AUTODESK UNIVERSITY 2014

Say Goodbye to Paper: Using Autodesk® Revit® Structure in a Digital Shop Model Review Process

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SE6636 This class covers the use of Revit Structure software in a workflow designed to share the engineer's model directly with a fabricator for downstream use. It is a natural step to be able to take models to the next level by using them in a digital review process, and this class will show how paper-based shop drawing review can be minimized, if not altogether eliminated. We will present a case study that describes how a digital shop model approval process was used in lieu of the traditional paper shop drawing process, and we will see the value experienced on the project. This class will also touch on best practices and limitations, and it will show attendees how to create a checklist that will enable a project to utilize models as part of the shop drawing review process.

Learning Objectives

At the end of this class, you will be able to:

- Discover effective practices for sharing models produced in Revit software with downstream users
- Learn how to prepare checklists that are critical to a streamlined shop model approval process
- Understand the limitations to a digital shop model review process and learn how to address them
- Learn how to create a workflow using Revit software alongside with third-party communication programs

About the Speaker

Johann is a civil/structural engineering manager for Pelican Energy Consultants in the Greater New Orleans area. He has over 15 years of experience in engineering and construction in both the commercial and energy sectors. Prior to this role, he also managed the engineering department and the VDC department of the largest design builder in the New Orleans area. One of his passions is to research how BIM and VDC processes can be leveraged in structural engineering workflows and integrating reality capture techniques. Johann has given numerous lectures on BIM topics since 2009 to a wide range of audiences, including architects, engineers, contractors, fabricators, erectors, and owners. He has spoken at national conferences such as AISC's annual steel conference. Johann has a Masters and Bachelor's degree in Civil Engineering from Tulane University, is a LEED AP, and volunteers on the advisory board for Delgado Community College's CADD department.

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Joshua is a BIM engineer for Pelican Energy Consultants, in the Greater New Orleans area. Prior to this role, he was a BIM Project Manager on multiple project including: the WWII Land, Sea, and Air museum, the New Orleans Saints NFL Training Facility, the New Orleans Pelicans NBA Training Facility, and Tulane University Yulman Stadium. His experience in his career ranges from estimating, BIM coordination, project management, and structural engineering on a variety of commercial construction projects. He is passionate about developing new and innovative techniques in which BIM can be implemented and promoted. Josh has been a guest lecture at Tulane University and has given multiple

company-wide training sessions and presentation on BIM. Josh has a Bachelor's degree in Civil Engineering from Louisiana State University.

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Describe best practices for sharing models produced in Revit with downstream users.

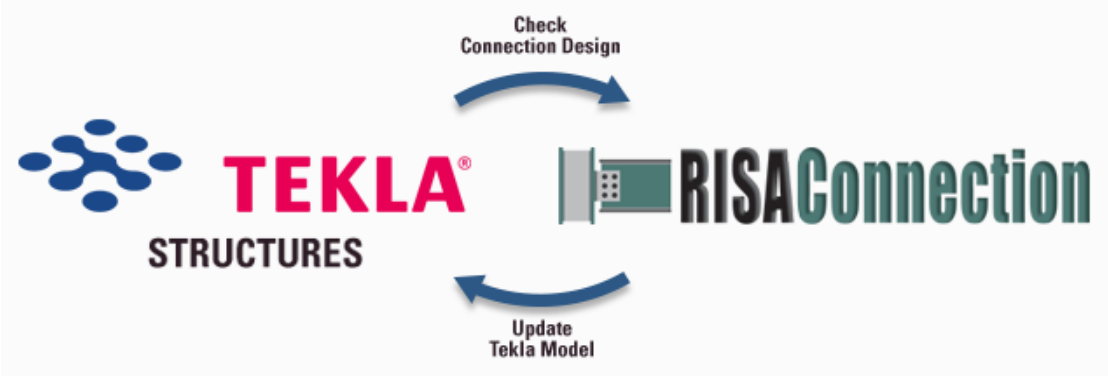
Developing a process for sharing models with downstream users such as fabricators is a natural next step in the evolving industry practice of model creation and its uses. When 3D models began to be used in the workflow, the philosophy that we employed was the idea that developing good models would produce good drawings as a byproduct. We have pushed that philosophy to say that we should develop good models to be able to share as the actual deliverable that gets used downstream. There are many best management practices (BMPs) for sharing models between engineers and fabricators. Below are BMPs we have identified over several projects:

1) Identify the versions of software and commit the stakeholders to keeping to the same version through the design-shop model-fabrication schedule.
2) Always test out the intended sharing protocol in advance. For example, if the structural engineer is using Revit Structure to author the design file, export the geometry in a DXF format and allow the shop modelers to import the file into their Shop Model software, such as Tekla or SDS/2. This process will ensure that the intended workflow will actually work, and if it doesn't go exactly as planned, at least you have the opportunity early on to troubleshoot or develop an alternative file sharing process.
3) Encourage the understanding that the intent of sharing models is to maximize automation, eliminate redundant tasks, and minimize human intervention but not human interaction. The testing of protocols as discussed in this material handout has the benefit of developing trust in the models by troubleshooting the model sharing process.
4) Manage stakeholder expectations by clarifying the Level of Development (LOD) of each role. The LOD definitions can be found in AIA E203-2013 and AIA G202-2013 documents or the BIMForum specifications released in August 2013. Typically the structural engineer's deliverables should meet an LOD 350. The fabricator requires an LOD of 400/500. Ensure that each stakeholder understands these expectations, and can commit to the level of development per the agreed upon schedule.

5) The structural engineer and fabricator should have the mindset of what's best for the project. Determining what matters to the client the most can set the design process in a particular path. However, presenting to the client not only the engineer's point of view, but also the fabricator and steel erector's point of view will go a long way to developing the collaborative spirit that makes projects go smoothly.

6) Consider connections! Connections are often overlooked when trying to determine how to approve shop models. Bolted connections are visible and can be part of a clash detection process. Moment connections and welding are not visible in a fabricator's model, so determining how connections will be approved should be clear from the beginning.

7) Have the engineer and fabricator consider using a digital workflow that includes using engineering analysis software (such as RISA Connection) and fabricator shop model software (such as Tekla Structures).

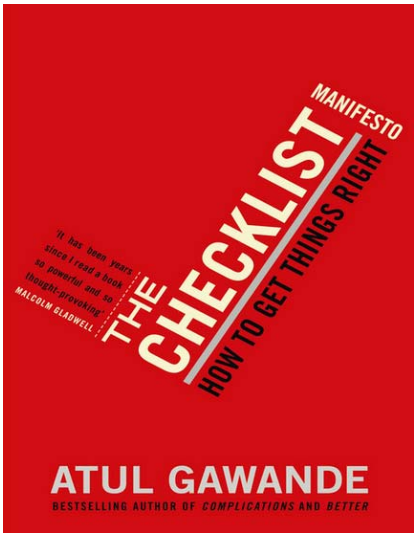


8) Involve the fabricator and steel erector from the beginning, if at all possible. This may depend on your delivery method, and if you're doing a municipal low bid delivery system, you may want to approach your client to add funds at the beginning of the project to "pay for preconstruction services" from a fabricator/erector. Convince your client that this bit of money up front will produce savings later, or at least will result in a more efficient, cost effective design (Use Item 9 below if needed).
9) Leave egos at the door! Just as engineers don't expect an erector or fabricator to know the latest engineering design techniques, the engineer should also recognize that they may not know the best practices of the times for the erector/fabricator.
10) Take into account the experience level of the team members. This encourages buy-in from stakeholders and will help determine what the team is capable of concerning technical skills.
11) Have the mindset that if you strive to make other stakeholders look good, then that reflects back on you. If you are passive about collaboration or worse, if you try to avoid other team members or allow them to fail, that's a sure fire way to have problems develop that WILL AFFECT YOU!
12) Encourage managed risk taking. If you're in a role that can encourage managed risk taking, by all means, let your team members bring ideas to the table. Great ideas can come from

anywhere. Don't be afraid to suggest and try something that hasn't been done before. If the idea makes a process simpler, or more logical to do, encourage it.

13) You may need to address culture at the firm(s) that are pulling together to do this. This is normally the job of a CEO/President. Enabling a transformative process like digital approval requires that the companies involved are open and encourages better ways to do things.

Prepare checklists that are critical to a streamlined shop model approval process.



Checklists are incredibly valuable in this type of process. We highly recommend reading Atul Gawande's *Checklist Manifesto* at your leisure to understand how checklists can help avoid making small simply mistakes which can turn into major problems unexpectedly. Reading this book a few years ago heavily influenced our thought process on what can be turned into systematic checks. These systematic checks can be identified as it applies to your own company and process, standardized, and enforced with the use of checklists.

