Technology

information and updates on the impact of technology on structural engineering

Structural Engineer-to-Steel Fabricator Model Sharing

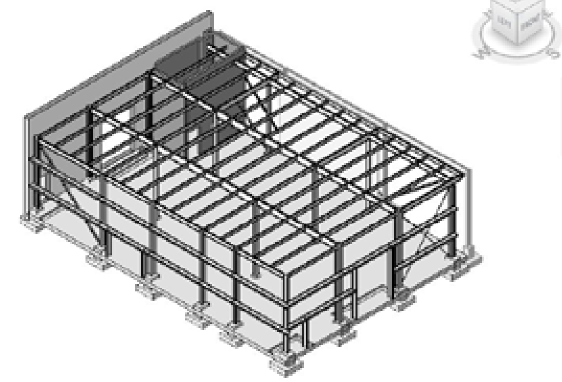
What Can We Really Expect?

By Thomas A. Faraone, P.E., LEED AP®

By now nearly all of us in the design and construction industry are on board with the concept of BIM and how building information models used in lieu of, or in conjunction with, 2D 'paper' drawings can provide measured benefits on a building project. Leading thinkers and practitioners in our industry have done a great job in studying the effects of BIM on the many project stakeholders and on how it impacts the way they do business. Whether it's cost or risk to a designer, construction schedule to a builder, how well software applications can exchange data, or *who* owns *what* in the process, we all seem to be hearing a unified, overarching message: BIM provides considerable benefits to all parties on a project and the difficulties associated with the transition to a BIM based process are manageable and short-lived.

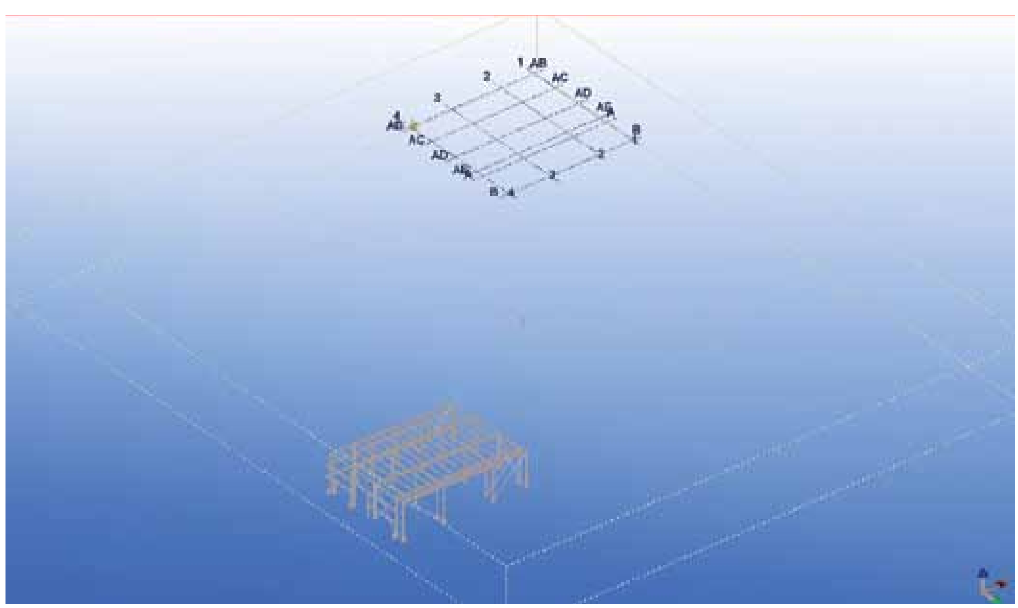
One area of BIM that requires more attention is: How useful and usable are the data contained in a model to a downstream user? What information should a structural engineer include in a design model to give the downstream user a benefit? Are data imported into a downstream application represented exactly as the upstream creator intended? Is the structural data in a Tekla® Structures model identical to the data in the Revit® Structure model from which it was imported?

