Autodesk University 2012

Structural Detailing for Wood: *Framing Revit with AutoCAD*

Steve Bumbalough: ITW Building Components Group, Product Manager, Global Software

Brad Blissit: Integrated Structural Concepts, Founder, President

Will Ikerd: IKERD Consulting, LLC, PE, CWI, LEED AP, Principal, President

SE2501: With Autodesk Revit Structure 2013 software, the power of prefabrication is finally a reality! This class will demonstrate how to use proven structural detailing tools built on the AutoCAD software platform to frame Revit models. We will show you how working collaboratively with your local wood truss fabricator provides powerful solutions for you as an integrated project delivery (IPD) structural engineer. The class will demonstrate 3D design coordination using wood trusses with web patterns in construction-level truss designs that are available to you in Revit or Autodesk® Navisworks® software. Truss manufacturers have traditionally been engaged in the supply chain late in the project schedule, making the real as-built truss information unavailable for coordination during the critical stages of design. As an IPD structural engineer, you will learn how you can now solicit truss fabricators for 3D Building Information Modeling (BIM) deliverables for your upcoming projects. The class will demonstrate coordination and clash detection that is often missed in a 2D framing review process.)

Learning Objectives

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

- Describe best practices for architectural modeling with structural domain information
- Use of collaborative workflows with truss and wall panel (component) fabricators
- Complete Autodesk Revit Structure model exchanges with tools in Autodesk® Building Design Suite
- Use clash detection for prefabricated wood structures

About the Speaker

Based in the DFW area of Texas, Steve is a Product Manager for the development of new software driven solutions for Structural Detailing on the Autodesk platform. He brings over 20 years of experience with fabricated wood structures to his position. His background includes not only design and engineering, but manufacturing and installation of all types of wood structures including custom and production single family residential design, multifamily, assisted living, military housing, and hospitality projects. Having operated multiple fabrication facilities and providing turnkey installation with his own framing crews, Steve brings a practical perspective to the workflows that make BIM solutions workable in this highly fragmented industry. Steve can be reached at steveb@itwbcg.com

About the Co-presenters

Will Ikerd, PE, LEED AP
au@ikerd.com
Principal, President
IKERD consulting

Will Ikerd is a nationally recognized consultant in structural engineering and building enclosures utilizing Building Information Modeling in both design and construction. Will also specializes in implementing BIM strategies for construction management firms interested in expanding their work in Virtual Design and Construction (VDC). He co-chairs the national American Society of Civil Engineers (ASCE) Structural Engineering Institute - Council of American Structural Engineering (SEI-CASE) committee on BIM, is co-chair of the BIM Forum's Designer's Sub-forum, and chairs the Structural Engineers Association of Texas Committee on BIM. Will is also a member of American Institute of Steel Construction (AISC) Technology Integration (TI) committee for the steel industry use of BIM and a member of American Concrete Institute (ACI) 131 Committee on BIM for concrete. He is a practicing professional engineer who frequently speaks and writes about BIM, civil, and structural engineering, and building enclosure design. He is Principal at IKERD Consulting LLC and can be reached at au@ikerd.com.

Brad Blissit
bblissit@integratedstructural.com
Founder, President
Integrated Structural Concepts

Brad Blissit is the Founder and President of Integrated Structural Concepts (ISC) based in Phoenix, AZ. ISC combines structural engineering with BIM and IPD to provide an integrated design-build solution for the multifamily wood frame market. With the early adoption of BIM, ISC continues to integrate technology with real world construction techniques, such as post tension foundation design, wall panel detailing, truss design and turn-key foundation and framing installation. His background in general contracting/homebuilding and long career in the multifamily component manufacturing industry provided a unique perspective on how wood frame projects are traditionally designed and constructed. Brad's vision for the multifamily industry is to create dynamic teams that use BIM and IPD to streamline the design and construction process, while eliminating risks for owners.

About this Session and Paper

This session is presented to show that the Architectural, Structural, and Construction BIM workflows that are changing the way structures are built, need not be restricted to concrete and steel systems. Timber construction is one of the most sustainable structural systems available today with new technologies that enable use of younger, renewable forests including small member sizes used in connector plated trusses, light frame wood systems, and engineered wood products such as I-Joists. Residential and light commercial buildings have been constructed using prefabrication methodologies since the 1950's and in times of resource challenged labor pools, wood components present an ideal opportunity to take advantage of lean processes that BIM and IPD make possible with Revit and other Autodesk based solutions.

The learning objectives of this presentation are demonstrated using two key market segments:

- *Single Family Residential* including production builders, custom, and semi-custom which can all benefit from BIM enabled workflows.
- *Multi-Unit Construction* which includes Multifamily residential, Hospitality (Hotels/Motels), Assisted Living, Dormitories, Military Housing, and other repetitive unit type construction.

