Sao Paulo are identical, built over a span

of a few years, and are clearly the product of building economics alone (you can see illustrations of these buildings at [skyscraperpage.com](http://skyscraperpage.com)).

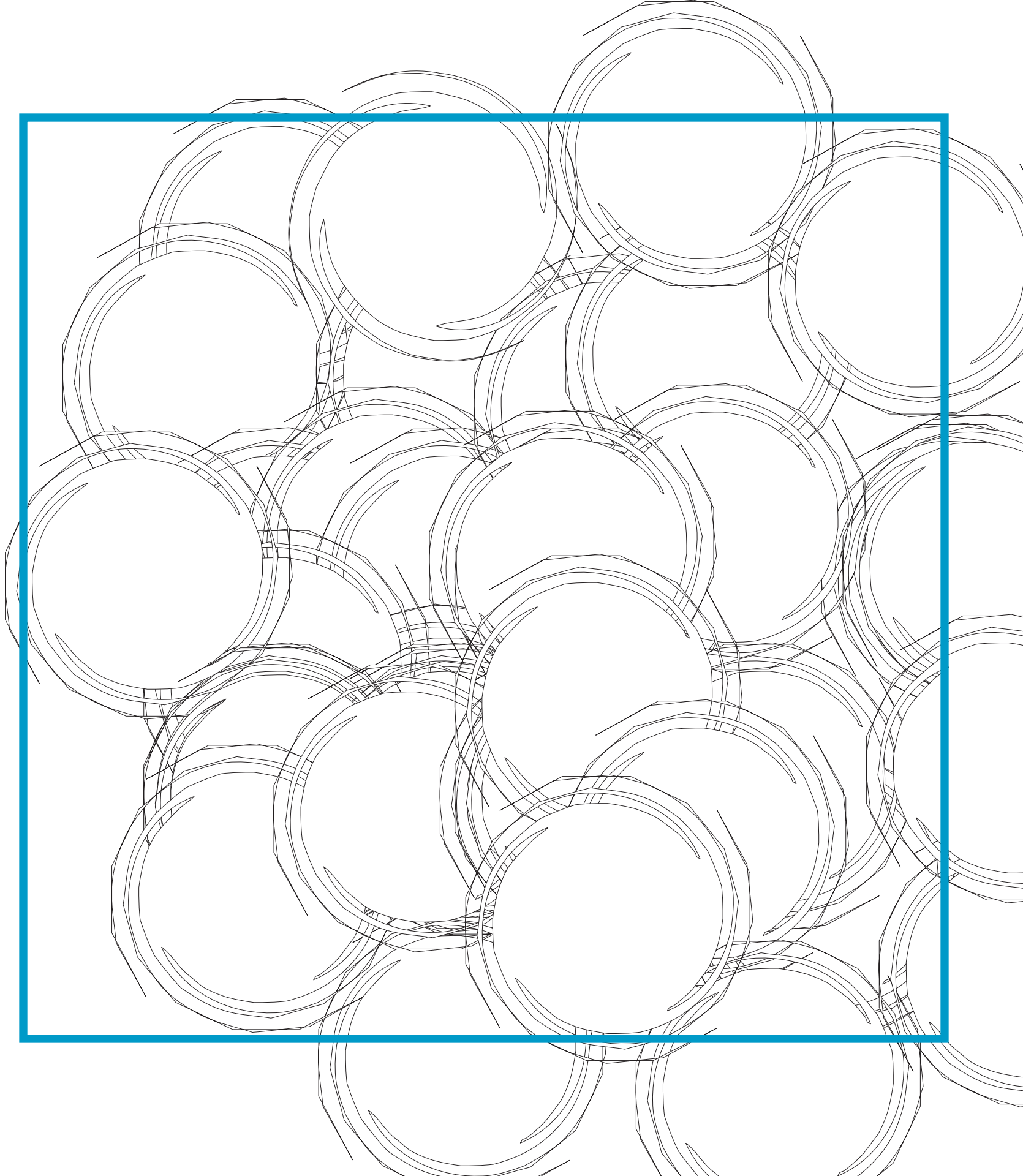
Yet another possibility is an almost complete decoupling of architecture and engineering. Future buildings may be simple structural armatures with dynamic skins of programmable LED's powered by sustainable energy sources, a logical extrapolation of what can be seen today in Times Square and many Asian cities. Delight provided by these buildings will constantly change based on the imagination of the future architect/programmer, almost completely freed from the constraints of traditional engineering.

This last scenario may be a bit too futuristic, but I believe that some form of paradigm shift in design is likely in the not too distant future. I believe it will be driven by mandates for sustainable buildings and will cause architects and engineers to be more collaborative. Architects will and should continue to lead the charge, but not in the traditional manner we now accept as standard practice. Architects will need to accept new constraints, and engineers will need to define these constraints with wide margins, so that they can be inte-

grated into a design that is both physically and aesthetically sustainable.

Closer collaboration should not be difficult. I have found the close collaboration between architecture and engineering to be quite natural, since I inhabit both worlds. I am, however, occasionally asked how I reconcile the differences between these disciplines in my own mind. This question comes from architect or engineer colleagues (mostly architects), and I have found it puzzling. I have never been asked this question by clients or professionals in other fields.

If demand for sustainable buildings enters the mainstream, new building forms will need to respond to new engineering constraints. Despite the professional stereotypes that will never change, collaboration between designers and engineers will become the norm as it already exists in other allied fields. The architect will once again return to using round wheels. ●



# Engineers Are Square, Architects Are Spiral

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Kate Simonen, RA, SE

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*Adapted with permission from an article previously published in LINE, the on-line journal of AIA San Francisco, volume 03/2004.*

In the course of teaching structural design in the architecture program at California College of the Arts, I had a student who, despite her creativity and intelligence, was struggling with the analytical component of the class. One assignment she turned in looked at first like a jumbled mess of numbers, but I then realized that she had found the correct solution. Instead of laying out her work in an engineering-logic, linear fashion, she had worked the problem out in a series of short steps that spiraled toward the very center of the page, where she found the answer. Her solution was a physical manifestation of how her mind worked. People solve problems differently, I concluded, and we have to teach to many modes of learning.

Engineers may be square, but architects are spiral. They think differently, and as most complex structures are the result of their collaboration, their differences are a potential obstacle to structural creativity and innovation. I believe that these differences are fundamentally reinforced through pedagogy, so if we want to overcome them, we will have to change how we teach structural design to both professions.

The education of architects is quite different from that of engineers. Engineering education is structured linearly, providing students with increasing levels of knowledge and skill and waiting until all of it is obtained before asking students to “design.” Moreover, structural design problems are typically limited to the sizing of select elements or structural sections. Ambiguity and uncertainty are rarely encountered. Engineering students come to assume that the problems they will encounter in practice will have singular solutions—“right answers.”

Architectural education’s studio structure creates a much different learning environment. Students are asked to explore problems that are often ambiguous and uncertain, while learn-

ing the skills of their profession “on the job.” There are rarely “right answers” to their problems, only better or worse solutions. And in the midst of this, architecture students are often asked to take a condensed, watered down version of the engineers’ linear training in structural design.

Not surprisingly, these programs do not spark much interest in collaborative structural design in either profession. Both are introduced to the topic as a dry set of predetermined facts rather than an exciting means of understanding structural behavior. Structural design needs to be taught differently to each profession, but both should learn it as a real design discipline that reflects the realities of practice. Doing so is crucial, because the problem-solving methods learned affect the range of potential solutions that can be envisioned.

#### **Analysis vs. design in engineering education**

Although I received an excellent engineering education, we were not really taught structural design. Real structures only entered the curriculum after two years of structural engineering coursework. I was amazed to find that the beams I had analyzed had real life counterparts. With a master’s degree in structural engineering, I could analyze and size a predetermined beam or truss—and even a complex lateral system—but I couldn’t design them.

Looking back, I can recall only two of my teachers who were interested in teaching structural engineering as a design discipline. Professor Gerstle at Boulder and Professor Scordelis at Berkeley belonged to the post-war generation of engineers who learned structural design before the era of the computer. To simplify problems to a level where they could solve them, they had learned to visualize and

hypothesize structural behavior. So this is how they taught.

Both were captivated by the marvelous uncertainty of construction. When Professor Gerstle showed slides of Maillart’s bridges in construction, you could feel his excitement about the innovative potential of long spans. Through his lectures, I saw for the first time that as an engineer I would be directly involved in building these physical structures. Professor Scordelis described walking on top of a concrete shell, looking for cracks, and how he would find small cracks and make a note to add more reinforcing in those zones next time. It was a relief to realize that, even with complex analysis, there was still unknown behavior—and that intuition and experience were just as important to the realization of the project as analytical skill.

Analysis is important to engineering, and the more complex analysis that computers make possible creates many new opportunities for engineers. Yet, in capitalizing on them, engineering education has lost sight of design. The subject is presented through complex mathematical exercises, each with a correct answer. No one simplifies the problems anymore in order to think visually about them and hypothesize how a structure will behave—not when they can model the structure mathematically and make those predictions with exactitude. Consequently, students have forgotten about design and construction. They become experts in analysis, without fostering their creative imagination. They cannot design. Their architect peers, when exposed briefly to the same curriculum, lack the intuitive grasp of structural behavior that would extend their imagination in that direction and enable them to collaborate effectively in designing structures.

#### **Bringing design back into the picture**

Engineering education has largely abandoned visualization and approximation as methods of structural analysis. Graphic analysis of trusses or moment distribution, in which the final deflected shape is visualized, are examples of such methods, common before computer software for structural analysis came on the scene. They help students develop an intuitive understanding of structural behavior in a way that computer-based analysis does not. They need to be re-introduced, along with three-dimensional drawing. Without them, engineers have difficulty both imagining the complex interrelationships of a building and its structure and developing and presenting their ideas. More importantly, engineers need to appreciate that, as shapers of the physical world, they need to consider aesthetics and meaning just as much as strength and efficiency. Without this conceptual frame, they cannot engage in the dialogue necessary for creative collaboration.

