Are Young Engineers Unprepared? A Young Engineer Answers

BY EYTAN SOLOMON, P.E., LEED AP

A critical look at the concerns of our elders.

DEBATE OVER THE perceived inadequacies of structural engineering graduates has reached a fever pitch. Some say that young engineers today are not technically competent, that they have no engineering judgment or intuition, and that these deficiencies will manifest through poor designs into an increase in structural failures and collapses. To these ominous claims I offer not quite a rebuttal, but a reasonable continuation of the discussion from the viewpoint of that brash young engineer whom everyone fears.

How Have Things Changed?

Few will deny that the engineer of today is faced with more information than 100, 50, or even five years ago. High-strength steel, high-strength concrete, prestressed concrete, fiber-reinforced concrete, and structural glass are just a *few* of the new construction materials of our generation; finite element analysis (FEA), building information modeling (BIM), and sustainability are just a *few* of the new design paradigms; and globalization, intelligent technology, and digital fabrication are just a *few* of the new industry standards.

Similarly, the codified laws by which we create structures have also expanded and sharpened. The bureaucratic, legalistic, rule-fixated demeanor of our society—a character that does not necessarily yield negative results—has given rise to building codes and design guidelines that are voluminous and complex without precedent.

Clearly, structure geometries today are more complicated than before. Increasing sophistication in computer hardware and software is both a cause and effect of the ever-more "funky" designs that come across our desks. I once sat with the president of my firm, an engineer who has seen it all in his 50-odd years of practice, to look over the latest fantastical proposition from a certain "starchitect." "Why do they want to do this?" he implored sincerely before we both realized the answer: "Because they can."

In the Frank Gehry age of architecture, it is impossible to design many buildings without a computer and, in fact, it is impractical without a tremendous reliance on computer analysis. We feel sorry for our architect friends who log endless hours on AutoCAD, but many engineering students come out of school to work as "desk monkeys" on Revit, RISA, or SAP models for geometrically complex projects. How much "intuition" can one really attain in such an assembly-line environment? Does this inherently cause a disconnect between the "first principles" learned in school versus a young engineer's day-to-day practice?

When our elders went to school, the truss and beam designs of steel and concrete were perhaps closer to what they would actually work with after graduation. Now the 3D modeling program is absolutely essential to an engineer's ability to analyze and design complex structures efficiently and is very often linked directly with drawing production and construction logistics as well.

With the increased complexity in materials, codes, and geometries, engineering educators find themselves scrambling to catch up with the pace of industry, while at the same time struggling to retain the fundamental courses in mechanics, analysis, and design. A special education committee for ASCE recently noted that civil engineering students today, on average, earn at least 20 fewer credits—including 18 fewer credits for engineering topics—than did their counterparts in the 1920s.

Today's engineering schools must, out of necessity, adapt to the times. Many offer classes with more direct preparation for industry practice, such as computer design and drafting or group work and project presentations. Some schools have increased the time to complete the engineering degree from four years to five years. And some programs, though they must compose a minority, have resisted additional computer-oriented courses so that the undergraduate curriculum can concentrate on fundamentals of analysis and design.

How Have Things Stayed the Same?

Despite all of the new challenges, I contend that the same timeless principles of engineering, experience, and management apply as much to our generation as ever before. Some structural engineers young and old hold a preconceived notion that the way to gain engineering judgment is by performing long hours of calculations by hand. But while the ability to do hand calculations is undeniably important, it is equally necessary to cultivate engineering judgment and intuition by walking construction sites, arguing with—and teaching—architects, hearing war stories from contractors and older engineers, and seeing how project after project is "solved" with different materials. A legendary professor at Columbia University once said, "The best engineer is the one with grease under his fingernails." With a constant objective of educating oneself, every moment of every day can be a learning experience.

My next contention is that the image of past genera-

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tions of engineers working exclusively in an "ivory tower" of first principles must be a myth. Automation and "shortcut" methods have been part and parcel of structural engineering for more than a century, and the computer is no more inherently evil than its predecessors. In his excellent, thoughtful essay "Don't Blame the Computer for Mistakes!" Bashar Altabba "vividly remembers the days when similar arguments [about computers] were being made about handheld calculators, back when these were first introduced. Some schools even banned their use… At that time, the proposed solution for complex calculations was a simple one: Just use a slide rule like 'real engineers' do! Does anyone today still hold this view about handheld calculators?"

