I'll Volunteer to Review the Shop Drawings

BY BRIAN QUINN, P.E., AND LISA WILLARD, P.E.

Exciting advances in technology are changing the way engineers and structural steel fabricators approach shop drawings.

MOST ENGINEERS WOULD AGREE that shop drawing review is typically not the most exciting phase of a project; however, new tools are changing the way engineers think about shop drawings while improving review quality and decreasing review time.

Advances in technology have improved the means by which shop drawings can be reviewed and increased collaboration between engineers and fabricators/detailers. It is important for designers to understand how new technology is changing the ways in which shop drawing review can be accomplished and how to leverage these technological advancements.

Traditional Methods

Traditional methods of shop drawing review can be quite inefficient and frustrating. Do you find yourself searching for the biggest available workspace in the office so you can lay out all the shop drawings along with your design drawings? Then do you page through numerous 2D piece details and erection plans, all the while going back and forth between the shop drawings and your contract documents? How laborious is it to write your comments on the drawings and transfer those comments to multiple sets? It's no wonder shop drawing review is typically viewed as a "necessary evil."

The review of structural steel shop drawings is an essential part of a project. As an opportunity to ensure that the shop drawings show what was called for on the design drawings, it safeguards the public. Also, it may be your last opportunity to catch problem areas of a project before they are approved for fabrication and erection. Typically, past this point, changes are expensive.

With the increasing complexity of projects, it can be challenging to visualize the structure in 3D based upon 2D drawings. Yet this is important to fully understand what the fabricator and erector are going to build.

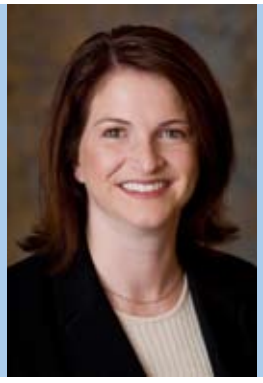
Improvements in the Process

Many steel detailers create 3D models of steel structures, which are then used to produce shop drawings and eventually to fabricate the steel. These same 3D models also can be used during the review process to various extents, depending on the method that works best for the design team. In his article "Structural Steel Shop Drawing Review: The Present—The Future," in the August 2008 issue of *Structural Engineer* magazine, Michael Gustafson of Tekla outlined three workflows:

1. 2D (traditional method)
   The 2D workflow is the traditional method by which most shop drawings are reviewed. Typically, 2D structural steel shop drawings are mailed to the engineer of record, who reviews them in conjunction with their 2D construction drawings and then returns them to the fabricator via mail. In order to decrease shipping/printing costs, some fabricators and engineers may transmit the shop drawings via e-mail as portable document format (PDF) files. This would still be considered the 2D workflow because there is no 3D model being used to aid in the review. Time and shipping costs can be saved, however, which is a benefit.
2. 2D-3D (combination of traditional method and new technology)
   In the 2D-3D workflow, a 3D model is used as an aid to the review process. This 3D model could be generated in a variety of formats as will be discussed later. 2D shop drawings are still the method used to convey approvals and comments (most commonly on paper, although PDF files may also be used). In addition, the 3D model may be used to provide additional information to the engineer.
3. 3D (full model review using new technology)
   In the 3D workflow, the actual model from the fabricator/detailer is used by the engineer to provide approvals and comments back to the fabricator/detailer. This workflow requires a higher level of training and collaboration, but once established provides multiple levels of benefits.

Let's discuss three specific ways that the 3D technology can improve the shop drawing review process in coordination with the last two workflows mentioned above.

Brian Quinn, P.E., is the founder and president and Lisa Willard is vice president of Holland, Mich.-based SE Solutions LLC. Their combined prior experience includes 21 years with RAM International (now part of Bentley Systems Inc.) They can be contacted through www.findyourtechnology.com.



Using the 3D Model as a Visualization Tool

There are multiple ways to achieve *enhanced visualization*, which include but are not limited to the following:

1. The structural engineer physically goes to the steel detailer's office where the detailer provides a "walk through" of the model to illustrate the more challenging areas of the project.
2. Web-based meeting technology (such as Webex, LiveMeeting, or GoToMeeting) allows the detailer/fabricator to walk through the model in an online meeting format. This strategy is particularly useful when the engineer and detailer are not in the same city.
3. The detailer sends the engineer an electronic 3D model of the project. Various file formats are available, such as CIS/2 files (and the engineer uses a free CIS/2 viewer program), 3D PDF files, and design web format (DWF) files. Minimal software learning is required, and typically no software cost is incurred by the engineer.
4. Some steel detailing software companies offer a model review technology. Under this scenario, the detailer sends the "native" model to the engineer who opens up this model in the same software and does visual reviews. The model review stations can be used to comment, approve, and review the model; however, the model cannot be altered in the review station.