The structural education of architects often leaves them feeling intimidated by knowing how little they know, and defensive about their ability to shape structure. The linear structures curriculum invariably means that they only master the most basic methods of structural analysis. Analytical skills *per se* are not so important for architects, however. They need to understand structural systems and concepts well enough to participate in their shaping.

To foster structural innovation, we need to begin the education of engineers and architects alike by developing their intuition and giving them problems they cannot solve without guesswork. This means abandoning linearity in favor of the “cyclical” teaching methods of the studio.

### How structural design is taught at CCA

The structures class that I teach for architecture students at CCA focuses initially on understanding structural behavior on a conceptual level and then testing this understanding through the schematic design of complete structural systems. Using design charts (found in Allen and Iano, *Architects Studio Companion*, Wiley, 2002), students can estimate member sizes to a level accurate enough for schematic design. At the same time, they explore the possibilities for structure as an aesthetic generator and form giver. The goal is to bolster their confidence in their structural intuition and prod them to ask for more analytical tools—which they can use to test their hypotheses about a structure’s configuration.

In the second semester, we use analytical tools to understand structural behavior. I teach engineering analysis as a way of thinking as well as a design tool. My architecture students learn that predicting structural behavior requires precise analysis. Instead of giving them a condensed version of a typical linear engineering curriculum, I take them through a series of exercises that gives them an appreciation for engineering rigor and a better understanding of structural performance. I use graphic methods of analysis—a throwback to another era—because they provide a direct visual connection between the forces involved and their implications for form. (I use Zalewski and Allen, *Shaping Structures/Statics*, Wiley, 1998, for this purpose.) I am especially interested in having the students describe the results of their analysis clearly, so they come to see it as a tool that can help move the design forward.

There is a third focus—on the collaborative nature of building design. Education puts

great emphasis on individual performance, but designing a building—as an iterative and explorative process—depends on sustained teamwork. So, we not only create opportunities for collaboration, but also for mutual understanding. To be effective, students have to be confident they can put their ideas across and grasp the ideas of others. We ground our architecture students sufficiently in structural design so that its language and thought patterns are no longer foreign.

The real goal is to give architects the confidence to lead the design process, including the overall configuration of the building structure, effectively. They are able to discuss structural performance and possibilities and understand the relationship between force and form. They can understand the rigor and complexity of engineering computation and follow the results when engineers present them. There’s no feeling of inferiority or defensiveness because they can’t do that analysis on their own. Self-confidence and mutual understanding create the right framework for collaboration, freeing architects to ask the kinds of questions that spur innovation.

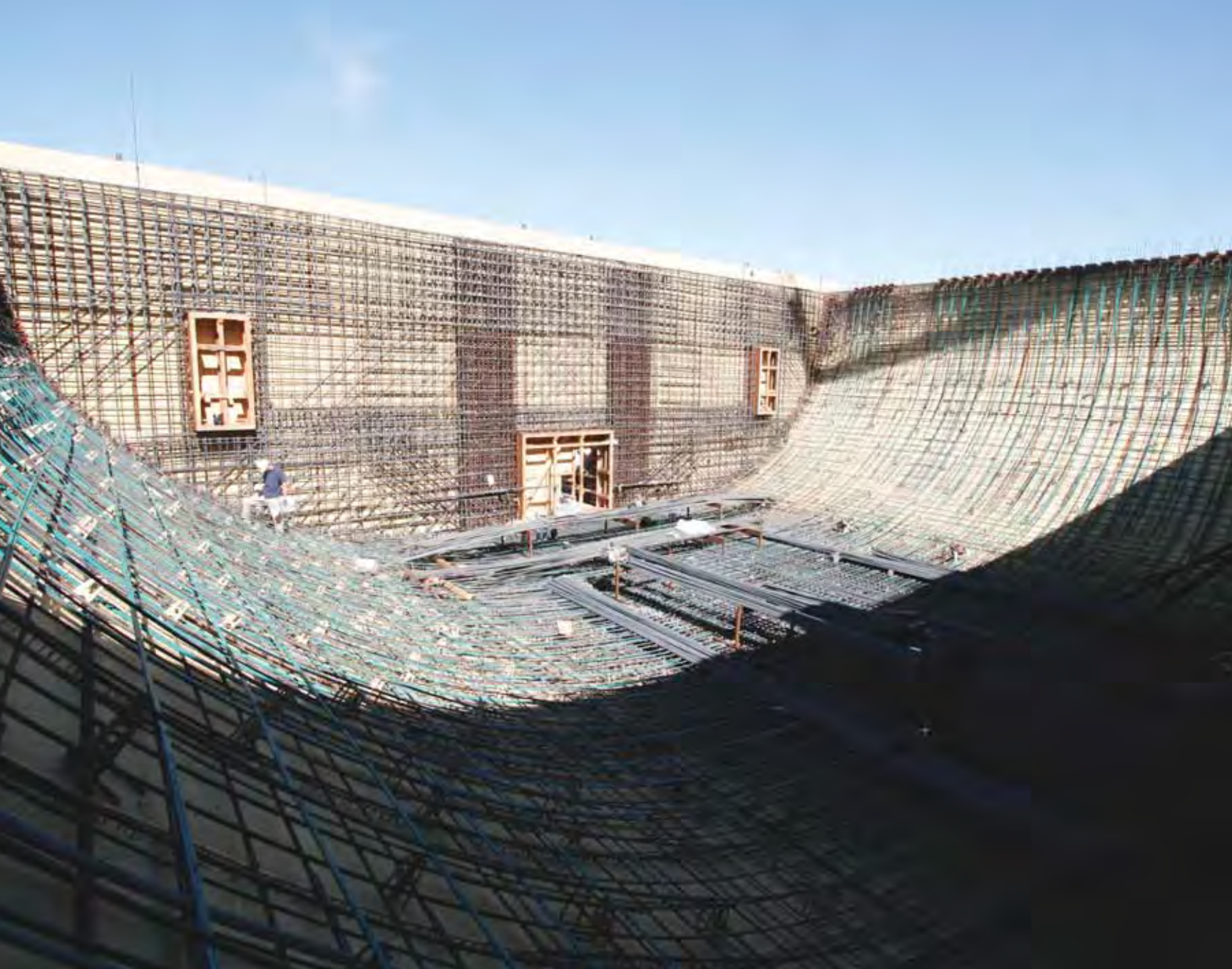
### Things have to change for engineers, too

Structural engineering students also need to learn early in their education that it’s not all square. Like their architecture counterparts, they should be asked to solve problems they don’t yet know how to solve—forcing them to guess and estimate and to confront ambiguity. They need to be exposed early to the real world, where singular solutions are the exception. Start with large, open-ended problems, then cycle back to the complex math and mechanics of materials used to understand more advanced structural behavior. That way,

when they get back to those large, open-ended problems again, they can tackle them with all that acquired sophistication, just as in real life, but with creativity.

The issue of collaboration is equally true for engineers. Over-focused on math and science, they can be uncomfortable or intimidated by subjective discussions. The engineering curriculum needs to open enough that students can have a more liberal education. Studying architectural and structural history, learning to draw three-dimensionally, getting direct experience in building construction—these are steps that would help them understand the real world, the physical world, in which they will work.

Squares are good, and so are spirals. Buildings are created using both linear and circular problem solving. Innovation demands that we search for an unknown outcome. Linear thinking on its own is not enough. If the goal is structural creativity, then the teaching of architects and engineers has to change—developing intuition, not just specialized knowledge, encouraging exploration, and giving every student the confidence and desire to collaborate effectively. ●



# Engineering Invention

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Grace S. Kang, SE



Stanley Saitowitz/Natoma Architects, Inc.  
Congregation Beth Shalom  
photos opposite: courtesy Forell/Elsesser; above, Bruce  
Damonte

The seismic lateral forces generated by the large mass of the bowl atop the pedestal were a challenge. The high center of mass generates large overturning forces, which argues for a deep foundation. Yet piles or piers would have been costly and disruptive, besides anchoring the mass of the structure rigidly to the earth and exacerbating the effects of ground shaking. Instead, the engineer placed the pedestal on a four-foot thick concrete raft. Dynamic analysis using records of actual earthquakes indicated that a beneficial rocking action would occur, lessening the lateral forces experienced by the structure.

Invention is the product of the imagination—the discovery, sudden or deliberate, of a way of getting something done. Invention may be a solution to a “problem” or an improvement on a situation or circumstance.

Engineering is the application of science by which properties of matter and sources of energy in nature are made useful to man. It is the useful application of science to how we live.

Both invention and engineering synthesize ideas that come from many sources. Looked at this way, invention and engineering are synonymous, exemplified in Archimedes’ screw moving water uphill, in the codices of Leonardo da Vinci, which illustrate methods of moving humans through the air, and in our generation’s development of surfaces that are “invisible” to radar and light.

In the built environment, invention in structural engineering is based on the application of mathematics, physics, the science of materials and their properties, and economics and their effects on how we live in *civitas*—in civilization. These sciences affect our infrastructure, shelter, and commerce.

## Common Ground

Designers want to make ideas work. It is helpful to understand the expression of an idea, and, more importantly, it is essential that the *source* or *root* of the idea be understood. If the main ideas or goals are discussed, then there can be a meaningful exchange and dialogue, and the design process can remain fluid and malleable. Designers want to create something that works in form and in function. A realistic solution will have to address aesthetics, function, cost, and expectations, among other issues.

