AUTODESK UNIVERSITY 2014

Delivering BIM-Based Structural Detailing Services

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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.

About the Speaker

Erich Bretz graduated from the University of Illinois at Urbana-Champaign with a Bachelor of Science degree in Civil Engineering with a minor in Computer Science and a Master of Science degree in Structural engineering. As a graduate student, he wrote software that performed simulations of the response of structures to earthquake ground motions. Upon graduation, Erich worked for TGRWA in Chicago, IL as a design engineer. After 2 years in Chicago, he moved to Denver, Colorado, where he worked as a structural design engineer and then structural project engineer for S.A. Miro, Inc. Part of Erich's responsibilities at S. A. Miro Inc. (in addition to typical project engineer responsibilities) included development of in-house BIM standards, firm-wide implementation of BIM processes using Autodesk Revit Structure, training staff in BIM processes, and initial development of the construction engineering services for the firm. In 2011, Erich co-founded MB BIM Solutions as a BIM-focused consultancy that provides construction-level modeling of structural systems and components for its clients. Erich is active in the Denver-area BIM community with Rocky Mountain Building Information Society and is a Revit Beta contributor.

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Introduction

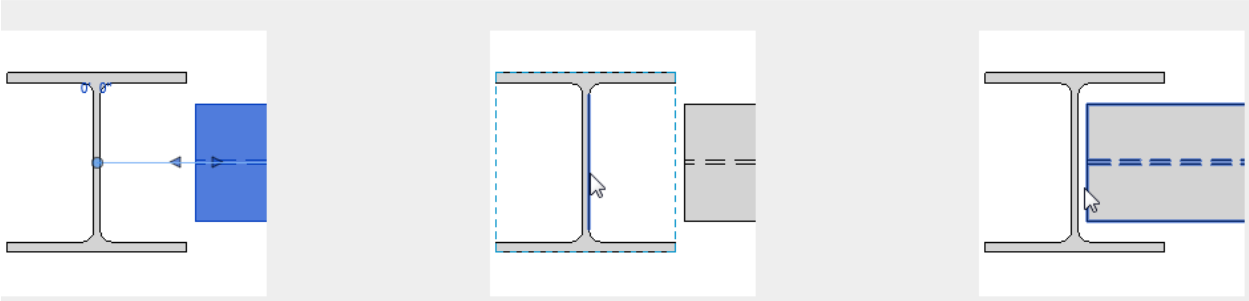
Due to new tools available to design teams and contractors, faster construction schedules, and the increased in integrated project delivery through the use of BIM, the 'who', 'how', and 'when' of shop drawings and fabrication models is changing. It is now possible to leverage a structural engineer's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

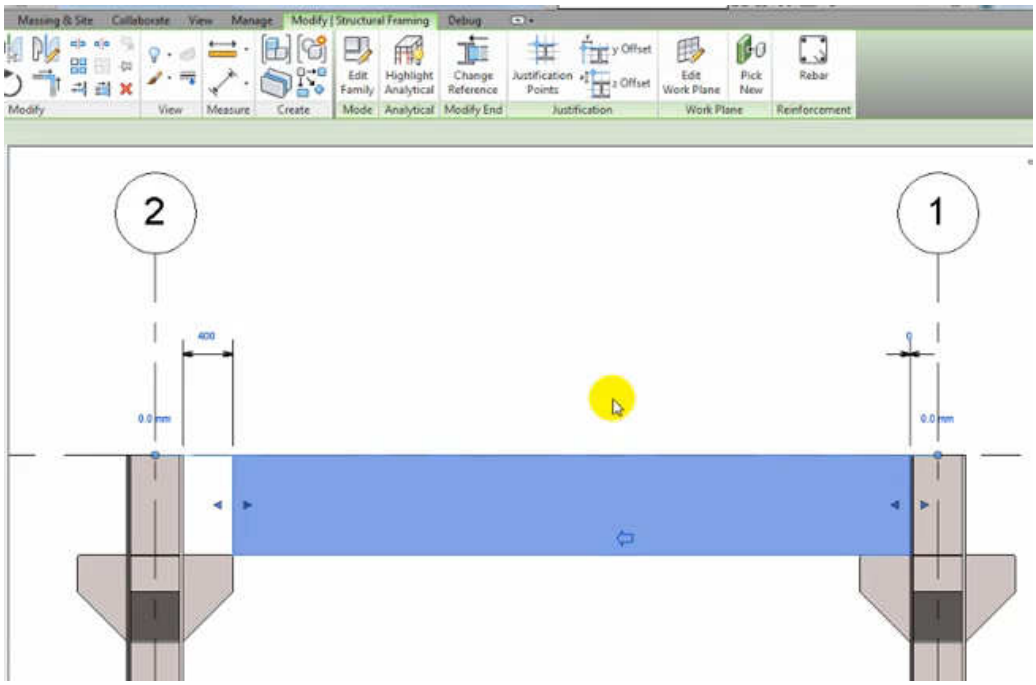
The 'who' is starting to change from fabricators and subcontractors to structural engineers, and BIM consultants. The 'how' is changing from 2D CAD for rebar, concrete lift drawings, and precast concrete, and from Tekla and SDS/2 for steel. Revit (and Advance Steel) can now be used to do this on a true 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 change 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.