General Overview: BIM and the Light Frame Wood Supply Chain

The Value of Residential BIM

There is no ROI on BIM without a Happy Owner! We can look down our noses at 2d CAD and draw LOD 500 quality 3d on every job, but if the wrong building gets delivered at the wrong time it simply is not going to end well. We've all experienced that in the commercial world where the stakes are high and the risks are higher. But nowhere is the Owner closer to the end game building delivery action than in the Residential market - the empowered Homeowner. Where else can the end Owner walk through the jobsite every afternoon on her way home from work, pick up the phone and wreak havoc on the harried contractor? As a result conveying architectural intent and design selections is paramount in the residential wood framing business. Fortunately, the smarter residential builders are adopting lean BIM driven processes and leading an industry typically known for low tech solutions. The wood framing supply chain is a direct reflection of that paradigm shift. Some get it… and some simply don't.

Figure 1-Happy Now?

Figure 2-Happy Then!

The Light Frame Wood Supply Chain

In order to deliver the value that the homeowner expects, the supply chain has to preserve the architectural intent from design to construction. This is not easy when you consider that the plans are typically redrawn or traced 5 or 6 times just to accommodate people using their own software solutions at every step in the process. The estimator uses one package, the wall panel or truss designers use something else, the I-Joist detailer, yet another. Is it any wonder we have so much waste lumber going to the landfills! With today's Revit extensions, the architectural model can be transferred directly into BIM enabled framing solutions.

Figure 3-The Value Chain

Although wood trusses and wall panels have been around for decades, only with recent BIM advances can upstream building designers take advantage of intelligent BIM workflows. However, not all BIM is created equal. For decades, being the Structural Engineer of Record (SEOR) meant adding some design calc information to 2d construction documents and waiting for the dreaded stack

Figure 4-Truss Calcs! Look Familiar?

of truss calcs to see if the design intent made it through the gauntlet of redraws typical in the wood supply chain. The truss industry has been doing 3d modeling since it was possible in the 80's and 90's. But until now, as a building designer all you could do at the earlier stages was reference 2d Shop drawings to get the information to design a more efficient building. Today with Revit extensions you can communicate directly with your truss manufacturer and know exactly what you need to know.

Conceptual Trusses vs. As Built Trusses

Before BIM as a structural engineer you knew you were going to use trusses on a project, but unless you had a friend at the truss plant, you were just guessing at the final layout of trusses that would end up on your building. SURE, you knew you had the last say with shop drawing approval, but that was long after you had moved on to another project and had to go back and wrap your head around it again.

At design stage you typically draw 2d Conceptual Truss Profiles in the Design BIM to give the fabricator an idea of how you want them to layout the trusses in general terms. Forget about design loads trickling from above or supporting equipment or sprinkler piping from the trusses. Frankly you haven't cared because that's what the truss designer gets paid to do. But what about all the wasted phone calls in the last minute frenzy to deliver the project on time and under budget? Does all that really add value? Do you really see an opportunity here? You should if you want to be viable and relevant in your market.

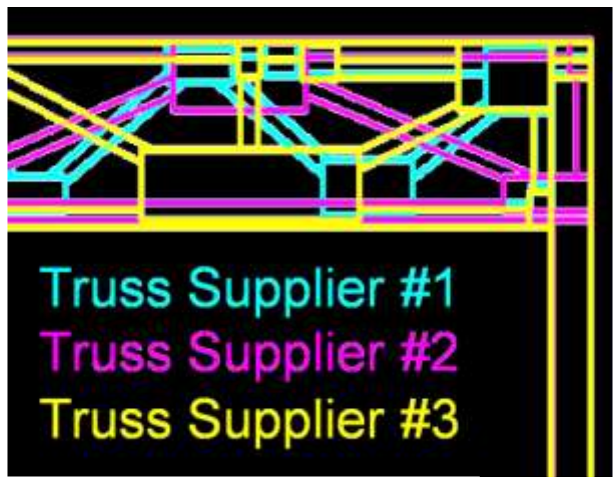


Figure 3-Where does the MEP go?

With Revit you can draw conceptual 3d Truss profiles, but how much value does that add without the rich data that is only available in the manufacturer's designed system and locked up in those shop drawings? An engineered truss layout is a system in which all the trusses work together. Shouldn't the trusses 'work together' with your other structural systems? Your steel moment frames? Your concrete foundations? Isn't this the value that the truss manufacturer adds to the project? Is it accessible in your BIM Model?

Shouldn't the trusses 'work together' with your other structural systems? Your steel moment frames? Your concrete foundations?

In the Post-BIM world of 2012, key truss and panel component suppliers are BIM-enabled. But all BIM is not the same, and all BIM workflows are not equal. Let's investigate a little deeper!

