AUTODESK UNIVERSITY

FAB20958

Structural Detailing Services by Structural Engineers – Who, How, When, and Why?

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Learning Objectives

- Learn how BIM can be used to bridge the information gap between design and construction for a typical project
- Learn how design data can be utilized to start construction activities earlier than a typical design-bid-build process.
- Learn what types of construction services can be readily offered by entities acting as the link between design and construction
- Learn what the advantages and disadvantages of such BIM-based delivery are to common project participants.

Description

Engineering firms big and small can extend their services into structural detailing by working closely with the fabricators and builders to connect design into construction. This presentation will discuss how a US-based structural BIM consultancy offers structural detailing services to their clients using BIM-based workflows. Attendees can expect to learn about why these services are offered, and what best practices should be followed to successfully implement BIM-based technologies for generating fabrication deliverables. Both Structural steel, precast concrete, and cast-in-place concrete detailing will be covered.

Your AU Expert(s)

Ryon Pax graduated from the University of Colorado at Boulder in 2011 with a Master's degree in Civil Engineering. Ryon started using Structural Revit in 2008 as an intern at S.A. Miro, Inc. After graduating from the University of Colorado in 2011, he continued to use Revit as a structural engineer for S.A. Miro through 2013. In 2013, Ryon made a career change to the BIM world where he is now working for MB BIM Solutions as a senior project engineer. As an engineer, he works closely with contractors to maximize productivity and efficiency as well as minimize cost through the use of BIM. Ryon currently uses Autodesk products for anything from creating basic structural drawings in Revit to clash detection in Navisworks Manage. He is also involved in developing standards and processes at MB BIM Solutions. Lastly, Ryon was a speaker and attendee at AU 2015 and is always looking for ways to take advantage and share is knowledge of the powerful tools offered within the Autodesk products.

Dan McCloskey received his bachelor's degree in civil engineering from the University of Illinois at Champaign-Urbana. After spending 2 years designing bridges for URS Corporation, McCloskey attended Purdue University, where he obtained a master’s degree in structural engineering. McCloskey then moved to Denver, Colorado, where he worked as a structural design engineer and then structural project engineer for S.A. Miro. During his 5 years with Miro, McCloskey became an in-house expert in Revit Structure software, and he helped develop Building Information Modeling (BIM)-based structural detailing services. In 2011, McCloskey co-founded MB BIM Solutions as a BIM-focused consultancy that provides construction-level modeling of structural systems and components for its clients. McCloskey is active in the Denver-area BIM community with Rocky Mountain Building Information Society, has taught several classes at Autodesk University, has been published in AUGIWorld magazine, is a Revit Beta contributor, and is also a Revit Gunslinger participant.

Introduction

Due to new tools available to design teams and contractors, faster construction schedules, and the increase in integrated project delivery through the use of BIM, the 'who', 'how', 'when', and 'why' of shop drawings and fabrication models is changing. It is now possible to leverage a structural engineer's design model to create shops drawings and fabrication models for rebar, precast, structural steel and miscellaneous metals, and to create concrete lift drawings.

The 'who' is starting to change from fabricators and subcontractors to structural engineers, and BIM consultants. The 'how' is changing from 2D CAD for rebar, concrete lift drawings, and precast concrete, and from Tekla and SDS/2 for steel. Revit (and Advance Steel) can now be used to do this on a true BIM platform, with the advantage being to re-use the information and knowledge in a design Revit model further downstream into fabrication and construction. The 'when' is being changed from a linear design-bid-build structure to a collaborative structure in which shop drawings and piece drawings are being produced in the late stages of the design process. This new approach enables schedule and constructability efficiencies by engaging the fabrication and construction team's knowledge and preferences before design is complete.

General Who/When/Why/How

In general, making the switch from traditional shop drawings and fabrication level drawing to using BIM to create these drawings has an effect on how the process works from start to finish. BIM can be used by engineers and BIM consultants to create fabrication level drawings for rebar, precast, structural steel and concrete lift drawings.

Who (and Why)?

Making the switch from fabricators to BIM consultants and engineers to create fabrication drawing affects many different entities in different ways. As outlined below, the process is much more collaborative with each member to the team having a seat at the table early in the process.

Design Team

Because of the collaborative nature, using BIM for fabrication drawings presents less risk to the design team, yields a higher quality product and creates less adverse relationships with the construction team.

Fabricators and Subcontractors

The drawing quality and coordination level is improved through the use of BIM resulting in more efficiency and accuracy for fabricators and subcontractors.

General Contractors

Having a seat at the table early in design, general contractors are able to influence design decisions. This, along with the better drawing quality provides less risk and less waste for the GC.

Owners

Owners will see a better product with less change orders, faster scheduled and lower overall cost through the use of BIM for fabrication drawing.

When?

Making the decision to switch from fabricators to BIM consultants or engineers to create fabrication drawing needs to be made as early as possible. As outlined above, having all parties at the table early on is an important step in the process. However, depending on the service offered, the exact 'when' can vary. Having the process implemented early in design allows the

GC to begin construction planning early. The models can be used early in design to assign data, estimate quantities and plan construction activities. These models can then be fine-tuned and taken to fabrication level models used to produce drawings.