Overview of Revit Tools for Shops Drawings

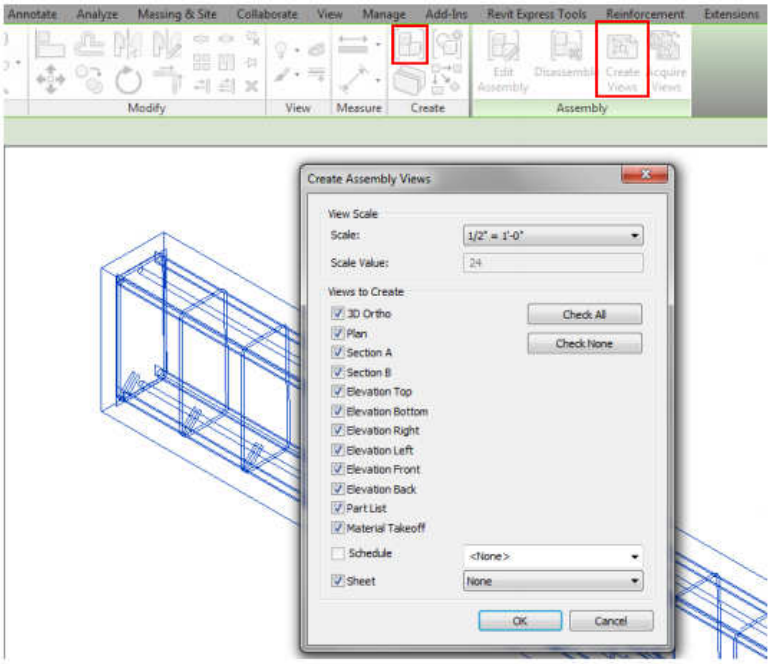
Though the tools for each structural component are somewhat different, there are a few tools that are important to understand and use correctly to create a fabrication model rather than a design model:

- Model the building as it will actually be built!
    - Split CIP columns and walls floor-to-floor, or in 2-story lifts if that is likely to be used by the construction team.
    - Split steel columns at actual splice lengths, rather than a single column for several stories.
    - Split walls horizontally (using the split tool), and then disallow the join to represent the true pour sequence.
    - Model the framing with geometric accuracy – learn to use the new structural framing enhancements in Revit 2015.





- Assemblies tool – similar to a model group in which a group of model elements are grouped together and can be re-used.
    - Assemblies have the benefit of being able to automatically create views, sheets, and schedules that recognize the components of that assembly.



- Parts tool – divide CIP concrete elements (or precast walls panels) into parts that represent the actual pour or piece. The part can then be manipulated (reinforced, added parameters, etc.) separately from its 'original' entire component.
    - Also use this to separate out the concrete portion of a wall component that has several layers.
- Add-ins made specifically for creating shops drawings:
    - CTC's Fab Sheets – for CIP concrete, assign pours to groups of concrete elements and automatically create views and sheets for each pour.
    - SofiSTIK's reinforcement add-in – speed up the annotation of rebar shops.

Rebar Modeling and Shop Drawings in Revit

Why (and When) to Model Rebar:

Modeling rebar for an entire building is very time intensive and takes considerable effort. Modeling rebar for the sole purpose of meeting an arbitrary BIM LOD (level of detail) requirement is not recommended, unless that rebar model is going to be pushed downstream into fabrication/construction and used to save schedule or money.

Why/When to Model Rebar:

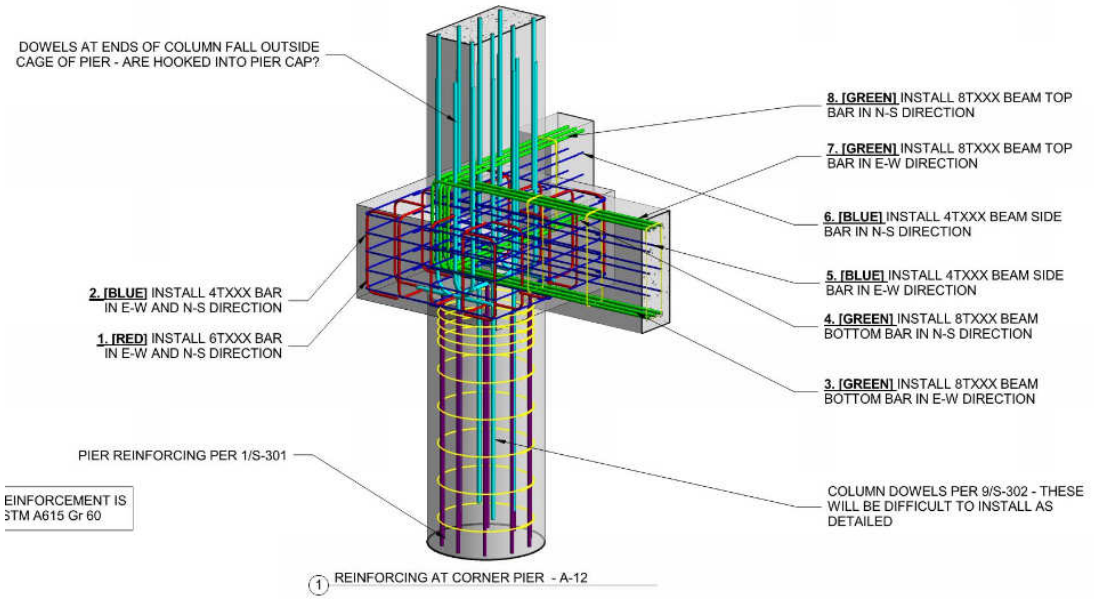
- Shop drawing production
    - Why = construction schedule and material tonnage ($$) savings
- Constructability, congestion, and coordination studies
    - Why = better constructability, reduced congestion issues, enhanced coordination