Effective design is founded in exploring solutions that can address more than one issue, while enhancing function or purpose. The collaboration of engineering with other design disci-





plines is fruitful when all the issues are raised from various vantage points, so that the common ground, the common goal can be identified. It is about embracing “what-if?” and finding out “why.” Addressing questions of “why” gets us closer to the root of an idea. If there are other ways of addressing that idea, then solutions can be explored.

There are numerous considerations weighed in coming to a solution—constrained budgets, limited energy sources, limited space, and short and long term performance expectations. Understanding and prioritizing each of these considerations is essential to zero in on an appropriate solution.

#### **An Early Example and a Recent One**

The development of Gothic cathedrals through the centuries was spurred by the imagination and fervor of the church and their master-builders, and executed by diverse trades of masons, carpenters, and metalworkers. The Chartres Cathedral nave soars at 38 meters (124 feet) with rib-vaults that flow down the sides of the nave to rest on clustered columns. At the exterior of the building, flying buttresses with arching arms stiffen the column-piers and direct the thrust of the canopy to the ground. This cathedral, constructed of discrete blocks of brittle material, exemplifies the refinement that occurred over centuries, evolving from massive, stacked blocks to become skeletal, so that glass and light become the primary features of the cathedral.

Form can be based on analogies found in nature. Nature is efficient and is a constant source of inspiration: ribs strengthen and reinforce thin sections around them, springs and coils move flexibly, tubes and branches are models of compressive or tension, and tap roots provide anchorage.

Santiago Calatrava, architect and engineer, combines his training in both fields and expands on them through his sketches and sculpture. His work is derived from his diverse and artistic background, and his building and bridge structures are sculptural and articulated. The proportions of his works make sense and fit together, reminiscent of their anatomical basis. In his Sundial Bridge over the Sacramento River in Redding, California, the arc of the pedestrian bridge deck is suspended from cables from a single mast that leans back to the riverbank. The angle of the mast creates a palpable visual tension from the support through the steel cables to the glass roadbed. This visual tension reflects the engineering tension as well—the cable-stayed bridge is configured in such a way that the forces on the mast and foundations are not optimally minimized. Nonetheless, those forces are addressed, and the entire bridge, from the curved abutments, the arcing walkway, and the splayed cables to the swooping cantilever mast is sinuous, fluid, and expressive.

#### **Knowledge of Properties Is Fundamental**

The exploration and understanding of material properties is fundamental to structural invention—the compressive attributes and jointing limitations of masonry, concrete, and glass; the tensile and flexible characteristics of steel shapes, tendons, rods, and tubing; the lightness of thinner steel members and the limits as dictated by their geometry and crippling tendencies; the unique characteristics of wood depending on the direction of the grain and the direction of the forces; and the elastic and flexible limitations of membranes and woven materials. An understanding of the fasteners that join materials together is critical, as well. Fasteners must be compatible with respect to corrosion potential and thermal expansion rates across dissimilar materials.

#### **An Example of Non-Transparent Form**

Design of form can be realized through pure technological skill. Congregation Beth Shalom in San Francisco has a distinctive bowl resting on a pedestal; its shape includes both flat and curved surfaces, unlike a typical shell of revolution, such as a dome. The transition from level floor at the low point to nearly vertical wall at the top suggested a structural transition from a flat plate to a



deep wall beam, both in the same curved element. The curved slab is hung like a catenary ribbon from its own upper edges, which are supported by the outer ends of the side walls. These walls act as cantilevered beams, carrying gravity loads to the pedestal. A three-dimensional network of post-tensioned tendons reinforces the slabs and walls, allowing the structure to behave in this way, while limiting cracking and deflection. The form is created and expressed in the material, yet the way the form is achieved—through the network of tendons—is not transparent, contributing to the mystique of the design.

#### Tools to Enhance Resources

The earliest tools of structural engineering are experience-based and experimental. Some examples are deliberate and empirical, such as the construction of the dome at the cathedral in Florence, and some fall into the category of trial and error, such as the choir at Beauvais, which was intended to be the “tallest and widest” until its collapse and reconstruction. Gaudi devised forms from hanging models that created shapes, which he inverted. More than a generation ago, thermoplastic materials were loaded and isostress areas (areas of equal stress) were graphically shown with color. More recently, empirical testing with physical models that are appropriately scaled in mass and size are loaded with wind, fire, or shaking bases that simulate earthquakes. Such physical tests provide one source of information.

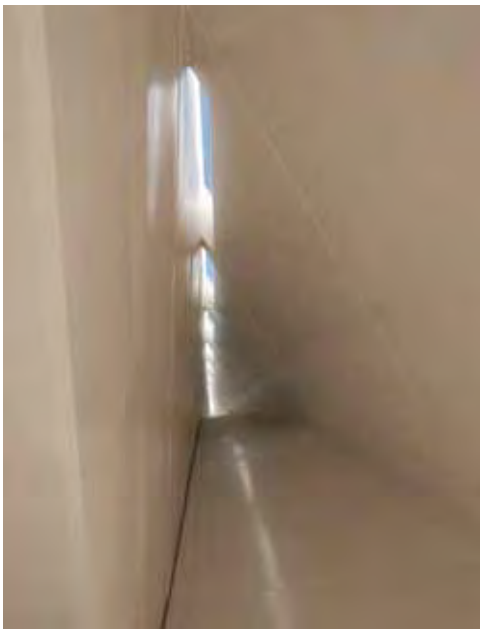
Another source of information is provided by computer analysis. Numerical computation is an extremely powerful tool. The speed of iterative calculations is fast, the graphic output of results can be visually revealing, enabling the engineer to perform numerous parametric studies, and the computer can be used to optimize load paths. Optimized design can also be achieved by a numerical sensitivity analysis in which a shape can be subjected to load, the stresses and deformations calculated, and the geometry of that shape automatically altered mathematically so that the stresses and deformations are minimized. Each succeeding iteration generates a form that further minimizes stresses and deformations, creating mechanical efficiency with minimal use of materials.

The effectiveness of these tools is as good as the data that goes in, and the interpretation and application of results that come out. If the information, boundary conditions, physical constraints, and material behaviors are not appropriately modeled, then the results may be misleading. An effective analysis is based on knowledge and prediction of realistic conditions. The results of analysis need to be scrutinized, compared, and tempered with physical, empirical evidence.

#### It's Not a Free-for-All

Creative engineering is dependent on the engineers, their resources, and their collaborators in both design and construction. Communication is essential for the best outcome. Creativity comes from broad thinking, from the ability to embrace ideas outside of the normal realm, and from the application or synthesis of those ideas to another application. Creativity may also come from the imaginative application of an existing idea to a new situation. Creativity is about knowing how to create a prototype model, knowing what to look for in the modeling, and knowing how to interpret results and refine them further.

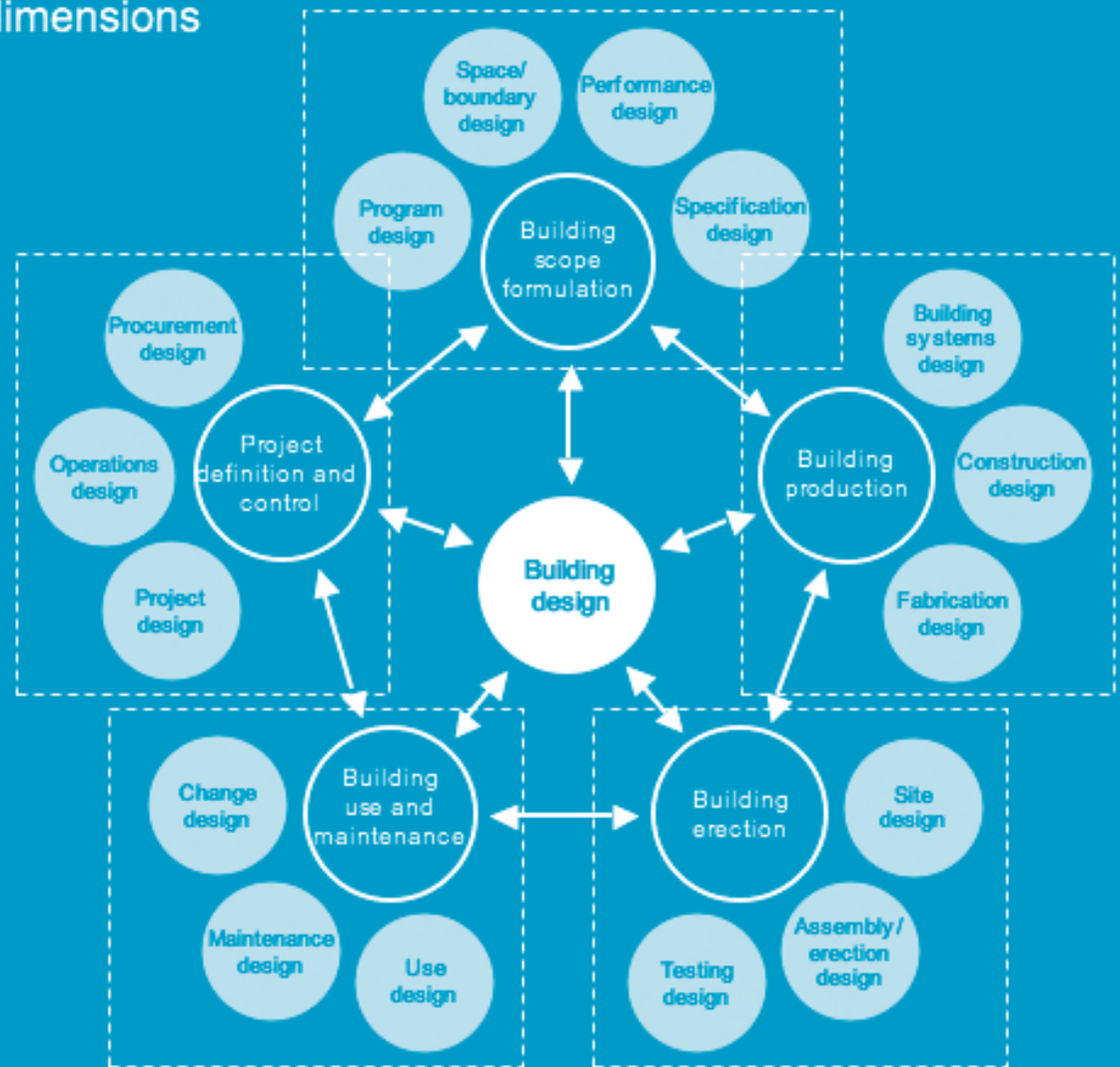
Recognizing what aspects are fundamental to a refined solution is an important skill. From broad-based thinking, selective deliberation is required. A common thought is that there is a solution for anything. And indeed there may be. Exhibitionism can be indulged in various ways, and “brute force” will always yield a solution of sorts. However, a refined, elegant, spare, and efficient design that informs and responds to form as well as function requires thought, creativity, and discipline, freedom *through* discipline not freedom *from* discipline. Structural creativity requires both imagination and discipline, the fundamental tools of invention. ●