Why (and why not)?

With construction schedules getting faster and owners wanting 'more bang for their buck', BIM-produced fabrication drawings can be used to expedite the process with a higher quality product. However, there are cons to using BIM produced fabrication drawings.

Advantages

In general, using BIM to produce fabrication drawings yields a higher quality product, a faster schedule, less field issues, more accurate drawings, field efficiencies, material savings and more available data.

Disadvantages

Using BIM to produce fabrication drawings doesn't make sense for every job. And using BIM to produce fabrication drawings vs. the traditional process requires a change in mentalities. This process requires more communication; the roles are less defined and there is a change in risk structure.

How?

Producing fabrication drawings using BIM can be accomplished using a number of different 3D modeling programs. Using specific modeling techniques, fabrication level models are created with a much higher level of detail.

Common Programs Used

Depending on the service offered, different Autodesk programs can be used. For rebar shop drawings, precast shop drawings and concrete lift drawings, Revit is common (Tekla can be also used). For steel shop drawings both Advance Steel and Revit can be used to produce shop drawings (Tekla and other steel detailing software is available as well). There are also add-ins and 3rd party programs available to make modeling and annotation more efficient.

Modeling Techniques

Modeling for fabrication level drawings requires a much higher level of detail in comparison to modeling for typical construction documents. For example, the model should be split up by sequence (columns and walls split at each level) with specific data assigned to each piece. There are also tools within each program that should be used to make modeling and annotation more manageable (assemblies in Revit).
Another very important technique that can make or break a project is to make use to the other available models. If available, the design models should be used as a starting point and for coordination down the line. These can be used to model correctly and ask for confirmation when there is a discrepancy in the drawings. These models can also be used as a communication tool with the design team. Other subcontractor models (MEFP, steel, precast) can also be linked in and/or used for coordination.

Rebar Modeling and Shop Drawings in Revit

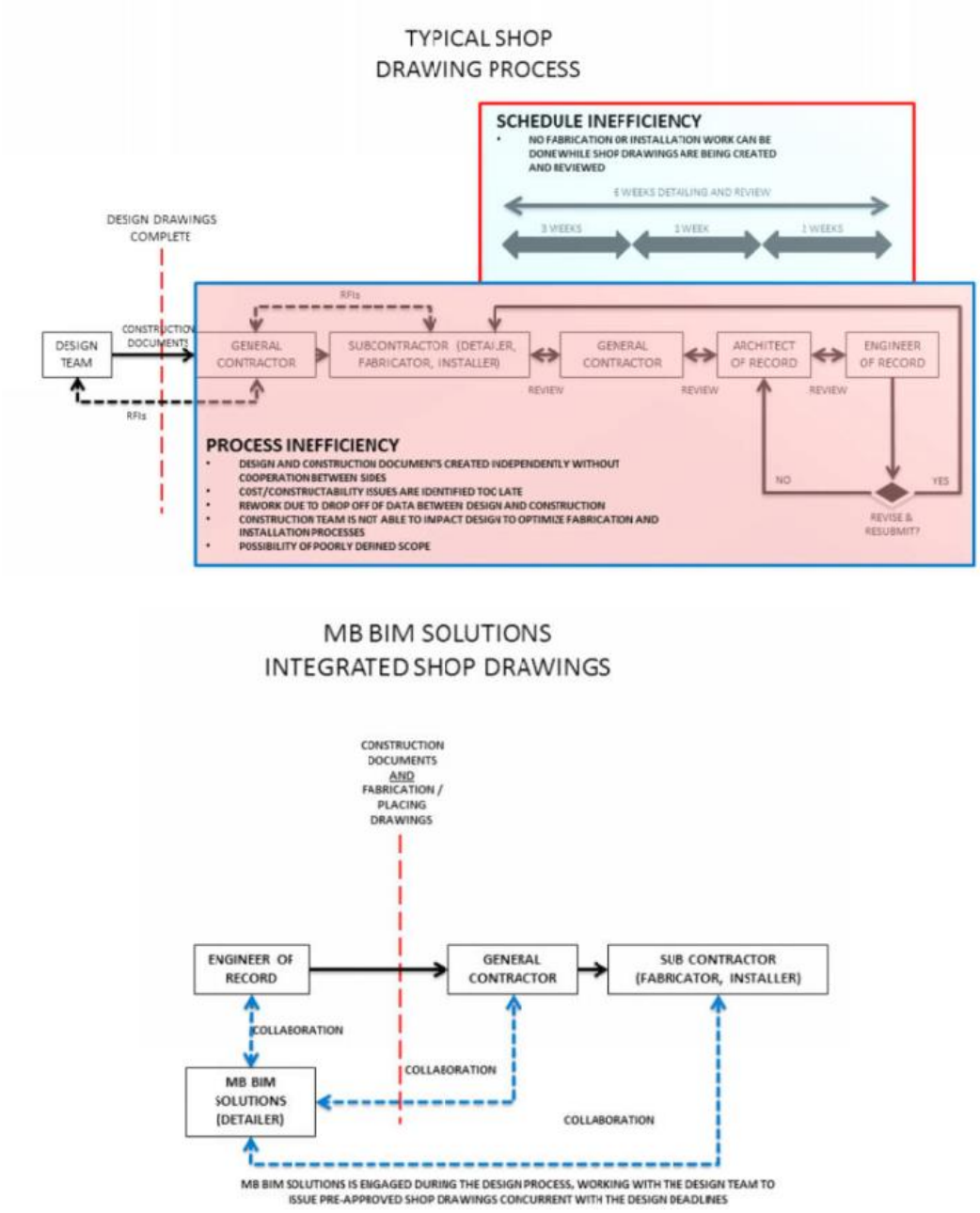
Traditionally, rebar shop drawings are created using 2D CAD by the rebar fabricator. Because of the advancement in tools within Revit, these can now be created in Revit by the structural EOR or a 3rd party BIM consultant.