Why/When NOT to Model Rebar:

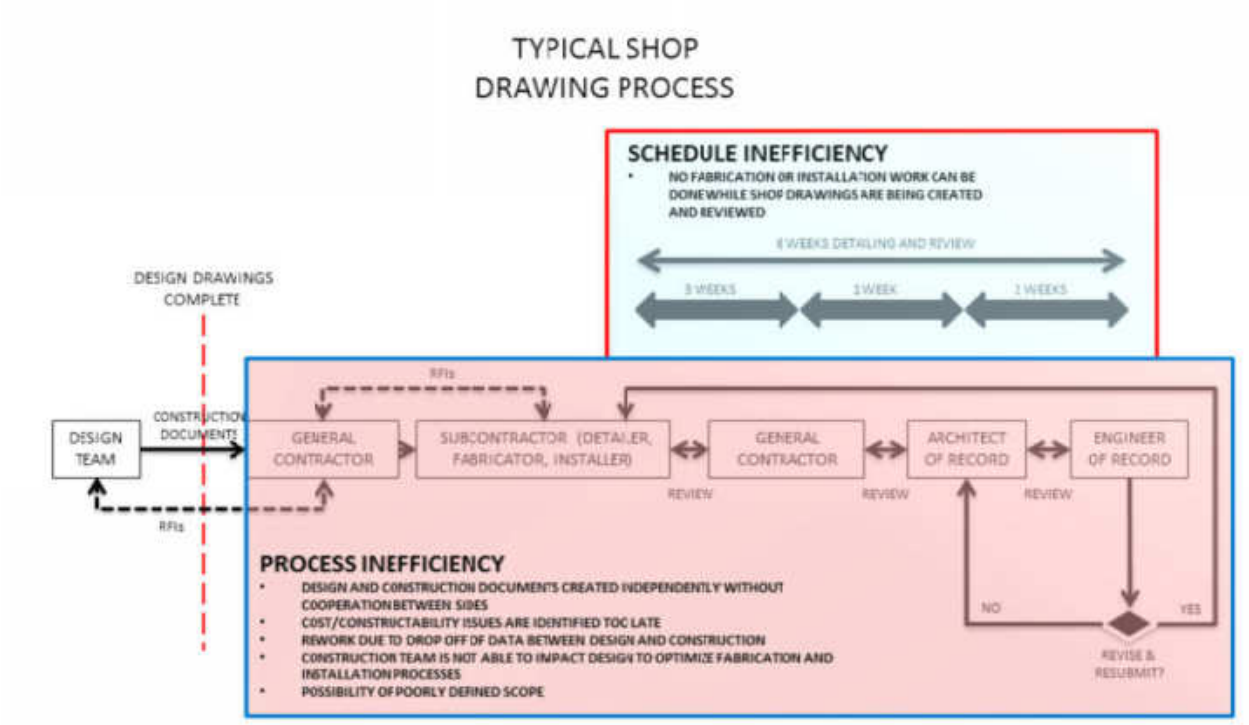
- Because you can
    - Why not = you'll blow your budget
- To draw details for construction documents
    - Why not = you'll end up chasing around bar in other unrelated views, modifications are more of a pain, and you can draw details faster using detail components