Identify "checklist-able" items

Items that should go on a checklist should be simple and may seem straight forward to do, but being able to document and track something as simple as "Are all models using the same X,Y,Z reference upon import?" goes a long way to avoiding just one more thing that can eat up time to address or fix later in the process.

The Council of American Structural Engineers (CASE) publishes CASE Document 962 D (2003) titled *A Guideline Addressing Coordination and Completeness of Structural Construction Documents.* This guide is a great tool to use as a baseline for starting a checklist if you're a structural engineer. However in 2003 when it was issued, BIM was not yet in the mainstream. Therefore, expanding the checklist to include BIM related issues and fabricator related issues is required. Below is a

Council of American Structural Engineers (CASE)

sampling of checklist items we typically have on any given project where Structural Engineers and Fabricators are willing to share models:

1) Identify the software vendor and the version number that each entity (structural engineer and fabricator) is using.
    a. Value: The version number is important as different team members may upgrade at routine times of the year, and unless a particular project has defined this expectation in a BIM Execution Plan or specification, there is a chance that a shop modeler may deliver an incompatible file to a fabricator's CNC machines.
2) How will bolted connections be approved versus moment or welded connections?
    a. Value: Typically fabricator models don't show moment or welding in model, but checking bolted connections is feasible as they are visible. See if the structural engineer is ok with maximizing bolted connections as it speeds up steel erection versus welding and moment connections.
3) If moment bolted connections are used, is top plate shipped loose?
    a. Value: Having bolted moment connections are quicker installations, however, if a metal deck and concrete slab is used, try to avoid the bolted connection on the top flange of the steel beam and simply apply a top plate and weld. Typically the bolts on the top flange will create a congested condition. Use a shop welded bottom plate (which acts as a seat plate for erection) as part of a bolted moment connection.

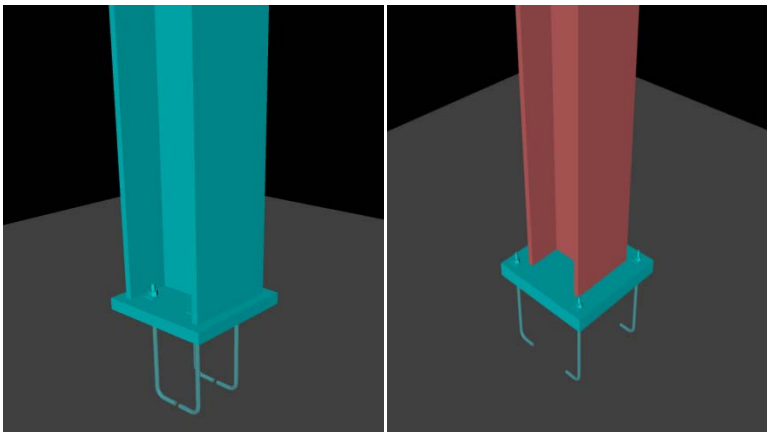
4) Will you be required to submit paper based approvals due to a jurisdictional or local permit office requirement?
    a. Value: Identifying this requirement will help factor into the shop model approval schedule. In New York City, Department of Buildings requires paper based shop drawings approved by the fabricator/erector prior to steel erection. In New Orleans, Louisiana, no such requirement exists.

NYC Buildings VS. CITY OF NEW ORLEANS ONE STOP PERMITS & LICENSES

5) Will the project delivery be optimized by phasing the steel fabrication? If so, ensure the structural engineer designs the framing with splicing considered.
    a. Value: Phasing a job allows the structural engineer to focus design resources on a portion of the project and can allow the schedule to advance by having the

fabricator start early. Encourage the structural engineer to design phased portions to be laterally self-sufficient to cut down on temporary bracing requirements.

