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Precast Concrete Construction – Why Should I Use Revit?

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Learning Objectives

- Learn how workflows using Revit can be used to create more opportunities for precast concrete manufacturers in the marketplace for structural systems.
- Demonstrate strategies for delivering precast concrete projects using Autodesk Revit.
- Learn about market trends affecting the selection of structural systems, and how precast concrete can capitalize on these trends through the use of Revit.
- Learn about how data extracted from a fabrication model created in Revit can be used in many aspects of precast concrete delivery.

Description

The delivery of precast concrete structures is facing a dramatic change in how these structures are documented, fabricated, and constructed. Due to the presence of highly effective 2D tools, the precast industry has been slow to adopt the use of Revit. At the same time, other structural systems that have adopted BIM have been able to achieve certain advantages in the marketplace. However, unique qualities of precast construction, most notably the speed of construction and the turnkey nature of the delivery of the structure, creates the ability for a precast concrete manufacturer to gain a significant advantage in the marketplace through the use of Revit and BIM in general. We will discuss the use of Revit in precast construction and explore how it can be used to service many aspects of the precast concrete process while improving service to Owners and Developers. Attendees will learn about Revit model creation strategies and workflows and 3rd party tools that can be used in this process.

Your AU Experts

Erich Bretz's ability to quickly and effectively solve engineering challenges has given him the opportunity to work on a wide range of construction projects including healthcare, educational, institutional, multifamily residential, resort, office, and retail projects. In the recent past, he has established himself as a leader in Building Information Modeling (BIM) and virtual design and construction (VDC) technology. His extensive knowledge of these technologies has given him the opportunity to bring real value to owners, general contractors, fabricators, architects, and engineers on many projects. Bretz holds a BS in civil engineering with a minor in computer science, and an MS in structural engineering, all from the University of Illinois.

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.

Introduction

A convergence of forces is pushing precasters into replacing the AutoCAD based tools of the past that were used to create erection drawings and piece drawings with Revit and BIM tools. These forces include: Owners and GCs putting pressure on precasters to provide models that can be used by other project participants, the need for software tools that support a data-rich environment, the need for process improvement in the creation of fabrication documents, and finally the need for greater efficiency in project delivery. With the emergence of Revit as a piece of software capable of producing fabrication drawings, precast concrete manufacturers now have software tools that enable them to join the BIM revolution.

FIGURE 1: PRECAST PARKING GARAGE, DETAILED USING REVIT, WITH AN OVERLAY OF THE REVIT MODEL

Current State of Documentation in the Precast Industry

Currently, precast concrete manufacturers are using erection drawings and piece drawings developed in AutoCAD. Portions of the drawing creation process are automated through the use of sophisticated custom written routines and add ins. These tools have been refined over time and are quite sophisticated, but it appears as though the AutoCAD platform that these tools were built on is no longer able to support the needs of current construction projects. Present-day projects are requiring that they are delivered faster, cheaper, and better (this is discussed in more detail in the next section), and the tools used to deliver projects must evolve to facilitate those requirements. To most GCs and their subcontractors, this means the use of BIM and creating data-rich 3D models that drive fabrication. In response to these needs, current tools have the ability to embed pseudo-3D intelligence into drawings, but in order to produce an actual 3D model that can be used by other project participants, a ‘shadow’ model is required. With AutoCAD based systems, this shadow model must exist independent from the project documents, with no relationship between the modeled version of any element and the detailed version that appears on erection and piece drawings. This lack of connection between the elements that are being fabricated and installed (the 2D erection drawings and piece drawings) and the elements that other project participants are using for coordination (the 3D ‘shadow’ model) is problematic because:

- Maintaining two versions of the same information requires a duplication of effort. This slows down the entire process and imposes costs on the precaster.
- Effective clashing against a 3D ‘shadow’ model requires that the model has been kept up to date with the other project documents. There are strong incentives for this effort to be a low priority.

Perhaps the most serious challenge with AutoCAD workflows is change management. Fast paced projects have created the need for construction activities to begin long before design is complete. As such, the precaster must be prepared to make changes to work that has already been documented. Because there is no relationship between drawings produced in AutoCAD, any change to a project must be chased through every document that shows any representation of the portion of the building that changed. For example: if a column is moved, the move must be made in every plan, elevation, partial plan, and detail that shows the column. Additionally, the framing around the column must be revised, and the same changes must be chased through all of the same documents and the piece drawings for the framing. The lack of continuity between documents makes it easy for things to get lost, and requires a good technician to make sure that all of the changes are updated properly in all of the documents.