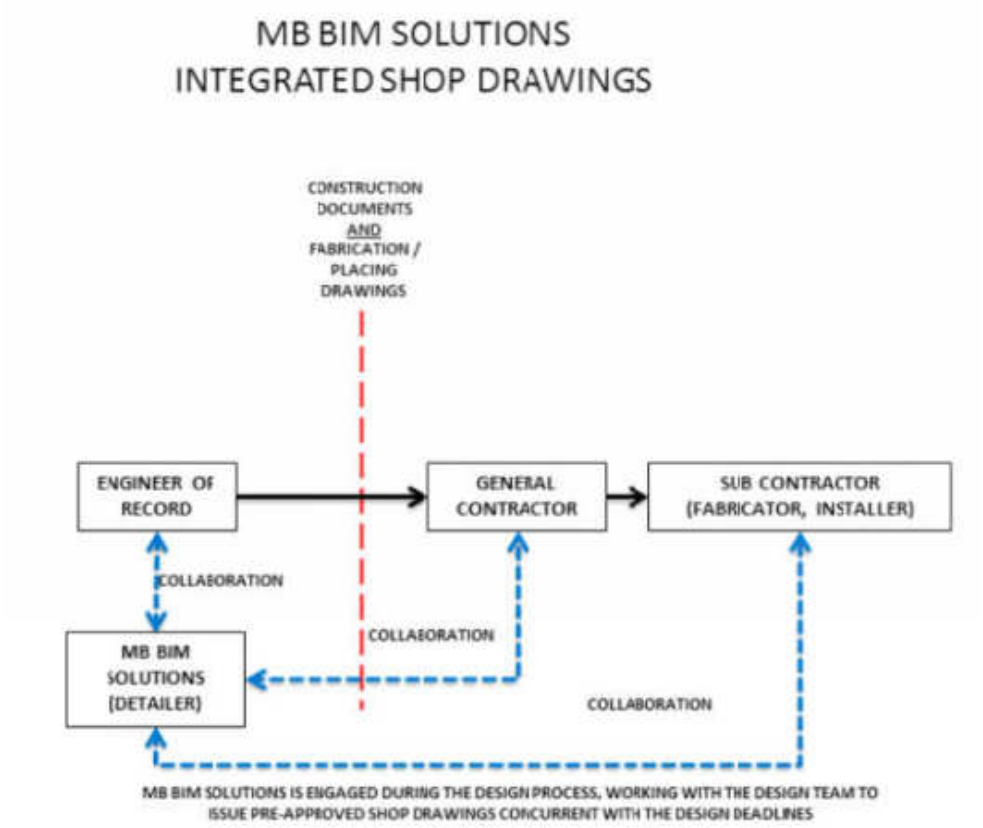
Advantages of Rebar Modeling and Shops:

- Reduced tonnage/material costs
    - Our experience (as well as others in the industry) has shown a 10%-20% rebar tonnage reduction from the modeling process
- Reduced RFI's
    - A more integrated approach allows questions to be quicly answered in a less formal manner
- Reduced congestion and enhanced constructability



- Reduced RFI's
    - A more integrated approach allows questions to be quicly answered in a less formal manner
- Schedule!!!
    - Using an integrated approach to reduce schedule inefficiencies that are due to the linear nature of the process and the data drop-off.

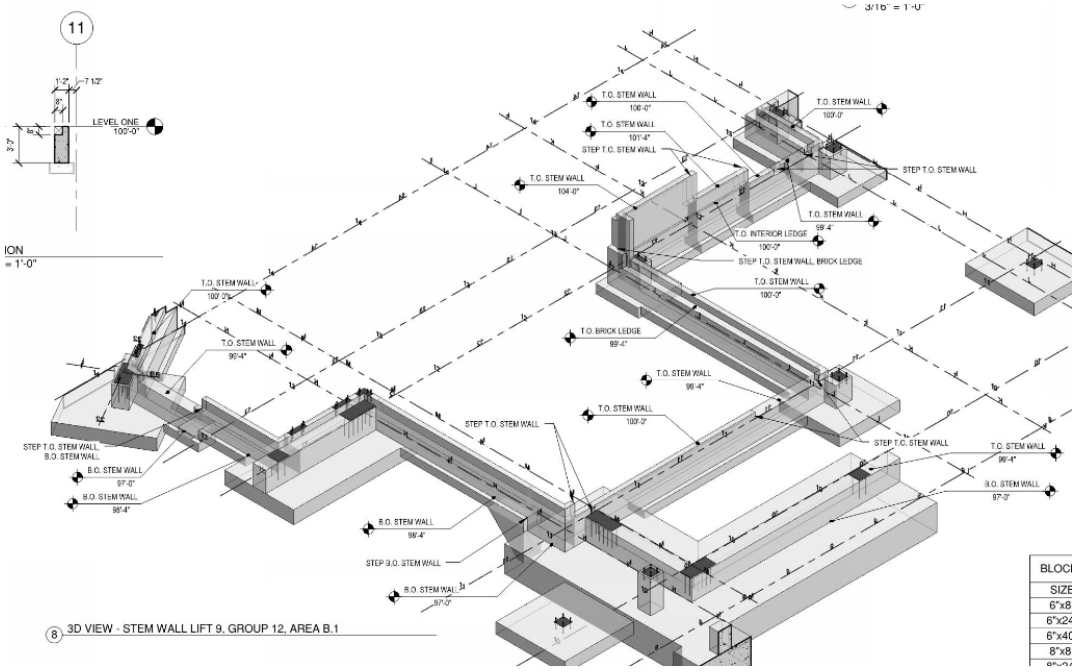

TYPICAL SHOP
DRAWING PROCESS
SCHEDULE INEFFICIENCY
NO FABRICATION OR INSTALLATION WORK CAN BE DONE WHILE SHOP DRAWINGS ARE BEING CREATED AND REVIEWED
6 WEEKS DETAILING AND REVIEW
3 WEEKS
1 WEEK
2 WEEKS
DESIGN DRAWINGS COMPLETE
RFIs
CONSTRUCTION DOCUMENTS
DESIGN TEAM
GENERAL CONTRACTOR
SUBCONTRACTOR (DETAILER, FABRICATOR, INSTALLER)
GENERAL CONTRACTOR
ARCHITECT OF RECORD
ENGINEER OF RECORD
REVIEW
REVIEW
REVIEW
RFIs
NO
YES
REVISE & RESUBMIT?
PROCESS INEFFICIENCY
DESIGN AND CONSTRUCTION DOCUMENTS CREATED INDEPENDENTLY WITHOUT COOPERATION BETWEEN SIDES
COST/CONSTRUCTABILITY ISSUES ARE IDENTIFIED TOO LATE
REWORK DUE TO DROP OFF OF DATA BETWEEN DESIGN AND CONSTRUCTION
CONSTRUCTION TEAM IS NOT ABLE TO IMPACT DESIGN TO OPTIMIZE FABRICATION AND INSTALLATION PROCESSES
POSSIBILITY OF POORLY DEFINED SCOPE

