What is Structural Engineering Exactly?

By Erik Nelson, P.E., S.E.

This is the first in a series of articles that will lay out my thoughts about my profession. I start with some common definitions of structural engineering and then present my own perceptions.

A popular but limited definition of structural engineering is *"the art of molding materials we do not wholly understand into shapes we cannot precisely analyze, so as to withstand forces we cannot really assess, in such a way that the community at large has no reason to suspect the extent of our ignorance."* (For its history, see Jon Schmidt's "InFocus" column in the January 2009 issue of STRUCTURE, "The Definition of Structural Engineering.") This is clever and fun but only addresses uncertainty of forces and materials. What a limited understanding of what we do! Yes, we are experts in the ability to make decisions under great amounts of uncertainty, but that is only one aspect of our work. Stress and strain are necessary calculations but represent only a small fraction of all that we do; otherwise, we could be completely replaced by computers. Those of us who do genuine engineering are never concerned about this.

Another flawed definition comes from the British Institution of Structural Engineers: *"Structural engineering is the science and art of designing and making, with economy and elegance, buildings, bridges, frameworks and other similar structures so that they can safely resist the forces to which they may be subjected."* This sounds pretty good, right? Unfortunately, it fails completely in describing how one goes about designing. Like most other definitions, it puts too great an emphasis on force resistance. Yes, we proportion members based largely on forces, but that is only one of many design considerations – we also have to take construction practices, architectural constraints, client needs, and many other factors into account. As Hardy Cross famously put it, "Strength is essential, but otherwise unimportant."

The American Society of Civil Engineers unfortunately defines civil engineering thus: *"The profession in which a knowledge of the mathematical and physical sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically, the materials and forces of nature for the progressive well-being of humanity in creating, improving and protecting the environment, in providing facilities for community living, industry and transportation, and in providing structures for the use of humankind."* How could a definition of engineering omit the most important word – design! This one is lengthy and dull, and fails to describe what we do, instead focusing on the end product, what we make. Saying that a cook makes cake does not describe cooking very well.

Here is more of the same from the National Society of Professional Engineers (NSPE): *"Engineering is the creative application of scientific principles used to plan, build, direct, guide, manage, or work on systems to maintain and improve our daily lives."* This suggests that our creativity is not employed for artistry, self-expression, costs, or constructibility, but solely for science. That is just plain weird – and wrong. The applied science portion of what we do is actually the easiest and most straightforward. It is objective and has its own linear, step-wise methodology. That is why young engineers are doing the calculations and the modeling, while more experienced engineers are doing less. Yes, it needs to be right, so there is a lot of responsibility in this phase; but that does not necessarily make it difficult. The experienced ones are doing the other 90% of what we do, the more difficult tasks that require much more than calculations. Design is the other 90% of engineering that is only achieved after one graduates from being a mere applied scientist (or technician) to being a genuine engineer!

It is a widespread misconception that engineers are applied scientists. Scientists are applied scientists. Most of our engineering educators are applied scientists. Scientists make sense of what exists in nature. They test and examine nature. Scientists discover. Engineers take nature and make what exists outside of it. Engineers invent and create. Engineers are makers. Engineers are designers. Alan Harris put it succinctly: "Engineering is no more applied science, than painting is applied chemistry."

Here is my own definition: ***"Structural engineering is the design of BIG things."*** The know-how required to do this is immense and is only obtained via lifelong learning. Engineers are 1% to 10% of each of the following:

- Scientists
- Mathematicians
- Computer Scientists
- Information Seekers (State of the Art)
- Specialists in Systems
- Experts in Construction
- Citizens of a Locality of Construction Practices and Material Availability
- Cost Estimators or Experts on Best Practices to Reduce Cost
- Experts on Local Fabrication and Construction Technologies
- Experts on Building Codes, Specifications, Standards, Guides, and Regulations
- Risk Evaluators and Code Interpreters
- Experts in Calculations
- Experts in Three-Dimensional Representation in the Mind
- Experts in Synthesizing Complex/Unsolvable Things into Simple/Solvable things.
- Experts in Analysis Modeling Using Software
- Skeptics of Engineering Software
- Debaters of Efficiency, Economy, and Elegance
- Artists, Philosophers, Poets, and Dreamers with Unconstrained Self-Expression
- Drafters and/or BIM Specialists
- Collaborators Working Within Design Teams
- Listeners of the Vision and Needs of the Project/Client/Architect
- Users of Rules of Thumb (Heuristics)
- Experts in the Ability to Make Decisions Under Great Amounts of Uncertainty

Structural (and civil) engineering is the design of big things. This definition may contribute to a positive "rebranding" of the profession which may improve the career appeal of our profession and hopefully help with the dismal 50% retention rate in our engineering schools. We have a marketing problem of clearly describing what we do. Engineering is so much more than completing calculation procedures!▪

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