above and opposite: Santiago Calatrava, Sundial Bridge,  
photos by Grace Kang

## Figure 1 – The five dimensions of building design

The idea of the building procurement process as a network of design and coordination activities.



# Clever Beyond Engines

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Paolo Tombesi

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For architects, reflecting on engineering has always proved difficult. No matter how good the initial intentions, more often than not the discussion ends up in some form of comparison between engineers and architects—be it about history, education, professional attitudes, cultural inclinations, agency functions, or else...

Rather than focusing on the verb, “to engineer,” we tend to concentrate either on the socio-technical implications of “being an engineer,” or on “engineering” as a noun defining areas of technical expertise conventionally understood as complementary to the architect’s.

There is no harm, of course, in taking or nurturing such a social view of the work; but it may be useful to ask, particularly in the context of this issue of *arcCA*, whether the direct, almost automatic association between agents and actions, or official knowledge and practice, can help articulate—and possibly overcome—the challenges internal to building design today. In other words, does the discussion of design (or engineering for that matter) need to retain explicit ties with identifiable professional domains and/or profiles? Should we continue to rely on conceptual categories that date back to the eighteenth century, and which reflect a vested interest in portraying and communicating a specific model of practice based more on the existence of social contracts than actual methods of work? Or should we rather try and let corporative notions go for a moment, turning ourselves into empirical diggers of design data that can help us decide whether the intellectual dynamics at work within building projects suggest changing geographies of authority, authorship, and alliances?

I am convinced that, if we are serious in scrutinizing professions to shed light on the organizing capacity of contemporary practice, we need to rethink the very description of the work carried out under its banner. In order to do this, attention must switch from social roles to design tasks or skills, from occupations to problems.

Engineering itself stands as a testimony of the flexible nature of the concepts we use. If one

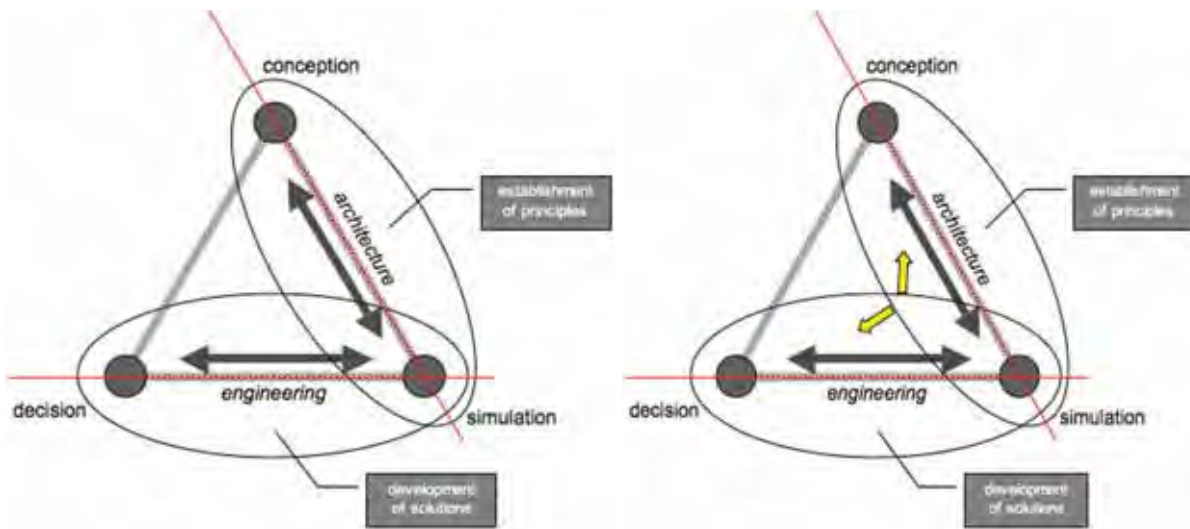


Figure 2: The relationship between architecture and engineering in the design process.

follows the dictionary, not all engineers are the same. In the English-speaking world, the term “engineer” has always sported a mechanic-like connotation, since its root derives from—and therefore denotes the ability to deal with—more or less complex machines (or “engines”). In most romance languages, by contrast, it is associated with ingenuity or “cleverness”—the innate quality that enables *ingegneri*, *ingénieurs* and *ingenieros* to be resourceful, act with originality, devise new explanations or methods, and thus invent.

The semantic slippage from *engines* to *cleverness* is an etymological oddity and should not be carried too far; yet it epitomizes the difference between defining an expert group on the basis of the devices it works on and with or in relation to the ability to devise. Depending on the framework adopted, engineering can be discussed as an occupation/discipline or as an intellectual practice—that is, a way of thinking strategically and theoretically about anything.

Now, if engineering is equivalent to “being ingenious” rather than “being an engineer,” the activity we label “engineering” can pervade the entire building process, much in the same way as design does the moment we disconnect it from the qualification “architectural.” To take a prosaic view, it becomes a problem-defining, problem-solving, information-struct-

turing activity that, on the basis of understood conditions and rules, however partial or “rationally bounded,” defines and communicates a specific course of action. According to this description, design-definable work would enter all dimensions of the building procurement process, irrespective of the architect’s engagement, from building scope formulation to building production, building erection to building use and maintenance, project definition to project control (Figure 1). By the same token, ingenuity is required—and it is indeed employed—across the entire project board.

Once we arrive at this dialectical conclusion—that design activity and ingenuity cannot possibly be limited to the areas covered by one or two professions (however broad these may be)—we have a blank slate on which to draw a truly original portrait of practice. Its defining traits can and should still be based on the generation and management of design capacity, but the social body in charge of (rather than entrusted with) it would not be determined *a priori*, but instead would require “fieldwork analysis” to be identified.

Which brings me to what should be the central question of a reflective discussion on engineering: not just “What do engineers do?” but, instead, “Who are today’s engineers? Who works, in fact, as an engineer? Who practices

the art of engineering?”

These questions are neither trivial nor without consequence. To answer them, we need to consider rigorously how design gets articulated into the specific functions related to the various aspects of the building process, then to produce taxonomies with the power to describe the work that ought to go into it. Doing so would make it plausible to turn architects’ mental image of construction around and think of the building process, with all its ramifications, as a “system of design production” (or a process of concurrent engineering) independent of the profession—a cycle, that is, within which all the information necessary for the implementation of the building is conceived, assembled, and exchanged.

To make it clearer: the moment we extend our discussion on ingenious practice to the various types of intellectual activity required to conceive a building and implement its construction, the design task is transformed from an intra-organizational to an inter-organizational set of activities and goods. How this system organizes to deliver its product, what logics it follows in doing it, what it is constrained by, and how many units of production it consists of, then become the real objects of the discussion.

It should not come as a surprise that such

	building design															
design dimensions	building scope formulation			building production		building erection		building use and maintenance			project definition and control					
sub-design tasks	program	space/boundary	performance	specifications	building systems	construction	fabrication	site	assembly/erection	testing	use	maintenance	change	project structure	operations	procurement
establishment of principles	← architecture →															
development of solutions	← engineering →															

Figure 3: The relationship between architecture and engineering in the design process.

analyses have not been carried out in force for decades, possibly as a result of the backlash caused by the use and abuse of design theory and methods in the 1970s. The consequence is that we tend to perpetuate, based on casual documentary evidence, a socially consistent view of the design professions as fiduciary agents of the client, sometimes engaged in sibling rivalry . . . at the same time that professional bodies come out with new design-assist contracts, and trade specialists increasingly sign as engineers of record.

So, what can or should be done to bring rhetoric and reality on a par?

My suggestion is as follows. Let's take the concepts of architecture and engineering at face value, for what they are supposed to mean in the field of ideas, rather than whom they are supposed to represent in the field of professions. The definition of their scope is embedded in the language, and we can assume it as appropriate: the construction of principles (or the principles of construction) for architecture, and the carrying out of an enterprise "by skillful or artful contrivance" for engineering (as per the dictionary).