Who?

A BIM consultant (or EOR) is hired by the concrete subcontractor or GC and works closely with the structural EOR, rebar fabricator and installer to create rebar shop drawings using Revit.

When?

If the structural EOR is used to create the rebar shop drawings, the detailer can begin detailing rebar during the design phase. If a 3rd party BIM consultant is used, they can also begin detailing during design but would need to work closely and in constant communication with the structural engineer and contractor. The detailer can use a “red light / green light” approach to work on the areas that are the highest priority or the where the design has been completed. Ideally, an integrated approach is used to reduce schedule inefficiencies due to linear nature of the process and data drop-off.



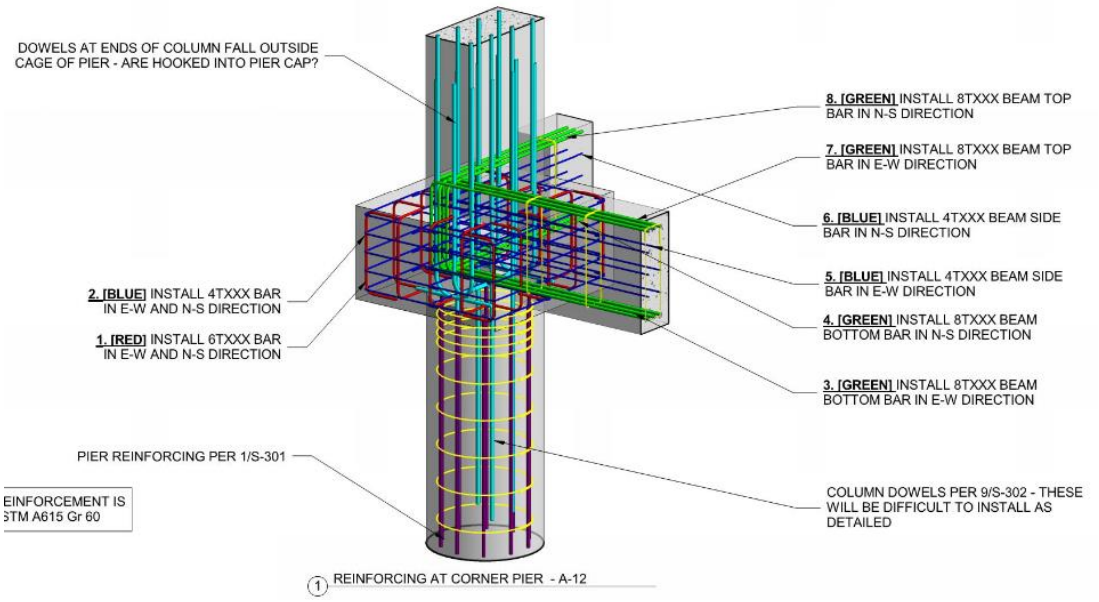
TYPICAL SHOP DRAWING PROCESS VS. INTEGRATED APPROACH

Why (and why not)?

Depending on the job, using BIM to create rebar shop drawing may or may not be the best approach.

Advantages

- Schedule: As discussed previously, the schedule can be accelerated by leveraging the structural engineers and working closely with the contractor and engineer to produce more complete and coordinated drawings faster. If the EOR is the detailer, the shop drawings are pre-approved.
- Reduced tonnage and material savings: Experience has shown a 10-20% rebar tonnage reduction due to the modeling process. When BIM is used to produce shop drawings, every piece of bar is modeled without any fluff. The engineer can also work to save tonnage by minimizing splices and cutting out other unneeded bar.
- Efficiency Savings / Enhanced Coordination: The detailer is involved with the design team, installer and fabricator to provide more constructible, more coordinated drawings. This process reduces RFI's because the integrated approach and allows questions to be quickly answered in a less formal manner.



COORDINATED AND EASY TO FOLLOW DRAWINGS

- Accuracy: Because the rebar is hosted within modeled elements in Revit, the host element must be correct. Working with the engineer and the design model, the detailer can ensure that these modeled elements are more accurate and therefore the rebar is more accurate. Because every piece of rebar is modeled and the data within Revit is live, if the model is correct, the drawings are correct.