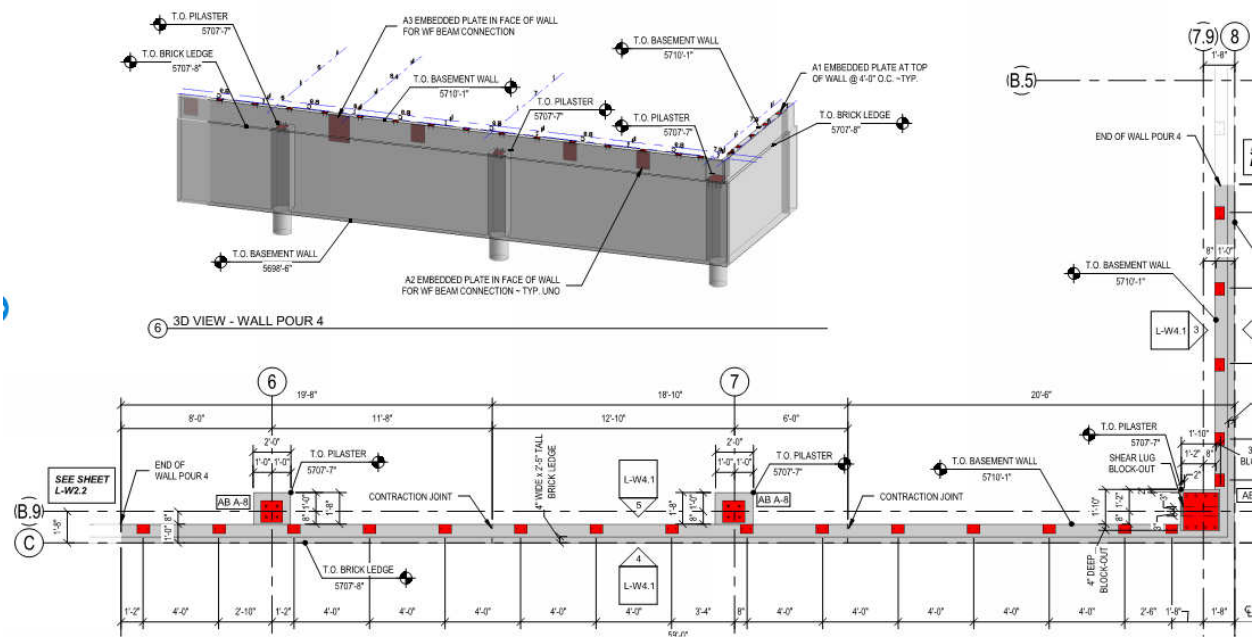

MB BIM SOLUTIONS
INTEGRATED SHOP DRAWINGS
CONSTRUCTION DOCUMENTS AND FABRICATION / PLACING DRAWINGS
ENGINEER OF RECORD
GENERAL CONTRACTOR
SUB CONTRACTOR (FABRICATOR, INSTALLER)
COLLABORATION
COLLABORATION
COLLABORATION
MB BIM SOLUTIONS (DETAILER)
MB BIM SOLUTIONS IS ENGAGED DURING THE DESIGN PROCESS, WORKING WITH THE DESIGN TEAM TO ISSUE PRE-APPROVED SHOP DRAWINGS CONCURRENT WITH THE DESIGN DEADLINES