More specifically, on a structural steel building project, when a structural engineer hands a model over to a steel fabricator, what can the fabricator expect in terms of useful, usable information? Or, as the author's friend and colleague David Aucoin of Pruitt Eberly Stone Engineers (PESE) asks: "What's in the arrow?" David's question refers to any one of many typical graphical depictions of the BIM process that show the relationships of the stakeholders and with whom they share information. This typical graphic of the BIM process usually has boxes or circles connected to each other with arrows. The arrows depict the exchange of information between two stakeholders. What is in that arrow? What information does the downstream user get when he or she receives a building information model? What due diligence must an engineer perform to insure more useful and usable downstream data via model sharing? The answers to these and similar questions is "It depends."



3D view of Revit validation model.

The author had the recent privilege of participating in a model sharing study with David Aucoin, P.E. of PESE and Mike Samilski, P.Eng of DOWCO Consultants. The study involved export of a structural design model created in Revit Structure through the Industry Foundation Classes (IFC) neutral file format and import of the IFC file into Tekla Structures. The process and results were carefully studied. The author also had the recent opportunity to participate in the bidding of the structural steel on two projects, one with the use a RevitStructure model and the other with only drawings. The experience of both the model sharing study and the bidding comparison was both



Offset of native Tekla grid relative to original Revit grid.

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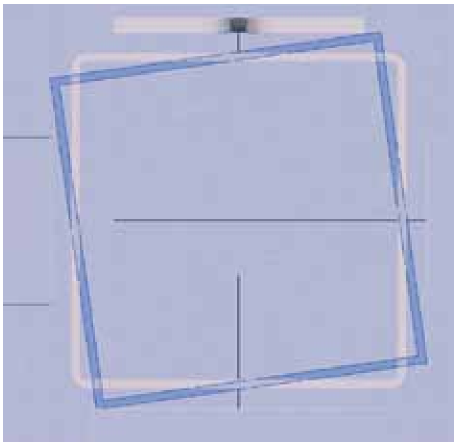


HSS members in Tekla model (blue) rotated 8 degrees after conversion from IFC.

fascinating and educational, and it behooves all design and construction stakeholders to take the time to learn and understand the reality of model sharing.

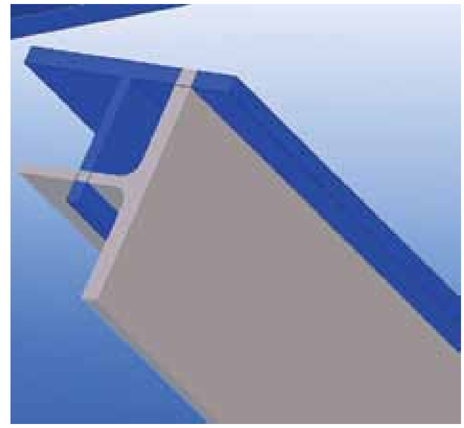
Revit to Tekla Study

The model sharing study was based on a 6,000-square-foot, one-story structure. This was, in fact, a real project out of PESE's Atlanta office. The building footprint was roughly 75 feet by 50 feet and was laid out in a 5x4 column grid. The design model was created in Revit Structure 2011 by David Aucoin and his PESE staff.

Prior to the handoff of the Revit model, approximately one hour was spent by Mr. Aucoin on quality assurance checking of the model. This included the use of 3D views, filters, schedules and other model review-ing tools to compare the model to the 2D documents. A PDF set of 2D documents was provided with the model. The model was imported into Tekla Structures v16 using the Tekla IFC Object Converter with file transfer protocol IFC 2x3. IFC 2x3 is the February 2006, and latest, release of IFC and is supported by nearly all software developers to facilitate neutral file exchange. IFC 2x4 has been published but is not expected to be fully implemented for another two years.

