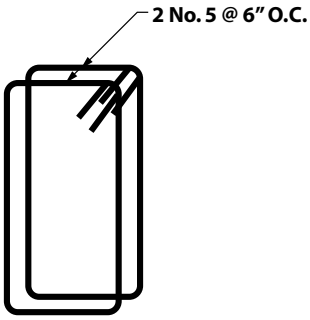
Measure Twice, Cut Once

By John Tawresey, S.E.

This is the last article in the series of six. It is about the most important part of risk management – technical quality. By *technical* we mean proficiency in our practice of the knowledge and skills of structural engineering, and by *quality* we mean a degree or grade of excellence.

A theme of this series is that risk management is mostly about managing the technical quality of our professional practice. The other aspect of risk management, business practices, is very important also. However, by far the best way to avoid an unfavorable project outcome is to avoid problems on our projects. In this article we will continue the dialogue by directly addressing the technical quality of our work.

The simplest of mistakes can result in claims. It is easy to make mistakes. We make thousands of decisions on each project and any one decision could result in a mistake and a claim. Take for example the communication to the contractor depicted on a detail shown in *Figure 1*. The concrete beam was built, and then exhibited excessive diagonal cracking. An X-ray investigation revealed that the contractor had placed two No. 5's at 6 inches on center, not the four No. 5's the engineer intended. A claim resulted. It cost the structural engineer nearly a hundred thousand dollars to fix the problem.



There are endless examples of claims resulting from simple and minor mistakes. Finding them is difficult. What can we do?

Avoiding mistakes brings to mind images of checklists and peer reviews. Both are important activities to avoid mistakes and should be part of everyday practice. The power of using check lists was demonstrated a number of years ago during a series of loss prevention seminars conducted by SERMC. A set of structural drawings was offered to the attendees with the instruction to find as many errors as they could. The number of errors found varied significantly by participant. Next, a checklist was distributed and the process repeated. Most participants found as many additional errors as they had found the first time. Check lists work. Check lists are a way to avoid making the same mistake more than once.

Peer review, either by in-house management as part of the quality control program or by an independent reviewer, is also a powerful mistake-finding tool. Periodic review of the design as it progresses can find errors. Outside, independent peer reviews are now more common, and most structural engineers welcome this process when offered by the wise owner or client.

But checklist and peer review usually occur after the fact, and fixing the problem is usually more expensive than doing it right the first time. Measure twice cut once. Do it right the first time. Are there other ways to avoid mistakes that prevent them from happening in the first place?

The answer is yes. There are many processes that can be put in place while doing a design that can reduce the probability of making mistakes. For example, before doing an engineering analysis, here is a list of questions to be asked. It is the "measure twice" part of the familiar saying.

1 Is this engineering work necessary to meet the project goals and quality? If the goal is to determine how deep a beam is required during the preliminary design stage, frequently no detailed analysis is required. Yet, an error in a more detailed analysis at this stage (particularly with limited information) could follow through the process and end up in the design. Or, how many times have you completed a detailed analysis and design that is subsequently changed or deleted from the project? Sometimes the detail remains on the drawings even though it is not used. Is it a mistake to include an unused detail on a set of drawings?

2 Is the level of design or analysis consistent with the selected quality level for the project? How many times is the component to be used – designs will probably be different for one use versus 1000 uses. How well do we need to understand the structural behavior of the component? For example, performing a seismic pushover analysis on a "development grade" one-story shopping center is probably not a level of analysis consistent with the level of quality for the project. There is a much higher probability of making a mistake in a pushover analysis than using the simpler equivalent lateral force method.

3 Is there an easier or faster way to accomplish the same result? Prior to entering into a complex analysis (usually a computer analysis), the designer should estimate the expected results to ensure the validity of the more complex (computer) results. Or, could an upper-bounding solution suffice in order to avoid detailed costly and more mistake-prone analysis? The simplest design is usually the most elegant, least costly and least risky.

4 Is there a positive benefit for this analysis? The positive benefit should be either a reduction in project cost, design cost or improved project performance. If it is not, don't do the activity (don't cut).

Here is an example of how these questions can work. It involves a condo project. During an investigation instigated by other problems, the design of a 10-inch masonry cantilever retaining wall came into question. The design showed the reinforcement to be placed 3 inches from the soil side of the wall. Unfortunately, the section did not show the soil and was cut on the foundation plan backwards. Investigation showed that the mason built 100 feet of wall with the reinforcement 3 inches from the non-soil side of the wall. The wall showed no signs of distress, but the cost to remove and replace the wall was added to the claim. Further analysis demonstrated that the reinforcement could have been placed at the center of the wall.

Let's try our analysis criteria on this situation. The engineering was necessary (1), and probably consistent with the project level of quality (2). But there was an easier way (3), and the more complex placement of the bars did not result in a positive benefit to the project (4).

Now, whenever possible I place the reinforcement at the center of the wall. Even the dyslexic mason usually gets it right.

In summary, it is easy to make a mistake that will result in a claim. And, mistakes will happen. Finding the mistake after it is made must be part of a quality control process. Checklists and peer reviews are valuable tools. Additionally, it is good risk management practice to develop processes that lower the probability of making the mistake in the first place.▪

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Risk Management Recommendation: Develop design and analysis processes that reduce the chance of making mistakes.