Precasters have been slow to adopt Revit and BIM because their AutoCAD based tools are very effective for their current workflows. For example, AutoCAD automation tools are much more advanced than those that are currently available in Revit. These tools dramatically increase the speed at which repetitive tasks such as dimensioning can be done. However, Revit is quickly catching up with the addition of 3rd party tools and continued investment by Autodesk. Additionally, the many precasters have built their electronic infrastructure (material and resource planning software, scheduling software, etc) around AutoCAD tools, and changing to a new piece of software will require those tools to be reworked. Conversely, as these tools age and evolve, support for AutoCAD workflows is fading.

Market Trends that are Forcing Precast Concrete Manufacturers to Change Processes

Faster. Better. Cheaper.

The ‘Great Recession’ was a very difficult time for the construction industry – in just two years, non-residential building construction in the US fell by more than 50%. During that time, market forces affected the way that buildings were delivered, and many of those forces have remained even as the building industry has rebounded.

- Increased competition: Owners have treated general contractors and their subcontractors, and in turn the building's structural system as a commodity. As such, precasters must look to differentiate themselves from other structural systems.
- Technology: GCs are looking for ways that they can improve the building process for Owners and increase coordination with other project participants. The use of BIM has become a standard project requirement and the 'price of entry' for many projects.
- Convergence of design and construction / greater collaboration: The lines between design and construction have been blurred, and the practice of design professionals 'dropping off' designs and construction professionals 'picking them up' with no continuity in between is inefficient and impractical. BIM tools can help to prevent this information 'drop off'.
- Speed to market: During the recession, Owners required construction schedules to be compressed, and GC's (and their subcontractors) were willing to accommodate with work in short supply. As we emerged from the recession, Owners have continued to demand similar scheduling. Precast already has a significant advantage in speed, but nonetheless there are opportunities for improvement.
- Design complexity: BIM tools have improved processes for architects and engineers. With better tools, architects have been able to be more creative with their designs.
- Changes: The cost to architects to make design changes has been driven down through the use of BIM tools (for reasons stated above), so they have become more commonplace. The tools that precasters use must be able to adapt to those changes.

What Advantages does the Use of Revit Offer a Precaster?

In the previous section, we talked about the shortcomings of the AutoCAD based tools used by precasters. Revit and BIM have the opportunity to resolve those shortcomings, and offer much more to the precaster and to the projects that they are engaged on.

To understand where opportunities lie for precasters, it is important to first look at why precast concrete structures are different than other structures that employ other structural systems:

- There is a wide range of variation between one precaster to another not only in fabrication capabilities, but also in product dimensions, fabrication preferences, and erection preferences and techniques. Contrast this to steel structures (where a W10x12 from one fabricator is exactly the same as a W10x12 from another fabricator) and rebar manufacturers (where a #4 with a standard hook on it is the same regardless of who does the bending). Because of this, the whole precast system is somewhat proprietary. This lack of uniformity is good and bad – it makes the design and specification of a precast structure confusing to an engineer of record, but also creates an opportunity for a precaster to provide expert support to designers and contractors to help them understand the structure.
- Precast framing and cladding offers a great deal of design flexibility, and as such is a desirable material for both architects and engineers to work with. Framing is capable of achieving significant spans with minimal depth. Cladding is durable and capable of achieving complex custom forms and at the same time being a structural element.
- Installation of precast structures is very fast – in most cases is faster than steel construction, and almost always faster than cast-in-place construction. As soon as precast framing is installed, a strong, working platform is created – there is no waiting for concrete to cure as is the case in steel and cast-in-place construction.

- Overall project safety is enhanced since product is cast off site and simply assembled on site.
- Since casting is done in a controlled environment, there is much greater quality control with precast products. Additionally, product can be checked before it is shipped to the site.

The challenge for every precaster is to examine these differences, take advantage of the opportunities that the differences present, and to find a way to overcome the detrimental differences between precast and other structural systems. We believe that Revit is a great tool to achieve these goals.