6) Encourage structural engineer to focus on column dimensions that minimize waste for the fabricator.
    a. Value: Typically fabricators quote and purchase in 5 ft increments. If designing an office building, try 31 ft square bays with W12x65 columns. The W12x65 is a near perfect 12 in square, which means the fabricator can order an exact 30 ft girder or secondary beam system, which equates to no waste. This saves costs in material and has no adverse effect on erection.
7) Identify if the shop modelers are 3rd party stakeholders, in-house fabricator shop modelers, or are part of the structural engineering firm as a separate contract.
    a. Value: Identifying the contractual relationship of the shop modelers will lead to clarifying the expectations of all the stakeholders. There may be opportunities to streamline the process if the shop modelers work within the same organization as the structural engineers.
8) Do base plates have anchor bolts within the footprint of the steel column shape or will they be outside of the footprint?
    a. Value: In early design, encourage the engineer to determine whether



base plates are required to be oversized (anchor bolts outside of footprint and/or require a recessed pocket in the slab to avoid tripping hazard or minimize furring area requirement around the column) or if the anchors can satisfy the design loads by staying within the confines of the column footprint. Determine the pros and cons to help guide the decision. This will help the foundation detailing as it will be identified early.

9) Suggest that the engineer show 2 erection bolt locations at lateral bracing locations.
    a. Value: Steel erectors prefer having 2 erection bolt locations at each end of a lateral brace, such as an X brace or diagonal brace, as it speeds up erection due to being able to line up the structural member quicker. Steel erectors can cut down as much as 50% of the bracing installation time with this technique, and the cost of an extra bolt is minimal.

Identify and describe the limitations of a digital shop model review process and how to address them.

Various Project Delivery Methods

For the New Orleans based project case study, limitations included having only the Structural Engineer using Autodesk Revit, while the rest of the design team were on AutoCAD 2D. Although the Structural Engineer was able to use the AutoCAD files as overlays, the project was considered to be a partial BIM-enabled project. The MEP engineers did not use 3D models so clash detection and other typical BIM processes were not used. Extending the engineer's model to the fabricator was the only true use of BIM on this case study.

The "Buy In" Stage

Communicate early in the project. Let other stakeholders know the potential pros and benefits of this process. As equally important is letting the stakeholders know the limitations of not using this process, as it's very unlikely that after the project has started, the stakeholders will then modify their processes to employ a digital shop model review process. One of the first questions I always hear is "what about liability?" I always present the scenario where a shop modeler gets interrupted by phone calls, emails, people, etc…, then you hope that they return to the right location and not overlooked something. In the traditional set up, they replicate a model based off of PDFs or paper. That takes time, and in my experience, is much more error prone than simply importing the 3D geometry from a model designed for downstream use (digital way).

Create a workflow using Autodesk Revit along with third-party communication programs.

It's important to point out in the workflow the communication software that we have used, as these programs allow these new workflows to actually occur. Just as companies like Autodesk, RISA Technologies, and Tekla have developed more and more capable programs that interact with each other through bi-directional linking, attention should also be brought to other software programs that allow the facilitation of the stakeholders to effectively communicate.

Prior to adopting what we use today, communication typically involved emails and phone calls between the engineer and the shop drawing detailers. This was a slow and cumbersome system. If the engineer's plans were not up to par and left many details up for interpretation, this would also slow down the overall process.

So in addition to the design programs, GoToMeeting was used to see the computer screen of the fabricator which displayed the model in real time from another state, and in Gilbane's current project, different country (Philippines). Microsoft Office OneNote is used to help document, screenshot, track, and share the questions and issues we came up. We also like to use JoinMe and TeamViewer to do spontaneous virtual meetings, mostly because it's simple and free.

If Autodesk Navisworks is available (and typically it is in most of Autodesk's suites), we highly recommend exporting from Revit the engineer's model and import into Navisworks. Using Navisworks Freedom as a viewer by all stakeholders can allow questions to be developed ahead of a meeting, for example the day before, and these questions can be submitted in the form of a screen shot with comments with Microsoft Onenote. Another program, Bluebeam Revu CAD, allows the export of a 3D PDF from Navisworks. This 3D PDF is compatible with Adobe Acrobat for downstream users who may not have Bluebeam. Using Bluebeam's feature of 3D Callouts allows embedment of comments within a 3D PDF, which further enhances communication of issues in a visual way.

We recommend identifying early as part of a checklist which third party programs or vendors are preferred, successfully used, and most importantly, tested by all stakeholders with test models to validate the internet connection speeds. If a particular suite of programs was successful in a

workflow on one project, do not assume it will automatically be successful on the next project. Several factors such as familiarity with the programs, willingness to test and validate, and corporate policies that may or may not allow certain software to be used can all play into whether a project can successfully utilize a given workflow. A meeting can be disastrous if this workflow is not tested beforehand. Presenting a workflow that stakeholders have not experienced can be daunting, so making the testing easy and straightforward is critical to the buy in.