The Tekla Import

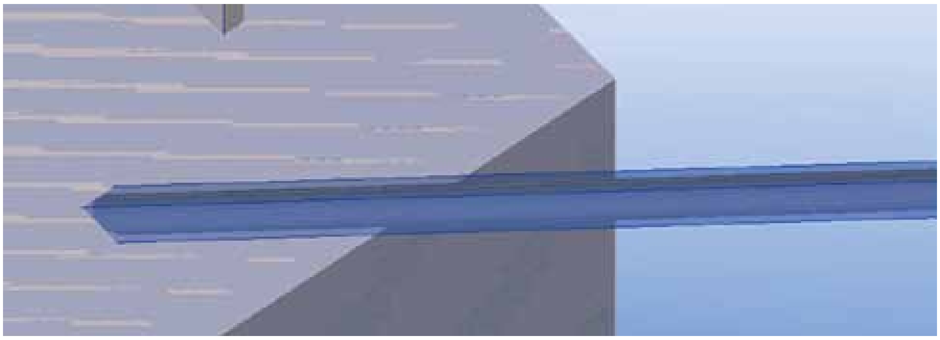
The import into Tekla required the set-up task of creating the structural grid by hand. The structural grid is not included in the IFC export from Revit. This took approximately 20 minutes for the 6,000-square-foot, 5x4 one story grid. After import, it was found that the 0,0,0 origin of the native Tekla grid was nowhere near the 0,0,0 origin of the imported IFC reference model grid. Corrective action



WT members in Tekla model (Blue) rotated 90 degrees after conversion from IFC.

was required to align the native Tekla grid with the IFC reference model grid. This is a significant issue because origin offsets may continue to be problematic if and when the model is shared with other applications, either back upstream or further downstream.

The imported IFC reference model was then be converted to a native Tekla model. This was done with the Tekla IFC Object Converter. Once this conversion was done, the native Tekla model was overlain on the imported IFC reference model. A detailed comparison of the two models was



Round bars in original Revit model converted to square bars in Tekla model.

performed by Mike Samilski, the Tekla expert in the group, zooming, panning and cutting sections, checking for conformances of alignment, orientation and objects. This task is significant because it is a manual process performed by the person using the software. The success of this relies heavily on the talent and expertise of the user. This comparison revealed both import issues and converter issues.

Import Issues

The IFC reference model comparison to the native Tekla model revealed several issues related to the import. These are in addition to the origin alignment issue described above.

Imported member lengths are 'cut lengths'. The length of the member is cut back to the edge of the flange of the supporting beam or column. This is due to the way the IFC export is set up in Revit. To get full lengths in the Tekla model, the Tekla user must extend each member to the web of the supporting beam or column. Fortunately, Tekla has an automated feature that extends cut members to the webs of the supporting members. However automated, the user must manually run this automated feature.

In the study project, the group found that one concrete column pedestal was missing. Although this is of no great concern to the structural steel portion of the project, it is nonetheless an import issue. The reason for this was not explored in the study and could simply be an issue of the parameters assigned to that particular item. The group also found that two diagonal braces were not imported due to these to items being tagged as part of the 'existing building' phase of this particular project.

Tekla IFC Object Converter Issues

The following three issues were identified after conversion of the imported IFC reference model to the native Tekla model:

1) HSS columns were found to be rotated approximately 8 degrees about their vertical axis;
2) WT diagonal braces were rotated 90 degrees about their long axis; and
3) Round bars (used as lateral bracing) were converted to square bars.

These issues were corrected in the Tekla model by hand. Approximately 40 minutes were spent performing the model comparisons, and checks and corrections.

Structural Steel Quantities

Of great importance to the structural steel fabricator in any project are the structural steel quantities. Will model sharing improve the process of estimating and bidding a job? To address steel quantities, the study included a comparison of the quantities in the Revit design model to the quantities in the corrected Tekla model to, lastly, a quantity take-off created by hand from the 2D PDF documents. Thanks to estimator Ryan Weakely at Banker Steel for his time and effort in performing the 'by hand' quantity take-off. Each method produced different quantities, as shown in *Table 1*.

Table 1: Quantity take-off comparison.

Method	Pieces	Tons	Time Spent
Hand	136	28.4	50 min.
Revit	123	27.1	10 min.
Tekla	130	30.4	10 min.