External / Project Specific Benefits When a Precaster is Using Revit

- By sharing a Revit model, the precast elements (modeled by the precaster) can be modeled by the entity that is most knowledgeable of those elements. It is common for structural engineers to lay out precast framing in a manner that they see fit, only for that framing scheme to be redone when the precaster starts their work. Sharing of models by precasters eliminates this duplication of work, and allows the EOR to focus on other portions of the structure.
- For projects that utilize a precast cladding system, having the precaster model those elements gives everyone clarity on what will be delivered and ensures that the architectural requirements can be met. Model sharing also provides a tool to facilitate discussion between architects and precasters.
- Model sharing enables the general contractor to perform clash detection between the various trades, and allows other project participants to plan their work around the precast structure.
- The total time required to deliver a project can be reduced by engaging a precaster early on in a project. Using Revit to communicate with designers allows for decisions to be made quickly and effectively. Also, since the model created during the design phase of a project is used to create fabrication documents, meaningful construction planning activities can take place during design. This increases the overall speed of a precast construction project.

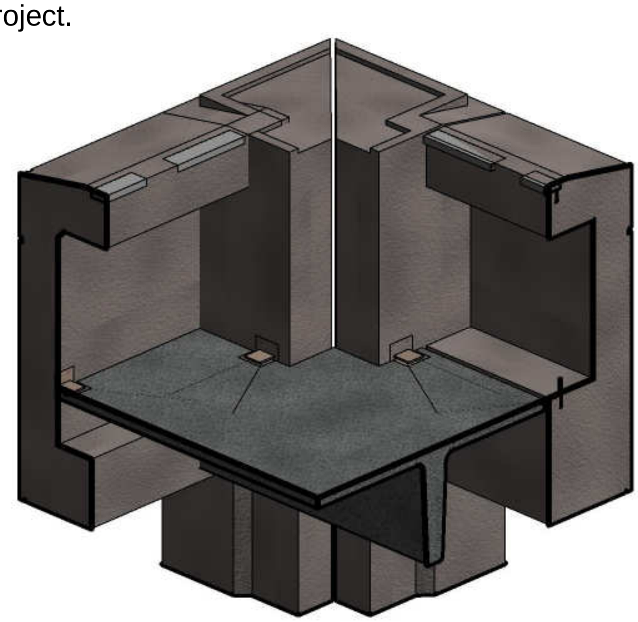

FIGURE 2: PRECAST BEAM-COLUMN CONNECTION

Internal Benefits to the Precaster When They Are Using Revit

- A precaster effectively becomes a member of a design team when they share models. This gives the precaster a ‘seat at the table’ and enables them to influence and convey the impact of design decisions as they are being made. In the traditional project structure where the precaster’s knowledge is not as accessible, designers often make decisions that will need to be revised when a precaster is engaged on the project.
- With a ‘seat at the table’, precasters are now able to bring more value to any project. This enables them to more effectively communicate their needs on a project, such as product capability, scheduling, crane placement, shipping routes, etc.
- Revit is very good at collecting data and displaying that data in many different ways. Knowing the type and quantity of everything that is needed on a project is very important from a material planning perspective. Using AutoCAD, it was complicated to get an accurate count of all of the plates, rebar, erection material, lifting elements, etc that is required for a project. The schedules required to do this can easily be set up in any Revit project.
- In terms of software usability, Revit is easier and more intuitive to use than AutoCAD.
- Precast fabrication modeling leads to an overall better product. Having fully coordinated models and drawings reduces errors.