Was not the slide rule itself introduced to cut down longer pure-hand calculations?

I do not deny that over-reliance on computer output without proper care and consideration (such as a senior engineer checking the results) can be detrimental, even gravely so. However, I do question whether design automation is truly an entirely new problem. One of my superiors says that no computer program, ultimately, is anything more than a "glorified spreadsheet."

I next take issue with our elders' fear of declining competence and intelligence in young engineers. I will not argue against individual anecdotal claims such as, "I have seen engineers with eight or more years of experience with no engineering intuition or common sense."

There are, have been, and will be good engineers and bad engineers, just as there are, have been, and will be good doctors and bad doctors, good lawyers and bad lawyers. And like any other business, the engineering "org" chart is a triangle with few at the top and many at the bottom. I'm sure the harbingers of doom know at least a handful of good young eggs, and might these be the few to ultimately succeed those at the top? (And isn't that the way it has always been?) The senior people at my firm think of recent graduates as apprentices, with the idea that one's first office has the obligation to provide that link between the university and the workplace.

On a deep philosophical level, it is not surprising for our elder engineers to fear the future. One professor at the University of Buffalo has noted that "it is natural that older engineers have a lack of confidence in younger engineers." Ours is a serious and difficult profession to protect both the public's safety and the client's money; this responsibility should instill a sense of pride and self-confidence. Like King Lear, we want to see our realm passed on to proper hands, and we hope for a brighter outcome than he found. It is easy to fear that one's successors may be unprepared if they do not follow exactly in one's footsteps. However, difference does not imply inferiority.

What Should We Do?

Many have offered solutions, perhaps the most well-defined being ASCE's policy 465, which proposes to expand and deepen civil engineering education at the university level. In theory this will bolster the engineering student's body of knowledge to a level certainly not yet on par with, but closer to that of, a medical or law student. While there are countless outstanding engineers who never pursued a master's degree (as well as the inverse) there may be no tangible way to demonstrate to the lay public the educational rigor of the engineering profession (besides drastic salary increases) without raising the bar of degree attainment. I support the policy 465 initiative.

Previously I touched on the rise of the unconventional, computer-enabled, "funky" architectural schemes with which we structural engineers are compelled to work. I contend that structural engineers must "take back the funk." We must lead in this geometric revolution, on equal if not superior footing to the starchitects, because we ultimately hold the keys to the realities of strength and stability. Are the works of Frank Gehry and Zaha Hadid any more inspired than those of Eduardo Torroja and Eladio Dieste? Besides Santiago Calatrava's projects, I fear that engineers have fallen into the complacency of merely reacting to the architects' dreams, while it rarely occurs to us to have the dream first.

Another suggestion, made publicly by NCSEA President Ed Huston, is to dig up—out of books, notes, and individual experience—all the "rules of thumb" and "reality checks" engineers have acquired over the years and circulate them among peers both young and old. I agree with this sentiment. No matter how complicated an analysis becomes, it is practically guaranteed that at some point in the process you will need to "prove" your design succinctly, in the space of a single page, to someone—a client, a colleague, a contractor, a senior or junior coworker, or, above all, your own conscience.

I encourage employers to ponder the true nature of our profession. Does anyone really start with intuition, or is this cultivated slowly over time? Is the computer really evil, or does it in fact *help* the engineer develop understanding because it challenges one's conventional thinking? Should an engineering firm be a hierarchy of those who "have" knowledge and those who simply run simulations, or should it be a place of continuing education between masters and apprentices? Even if we do "clean our own house," how do we deal with architects who produce designs in CAD that cannot be built, and construction managers who churn out schedules from Primavera without any intuition of their own? And what about the declining fees for our services?

As a final illustration, let us recall the story about William LeMessurier re-analyzing the entire Citicorp Building by himself in a cabin during the post-construction crisis concerning bolted versus welded connections, under the previously unconsidered effects of quartering winds. While his application of first principles in hand calculation is magnificent, the more important moral of this story is LeMessurier's global thinking, humanistic conscience, creative problem solving, and having the right priorities.

Let us too have the right priorities. Look inward and march forward! MSC

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