structural forum

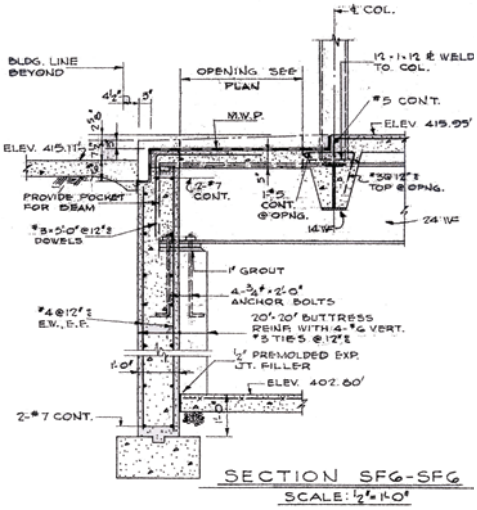
Structural Drawings

Why Some Drawings are "Down-Right Unacceptable"

By Clifford Schwinger, P.E.

The quality of structural drawings has plummeted over the past 25 years. The recent publication of CASE Document 962 D, "A Guideline Addressing Coordination and Completeness of Structural Construction Documents", is a promising sign that the profession is addressing this problem; however, implementing the changes needed to improve the situation won't be easy. As a structural engineer, I've witnessed firsthand the decline in drawing quality during my career.

From my "front row" seat I think I've figured out why this problem occurred – and more importantly I have some suggestions that might be worth considering for improving things.



Section through a basement wall; drawn in 1956

In order to understand what happened it's necessary to first review the way building structures were designed and contract documents produced years ago.

Prior to 1980, when engineers graduating from college entered the profession, projects had larger fees and longer schedules. There were no computers (except for mainframes) and every beam, column and base plate was designed by hand – mostly by young engineers. Many engineers spent the early years of their careers doing little more than repetitive manual calculations and drafting.

Young engineers gradually learned how to put together a set of contract documents - first by working on column and beam schedules, then by picking up red marks on plans and details, and then maybe by drafting some details from scratch. After a couple of years, the young engineer got a "feel" for what it took to design a building and put together a good set of structural drawings.

Fast-forward 25 years…

All those calculations that took months to do 25 years ago can now be done in a single morning by one engineer with a computer (ok, so I'm exaggerating a little). With the calculations finished up in the morning, what's the young engineer to do in the afternoon? Answer: the framing plans, schedules and details.

Fees are smaller, schedules are faster, and things now change more frequently during design than they did years ago because the expectation (by some) is that all a structural engineers have to do to accommodate major revisions to a building design is to "…push a couple buttons" on the computer.

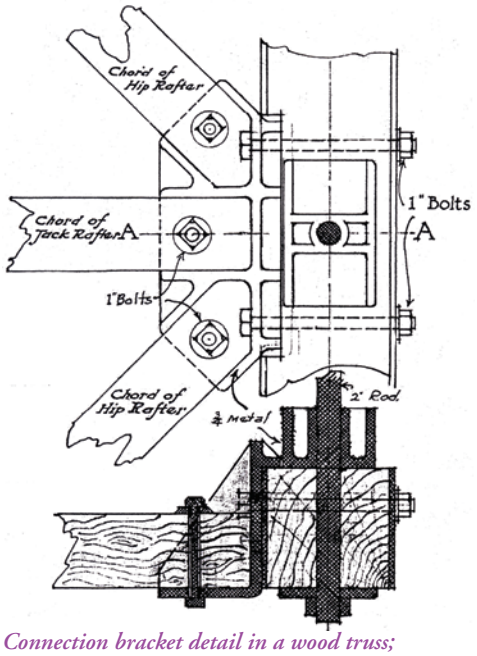
Today, the percentage of a project budget allocated to "number crunching" is a smaller portion of the total budget, and in order to keep young engineers busy they are taking on greater responsibilities earlier in their careers than did their predecessors. Now we have young engineers with little detailing experience (and often no drafting experience) taking on a greater share of project responsibility earlier on in their careers, guiding "CAD operators" who are usually able to provide only minimal (if any) drafting guidance to those engineers.

Structural drafting has become a lost art. And, many CAD operators don't have a clue as to what it is that they're drawing – many are just converting squiggly red pencil lines into straight black lines on the computer. Whereas artistry, speed and a basic knowledge of building structures where of equal importance years ago – now it is often only speed that counts.

With the increased usage of computers, experienced structural drafters had to learn CAD in order to continue working in their profession. The value of experienced and skilled structural drafters was diluted by the computer-savvy youngsters entering the profession – who in most cases had little or no training in structural drafting. While many of these engineers had considerable structural drafting skill, because they were not trained in CAD, they were now "locked out" of the drawings. If something didn't "look right" on a drawing, the engineer couldn't just grab an eraser and pencil to fix it at the last minute. They had to inform the CAD operator of the error, who then fixed it and plotted out another check plot – if there was time. Errors gradually became acceptable with the understanding that "the contractor will understand what we're saying". Mediocrity became acceptable.