Architectural Modeling with Structural Domain Information

In order for Construction BIM to add value it must receive Structurally accurate geometry and attribute information from the Design BIM Model.

Models Should be based on Available Construction Materials

One of the most compelling reasons building owners invest in BIM modeling is to determine true costs of the building as early in the design process as possible. True cost is dependent on true materials. With Revit the user is actually building the model virtually with real materials. Just as a W shape is a real material with real properties for design and quantification, wood beams and sheets are real objects when you set up your families correctly. A 2x4 wall can actually be modeled with 2x4 studs and plates. A header over a door or window is actually modeled using dimensional lumber, connector plated headers, or engineered wood products. Only when modeling with real materials in real dimensions can you get real benefits out of BIM for all workflows downstream from the building designer. As the model passes through the supply chain, it is imperative for costing and procurement that quantities are generated using true products.

> Only when modeling with real materials in real dimensions can you get real benefits out

Models should be based on Actual Structural Geometry

Wall and Floor Geometry

- *Did you know that east of the Rockies, pre-cut (PET) studs are typically 92-5/8" long while Doug Fir out west runs 92-1/4"?*
- *Did you know that a 2x4 is 3-1/2" thick in North America? A 2x6 is 5-1/2"? Do you still draw walls 4" or 6" thick including drywall?*

In your Structural BIM models that you would like to share downstream with the supply chain, you should be using a 3-1/2" Structural core in your Wall families and the height should be based on the standard pre-cut studs available in the market where your project is being

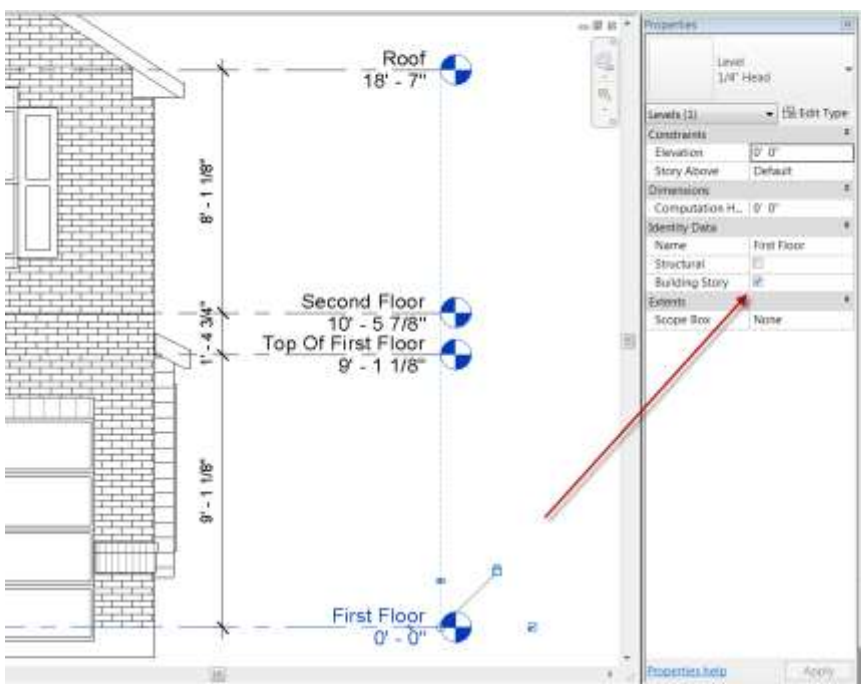


Figure 4-Proper Structural Geometry is Essential so Support Prefabricated Workflows

framed! Setting the Story parameters at each level is essential to support external BIM workflows including IFC.

Roof Geometry

Light frame wood roofs come in two repetitive member systems: Rafters and Trusses. How you set up your roof families and geometry has a tremendous impact on the downstream usability of your models. A rafter system consists of individual members framing into one another in an intricate balance of compression and tension. A rafter roof will typically require an entirely secondary ceiling joist system that is, for the most part, independent, but must nonetheless interact with the other structural systems within the model.

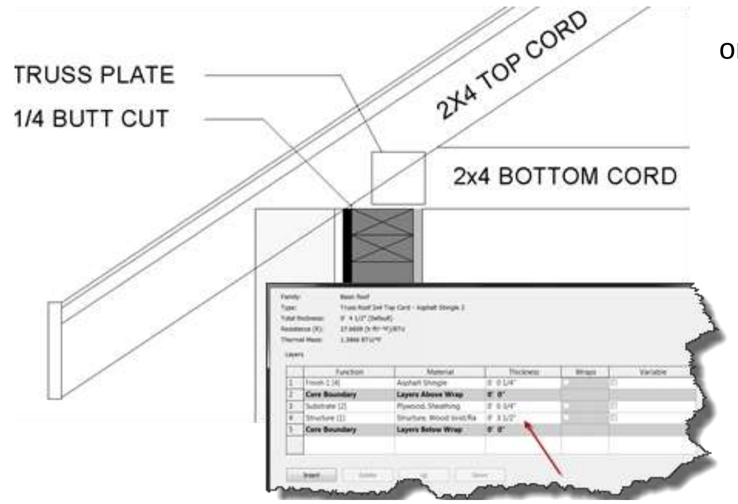


Figure 5-Proper Structural Geometry is Essential so Support Prefabricated Workflows. An eave detail set up for trussed roof is shown here.