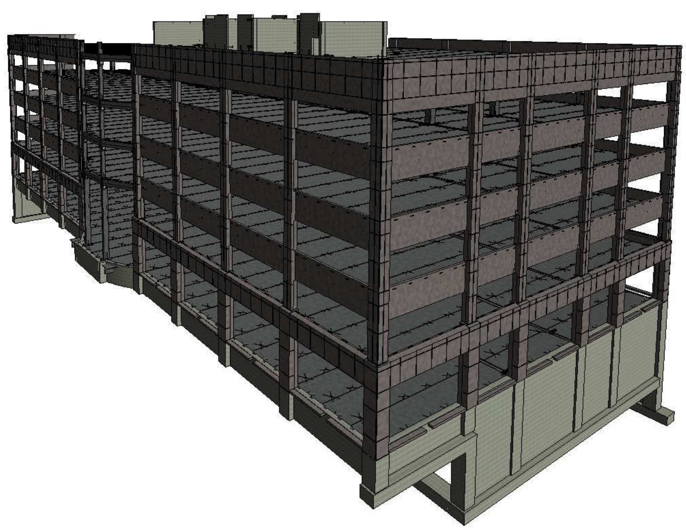

FIGURE 3: PRECAST OFFICE BUILDING

Revit Workflows for Precast Fabrication Modeling

Differences Between CAD Processes and BIM Processes

The main difference between CAD and Revit workflows is the required flow of information. For example, in CAD, if the elevation of a drain in a precast parking garage changes, updating plans is a relatively simple task – it only requires changing of a number that represents the actual elevation. When creating a fabrication model in Revit, a drain elevation change requires rewarping of the framing around the drain and is much more time consuming. In both cases, it is obviously much more efficient to minimize the amount of changes and to minimize rework. In addition to rework, changes impose an element of chaos on a model that makes quality control much more difficult.

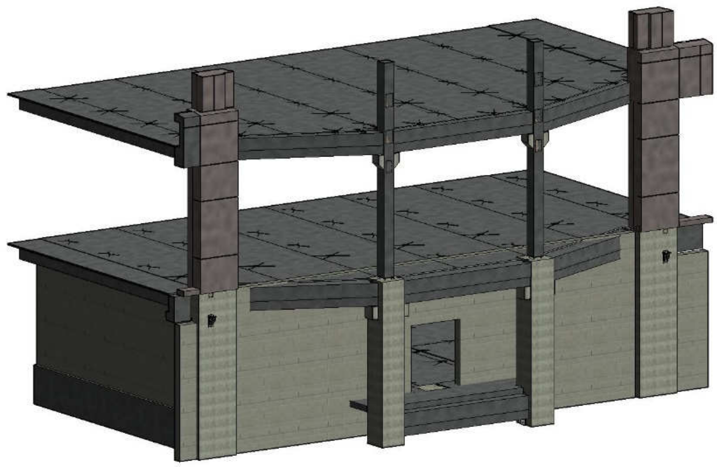

FIGURE 4: PRECAST FRAMED ROTUNDA

When we start projects, we look for items that present modeling risk (such as the elevation example noted above) and build the model in an order that reduces that risk as much as possible. Some common key pieces of information that present modeling risk include framing elevations, stair and elevator core dimensions, geometry of exposed precast elements, precast wall panel joints, precast column panel joints, and cast-in-place elevations (foundations). Additionally, we wait to model any connections until all of the framing is nailed down since (for the most part) there is very little coordination value in modeling connections early and changing them at a later date is difficult.

A rough outline of the steps that we take in creating a fabrication model are listed below. Note that these steps are modified with each project as some projects have different needs than others. We also produce and distribute sets of drawings early and often in projects as a means to flush out design, coordination, fabrication, and erection issues as early as possible.

1) Perform initial model setup (add grids, levels, etc). Align the precast model with the models of the other project participants.
2) Model cast-in-place elements that support precast. Use the model to generate questions of the design team.
3) Model the cast-in-place topping slabs. Seek design team confirmation on all elevations
4) Lay out the precast walls and columns including joint locations. Seek design team confirmation on all joint locations.
5) Model precast spandrels and beams. Seek design team confirmation on the geometry of these elements.
6) Model the remainder of the precast framing.
7) Warp framing as needed.
8) Add corbels where required. Look for conflicts with other trades.
9) Model connections at horizontal framing

10) Model connections at vertical framing
11) Create erection drawings
12) Mark pieces
13) Issue erection drawings for design approval
14) Add reinforcing and lifting to the precast pieces. Look for opportunities to copy these elements to other pieces.
15) Issue piece drawings

Precast Piece Drawing Philosophy

At the heart of the piece drawing process is Revit's assembly functionality. Each unique precast product is made into an assembly, and the piece drawings for that product are created using the assembly views and schedules. The assembly tool allows independent tagging, scheduling, and filtering of the elements in the assembly. This provides an excellent means to document and detail the piece independent of the whole building model, but at the same time maintain a connection to the model, allowing changes made to be automatically reflected in both. Another other unique property of the assembly functionality is the ability to detect when one piece is exactly like another piece. In our experience, however, relying on this functionality to detect unique pieces is not a good idea because it results in too many unique assemblies. It is very difficult to make one precast piece exactly like another in every way (all embeds, cuts, blockouts, etc). As an alternative, we have been using schedules that show the length, width, and weight of each piece as a good first pass at finding unique pieces, and then doing a careful visual check to determine if pieces really are exactly the same.