Years ago, drafters generally had more "ownership" of the projects on which they worked. Because the drawings were literally taped onto the drafter's drawing board, there was usually only one "hand" on each sheet. With CAD drafting there is often a philosophy that as long as everyone follows a set of office standards, you can have multiple people working on a single sheet and drawing uniformity will still be maintained.

Simultaneous to the introduction of computer drafting was the dilution of the technical curriculum in many engineering schools. This dilution occurred under the pretence of making the graduates of engineering schools more "well-rounded". While the intentions may have been noble, we are now faced with a situation where many of today's college graduates with B.S. degrees are less well prepared when walking into their first job than were their predecessors with similar credentials twenty-five years ago.



Connection bracket detail in a wood truss; drawn in 1904

Here are some suggestions for solving the problem of poor quality structural drawings:

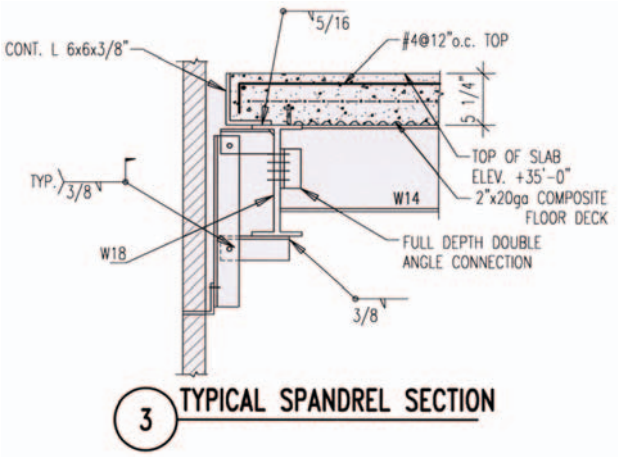
Engineering firms

Every structural engineering office must have a copy of CASE Document 962 D, and should use it as a baseline for establishing an in-house quality assurance program regardless of the size of the firm. Construction managers, general contractors, and lawyers are purchasing and reading this document in preparation to use as a weapon against structural engineers who are not diligent in producing high quality contract documents.

Every structural engineering firm must have quality assurance plan. In small offices, the quality assurance plan might include "in-house" reviews at various stages of design by someone who is not working on the project in order to get a "fresh set of eyes" on the drawings. In medium sized firms, quality assurance might incorporate the employment of a full time engineer whose sole task is that of answering technical questions and training new engineers, establishing office standards and procedures for design and drafting and reviewing all contract documents at various stages during design. The employment of a full time quality assurance manager in large engineering firms is, in my opinion, an absolute necessity. Ultimately those firms who ignore drawing quality and who focus solely on providing the minimum product at the lowest fee will lose a competitive edge in the marketplace.

Engineering Schools

Engineering schools must halt the dilution of the technical curriculum. The push to make a Master's degree a minimum requirement for employment or professional licensure is not so much a reflection that structural engineering has become a more complex profession – it is more the result of the undergraduate civil engineering curriculum having been severely diluted of structural engineering courses for the sake of providing a broader education. An ideal solution for making engineering graduates with bachelor's degrees more knowledgeable about structural engineering would be for universities to provide students the opportunity to obtain a Bachelor's Degree in Structural Engineering, instead of structural engineering courses being ancillary to a Civil Engineering curriculum. A Structural Engineering program would focus primarily on structures with secondary instruction on drafting, detailing, and coordination of structural systems within the total scope of the project.



"Fictitious" modern-day CAD-drawn detail showing many common drafting and detailing errors. How many can you find?

Most structural engineering courses offered in universities today focus solely on analysis and design. It's my opinion that if courses were offered to teach the fundamentals about how to produce contract documents (drafting, specification writing, etc.), those courses would be of more benefit to young engineers (and their future employers) than would be additional coursework in advanced structural design.

I've noticed that many young engineers right out of school often tend to over-analyze things. That's because analysis was all they were taught in school. Many seem to "over-analyze" and "under-detail". Maybe if they were taught the basics of drafting and detailing, as well as the basics of how the total building went together (i.e., interface between structural, architectural, MEP, etc.) they would be more productive "out of the gate" on their first job.

Last Words… but not the end of the story!

In today's complex and fast-paced world of structural design and building construction, there is no place for mediocrity on the document that communicates a structural engineer's design – the structural drawings. The need for producing high quality structural drawings is not an option – it is an absolute necessity.■

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The author has provided STRUCTURE magazine with the answers to the "Drawing Errors" graphic in this article. Email us your answers, and we will let you know how you scored, and send you the solution. Email your responses to ***publisher@structuremag.org****. Please use "Structural Drawings March 04" in the subject line of the email.*