Disadvantages

- Change in risk: Because the rebar fabricator is no longer detailing the rebar, they are no longer accepting the risk for either the total rebar tonnage or detailing errors. Typically, rebar is bid on a lump sum basis by the fabricators. In this process, they bid on a unit-price basis, and now the GC or concrete subcontractor accepts the risk for the final bar tonnage (and reaps the reward of the tonnage savings). Likewise, the

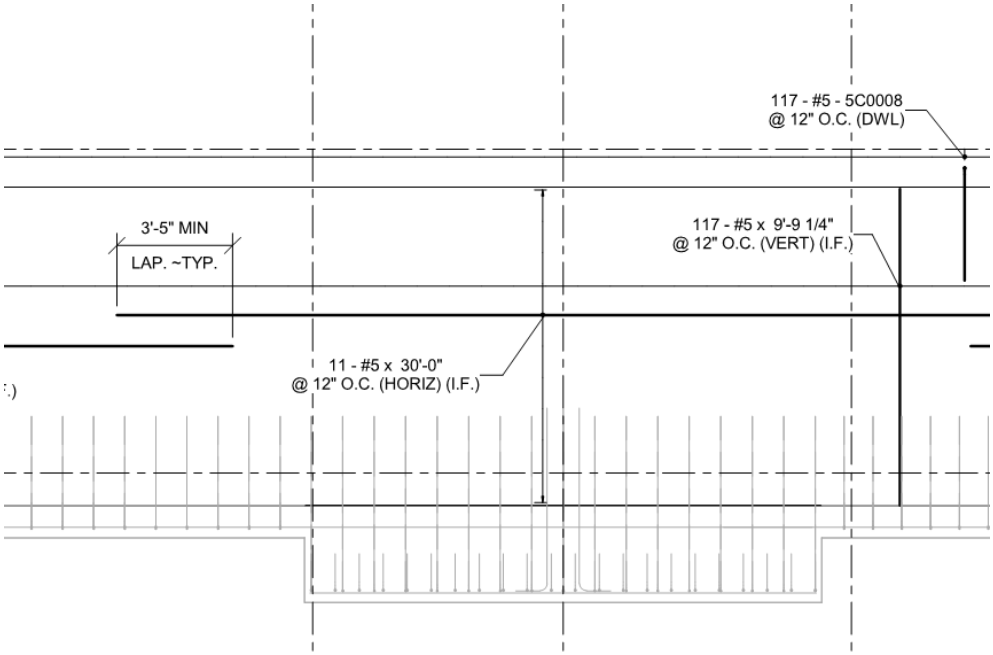
rebar fabricator assumed the risk of mis-detailed bar in the old system, and now this risk is transferred to either the entity hiring the BIM-based detailer, or that detailer.
- Knowledge of industry standards/preferences: When a 3rd party modeler or structural engineer is the rebar detailer; they may not fully understand industry standards. The EOR may not know the necessary requirements needed to fabricate and/or install rebar.
- Aesthetics: The shop drawings don't always look the way the installer is used to seeing them.
- Certain jobs do not make sense to use BIM for the rebar shop drawings: Extremely complicated and very simple jobs. Simple jobs where 2D shop drawings are just as accurate and can be produced much quicker do not make sense to use BIM. Extremely complicated jobs where there is a lot to figure out and extra fluff is needed for field modifications, are also not ideal for BIM produced shop drawings. The complicated jobs make more sense when they are done in conjunction with 3D concrete lift drawings.

How?

For creating rebar shop drawings using BIM, Revit is the ideal software. As mentioned previously, leveraging design team models to get started and use as a coordination tool is the best approach. Creating custom parameters and using the out-of-box parameters should be taken full advantage of to create schedules, tags and view templates.

Tools in Revit

- Rebar numbering: Using the partition parameter in Revit, allows the detailer to easily number bars and manage the data.
- Multi-rebar tags: Muli-rebar tags can be used to tag sets of rebar with extents and dimensions if needed.
- Rebar specific tools: rebar presentation, rebar layout tools, cover settings, area/path reinforcing.



REBAR SPECIFIC TOOLS USED TO CREATE SHOP DRAWINGS IN REVIT

Add-ins for Revit

- SOFiSTiK Reinforcing detailing: SOFiSTiK offers more tools on top of the out-of-box rebar tools for adding, modifying and annotating rebar. This software also is pushing towards linking analysis results and rebar generation within Revit.
- Graitec PowerPack: This tool is also geared toward analyzing structures in Revit and automatically modeling the rebar based on the results

Creating Cast-in-Place Concrete Lift Drawings in Revit

Creating concrete lift drawings using BIM is a no-brainer. Building the concrete structure virtually forces the modeler to understand the structure. Revit provides a means to present it in a way that is easy to understand.

Who?

A BIM consultant is hired by the concrete subcontractor or GC and works closely with the Structural EOR, concrete subcontractor and other trades to create concrete lift drawings using Revit. The EOR can also create concrete lift drawings but it would need to be a separate team or a fresh set of eyes. One of the main objectives with concrete lift drawings is to flush out issues with the design drawings, so it doesn't make sense for the EOR to produce both.

When?

