Educating Students

about the Proper Use and Interpretation of Design Aids and Software

by Dr. Andrea Schokker, University of Minnesota Duluth

As engineering professors, we are responsible for giving students the background and theory they need as well as acquainting them with the design aids and tools of the profession. Design aids and software are critical to a practicing engineer, but, as with any tool, they must be used for the applications for which they were designed.

I want my students to be ready to step into their first engineering jobs with as much practical understanding as possible. However, I also want to make sure we have done a good job building a base of knowledge, including critical and innovative thinking, so they can go beyond the "cookbook" approach (or, as one of my professors used to say, "So you can design more than a one-bay chicken coop"!).

Teaching engineering judgment alongside the design process ensures that our students never just accept an answer blindly. I remember sitting in a Master's thesis defense early in my career where a colleague's student presented his findings on a purely computational project. He showed results that were consistently huge (several feet thick) for a fairly short-span concrete slab. I asked him if that seemed reasonable, and he said, "It's right because I got it from the computer." I knew then and there that I could not allow any student that came through one of my classes or my research groups to have that kind of dangerous view.

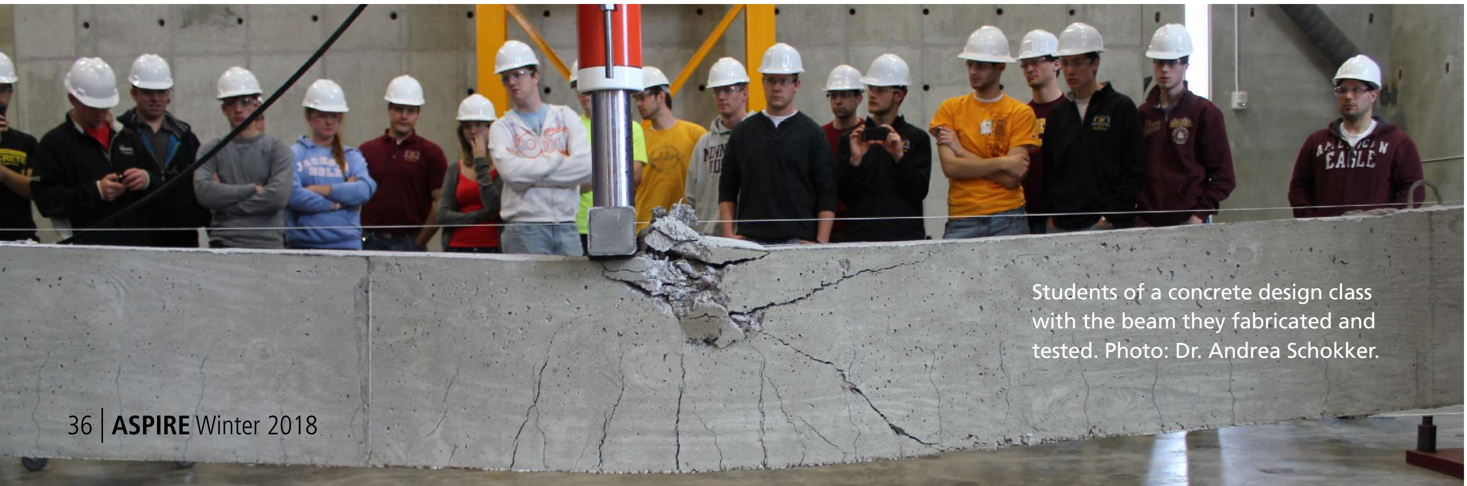
My approach is to move students into the use of design tools early in their design classes, while simultaneously challenging them with questions about the assumptions used in the process. We often use design aids and software to work on problems, and then I ask for a hand calculation for comparison. My students always know my next questions will be, "Does your hand calculation match the value from the table or computer output? Why or why not? What assumptions were made?"

Likewise, I spend time showing them the steps I use when looking at computer output. Today's programs can show results in a highly visible format, which enables the engineer to catch potential problems more quickly than when scrolling through a list of numerical output on the screen (as I remember doing with the early programs). Today's students have an inherent trust in computers, which means it is important to help them understand that "junk in equals junk out" is a major source of errors and that the way to check the input is to be able to judge the reasonableness of the output.

I tell them that I always start with a plot of the input (are the loads in the right direction and where I want them?) and then go to a deflection diagram rather than other output (does the shape and magnitude make sense?). I also teach them to consider the bounds or extremes on a solution by reducing it to a basic problem that they can do quickly by hand or in their heads to see whether the order of magnitude is reasonable. In our curriculum, we have also incorporated both small- and large-scale demonstrations to help students visualize structural behavior and to compare laboratory results to hand calculations and design aids.

Engineering judgment comes from years of experience, but its development can also be jump-started by ensuring that students realize that no design table or software is magic. When engineers use a tool, they must understand how it was developed or, at the very least, the assumptions that are built into it. They also need a way to do some basic checks of magnitude of the solution. I emphasize that design aids and software are a great starting point, but one's education as an engineer is vital for true problem solving and final design. In our field of structural engineering, the point of life safety is often one I use to drive home the significance of critical-thinking skills. In class, blindly accepting results may affect a student's grade but, in the profession, that approach might mean significant economic loss or, much worse, loss of life.

Our students will have much to learn on their first jobs, but I think a good professor understands that the educator's duty is to ensure a strong base of knowledge and an understanding of both how to use tools as well as their limitations.



Students of a concrete design class with the beam they fabricated and tested. Photo: Dr. Andrea Schokker.