Trussed roofs, often referred to as trussed rafters or connector plated trusses, eliminate the requirement for a second system of ceiling joists as the profile of the truss creates both. However, for this to work, the geometry at the eaves of the building must be set up differently for trusses than for rafters.

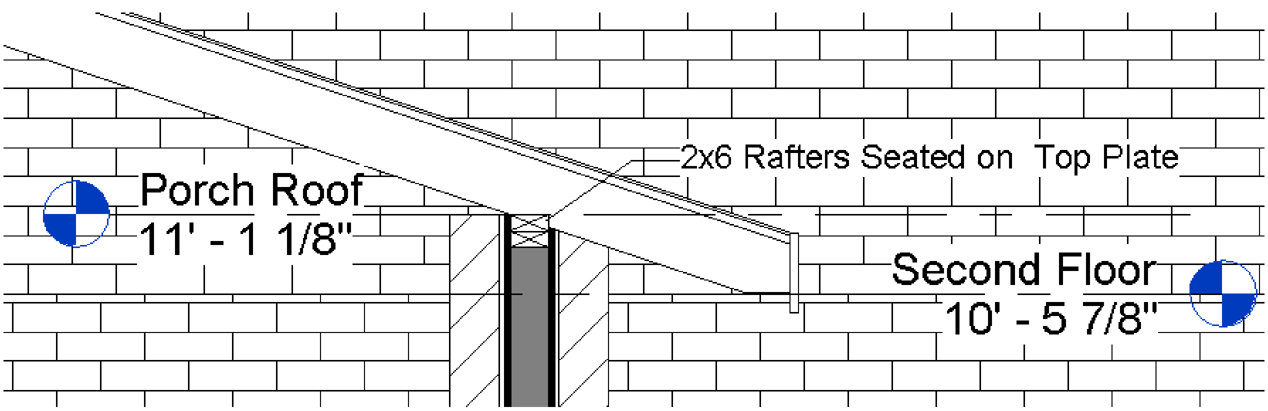


Figure 6-An Eave with geometry for a Rafter style roof is shown here.

Door and Window Families

One of the beauties of Revit is the rich set of parameter data that can be made available on the families. Doors, windows, fireplaces, and medicine cabinets are just a few of the items that affect the geometry of the wood frame. Whenever one of these objects penetrates a wall, the framing must react accordingly, inserting a header or lintel to distribute vertical loads around the opening and applying the support members at each side of the opening. But to get these positioned correctly in the wall framing, it is important to add the rough opening information to any family that will penetrate the wall cavity. The examples below show where this information should be entered for Door and Window families. This represents the actual size of the hole to be cut out in the wall framing and sheathing, if desired. This information is typically available from the manufacturer of the product.