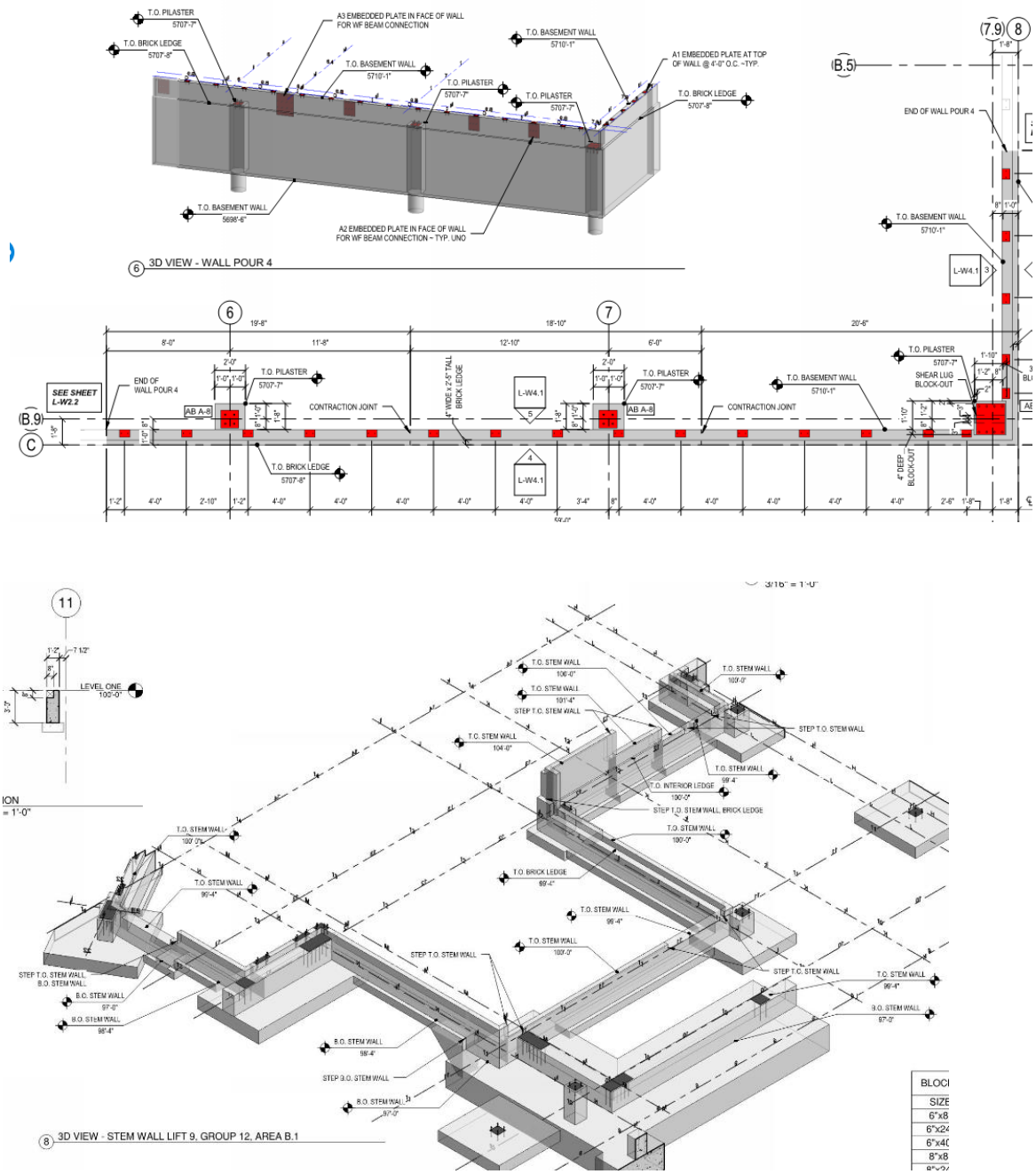
For concrete lift drawings, it does not make sense for the modeler to begin drawings until the design is close to complete. Although, the modeler can work with the contractor early in the process to do pour planning, sequencing and initial material estimates. When producing the concrete lift drawings, the modeler should work closely with the contractor to understand schedule and sequencing. Similar to rebar shop drawings, the modeler can use a "red light / green light" approach to work on the areas that are the highest priority.

Why (and why not)?

Similar to rebar shop drawings, using BIM to create concrete lift drawing may or may not be the best approach.

Advantages

- Schedule: As discussed previously, the schedule can be accelerated by leveraging the structural engineers and working closely with the contractor to produce more complete and coordinated drawings faster.
- Quantity Management/Accuracy: Data within the model such as pour number, volume, etc. can be used to manage and report accurate quantities. Because the model is coordinated using the design model and EOR, the model is accurate. Because the model (and data) is live, the quantities, dimensions and views are accurate.
- Enhanced Coordination: This process reduces RFI's because the integrated approach allows questions to be quickly answered in a less formal manner.
- Enhanced productivity from field crews: Drawings are dimensioned with clear, concise dimension strings laid out in a manner consistent with how the tape is laid out. This, in addition to isometrics for field labor visualization, results more productive crews.



COORDINATED AND EASY TO FOLLOW DRAWINGS

Disadvantages

- Lack of participation by CIP internal team: When a 3rd party modeler is used to create the concrete lift drawings vs. an internal member, the team that is actually doing the building does not get the benefit of understanding the structure as well as the modeler. Also, the modeler may not know specific requirements or preferences of specific concrete subcontractors.
- Certain jobs do not make sense to use BIM for concrete drawings: Simple jobs where 2D lift drawings or even contract documents are just as accurate/easy to follow and can be produced much quicker do not make sense to use BIM.