The 3rd party tools that are discussed later have great tools for automatically creating assemblies. The key to these tools is that they perform clash detection on the main part geometry (the product); any other element that clashes with the main part is automatically placed in the assembly of the main part. The tools then assign data to the custom parameters of all of the parts in the assembly, giving the user the ability to create schedules that utilize filters that operate on that data. Of course, there is some error checking that must be done when creating assemblies, as it is common for unwanted elements to clash with the main part and thus must be removed. Additionally, erection material typically does not clash with the geometry of main parts, so those elements must be manually added to the assembly.

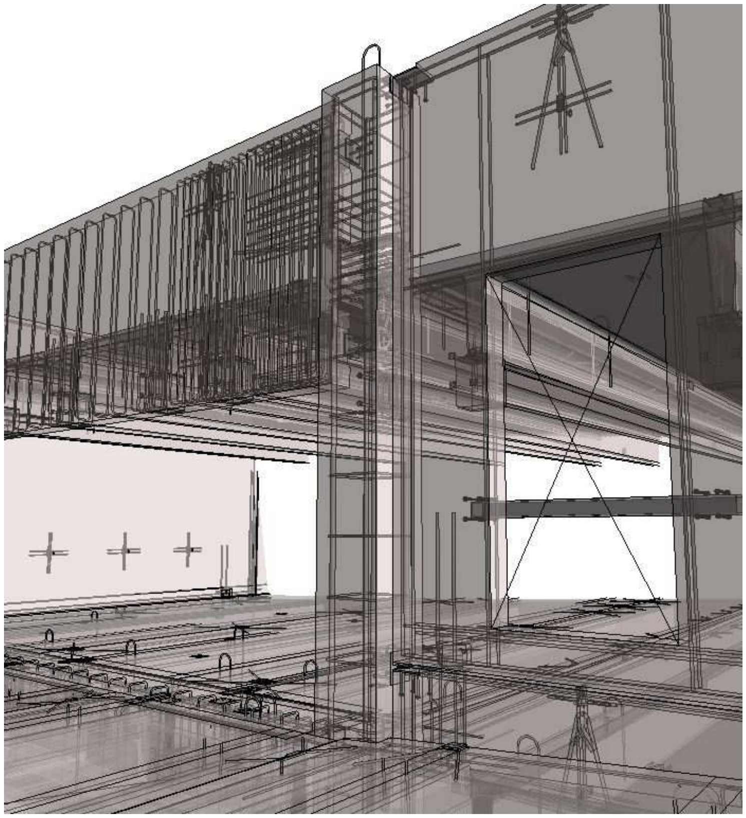

FIGURE 5: PRECAST FABRICATION MODELING

Parameters

We utilize several custom parameters that are used to drive the assemblies, the schedules within the assemblies, and the other project views. Some of these are as follows:

- Piece Control Number: the unique number for each piece in the project
- Assembly Mark Number: the mark for each unique piece in the project
- Plate Host: a parameter that allows you to filter piece drawing schedules to show only the embedded elements that are part of a single assembly
- Plate Category: allows you to filter between standard plates, erection material, rebar, etc in piece drawing schedules
- Piece Design Type: the unique design identifier for each piece
- Assembly Weight: a parameter that computes the weight of a piece
- Various view parameters: precast manufacturer specific parameters that are used to drive views, schedules, and filters as needed