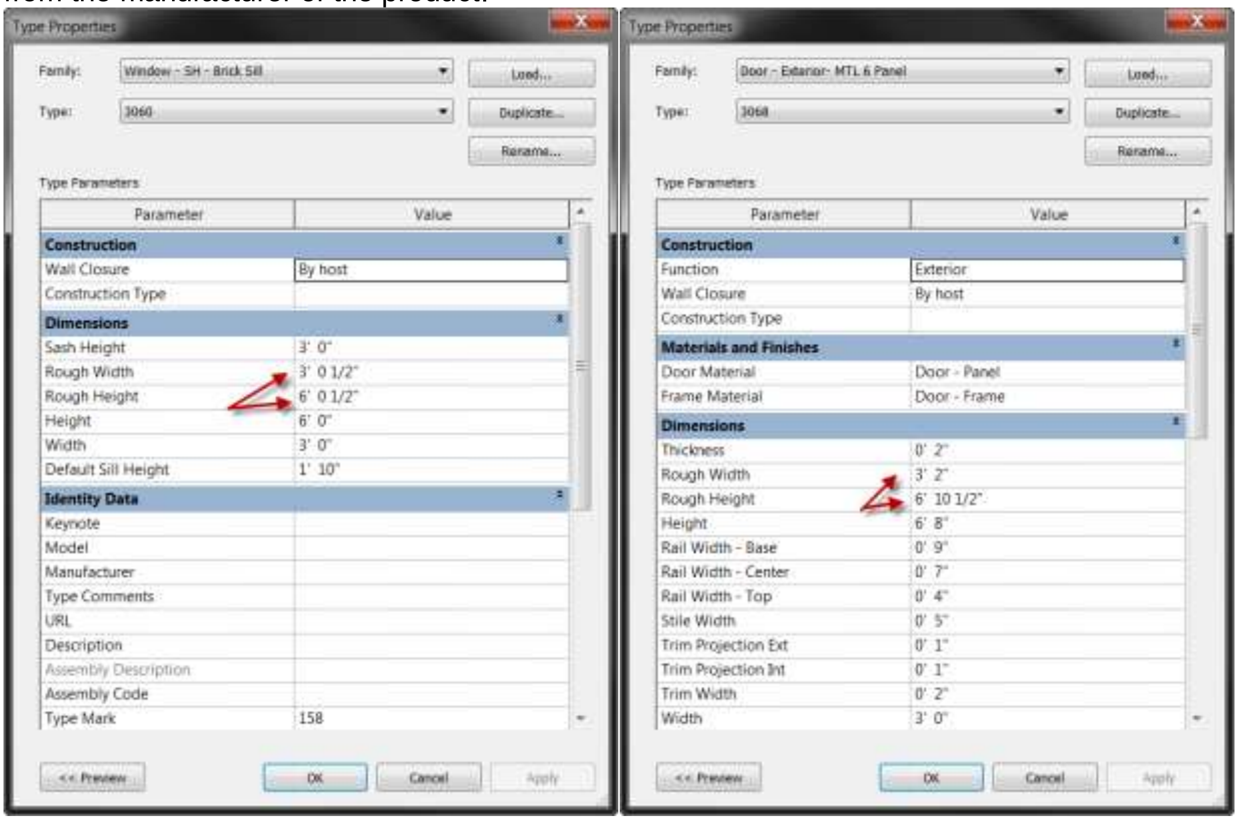


Figure 7-Set up of rough opening information is important to support prefabricated wall panel workflows.

Collaborative Workflows with Wood Component Manufacturers

The whole point of setting up your initial model and families with proper structural geometry and parameters is to support downstream construction workflows. One use of Revit BIM data is the generation of Quantity Take Offs. Another tremendous opportunity is taking advantage of prefabrication workflows in the light frame wood market, more precisely trusses, wall panels, and I-Joists. There are numerous solutions in today's market to transfer Revit models to 3rd party framing solutions. The solutions used in today's demo are built on one of the AutoCAD Building Design Suite® products, more precisely, AutoCAD Architecture®.

Roof and Floor Truss Manufacturers

At this point, the Revit model is exported in a format acceptable to the truss manufacturer with whom you are collaborating. There are typically two flavors of model data exchange. One is the IFC model which is quickly becoming the international standard for exchanging such rich model data. The other and more typical approach is via a proprietary 3rd party plug-in that facilitates the rich full model data exchanges between BIM softwares required to support manufacturing accuracy. This is the case in the software being used in today's demonstration.

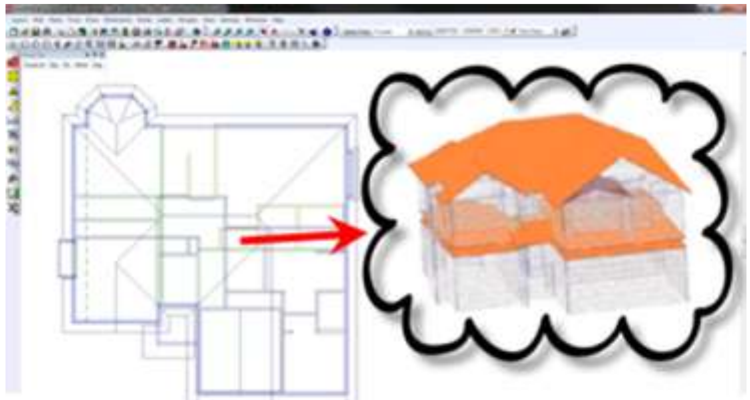


Figure 8-Model Roof Geometry should seamlessly Import

Once received into the truss software solution, the truss designer should have accurate:

- roof plane and overhang information
- proper levels and bearing heights
- identified bearing locations
- Exposed surfaces to pick up wind resistance
- Other information such as shear walls depending on the design workflow that has taken place to date on the model.

Of course, as the old axiom goes, 'garbage in, garbage out' so even though Revit plug-ins may provide tools to help establish geometry and parameters, there is no replacement for building system knowledge. This is at the heart of collaboration and presents the greatest opportunity to add value to adjacent partners in the supply chain.