The establishment of principles (architecture) thus goes hand in hand with the development of solutions (engineering) to define the intellectual component of the design process,

which, as we know, consists of three functions: envisioning, deciding, and transferring. Architecture is the process helping us envision the future by establishing organizing principles that develop in the space contained between conception and representation; engineering is the tool that brings us closer to their implementation by taking decisions based on the creation and evaluation of feasible alternatives (Figure 2). There is little doubt that, when put this way, architecture and engineering are consequent stages of the same process, connected through all the simulative activity that serves to represent ambitions, assess their potential, and translate them into action. As expected, initial conception and final decision about a design can be drawn closer together either by making the two ends of the arrow converge socially—that is, by managing the two tasks under the same roof or hat—or by expanding the area of communicative simulation, which is where design debate and adjustments take place.

Once we use "architecture" and "engineering," thus defined, to energize the tired notions of "schematic design" and "design development" internal to the building project, they become ubiquitous: every sub-design task needs architecture (the recognition of this simple truth would alone be a great step forward), and each architectural thesis, no mat-

ter its domain, demands proper engineering testing and support (Figure 3). But, since the labels we employ are tied to the function being performed rather than the party performing it, it is plausible to expect, when the situation requires it, architectural practitioners to engineer (i.e., to test, perfect, hone) their design, and engineers to work on the architecture of their system specialties. The problem may well turn out to be that, at times, architects do not do enough engineering, and that engineers don't do enough architecture.

But we might discover that, in particular areas, both architecture and engineering, in the sense put forth here, are either absent or carried out by significant "others." In this case, I play the optimist. Using the rubric of architecture and engineering to expose the existence of alternatives to the customary social division of professional labor in the design of the built environment could be both intellectually powerful and professionally cathartic. One would hardly need a more forceful depiction of practice to trigger, at last, grounded reflection on the structure of design sub-contracting, the evolution of the network firm, the alteration of the triangle of practice, and the advance of new building (and design) information models. ●



# Getting on the Same Page:

## An Interview with

Susie See and Andrew Corney

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Kenneth Caldwell

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*Electrical engineer Susie See was recently appointed executive vice president of WSP Flack + Kurtz. Andrew Corney is a director of Advanced Environmental, an in-house specialist environmental design studio. We interviewed the two at their office in Foundry Square in San Francisco, to learn their ideas for getting architects and engineers on the same page when it comes to global sustainability.*

**Q: What do you wish architects understood more about engineering?**

**Susie See:** I think architects know a whole bunch about engineering, and engineers know more about architecture than they admit. Architects know we can cool a large glass box, and engineers know why architects like glass boxes. We are both struggling with how to make a glass box comfortable and energy efficient. It is a group effort to make a good building, and if the folks that live in the building aren't happy, then the good architecture loses some of its power.

We're working to move towards a more integrative solution. Sitting in meetings all the time, architects say something and engineers say something else in response, but they're not communicating. It's like they're speaking two different languages. It's nice to have someone that speaks both languages and can help one person understand what the other person's trying to say. We would like to incorporate very low-energy HVAC systems, such as passive chilled beams—where chilled water runs through panels in the ceiling to air-condition the spaces. It saves energy, because water is a much more efficient medium than air for cooling. Right now, we're not doing a lot of chilled beam systems because the initial costs are high. When you look at the mechanical costs alone, it might not make sense to spend more money on that solution. Meanwhile, there can be a lot invested in the glass curtain wall to make it comply with California's energy code. Glass curtain walls might be great for daylight within the building, but in terms of low-energy air conditioning, they're not always the best solution.





Council House 2, City of Melbourne with DesignInc

**Andrew Corney:** This is a classic example where more integration can achieve a better outcome. Let's say that by using passive chilled beams we could reduce the floor-to-floor height by a foot—that's a big savings on façade costs. We might even be able to add a floor. Also, without an air system, we can give back shaft space. Now all of a sudden there's more leasable space. But architects and engineers need to work together to deliver a chilled beam system; unless the façade pays attention to cooling loads, the chilled beams won't work.

**See:** So now there is a trade-off with building costs that allows us to pay for a better building.

**Q:** How could architects and engineers move toward a shared language?

**Corney:** We encourage engineers to learn how to draw, so they can sit in a meeting with a pen and show something by drawing it. A lot of architects like it when engineers mark up their drawings and show how modifications could happen.

The other thing that I ask our team is, do you think if you took that home and gave it to your mother, sister, brother, husband or wife, would they understand it? And if they wouldn't understand it, then it might be that our client wouldn't either. If it's too complicated to write, you should be drawing a sketch to explain it instead.

**See:** I would like to make drastic improvements in the way we communicate information to our clients through 3D computer models, through graphics, through analysis software. As both engineers and architects work together on 3D models, we will have opportunities early in the design process to see where we can fully integrate systems, where there might be extra space in a building, where there might be areas that could serve two functions. Together we can identify opportunities to create spaces for filtered daylight to penetrate deeper into the building or model the angle of the sun at different times of the day and the year, to help us see where we can put shading.

**Q:** What are some examples of integration between architecture and engineering?

**See:** We are working with Pelli Clarke Pelli on an office building in San Francisco. We have an integrated green (landscaped) façade, reclaimed water for irrigation and toilet flushing, under-floor air conditioning, and photovoltaics on the roof. The green façade provides the right level of shading, and the underfloor air system allows for the desired ceiling heights. The systems all work together.

**Q:** What kinds of innovative techniques should architects know about?

**Corney:** On a number of projects, we're investigating a fanless air conditioning system. In most places, even in California, air conditioning is often 30 or 40 percent of a building's energy consumption. And a big proportion of air conditioning's energy consumption is just used powering fans to blow air around the building.

If we change the architecture a little bit and give ourselves more space to let air flow passively, and we apply heating and cooling in the right spots, and we take advantage of the fact that hot air rises and cold air falls, we can actually have air moving through the building without the use of any energy at all.

It requires an integrative process, because we need to bring HVAC components into the design of the architecture and work closely with the architects to make sure that everything is sized properly.



**Q: Has fanless air conditioning been used much in built projects?**

**Corney:** Yes. In Australia we've used fanless air conditioning on quite a few projects, like the Wendouree Centre for Performing Arts at Ballarat Grammar School in Victoria, which opened in 2006. This building has direct evaporative cooling and heating and not a single fan. The school speech day was held in December of last year—that's summer in Australia, remember—and it was something like 85 degrees outside. But it was comfortable inside the space, particularly on the lower tier, even though there were over 1,500 people in this hall.

There's another passive design strategy that works well in mild climates like Melbourne or the East Bay of San Francisco, where even if it gets hot during the day, at night it always gets quite cool. For the city of Melbourne's new office headquarters, Council House 2, we used chilled ceilings that rely on what's called phase-change material storage, with large tanks containing sealed balls with liquid that freezes at about 60 degrees Fahrenheit. At night, direct evaporation freezes the liquid, and then during the day, you can use that stored energy instead of chillers and cooling towers to provide the cooling. We were able to save an enormous amount of energy by taking advantage of the climate.

**Q: In terms of reducing our carbon emissions, how do passive design strategies compare with renewable energy sources as a viable solution?**

**See:** Right now we're seeing a lot of photovoltaics. They allow everyone to carry on with "business as usual"—all you have to do is put these things on top. But it's not necessarily integrated. And photovoltaics will probably offset somewhere around two percent of the overall energy consumption for a large building. It's a fairly expensive solution. If instead you design an HVAC system that's 30 percent more efficient than a conventional one, that's at least four times the energy savings of putting photovoltaics on top—with the same capital cost.

**Corney:** The sad thing is when we'll tell a client, "We could slash your energy consumption by 40 percent by incorporating passive design strategies"—and doing so might increase the project budget by one percent—they'll say no, because it would be easy for them to get a third party to come in and pay to put photovoltaics on the roof because of the number of incentives that are involved. There has to be a transition in the United States from the government backing winners like solar photovoltaics to an outcomes-based incentives system, where rebates and taxes are based solely on what the building's greenhouse gas emissions are going to be. It's amazing how much photovoltaics hold back everything else that's sensible, especially when they're much more about energy supply than building design.

**Q: Of course, photovoltaics are highly visible.**

**Corney:** Yes, but if you're an architect, and you want to do something visible, there's no better challenge than having someone say to you, "Turn your architecture into the building ventilation system." ●



top, phase change spheres; center and bottom, Wendouree Centre for Performing Arts, Ballarat, Victoria, Australia, McIlldowie Partners, photos courtesy McIlldowie Partners and Martin Saunders



# Seismic Experience

and Non-Prescriptive Design

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Yosh Asato

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When a 7.9 earthquake struck China's Sichuan province on May 12, 2008, the global structural engineering community mobilized, sharing information and data through formal and informal networks. Within a couple of weeks following the quake, engineers from around the world had visited the devastated area to learn firsthand about the damage incurred. Their observations are currently being disseminated through talks and articles and will eventually inform further study of the quake. This practice of visiting earthquake sites, which is decades old, offers a snapshot of the foundational relationship between engineer and nature that shapes the profession's collaborative culture.

The modern practice of structural engineering is deeply rooted in the idea of safety—making sure that buildings and infrastructure enhance lives rather than endanger them. In this regard, structural engineering can seem more akin to medicine than architecture. Both fields have groups of professionals and researchers grappling with some common life-threatening problems—the nature of heart disease, for example, or the behavior of a structural system during an earthquake. At the same time, anyone who has experienced a serious health issue is also aware of medicine's limits—that doctors are doing their best with the currently available knowledge and technology, which often falls well short of definitive answers.

Structural engineers also practice with similar limitations, with an added twist. Unlike heart attacks, which strike daily, significant seismic events are rare, which has several implications. The infrequency of major earthquakes means that the “opportunities” to see how structural designs perform and the ground moves in real life are equally rare; therefore, each event becomes a chance for the profession to learn and advance its thinking. At the same time, the rarity of such real life tests means that the science of seismic design has been slow to evolve and remains the profession's frontier. How engineers grapple with the inherent unknowns in some ways defines the spectrum of practice.