Which method is correct? The group did not have time to address this in the study. Are the differences significant? For the small project used in the study, perhaps it is not. What if the project was 60,000-square-feet, 300 tons and 1,300 pieces? What if the project was 600,000-square-feet, 3,000 tons and 13,000 pieces? The relative time spent producing quantities using the 'by hand' method is likely to increase significantly as the project size increases. The additional time spent producing quantities for the larger projects directly from Revit or Tekla is likely to be minimal. What about the differences in quantities? The difference between 2,700 tons and 3,000 tons is quite significant. The difference between 12,000 pieces and 13,000 pieces is also quite significant. These variations in quantities on larger projects will have a huge impact on the overall cost of the steel package. Which quantities should the steel fabricator use? Which numbers are reliable?

Model Sharing and the Bidding Process

Will a Revit model be helpful during the bidding process? The following are two cases at Banker Steel that help answer this.

In CASE 1, the author's company was recently asked to provide a budget proposal for a medium sized project, about 120,000-square-feet, 5 stories and 1,100 tons. The building layout was rather complex, with different levels having different footprints. The contractor provided 2D drawings via FTP download and also, to the author's delight, the engineer's Revit model. A quick comparison of the Revit model to the supplied drawings showed some obvious discrepancies. This proposal was requested at a time when estimating staff was unavailable due to other work loads. The author is not an estimator, and in order to provide our customer a budget proposal by the due date, a proposal using the quantities extracted from the Revit model was prepared. The quantity output from the Revit model was easily transferred to an Excel® file, which made for a quick estimate and an easy copy-and-paste completion of the contractors detailed bid documents. A note was included in the proposal stating that the model was used for the proposal despite the known discrepancies between the model and the drawings.

In CASE 2, the author's company bid the structural steel package on a large project – 14 stories and several thousand tons. Only

2D drawing documents were provided. There were over 80 RFIs submitted by the steel bidders seeking clarification on scope, quantities, finishes and details. About 10 percent of the RFIs received no response. Who answers these RFIs? They are answered by the A/E team. What is the A/E team doing when these RFIs come across their desk? They are usually working on another project. Many of these RFIs dealt with AESS and exterior steel finishes. One RFI requested a marked-up drawing noting the various members with the required finishes. The author submitted an RFI requesting a Revit model that included a parameter that tagged members with the specific finishes. The response was a set of drawings with 1- 2- and 3-star marks on the members where the 3 types of finishes are required. Did the A/E team put all the stars in all the right places? Did all the bidders find all the stars? The author would much rather sort data in an Excel file by finish than visually scour dozens of drawings looking for stars.

Conclusions

To see model sharing become more useful and more commonplace, we have to continually address two overarching principles:

1) Data Validation
The data exported from one application and imported into another must be reliable. This applies to user issues, where modeling techniques and software settings must be learned and understood as to how they relate to not only the user's end product, but to downstream users of their work. This also applies where data export and electronic conversion of data from one format to another may result in a slight change in the data. Software users and vendors have a shared responsibility to overcome these issues through continued use, study and education by and of all parties. Users must transfer data and openly look at the result, and report issues to software vendors. Software vendors must openly receive such issues and respond promptly with user guidance and tweaks to their software converters.

2) Modeling for Downstream Use
Most model users today create models to use for their own internal purpose, within their own 'silo'. Model sharing, as it exists today, is usually limited to use 'for assistance only' or 'at user's own risk'. 2D documents still govern. Models are simply not given the attention they need to be suitable for downstream use.

We all have an obligation to learn how and why model data can and will be used by downstream users. We have a responsibility to provide and accept models with the understanding that model sharing is a work in progress, an evolving practice. A model may not be 100% perfect. Drawings certainly aren't 100% perfect, and we seem to be entirely comfortable with that. Use a model and see what you get. Ask the upstream creator to clarify or include more information if you need it. This is no different than the typical RFI.

And if you want finishes on steel, put it in the model. Don't put stars on the drawings.▪

All graphics courtesy of David Aucoin of Pruitt Eberly Stone Engineers, and Mike Samilski, The DOWCO Group.