Wall Panel or Timber Frame Manufacturers

Whether used for modeling site framed or panelized wall frames in specific markets, the Revit model data is rich enough with data to bring tremendous productivity enhancements to the wall manufacturer. As described above, geometric design intent is automatically interpreted based on wall height, level positions, and rough opening parameters. The manufacturer can then concentrate on his core strength and adding the value to his part of the supply chain in breaking and bundling walls and optimizing lumber and sheathing usage.

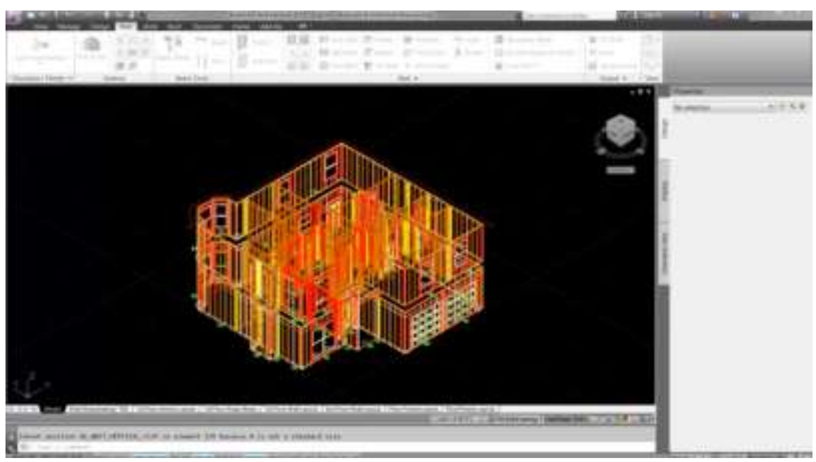


Figure 9-Framing the structural core of the wall should be a snap

Special framing to support loads from the trusses above can now be applied to wall panel and hardware solutions that tie it all together finish up the package design. Advanced Framing techniques and other value propositions are finally within reach of the BIM enabled workflow.

EWP Floor Systems

The ubiquitous I=Joist floor system enjoys roughly a 50% market share in the light frame wood market. The various manufacturers have solutions that can receive BIM model data just as the truss and panel industry can. The level of detail received is only limited by the BIM strategy of the EWP manufacturer and is dependent on the richness of the data that can be interpreted by the I-Joist import solution. Truss and wall information can be shared between such solutions.