“From the outside, structural engineering appears deterministic, discreet, and measurable,” observes David Mar, principal of Tipping Mar + Associates of Berkeley. “But with engineering, there is always an underlying question of how comfortable you are with what you don’t know—the gap between what your analysis predicts and what will actually happen.”

That lives are at stake spurs a desire for professional consensus rooted in rigorous testing and research, which in turn fosters collaboration between practitioners and researchers, even those who may also be competitors. The prescriptive building codes used in the United States in many ways embody this consensus. They are developed by panels of experts who review and debate, often vigorously, every recommendation. In theory, they reflect the profession’s best understanding of how to prevent life-threatening building failures but not necessarily irreparable structural damage in a major earthquake.

The majority of engineers practice squarely within the realm of these prescriptive codes, using commonly accepted solutions for straightforward structures. But the comfort provided by this “safe zone” can cause collective blind spots with serious consequences. One of the most notable examples in recent times was the unexpected damage to steel moment-resistant frames in the 1994 Northridge earthquake. The poor performance of this popular structural system, and the resulting damage, caught the engineering and construction community largely by surprise.

According to Mar, the detail at the center of this episode—a full-penetration welding of beam flanges to columns—was originally developed and tested for highly redundant, skeleton-like structural systems with relatively small beams. Over time, however, the practical application of the detail evolved away from the tested systems, as engineers, by extrapolation, began using the joint in planer frame systems involving larger beams. While welding and inspection practices also shared some culpability, the poor performance of the steel systems in Northridge was a watershed event for the profession, which, having grown too comfortable with a particular solution, had extrapolated its potential use without adequate testing.

In fact, academic research had pointed to the potential risks of the extrapolated application, but the industry resisted the findings. “Researchers knew there was a problem [with the joints], but the problems kept getting explained away, blamed on bad welds in the tests,” says Joe Maffei, a principal of San Francisco’s Rutherford & Chekene. “The engineers, builders, and steel industry refused to believe the research, because it didn’t agree with our previous assumptions. Then, the Northridge earthquake came along and proved the researchers right.”

Although no steel moment frame structures collapsed during the Northridge earthquake, the unanticipated damage was a wake-up call for the profession. In the aftermath, advocates for non-prescriptive building codes have gained a greater audience as

heightened awareness of the prescriptive codes’ shortcomings has generated interest in alternative code models.

According to Maffei, a regular participant in code development committees, “The building code in the United States tries to do the impossible. It tries to distill several very complex sciences—ground motion, probability, and nonlinear structural behavior—into a set of design rules that are practical for an engineer to implement within budget. So, it’s not surprising that the codes don’t always get it right. In fact, there have been many more problems in earthquakes because people put too much faith in the building code rather than not enough.”

Performance-based and capacity design are two non-prescriptive approaches that engineers favor. A performance-based code targets post-earthquake conditions—from fully operational to near collapse—depending on a range of earthquake magnitudes and probabilities. Capacity design looks at individual components comprising a structural system and evaluates how each will perform given the sequence of events during an earthquake.

“Non-prescriptive design values the expertise of the engineering community while also making the engineer look more closely at the different components of a design,” says Mark Sarkisian, director of structural engineering for Skidmore, Owings & Merrill’s San Francisco office. “Prescriptive codes tend towards the macro, while non-prescriptive addresses the macro as well as the capacity of individual components.”

While this may appear to hint at individualistic impulses, the reality is that, to engineers, all structures are unique to varying degrees, depending on the building form, soil conditions, and other factors. Non-prescriptive design approaches are simply proposing a different way of evaluating the safety of these structures. In addition, non-prescriptive design also relies on professional consensus, but in the form of peer review.

Peer review counters another human nuance of structural engineering. Like other scientific disciplines, intuition plays an important role in structural engineering. An engineer might begin with a hunch, rooted in experience and practice, of how a building will behave in an earthquake, then develop and test a solution based on this intuition. The problem is that modeling and analysis are not as absolute and objective as they may seem.

“The human tendency is to see what you’re looking for,” observes Mar. “Computer models are like a lens: each has a distortion. Depending on what you choose to look at in your analysis—for example, the upper and lower strengths of construction materials or the foundation effects—you will see different things. A peer review system brings a different set of eyes—with different bias and skepticism—to the table.”

Collectively, the engineers interviewed for this story suggested a broader shift in philosophy. Designing for life safety alone is no longer enough from a cost and downtime perspective, a view informed by Northridge, where the

final tab reached into the billions despite the quake’s relatively moderate size. More fundamentally, with basic problems of preventing building failures largely solved, the frontier of engineering has shifted to seeking better solutions, framed in terms that building owners can relate to.

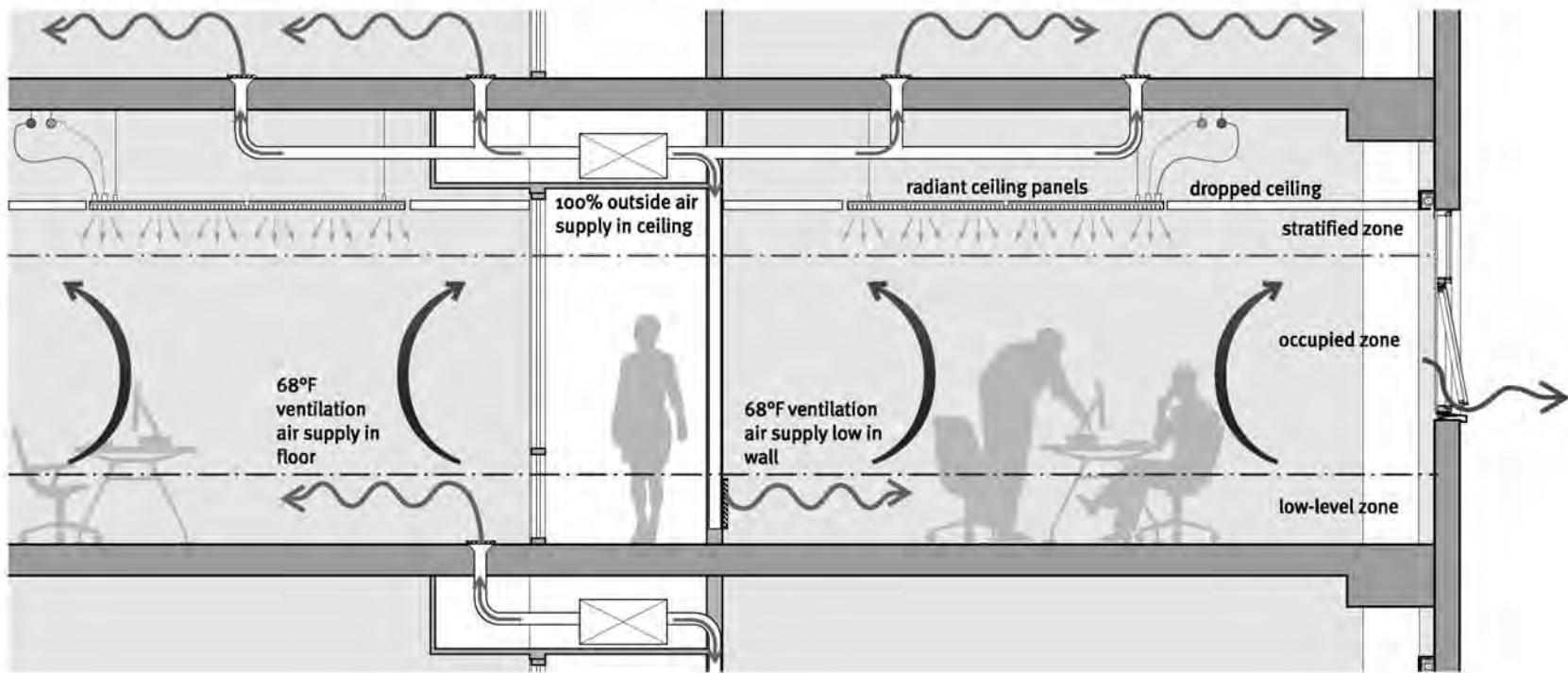
Maryann Phipps, principal of Estructure of El Cerrito and past-president of the Structural Engineers Association of California, explains, “Performance-based design and new technology such as BIM are changing the way we communicate and interact by improving our ability to describe options and risk in terms that clients care about: death, dollars, and downtime. By looking at the whole spectrum—the cost of better performance versus extended post-earthquake downtime, for example—we can help the client make smarter choices that consider costs over time.”

If an update of existing codes takes years, it is hard to imagine the time and process required to shift to a non-prescriptive code. The result is a hodge-podge of model codes and administrative bulletins enacted locally to address particular issues, such as the recent boom in tall buildings. In practice, however, this philosophical shift, along with new funding, has spawned an era of rich collaboration, as engineers in the field develop new approaches that are then tested by independent research. At the same time, research institutions are working together more and including more practitioners on their advisory panels.

Of course, building codes have always

lagged behind research, putting engineers in the position of mediating between what the code requires, what the research indicates, and what the client will accept. What is different now is that the new emphasis on performance, post-earthquake operability, and research has widened the gap. Currently, wood-frame, multi-family housing is a subject of discussion. The research indicates that at four- and five-stories in height, as compared with three stories and fewer, different structural solutions should be considered. How to convince a developer to go beyond code becomes one question, and how to design a solution that achieves higher performance without dramatically increasing cost is the other.