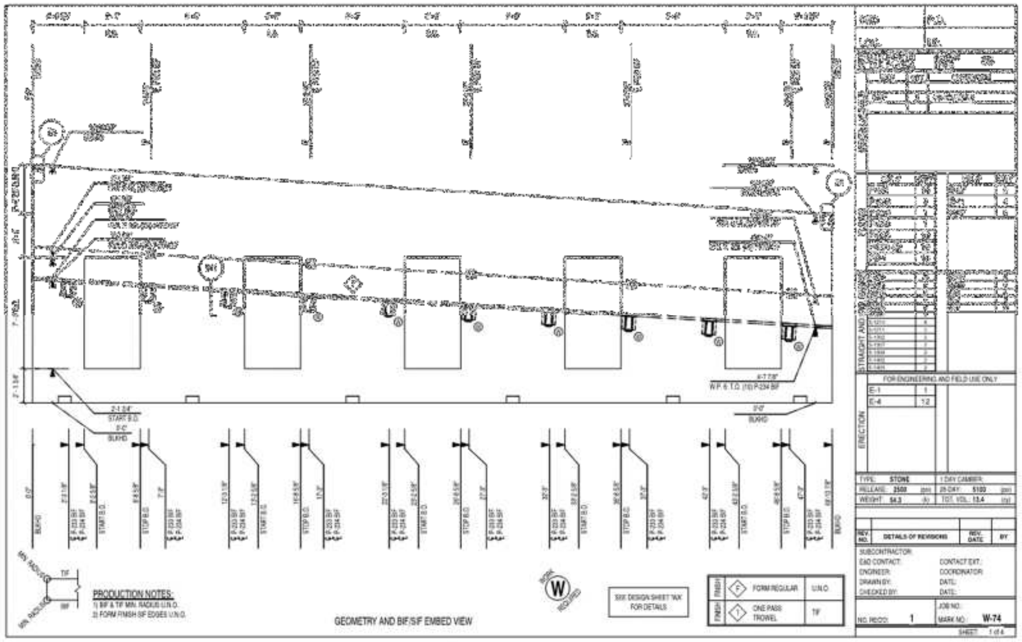

FIGURE 6: SAMPLE SHEET FROM A PRECAST WALL PIECE DRAWING

Schedules and Legends

Schedules are used during the piece drawing process to send data to the parts of the precast manufacturing process that are used during fabrication, delivery, and installation. See Figure 7 below for schedules that are used to separate data between erection material, the precaster's steel shop, and the precaster's rebar shop.

Some other ideas for how schedules can be used:

- Piece marking: Since it is difficult to use Revit's assembly creation tools to determine if an assembly is unique (for piece marking purposes), we use schedules that show a piece length, width, and weight as a first pass at identifying unique pieces.
- Product counting schedules: used to count the total number of pieces on a project, the number of plates, amount of rebar, etc
- Piece tracking: Used to track where a piece is in the piece drawing or fabrication process; each piece is marked as reinforced, annotated, checked, issued, or fabricated.

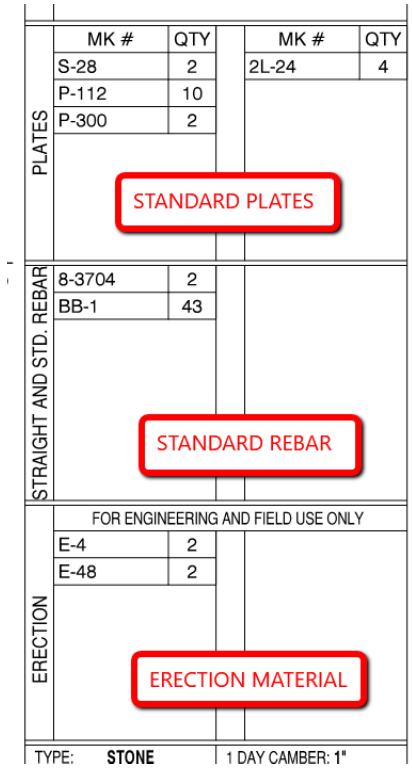

FIGURE 7: SAMPLE PIECE DRAWING SCHEDULES

We use legends extensively for text and details that are often re-used on the erection drawings and piece drawings in a project. Some examples of legends that

- Rebar bend diagrams
- Piece finish legends
- Typical piece details (used by several pieces in the project)
- Piece end indicators (end 1 – end 2)
- Assembly view titles

For piece drawing details, we take advantage of the extreme repetition of details by creating master detail sheets that contain all of the details that are pertinent to the product category. For each assembly, we only print the details that pertain to the piece under consideration.