How?

For creating concrete lift drawings using BIM, Revit is the ideal software. As mentioned previously, leveraging design team models to get started and use as a coordination tool is the best approach. Although the design model is a good starting point, when creating lift drawings it is important to model the building as it will actually be built. For example, columns and walls should be should be split by pour (no full height columns as is typical in design models). Creating custom parameters and using the out-of-box parameters should also be taken advantage of to create schedules, tags and view templates.

Tools in Revit

- Standard modeling and modification tools: Basic modeling tools such as walls, columns, beams and floors can be used to create the structure. Basic modification tools such as cut, join, split, etc. can be used to modify existing model elements.
- Parts tool: Parts allow the modeler to divide single CIP elements into pieces that represent the actual pour. The part can then be manipulated separately from its original (single) component

Revit Add-ins

- Fab Sheets by CTC: Fab Sheets automates view and sheet creation based on a pour parameter
- Tools4revit Quick Dimensions: Quick Dimensions allows the user to set dimensioning preferences and automatically create dimension strings.

Creating Steel Shop Drawings in Revit and Advance Steel

Creating steel shop drawings using BIM is not a new concept. Steel detailers have been using 3D models to create shop drawings for some time. However, until recently, this was done using software that a typical structural engineer could not operate. With the advancement of steel connection tools within Revit and the link to Advance steel, steel shop drawings can be produced by EOR's and 3rd party detailers (instead of the fabricator/installer), similar to the process described for rebar shop drawings.

Who?

A BIM consultant (or EOR) is hired by the GC and works closely with the Structural EOR, steel fabricator and installer to create steel shop drawings using Revit/Advance Steel. It is important that the detailer works closely with the steel fabricator because, unlike rebar, different fabricators and installers have very different preferences and standards.

When?

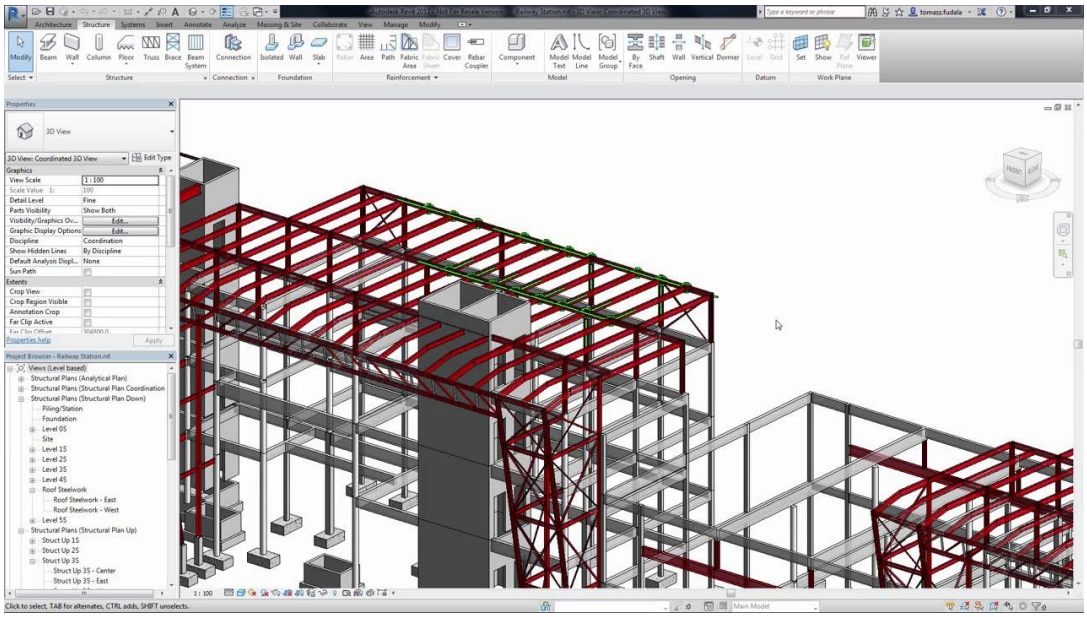
Similar to rebar shop drawings, if the structural EOR is used to create the steel shop drawings, the detailer can begin detailing steel during the design phase. If a 3rd party BIM consultant is used, they can also begin detailing during design but would need to work closely and in constant communication with the structural engineer and contractor. The detailer can use a "red light / green light" approach to work on the areas that are the highest priority or the where the design has been completed. Similar to rebar shop drawing and, an integrated approach is used to reduce schedule inefficiencies due to linear nature of the process and data drop-off.

Why (and why not)?

Depending on the job, using the EOR to create rebar shop drawing may or may not be the best approach.

Advantages

- Schedule: As discussed previously, the schedule can be accelerated by leveraging the structural engineers and working closely with the contractor and engineer to produce more complete and coordinated drawings faster. If the EOR is the detailer, the shop drawings are pre-approved.
- Efficiency Savings / Enhanced Coordination: The detailer is involved with the design team, installer and fabricator to provide more constructible, more coordinated drawings. This process reduces RFI's because the integrated approach allows questions to be quickly answered in a less formal manner. This results in a more constructible, better coordinated set of drawings.