But does a performance-based approach that allows engineers more latitude to reach for new solutions, while also requiring them to look more critically at those solutions, make better engineers? “If an engineer doesn’t understand what he or she is doing, a good building code isn’t going to solve that. That’s asking too much,” says Maffei. “But it is true that a good building code is extremely important in terms of helping engineers to do their job well.” ●



# The Paradox of Green Engineering

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Peter Rumsey, PE

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Global climate change and widespread shortages of basic resources today make the adoption of more sustainable building practices imperative. Yet the mechanical, electrical, and plumbing engineers who are often in the best position to reduce energy and water use in buildings are, paradoxically, often the most resistant to changing deeply ingrained, inefficient design practices.

As public demand for green buildings grows and they become increasingly crucial to our social and economic health and stability, design professionals must work to remove cultural barriers to the rapid adoption of sustainable building practices. It's not as much about new technology as it is about changing perceptions and behavior. In general, architects have been more receptive to sustainability – it's time for engineers to follow suit.

## What architects say about engineers

Here's a sampling of the comments I've heard about engineers from architects: "Don't engineers know anything about green design?" "Why are the engineers knocking down all of the green strategies?" "Can't we get more energy points?" "Engineers want to design thermos bottles with no windows." "I hate working with engineers!" Is there such a thing as a "green engineer" – or is this an oxymoron?

Much of this professional disconnect stems from differences in how architects and engineers are educated. Engineers are trained to accept "givens" and "rules of thumb." Our learning focuses on absolutes like  $Q = U A \Delta T$ ; the Second Law of Thermodynamics – Entropy Increases; heat flow through insulated pipes and walls; fluid dynamics; heat transfer, and turbomachinery. We're typically focused on system performance – that's why we'll often "default" to whatever worked on the last project.

Architects, by contrast, have a broader education, and are much more likely to be exposed to sustainability through ideas such as sun angles; building orientation, environmental context,

opposite: Clear but detailed schematic diagrams communicate how building systems operate in the context of typical occupant use.







opposite page left: A classic “Rule-of-Thumb” calculation table for HVAC equipment loads, virtually unchanged for almost 30 years.

opposite page right: A very common worst-case-scenario design condition. Source: *Labs for the 21st Century Best Practice Guide*, Minimizing Reheat

this page: This highrise in downtown Oakland, built before extensive HVAC systems became prevalent, uses a u-shaped footprint, generous windows, and thermal mass to deliver natural light and ventilation deep into the core of the building.

part of the answer. Good technology, in the form of new materials, systems, and equipment, is already available and has been for some time. I think there are three main parts to the solution: design collaboration, economics, and aesthetic models.

Better design collaboration between all members of the team – architects, owners, user groups, as well as the engineers, can be seen as a positive evolution in our industry, and is being driven by a number of factors, including increasingly sophisticated design software and rapidly escalating construction costs. Engineers need to adapt to this trend. We also need to develop better design communication tools – in my office, schematic diagrams are developing into a fairly extensive “vocabulary,” as we focus on creating visualizations that clearly explain our systems to technical and non-technical people alike.

On the economic side, I like to cite what my friend and colleague Amory Lovins refers to as “Tunneling through the Cost Barrier.” This means going beyond simple paybacks on a part of the system, and capturing efficiencies based on the whole system. It’s almost counterintuitive, but with the right design approach, it’s really possible to capture big savings at little or no extra cost. We really need to do this today, given our climate and energy situation.

One of the most dramatic differences between architects and engineers is that architects are highly focused on visual aesthetics, while the aesthetics that drive engineers concern things that are less visible. Aesthetics are

a key part of how we behave as designers, and there is usually a practical side to them – most of us still believe that form follows function. Aesthetics can drive inefficient, energy intensive design; why not have them drive sustainable design instead? Many of the best architects in the recent past had an intuitive understanding of what we now call “sustainability” long before green was hip. In fact, traditional building practices all over the world are rich in “sustainable” concepts that evolved over millennia, long before mechanical equipment was used to mitigate the heating, ventilating, and cooling problems created by glass and steel high-rise technology. We need to create and promote a new aesthetic model of sustainability: we know that end users love the look and feel of truly sustainable buildings.

### Recovering the Existential Pleasure of Engineering

Not that long ago in our history, engineers were heroes. We were the driving force behind the Industrial Revolution and all the ensuing technological development that has so utterly transformed our world. Somewhere along the line, probably around the 1960s, we became the focus of a public backlash against technology, and we withdrew into professional insularity and stopped innovating.

Fortunately, one of the saving graces of our profession is that inefficiency is irrational from an engineer’s perspective: when faced with a half empty glass, we’re inclined to think that the glass is too big, rather than half full. There is indeed a great pleasure in creating

elegant engineering solutions that celebrate efficiency, and we need to recover this joy in our work and share it more openly. Engineers will be the ones who come up with the solutions to our climate and energy crisis, and as we all know, the stakes are huge. Consider this:

Building systems last, on average, for 30 years. The average architect or engineer will design something like 10,000,000 square feet of buildings in his or her career. If these buildings are designed to be highly energy efficient (with 50% energy savings), the difference this can make for a single designer over a lifetime career is roughly equal to the energy produced by 3,700 large-scale wind turbines, or more than enough to power a city the size of Portland for an entire year. ●

### Impact on LEED:

MEP engineers impact 37 of 69 total possible points in the LEED NC v2.2 rating system

- Sustainable Sites - 2 points
- Water Efficiency - 3 points
- Energy and Atmosphere - 16 points
- Materials and Resources - 1 point
- Indoor Environmental Quality - 10 points
- Innovation Credits - 5 points
- Total: 37 points

### LEED Rating Levels

- Certified - 26-32 points
- Silver - 33-38 points
- Gold - 39-51 points
- Platinum - 52+ points
- Total Possible: 69 points



## Fluid Boundaries: the Philosophy of WET

above: At the **LA Music Center**, designed by Welton Beckett, several hundred water columns rise directly from the paving, surrounding on four sides a sculpture by Jacques Lipchitz, *Peace on Earth*. Choreographed to rise through a range of heights, the jets can be turned off to recover the plaza for large events.

right: WET's redesign of the **Seattle Center International Fountain**, which had originally been a part of the 1962 World's Fair, placed a giant, stainless steel dome in the center of the bowl-shaped plaza. A ring of pulsing water jets surrounds the dome, from which spout a series of arcing jets, in which children (of all ages) are free to play. Periodically, a 150-foot high column of water, driven by compressed air, erupts from the top of the dome.

right page, top: Universal City's **City Walk**, designed with The Jerde Partnership, features pulsing water spouts, swirls of mist, and a unifying, highly reflective water membrane.

right page, left: At first glance, WET's fountain at **Columbus Circle** in New York appears more conventional than these other examples. Yet, in fact, it reverses the typical relationship, placing the pools of water around the public space, rather than occupying the center of the space. And the edging of the pools is designed to invite seating—with one's feet in the water.

right page, right: **Millenia Walk** in Singapore also employs reflective water membranes across black granite. Because the granite surfaces are set flush with the adjacent walkways—the water membrane has essentially no depth—no barriers are required between the two.

Los Angeles based WET, founded in 1983 by Mark Fuller, designs and engineers water features, develops innovative technology, and provides ongoing maintenance. Its inventions include more than fifty nozzles and valves, water illumination systems, control technologies, fire features, and compressed air-driven water jets that use only twenty percent of conventional technology.

Central to WET's investigations is an aspiration to erase the boundaries between people and water in the built landscape. These half dozen projects illustrate several approaches to this goal, conceived both for pleasure and for safety.



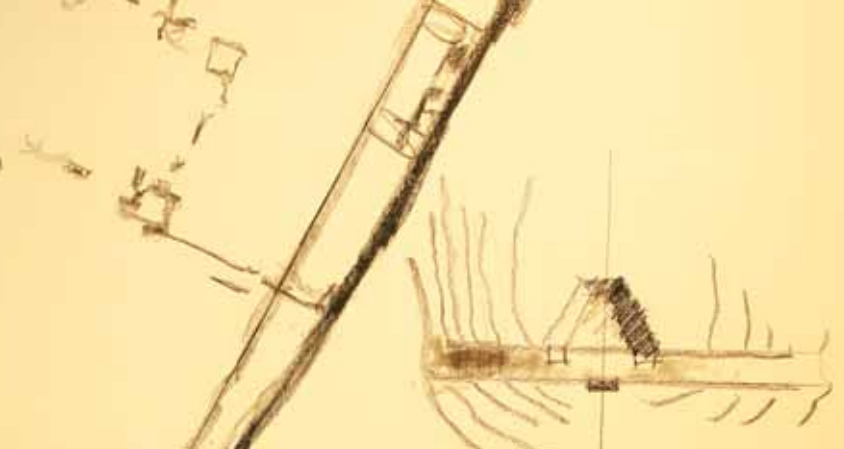
photography (c) 2008 WET Enterprises, Inc. All Rights Reserved



left: For SOM's **Gas Company Tower** in Los Angeles, WET extended the geometry of the elevator lobby, textile-like, with fingers of water that begin in the lobby and extend through the glazed wall to the exterior. Inside, the fingers of water are covered by glass plates, marked by a pattern of small, vertical jets of water. Outside, the glass plates are eliminated, and the jets rise subtly above flanking reflective water membranes over granite paving.



## The Other Academy Awards



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Therese Bissell

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*Jim Jennings and Neil Denari Receive the American Academy of Arts and Letters 2008 Academy Award for Architecture*

It's not every awards ceremony at which, on a drizzly late-May afternoon in an upper Manhattan, Beaux Arts hall—organ strains of a masterfully performed Charles Ives canzonetta in F having, moments earlier, only sweetened the air of cultured, faintly cosseted well being—the key address takes aim at the attendees. Particularly when that group comprises Jules Feiffer, Alison Lurie, John Ashbery, Richard Artschwager, John Baldessari, Kevin Roche, FAIA, and a good number of their peers.