Third Party Tools

There are a few third part tools that will automate some of the repetitive tasks that are required for precast fabrication modeling:

- Edge^Revit (http://www.edgeforrevit.com/) – we use this tool to automate the assembly creation process, and the piece drawings view and schedule creation process. Edge has a tool that automatically detects all of the elements that are cast into a single piece, adds those elements to the piece assembly, and assigns parameter data to those elements so the data can be properly displayed in the piece drawing schedules.
- AGA CAD Tools4BIM (http://www.aga-cad.com/products/packages/precast-concrete) – this addin can be used to automate the modeling of precast connections. There are also tools to automatically create assemblies (similar to Edge^Revit) and to assist in piece marking.

What Setup is Required Before a Precast Modeling Can Happen?

Preparing a good template that is precast manufacturer specific is essential to being able to deliver shop drawings efficiently. Most precasters have a library of the parts and the standard details that are commonly used. This is a list of many things that should be incorporated into a good template:

- Prepare all standard embed families (plates, rebar, lifting elements, etc.)
- Prepare whole standard connection families. These families should contain all of the pieces that are installed in both elements that are part of a standard connection.
- Develop the required precast product families, using the precaster specific geometry.
- Set up view templates for plans, elevations, piece drawings, and any other view that will be used on a project.
- Set up custom schedules within Revit that are required for piece drawings, data extraction, etc.
- Develop custom annotation elements.
- Develop custom parameters in addition to Revit out-of-the-box parameters to create and drive schedules, tags, views, view templates, etc.

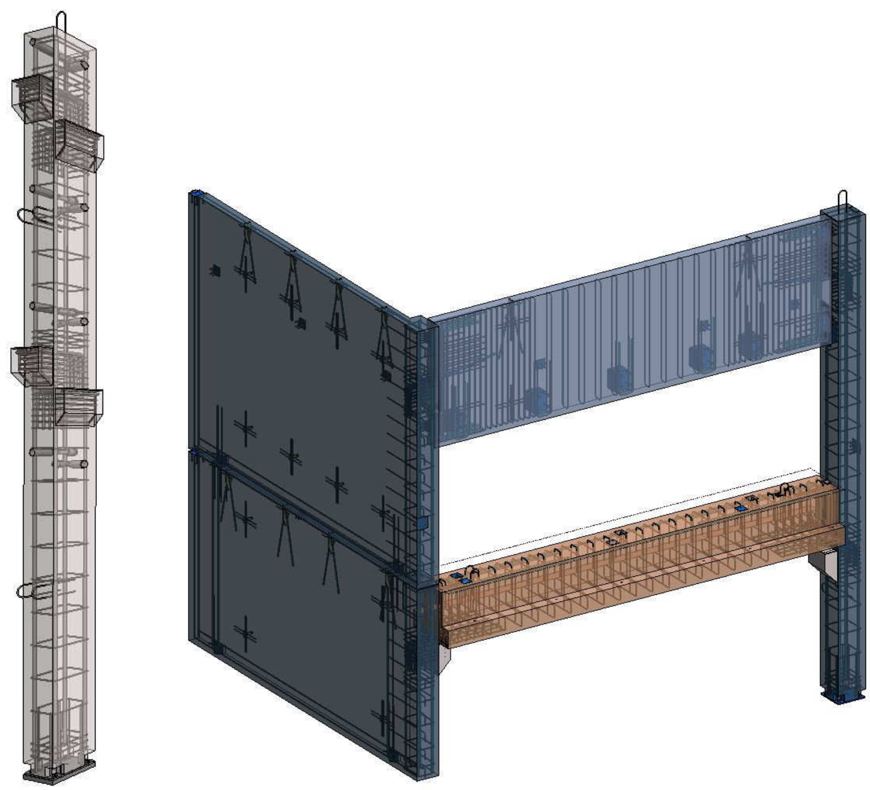

FIGURE 8: PRECAST PIECES WITH REINFORCING, EMBED, AND LIFTING ELEMENTS SHOWN

Some additional advice:

- Precision: model everything as precisely as you can. This is a lesson that most precasters have learned in the AutoCAD world, but it cannot be understated. It is best not to use linework, ‘dumb’ text instead of tags, fake dimensions, etc – these things tend to find a way to cause problems somewhere in a project. Keep data as clean as possible at all times.