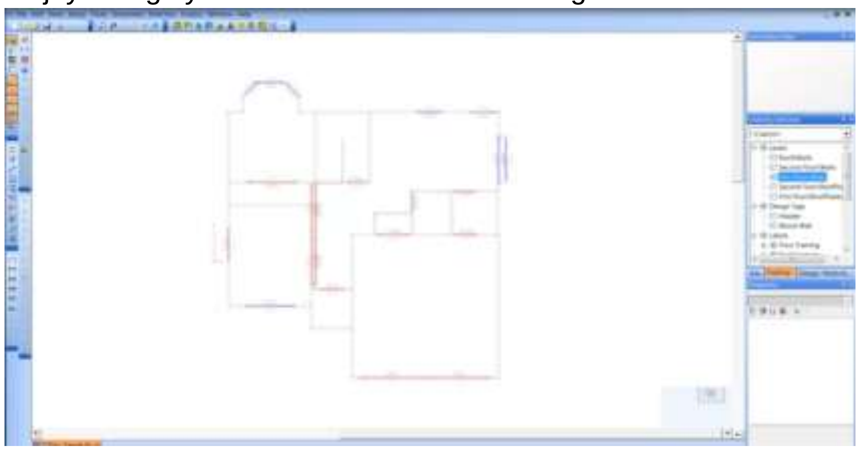


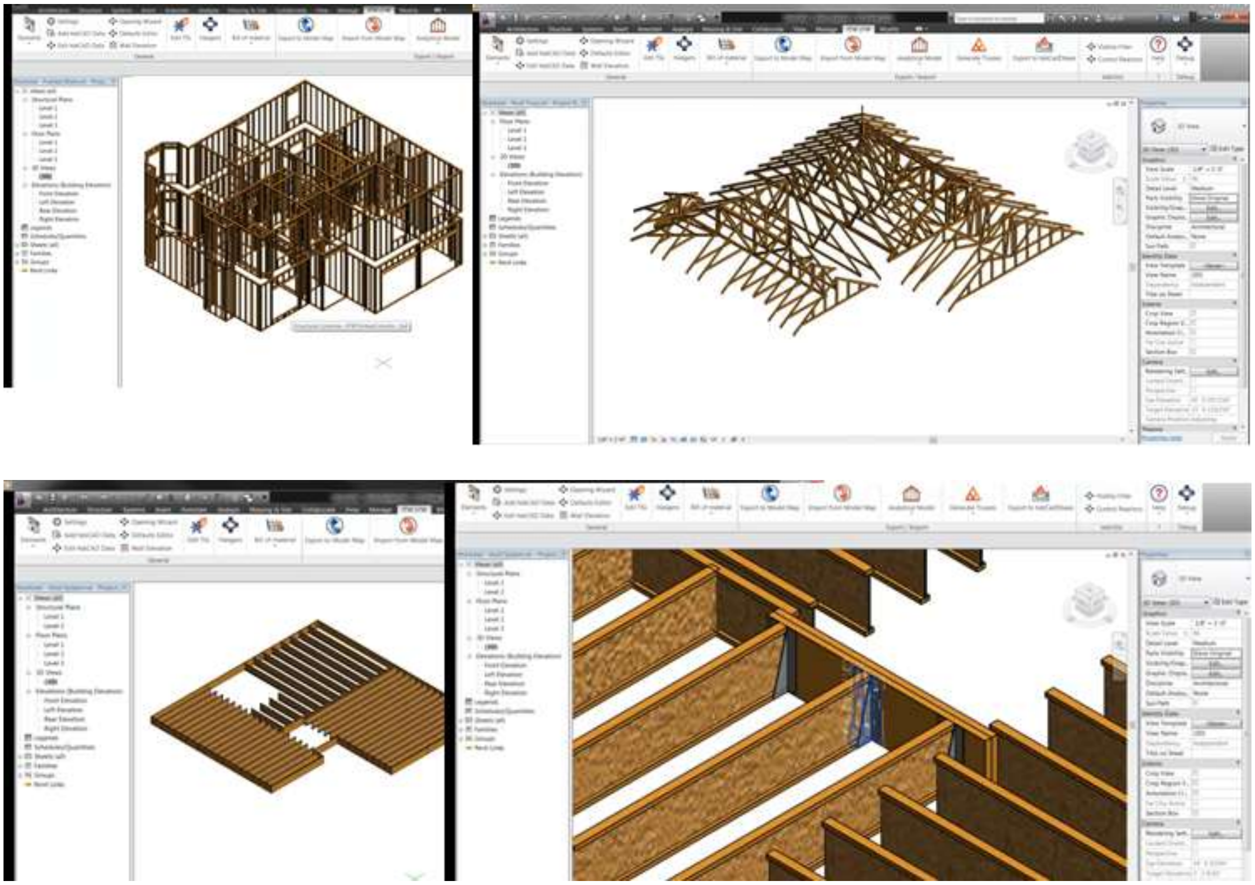
Figure 10- Open BIM-enabled I-Joist (EWP) Solutions share the same model as trusses and wall panels

Accurate Model Exchanges within the Autodesk® Building Design Suite

Complete Model Exchanges

The value of developing a light frame wood structural BIM model is reduced tremendously if the model is only a one way transfer from the Design BIM to the Construction BIM. Such a closed BIM solution, while beneficial to the supply chain, does not facilitate true model interoperability. In order for the Structural Engineer of Record to interface his structural steel or concrete systems with the corresponding timber framing, the results must be available inside the Design BIM. This is typically done using linked models in larger framed models.

Accurate framing representation is essential, for example, to develop shear wall locations and anchor placements needed by the foundation trades. Stepped foundations, or sloped lots that require partial crawlspace or basement systems will only bring complete value when the structural framing is federated back into the design model.



In addition, the powerful sectioning and scheduling tools inside Revit can take advantage of properly modeled and detailed structural framing ***only if it is present in the model!***