“Oh, yes,” the playwright-actor Wallace Shawn affirmed (in that voice) midway into his remarks to the annual convocation of the American Academy of Arts and Letters, “speaking of superiority, we ought to note that pretty much all of us here in this room are connoisseurs of superiority. Those enrolled in the Academy belong to one of the very few organizations in the country whose central function is to proclaim the superiority of its own members. And those in the audience are people who enjoy looking at people who have been called superior.”

His theme being global aggression (“The defense of privilege, the center of our lives for such a long time, is grim, exhausting...the feeling of superiority is not the only source of human satisfaction: imperial dreams are not the only dreams”), he incorporated the role and consequence of art. “People beguiled by the beautiful are less dangerous to others than those obsessed by the thought of supremacy.... If the art we



above, Jim Jennings, one of his drawings, and the installation; photos by Dan Dodt

create is beautiful enough, will people be so drawn to looking at it that they'll leave behind their quest for power?" The notion was a romantic one. And it was, inescapably, a superior choir of artists, writers, composers and architects to whom Shawn, in that sublime setting, was preaching.

The American Academy of Arts and Letters is an august, 110-year-old New York institution of 250 honorary members, elected for life. From the outset, annual prizes have been given for literature, music composition, painting and sculpture. In 1991, an Academy Award in Architecture was created (for an individual or partnership) "to recognize an American architect whose work is characterized by a strong personal direction." A second architecture award with the same purpose was added in 2000.

After the inaugural award to Rodolfo Machado, Assoc. AIA, and Jorge Silvetti, Assoc. AIA, California architects had a run for the next three years: Thom Mayne, FAIA, and Michael Rotondi, FAIA, in 1992; Franklin Israel in 1993; Craig Hodgetts, FAIA, and Hsin-Ming Fung, AIA, in 1994. It was conferred upon Eric Owen Moss, FAIA, in 1999; Greg Lynn in 2003; Wes Jones in 2007.

This year, for the first time, the Academy Award for Architecture recipients are two California architects not in partnership together: Neil Denari, AIA, and Jim Jennings, AIA. The 2008 selection committee, chaired by Henry Cobb, FAIA, and made up of AIA Fellows Steven Holl, Peter Eisenman, Richard Meier, Billie Tsien, Michael Graves, Charles Gwathmey, James Stewart Polshek, Hugh Hardy and Cesar Pelli, along with Ada Louise Huxtable, Hon. AIA, drew from a field of 36 candidates nominated by themselves and other members of the Academy. The vote—for both Jennings and Denari—was unanimous.

#### The citations:

Neil Denari was exposed to aeronautical engineering at Airbus just after architecture school. From this experience, he developed an intuitive grasp of the importance of structure, an interest in the defiance of gravity and a sensitivity to economy in the design of a building's envelope. These have profoundly informed his architectural ideas as well as his extraordinary architectural drawings. In making the transition from theoretician and teacher to designer of elegantly inventive and rational buildings, he has never compromised his values or his respect for the venerable "rules" of architecture.

The strong personal direction of the works of architecture realized by Jim Jennings has evolved slowly toward a personal perfection over many years. Inspired proportions, mysterious serenity of light and space, and intensity of materials and details have consistently characterized what has become an example of an architecture of inspired silence.

For Jennings, the good news was notice of the award itself—the slightly crazy-making news was that the lead time for designing, making and putting up the accompanying exhibition was a month. He decided to improvise: covering three walls totaling 12 by 38 feet, he used graphite to sketch elevations and details of various projects. Opposite that, he hung, on adjoining panels, a cantilevered anodized-aluminum model

of Visiting Artists House and a to-scale, backlit, stainless-steel detail of SOMA House. The New York office of general contractor Ryan Associates coordinated the fabrication and installation of the model and detail; Dan Dodt designed the lighting component and oversaw its positioning (initially, David Meckel, FAIA, had offered student power when it was seemingly going to have to be built and shipped from San Francisco). In the end it was a fast-assembled coalition of the willing—and one guy marking up some fairly venerable walls.

"Drawing shows a different side of architecture—more related to the process of making it than the result," Jennings said. "The other reason I went that route was that I don't have a warehouse full of \$50,000 models." In Cobb's estimation, the Academy wasn't slighted: "The exhibit Jim mounted was notably fresh and inventive in its use of the space and surfaces made available to him."

Denari approached the gallery show altogether differently: using binder clips on push pins to display prints of seven projects. "About five years ago," he explained, "we developed a strategy for exhibits when plans, details and models are optional—and that was to go cinematic. Because this one was self-curated, and we could do whatever we wanted, the idea was to get the images as big as possible, in a plain, straightforward but very considered way. Print them ourselves and hang them on the wall. See how much information could be generated per image."

Denari was speaking in Helsinki and couldn't be in New York for the ceremony. When told about the Shawn address, he expressed bemusement. "Superior? The word is loaded with cultural elitism and self-referentiality. But this thing is prestigious—there aren't too many steps up in the awards chain. In terms of what Wallace Shawn was getting at, and thinking about the award with a degree of humility, at the very least it's based on one's work rather than on one's status otherwise." ●

#### Neil Denari exhibit



David Meckel, FAIA

## Number of Licensed Engineers and Land Surveyors in California

92,008  
[www.dca.ca.gov](http://www.dca.ca.gov)

## Number of These Who Are Structural Engineers

3,500  
[www.dca.ca.gov](http://www.dca.ca.gov)

## Three Recent Books on Prolific Engineering Thinkers

*Pier Luigi Nervi*

by Claudio Greco (Luzern, 2008)

*Buckminster Fuller: Starting with the Universe*

by K. Michael Hays, Dana A. Miller, et al.

(New Haven, 2008)

*Cecil Balmond: Frontiers of Architecture 1*

edited by Michael Holm (Esbjerg, 2007)

[www.stoutbooks.com](http://www.stoutbooks.com)

## Three Recent Books about Big Engineering Feats

*Water-Works: The Architecture & Engineering of the NYC Water Supply*

by Kevin Bone and Gina Pollara (New York, 2006)

*The Tennessee Valley Authority: Design and Persuasion*  
edited by Tim Culvahouse (New York, 2007)

*Power, Speed and Form: Engineers and the Making of the 20th Century*

by David P. Billington and David P. Billington, Jr.

(Princeton, 2006)

<http://library.cca.edu>

## The Five Largest California Infrastructure Projects Currently Underway

Bay Bridge Replacement (Oakland)

Devils Slide Tunnels & Roadway (Pacifica)

Wastewater Treatment Plant #3 (Bakersfield)

New Freeway (San Diego)

Dam Seismic Retrofit (Tujunga)

[www.construction.com](http://www.construction.com)

## Structural Engineering Equivalent of the AIACC

SEAOC

Structural Engineers Association of California

[www.seaoc.org](http://www.seaoc.org)

## Top Ten California Engineering Firms by Valuation

Parsons	\$10.3 billion
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DMJM	10.0
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Bechtel	5.7
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ARUP	3.4
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Capital Engineering	2.6
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Psomas	1.8
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John A. Martin	1.8
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TMAD Taylor & Gaines	1.7
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Flack + Kurtz	1.7
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KPFF	1.5
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[www.enr.com](http://www.enr.com)

## Last Major California Bridge Built

Benecia Bridge, 2007

1.6 mile span, 7 years to complete

Original estimate \$286 million

Final cost \$1.3 billion

[www.construction.com](http://www.construction.com)

## Last Major California Tunnel Built

Caldecott Tunnel, Bore 3, 1964

Berkeley

[www.construction.com](http://www.construction.com)

## Seven Wonders of the Modern World

According to the American Society of Civil Engineers

Channel Tunnel

CN Tower

Empire State Building

Golden Gate Bridge

Itaipu Dam

Netherlands North Sea Protection Works

Panama Canal

[www.asce.org](http://www.asce.org)



## Ralph Rapson and UC Santa Cruz

Kenneth Caldwell



photo and illustration courtesy of Rapson Architecture

Ralph Rapson, FAIA (1914–2008), wasn't a California architect. He was a Midwesterner. Yet his kind of clarity led to a humane and flexible modernism that could respond to the West. With just one completed theater complex and one unbuilt house, he left quite a legacy in California.

One of his earliest published projects, Case Study House Number 4 (CSH #4), the “Greenbelt House,” was commissioned in 1945 by John Entenza, the editor of *Arts+Architecture*. Rapson and Eero Saarinen were the only two non-Californians invited to participate in the program.

In 1989, the Los Angeles Museum of Contemporary Art mounted a retrospective of the Case Study House period entitled “Blueprints for Living” and created a renewed interest in modernism across the globe. The museum took the bold step of constructing Rapson's house within the exhibit. His Midwest sensibility had resulted in a deceptively simple, 1,800-square-foot house that focused on the courtyard—a historic symbol of California's outdoor life.

In the innovative educational environment at UC Santa Cruz, his Performing Arts Center celebrates the fresh air and tall redwoods with an outdoor lobby. You are protected from the occasional rain by an oversized canopy that also happens to organize the loose diagram he designed in response to the forested site. Although more recent buildings have crowded the 1971 project a little, the bold forms are still visible through the trees. This important building can be understood as the progeny of his now-demolished landmark Guthrie Theater in Minneapolis. At Santa Cruz, he simplified the form and distributed the functions, but still created a dramatic focus for students and professional performers alike. I remember a folk concert there in the mid-1970s, not long after the project opened. You walked through the forest to a collage of angled roofs and were suddenly inside an intimate theater that felt like it held a few dozen seats, not 550. We can only hope that UC won't make the same mistake that Minneapolis did and throw away this great architect's gift. ●