This first level of improvement, visualization, would be applicable to both the 2D-3D and 3D workflows.

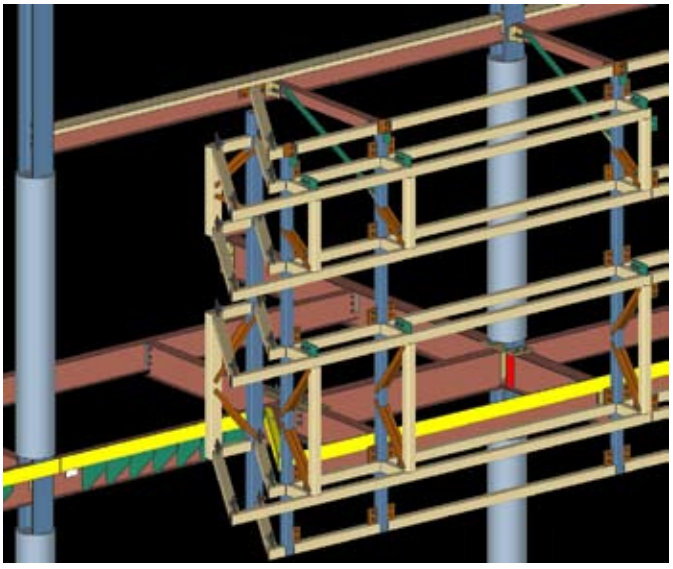


Figure 1: The availability of a 3D model can help reviewers visualize complex 3D relationships among structural steel members that otherwise might have to be inferred.

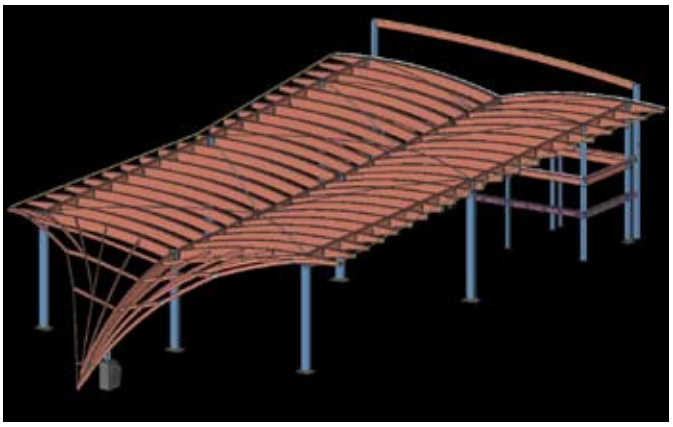


Figure 2: Individual elements of this information-rich 3D model of curved framing are shown as they relate to the rest of the structure, rather than as individual, isolated 2D drawings.

Retrieving Additional Information from the 3D Model

The second level of improvement comes in the form of *additional information* available to the engineer during the review process. Depending on the review process and software used, varying amounts of additional information are available in the 3D model.

For example, let's say the engineer wants to investigate a framing condition where multiple beams are framing into a column, and at that same location, there is also a braced frame connection with gusset plates. The engineer could first look at the modeled framing condition, zooming in/out and around the condition to see how all the pieces come together. Second, the engineer may want to check the reactions used by another engineer to design the connections. This can be shown by simply "clicking on" the member and looking at the loads. Next, the engineer may want to display the connection calculations, which are also just a click away. Finally, the engineer wants to bring up the "piece details" for each member framing into this column. This can all be done very easily using a 3D model.

Additional information available to the engineer may include the erection sequence of steel elements and RFI information on each member. The engineer may even import Building Information Models into the steel detailing model to coordinate the design intent directly with the detailer's 3D model.

Control Issues

Engineers can be skeptical of these new workflows for various reasons. For example, when models are shared back and forth, how can the engineer ensure that the detailer will not change the approval information electronically or the model data in general?

Tekla's Michael Gustafson, P.E., says these risks are handled in a number of ways. The engineer can lock reviewed pieces within the model review software, so that when the model is shared back to the detailer, the engineer's comments cannot be changed. Another way is to publish a model that is basically a record set of the reviewed model and includes the review status embedded within the reviewed pieces. Once these types of models are published, they cannot be edited.

A simple approach for engineers to keep in mind when implementing new processes using 3D models is to just make analogies to what they do with 2D drawings. Protecting reviewed models is similar to how comments on PDF drawings can be "burned" into the drawing so that no one can remove those redlines from the electronic drawings.

Case Study—Making Quick Work of a Green Roof Addition
Douglas Steel Fabricating Corporation, Lansing, Mich., has successfully implemented the 3D workflow process of shop drawing review with multiple A/E and engineering firms, including Harley Ellis Devereaux (HED), Southfield, Mich. Douglas Steel's Larry Kruth, P.E., says that once engineers have used the 3D workflow on a project or two, they don't want to go back to the "old way of doing things."