Creating Cast-in-Place Concrete Lift Drawings in Revit

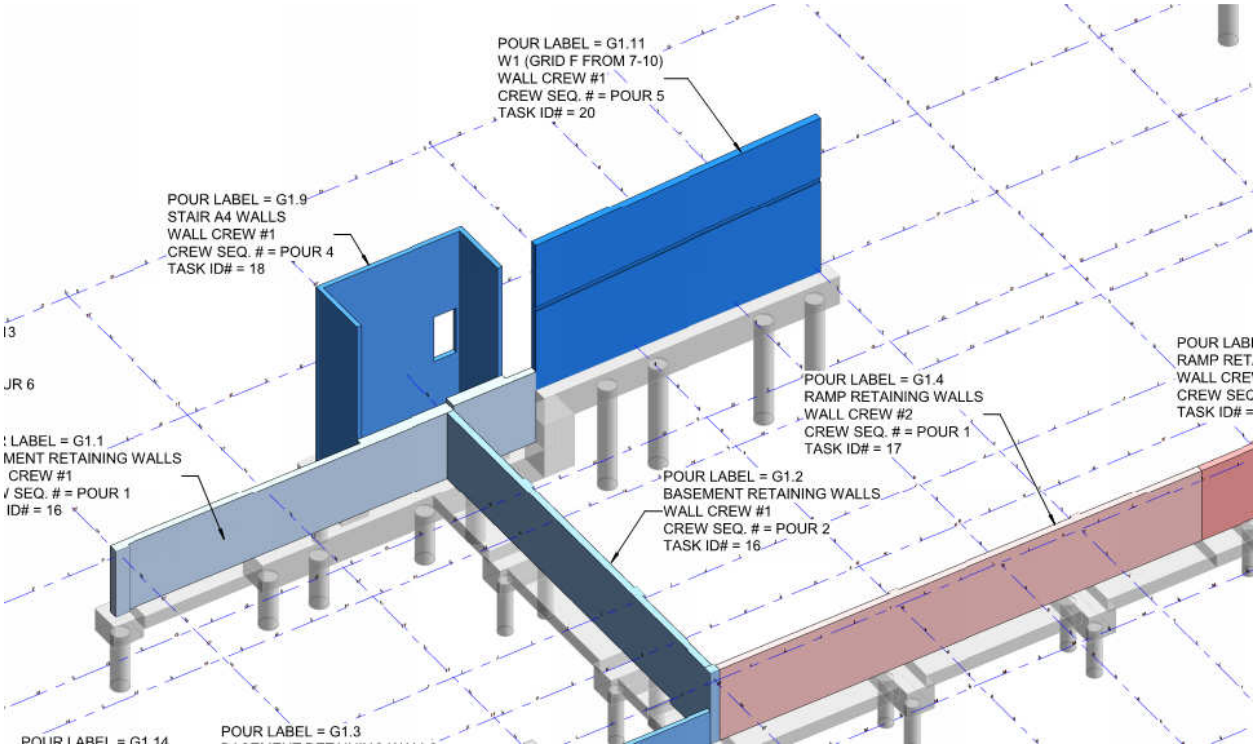
Several larger GC's that self-perform their CIP concrete work has begun to use a model to create concrete lift drawings, and in the last couple of years we have done this more and more for our GC and concrete subcontractor clients. These are the benefits that we are seeing:

- Enhance productivity from field crews:
    - Much is a result of enhanced coordination (below), but it is also the result of having clear, concise drawings with dimensions laid out in a manner consistent with how tape is laid out in the field.
    - Isometrics of each pour that allow for field labor visualization of complicated pour geometry, and QC that all embedded items are included.





- Sharing of the model, pours, and drawings (often to DWG) to the formwork team and rebar detailing team. This ensures everyone is using the same information.
- Enhanced coordination:
    - By included all cast-in elements as well as void forms, wall pours are figured out well ahead of time and contain all elements and data in one place.
    - Field crews do not have to look through design drawings and steel shops drawings. Concrete lift drawings from the model contain everything shown in the drawings from all disciplines, as well as embeds.
- Quantity management (embeds, CIP pour volumes), schedule visualization and crew visualizations.

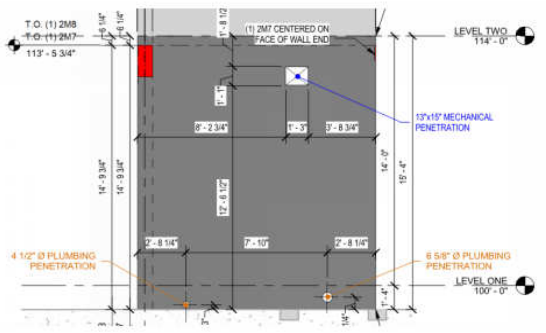


EMBEDS - POUR 4	
TYPE	COUNT
A1	20
A2	3
A3	1
AB Templ A-8	2
AB Templ D-8Rev	1

BLOCK-OUTS - POUR 4	
SIZE	LENGTH
3"x30"	2'-2"
4"x29"	78'-0"
4"x30"	1'-10"

Color Key for Penetrations:

Mechanical	(Blue)
Electrical	(Brown)
Plumbing	(Orange)
Fire Protection	(Red)
Formwork	(Green)



Modeling CIP Concrete and Components within CIP for Lift Drawings:

Modeling rebar cast-in-place and its embedded components in Revit for the purpose of creating concrete lift drawings (line drawings) is a bit different than how you would model the same elements for design documents. Items that are included in a concrete lift drawings model but not a design model are as follows, and typically incorporated from shop drawings or models from other trades:

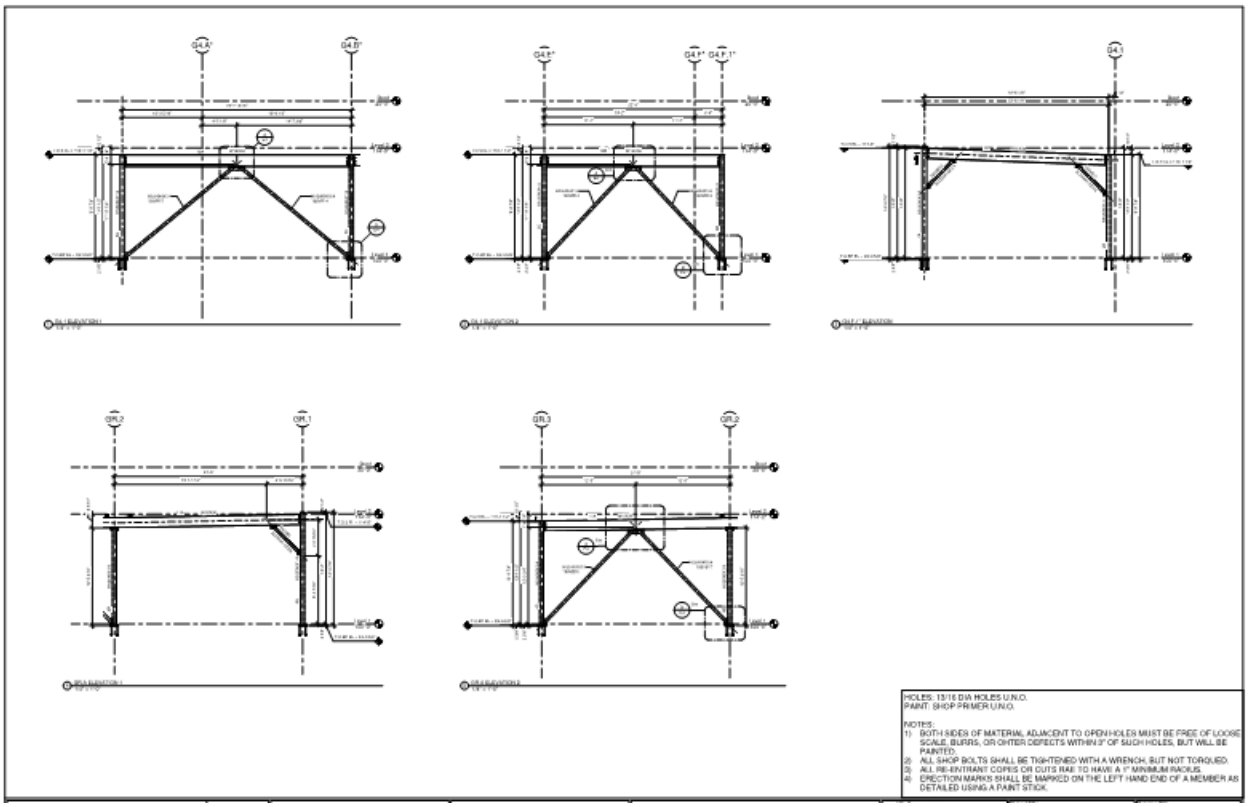
- Walls split up at correct pour breaks
- Anchor bolts
- Embeds
    - Elevators
    - Steel framing
    - Curtainwall
    - Precast
- Void forms
- MEP penetrations
- Future items to include, from feedback from our clients:
    - Point layout (Autodesk Point Creator) – export directly to the gun in the field.
    - Formwork

Structural Steel Shop Drawings in Revit and Advance Steel

In our market, there has been a push recently for EOR's to offer steel shop drawing services. This is partly a result of shortened construction schedules, and the desire to start creating steel shops drawings earlier in the design phase. It also has come from the desire to lose the data and knowledge drop-off that comes with the EOR creating a steel model from their design documents and then the fabricator scrapping that and starting over with a fabrication model to be used for shop drawings. This streamlined workflow has allowed for better coordination carrying through from design into fabrication (and then construction).

We have created steel and miscellaneous metals shops drawings for several jobs now, and have used both Revit and Advance Steel to produce these models and drawings. Revit is by no means a steel detailing software platform, and using it to do so is getting outside of the intent of the tool. However, it is practical to use it as an introduction to steel detailing for design teams on small, simple projects.

- Revit Advantages:
    - Seemless integration with design, and linking with other models
    - Low learning curve, staff doesn't have to pick up another piece of software
    - Cost of licenses
    - Ease of use with standard, typical framing elements, and small projects (smaller amounts of data management).
- Revit Disadvantages:
    - Lack of automation of piece drawings – no ability to automate dimensioning, piece marking, any other tools typical found in steel detailing software.
    - Inability to produce CNC output – this is HUGE and limits this to projects with smaller, less sophisticated fabricators
    - Need to create families and connection elements manually with more complex families, while in steel detailing software this can be done out of the box
    - Difficulty to create complex framing and highly detailed elements such as stairs



Round-Tripping a Steel Model From Revit to Advance Steel and Back

We see the ability to seamlessly link between Revit and Advance Steel as extremely promising, and think that this has the ability to change the typical workflow so that structural EOR's are able to effectively offer steel detailing as an added service. With the fairly recent acquisition of Advance Steel by Autodesk, the import/export capabilities are workable but with limitations, such as getting all of the platework and connection elements to come back into Revit (which is the main 'want'). We think that when this is working well and EOR's have familiarity with Advance Steel, they will be able to send models to Advance Steel during design phases, automatically add LOD 350 connection elements within Advance Steel, and then bring that back into Revit to help enhance coordination and allow live details to be drawn for atypical connections.