COORDINATED AND MODEL

- Accuracy: Because the model is coordinated using the design model and EOR, the model is accurate. If the EOR is also the detailer, they have intimate knowledge of the structure and can make decisions based on design intent.
- *More?*

Disadvantages

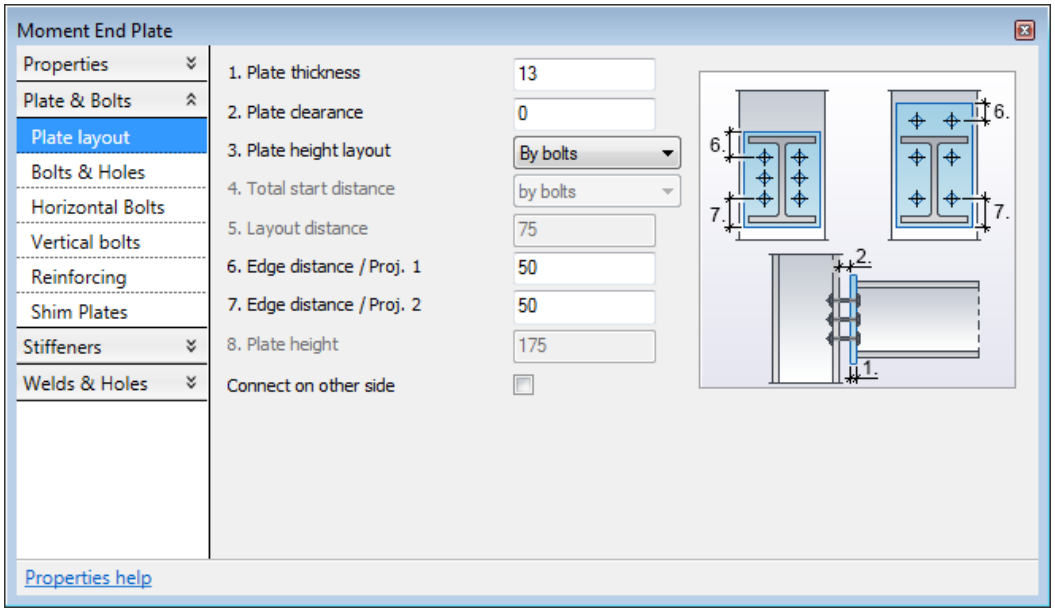
- Change in risk: Typically, the steel fabricator has accepted the risk of mis-detailed steel, and internally resolved issues between detailing, fabrication, and erection. In the new system, another entity is brought in as the detailer, which shifts risks off the fabricator (and allows blame to be placed elsewhere).
- Knowledge of industry standards/preferences: When it comes to steel detailing this is very important. Fabricators and installers have very different/specific preferences and capabilities when it comes to steel and steel connections (as opposed to rebar where there isn't much that can change). The engineer may not know what is needed to correctly fabricate and install the steel/steel connections.
- Aesthetics: Similar to connection standards, fabricators have specific standards for how the shop drawings are presented and annotated. If this is not done correctly, it could result in mis-fabrication or installation

How?

For creating steel shop drawings using BIM, Revit and/or Advance Steel can be used (separately or in conjunction). As mentioned previously, leveraging design team models to get started and use as a coordination tool is the best approach.

Revit Specific Tools

- Structural Connection Add-on: In Revit 2017, the structural connection tool add-on allows the detailer to add common connections between two steel elements. These connections can also be scheduled, tagged and modified.



STRUCTURAL CONNECTION IN REVIT

- Assemblies: In Revit, assemblies are used to group elements together that can be isolated to create views, schedules and sheets for that specific assembly. Note that structural connections cannot be included in assemblies.

Advance Steel Specific Tools

- Sheet Creation: Advance steel is a great program for automatically creating and annotating sheets
- Advance Steel Connections: Similar to Revit, Advance Steel can be used to add connections between 2 elements. These connections are more customizable than the Revit connections.

Combining Revit and Advance Steel

- Linking Models: With the advancements in linking between Advance Steel and Revit, all steel connections can be synchronized and transferred between Revit and Advance steel
- EOR can start with Revit to add the majority of the connections and then send it to Advance steel for custom or more complicated connections and to create sheets and drawings.
- Connection Checking: Revit has moved in the directly to allow connection designs to be checked natively within Revit.

Precast Modeling and Shop Drawings in Revit

Traditionally, precast shop drawings are created using 2D CAD by the precast fabricator. Because of the advancement of tools within Revit, these can now be created in Revit by the structural EOR or a 3rd party BIM consultant.

Who?

A BIM consultant (or EOR) is hired by the precast fabricator and works closely with the precast fabricator, and design team to create precast shop drawings using Revit. It is important the BIM consultant works closely with the fabricator because, unlike steel and rebar, precast is proprietary and therefore different between fabricators.

When?