- Model maintenance: periodically and regularly check over your model to make sure that things are correctly modeled.
- 3rd party tools: keep an eye out for new 3rd party tools that will enhance your productivity. New tools are constantly being developed. Also, Autodesk appears to be very interested in enhancing Revit's construction capabilities, so we should see improvements there also. A wish list item: automatic generation of dimension strings!
- Piece marking: be very careful when determining unique pieces. This is prone to human error and there does not appear to be a great way to automate the process.
- Coordination with other trades: be sure to get the most value out of your Revit project! Make it as easy as possible for other project participants to import your model and use what you have created. Start by making sure that your origin matches the established project origin!
- Template: it is critical to start with a good template. We recommend creating all of the pieces and parts that you may need on a project before starting the project. Have all of your templates and schedules set up. A great way to see if you are there: do a project simultaneously in Revit and with 'conventional' tools.
- Legends: use Revit's legends to automatically impose some uniformity on your projects and to take advantage of the repetition of use of notes, details, sections, etc.
- Working plans and working 3D views: create a series of plans and 3d views in the project for user specific notes and tracking design questions.
- Voids: use voids to cut single pieces – do not use the same void to cut through more than one piece. A single void cutting through multiple pieces creates problems during the piece drawing phase of a project.
- Pinning: use Revit's pinning tools to 'lock down' elements that are checked and correct.

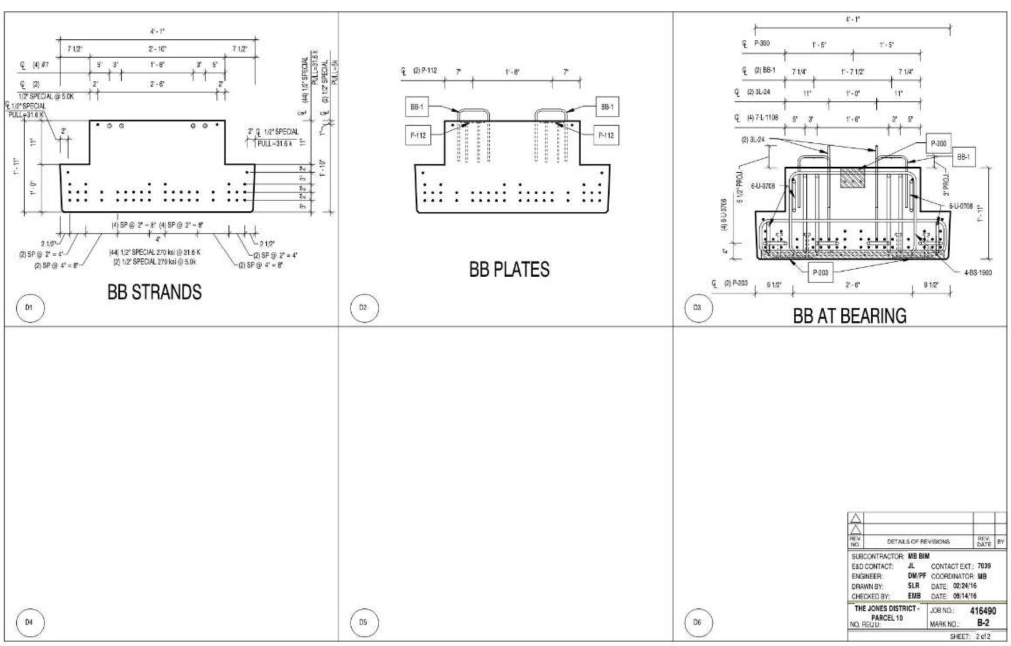

FIGURE 9: PRECAST BEAM DETAILS

What Does the Future Hold?

These are areas where opportunity exists to enhance a precaster's processes through the use of BIM:

- Estimating: performing model-based estimating and leveraging Revit's ability to quantify product. Also, estimating models can be used as a sales tool to demonstrate an understanding of scope to clients.
- RFID: create a tag for each (physical) precast piece, and scan the piece anytime it is touched. Use the model to store this data and to communicate where any piece is at any time during the process.
- Scheduling / Material Planning: Enhanced link between Revit and scheduling / material planning software.
- QC / QA: send fabrication models to designers to review electronically in lieu of paper drawings.
- Bed optimization: use Revit to automatically optimize pour sequencing and bed resources.