Precast Concrete Fabrication Modeling and Shop Drawings in Revit

Why to Create a Precast Fabrication-Level Models and Shops in Revit

The vertically integrated nature of the precast concrete industry presents many opportunities to leverage data created and managed in a BIM. This vertical integration is different than the typical delivery methods of other structural systems (such as concrete and steel). Additionally, because there are many facets to a precaster's total product (design, fabrication, delivery, erection, etc), there is substantial benefit to the re-use of data and information throughout all phases of the project (rather than re-creating data and information at each step).

For example, a model created during the conceptual design and estimating phases can be used to quickly compute the volume of material and number of pieces on a project, leading to better understanding of costs. This can happen long before production and erection are imminent. During the design phases of a project, the precaster's model can be used as a coordination tool, supplying a better service to the client that could be achieved through typical 2d drawings creation. During production, shipping, and erection, the model can be populated with data to accurately plan and sequence these phases. All of these activities can be done within the same model that was started early in the project.

Precasters creating Revit models of their product during the design phase, rather than the design teams, has advantages for both the precasters and the design team. Obviously this is not possible on all types of project delivery approaches, but should be practiced when possible. Having the precaster model the profiles of spandrels, layout of structural precast framing, and size of members results in a more cost-efficient design, better coordinated design drawings, and allows for best estimating and scheduling data to be captured and optimized early in the process.

The adoption of BIM by a precaster is a method of improving the overall level of service to a client. This improvement comes in the form of enhanced coordination that is possible through the use of the model, and also by allowing the precaster to deliver their product more accurately, more efficiently, and faster. The use of a BIM can permeate all phases of a precast project, offering an excellent return on investment.

Custom Parameters and Schedules – What Might Be Useful:

Everyone knows that Revit is very good at computing, counting, and representing data in schedules. These are some suggestions of some custom parameters that can be added to precast elements to automate tasks and some suggestions on ways to represent and extract data with schedules.

This is a short list of potential parameters and schedules that a precaster may find useful. Of course, every precaster's shop is different, so the things that one precaster finds useful may not fit well with the needs of another. Nonetheless, the overall idea is that the implementation of this kind of functionality into a good template is critical to the success of the modeling effort.

- A material take-off schedule showing the volume of concrete can be used to aid in the generation of a project cost estimate or bid early in a project. Additionally, this material take-off can be used to help plan for the material required during production.
- A count of the number of pieces and the type of piece can be used to plan production and operation of production beds. The piece count can also be used to facilitate production, delivery, and erection scheduling. During erection, the piece count can aid in determining the number of cranes, crane locations, and total erection duration.
- Counting of the number of connector plates needed to be installed in the cast-in-place concrete can ensure that the proper material is at the site when it is needed by the general contractor or concrete sub-contractor.
- A custom parameter that computes that weight and length of a member can be used to check the maximum dimensions of a member and the maximum weight that can be lifted in a specific crane orientation.
- A custom parameter that stores the design type of a framing element can make the connection between structural calculations and what is represented on the precast shop drawings clear to a reviewer.
- Piece marking parameters can be used to track a piece all the way from design to production to delivery and finally to erection. This information can be input into a precast concrete manufacturer's scheduling system.
- Proper marking can also identify pieces that are duplicates of each other but have different scheduling properties (for example – a beam that is exactly the same between two floors, but will obviously be erected at different times).
- Special components or components with a long lead time can be flagged to aid in material procurement and delivery.

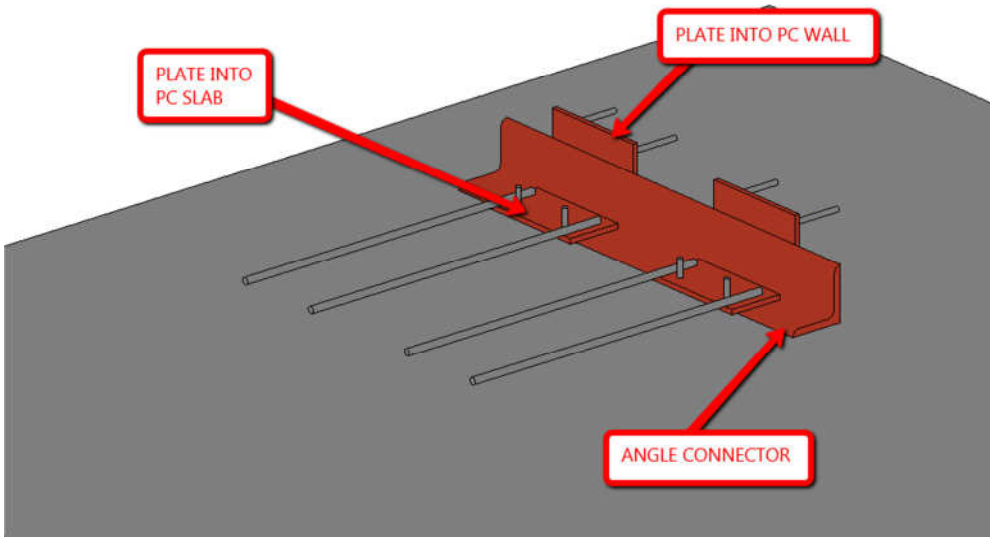


PLATE INTO PC WALL
PLATE INTO PC SLAB
ANGLE CONNECTOR