If the structural EOR is used to create the precast shop drawings, the detailer can begin creating precast shop drawings during the design phase. If a 3rd party BIM consultant is used, they can also begin detailing during design but would need to work closely and in constant communication with the structural engineer, architect and contractor. The detailer can use a "red light / green light" approach to work on the areas that are the highest priority or the where the design has been completed. Similar to rebar shop drawing and steel shop drawings, an integrated approach is used to reduce schedule inefficiencies due to linear nature of the process and data drop-off.

Why (and why not)?

Depending on the job, using BIM to create precast shop drawing may or may not be the best approach.

Advantages

- Schedule: As discussed previously, the schedule can be accelerated by leveraging the structural engineers and working closely with the contractor and engineer to produce more complete and coordinated drawings faster. If the EOR is the detailer, the shop drawings are pre-approved.
- Efficiency Savings / Enhanced Coordination: The detailer is involved with the design team, installer and fabricator to provide more constructible, more coordinated drawings. This process reduces RFI's because the integrated approach allows questions to be quickly answered in a less formal manner. This results in a more constructible, better coordinated set of drawings.
- Winning the Job: Modeling is becoming a requirement to win jobs.
- Accuracy: Working with the engineer and the design model, the detailer can ensure that the precast framing elements are accurate. Because every embed plate, erection plate and piece of rebar is modeled and the data within Revit is live, if the model is correct, the drawings are correct.

Disadvantages

- Knowledge of industry standards/preferences: Similar to steel, fabricators and installers have very different/specific preferences and capabilities when it comes to production, quality control, shipping, erection, etc. The engineer may not know what is needed to correctly fabricate and install the precast.
- Aesthetics: The shop drawings don't always look the way the detailer or installer is used to seeing it. Or, similar steel shop drawings standards, fabricators have specific preferences for how the shop drawings are presented and annotated. If this is not done correctly, it could result in mis-fabrication or installation

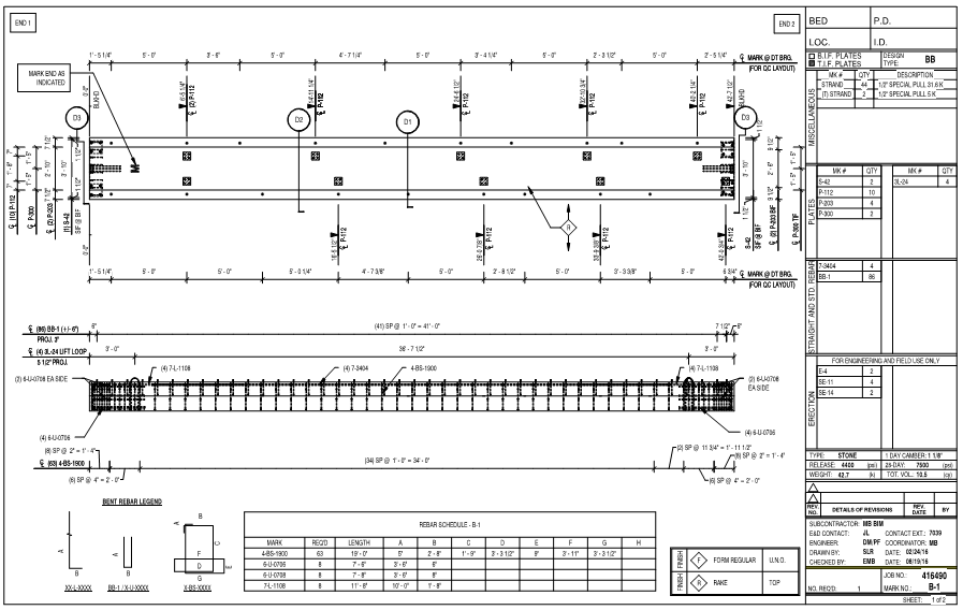
- Tools and resources have not caught up to Autocad routines: Many fabricators used autocad or some other automated routines that make producing shop drawings very efficient. Currently these are not available for Revit models.

How?

For precast shop drawings using BIM, Revit is the ideal software. As mentioned previously, leveraging design team models to get started and use as a coordination tool is the best approach. Creating custom parameters and using the out-of-box parameters should be taken full advantage of to create schedules, tags and view templates.

Tools in Revit

- Model Components: Precast members contain, embed plates, erection plates and other components. These can all be inserted as model components.
- Rebar tools: Rebar can also be inserted as a model component or the out of box rebar families can be used with the rebar tools
- Schedules: Live schedules in Revit are used a lot on piece drawings to quantify plates, rebar, etc.
- View Templates: Because the same view properties are applied to every piece drawing and multiple views, view templates should be used to keep the views consistent and make modifications easy.
- Assemblies: An assembly is the most important tool in Revit for creating precast shop drawings. An assembly is a group of model elements the can be isolated to create views, schedules and sheets for that specific assembly.



REBAR SPECIFIC TOOLS USED TO CREATE SHOP DRAWINGS IN REVIT

Add-ins for Revit

- AGACAD Precast Concrete Suite: A suite of Revit add-ins that assist in view/sheet creation, automatic dimensioning, and assembly creation.
- Edge for Revit: Edge for Revit is an Add-in that automates and many of the tools within Revit to make creating shop drawings easier. For example Edge will automatically create assemblies based intersecting elements and create the sheets with schedules and views based on a pre-established setup.