As one who has found the improved technology and increased collaboration very rewarding, HED principal Jim Corsiglia, P.E., S.E., now considers the traditional 2D workflow as "antiquated." The 3D workflow saves time, he says, and also improves the quality of the review.

One particularly useful application of the technology was on a project that already had been constructed. The owner decided to add a "green roof," which added significant weight to the roof structure. Instead of submitting numerous pages of calculations for the connection designs for HED to review, Douglas Steel simply posted its 3D model to the project FTP site. HED was then able to review the connections right in the model using a model review package from the steel detailing software provider, saving both HED and Douglas Steel significant time.

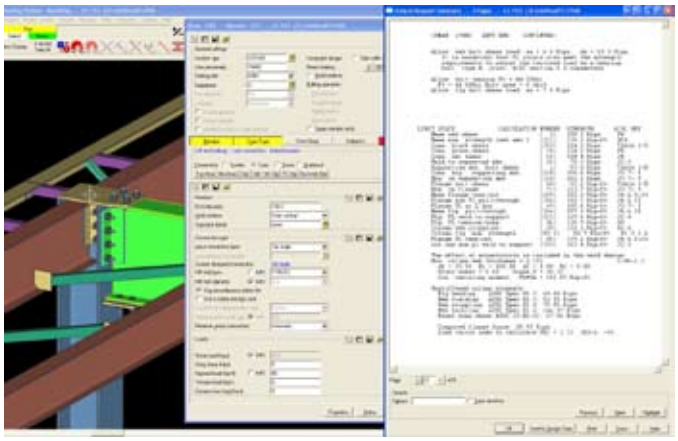


Figure 3: Properties and load calculations for a selected member are available at the reviewer's fingertips as a part of the 3D model.

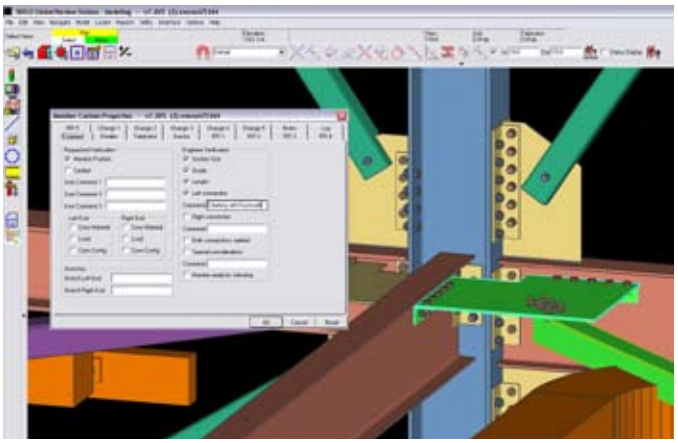


Figure 4: Various electronic forms allow reviewers to attach comments and approvals as part of the electronic model, although the model itself cannot be changed by the reviewer.

This second level of improvement, additional information, can be realized for the 3D workflow and possibly the 2D-3D workflow, depending on which methods are used.

Electronic Approvals and Comments

With a 3D model, the engineer is also able to *create electronic approvals and comments*. With this level of improvement, the engineer would need to use a model review station. Instead of writing all the comments and stamping approvals on paper, the engineer is actually providing those comments and approvals in the model itself. Thus, the process becomes more of a "model review." Using the example noted above for the additional information, the engineer could simply take one additional step and select the appropriate action for the member (approved, approved as noted, revise and resubmit, etc.) and provide any comments necessary for that member. This process can shave several days off of "turnaround time" on shop drawings, and the mundane and time-intensive task of transferring red marks onto multiple sets of shop drawings is eliminated.

The third level of improvement, creating approvals and comments, would apply only to the 3D workflow.

The AISC *Code of Standard Practice* (COSP) (March 18, 2005) addresses shop drawing review and approvals in Section 4, with specific references to approvals in Sections 4.4. The COSP is a "must read" for all engineers, regardless of which workflow you are using.

It's important to keep in mind that technology alone does not improve processes. Technology facilitates the ability to improve a process, but what is still extremely important is the *collaboration* between the engineer and fabricator/detailer. In taking advantage of new technologies, your collaboration needs to *increase*, which will provide benefits to both sides. More detailed information about enhanced shop drawing review processes can be found at **www.findyourtechnology.com**.

MSC

The authors would like to thank the following people who contributed to this article: Larry Kruth, P.E., and Rich Steffens, Douglas Steel; James Corsiglia, P.E., S.E., LEED AP, Harley Ellis Devereaux; Erleen Hatfield, P.E., LEED AP, Buro Happold; Michael Gustafson, P.E., Tekla; Michelle Eret, Design Data; Tabitha Stine, P.E., LEED AP, and Monica Stockmann, LEED AP, AISC.