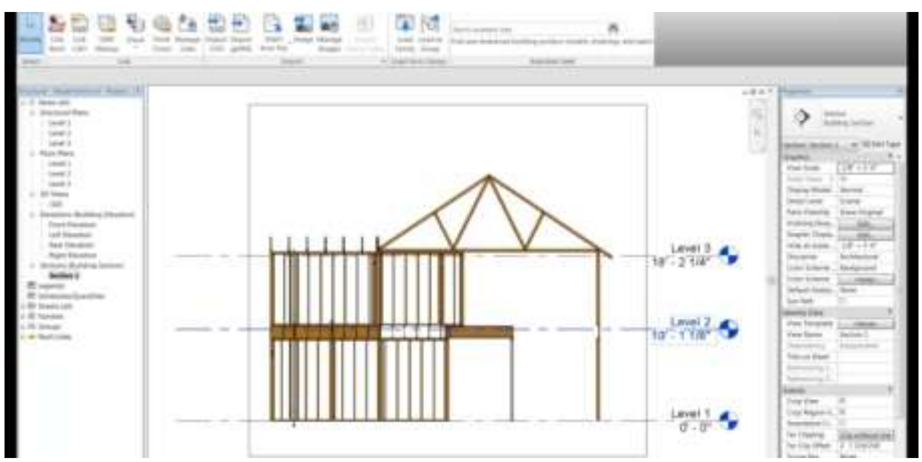


Figure 11-A few examples of how BIM should work for Manufacturing

Clash Detection within Prefabricated Timber Workflows

Figure 12-BIM enabled IPD should stop this kind of costly repair

One of the primary benefits of BIM enabled prefabrication workflows in particular, is the possibility to now perform clash detection on As Built trusses and other wood components. In this image, the plumber took his liberties in cutting the top flange of the I-Joist in order to get his drain into the floor cavity. In all likelihood he may not have had a choice depending on the location of the fixture above. But had a structural timber BIM been in play and a participating Piping vendor, there would have been significant savings on the engineers time to design a repair, the onsite framer to do the repair (and likely charge a premium) with the associated back charges and phone calls. In the example below, there was a duct chase allowed in the trusses by the manufacturer, but had the prefabricated ductwork arrived onsite, it would have had to be modified in the field to avoid cutting through several truss webs rendering them useless. At that point, what is the point of prefabrication?

Coordination with trade models is seen as one of the greatest benefits of supporting BIM in the light frame wood industry.

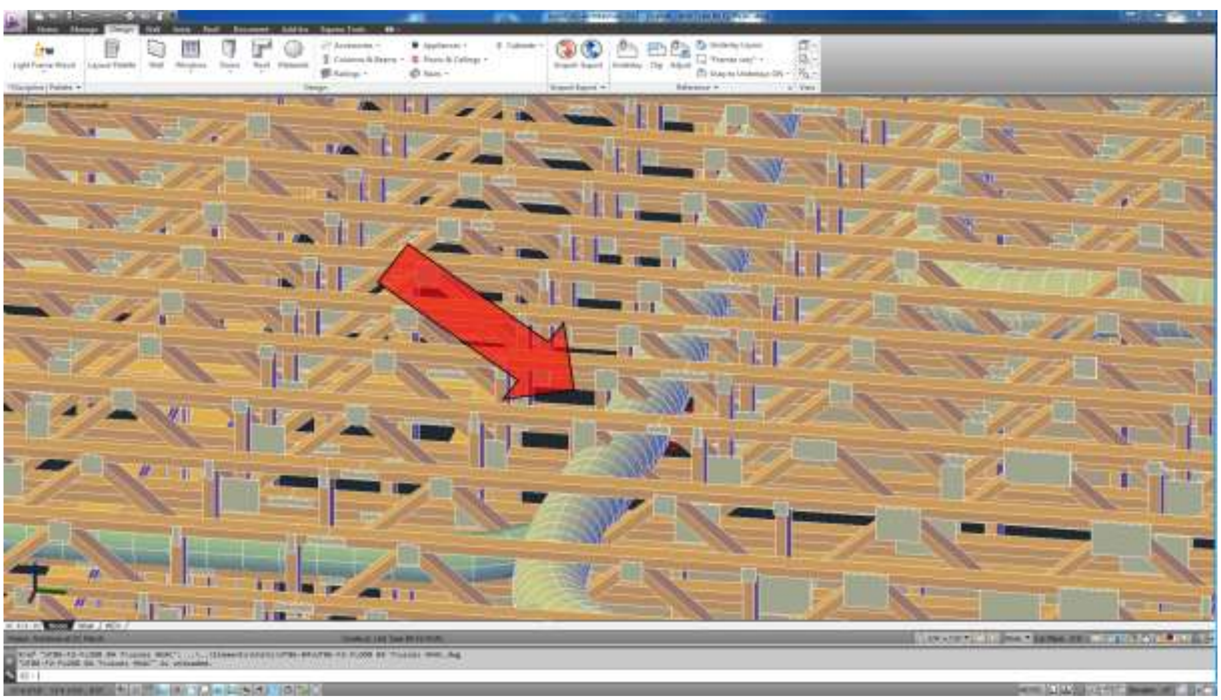


Figure 13-Floor Trusses are intended to accommodate MEP such as this Ductwork

Level of Detail, Light Frame Wood Trusses

Wood Floor Truss and I-Joist systems are a class of structural content that are made of engineered products and vary by manufacturer. As such, the generic joist content in Revit looks highly detailed but is not necessarily accurate as it relates to the chord sizes and web configurations. The joist depths and weight are correct. However, there are many different manufacturers who make I-Joists and Floor Trusses and they have considerable freedom to design the web configurations, truss bearing configurations, and chord build-ups. No two manufacturers will be the same as shown earlier. There is little value in designers creating custom joists to approximate these manufacture's unknowns. It is typically better to specify that the joist manufacture will provide a 3D model of their content as part of the shop drawings. This is particularly important if MEP or other trades need to run building systems through the webs of the joists as described

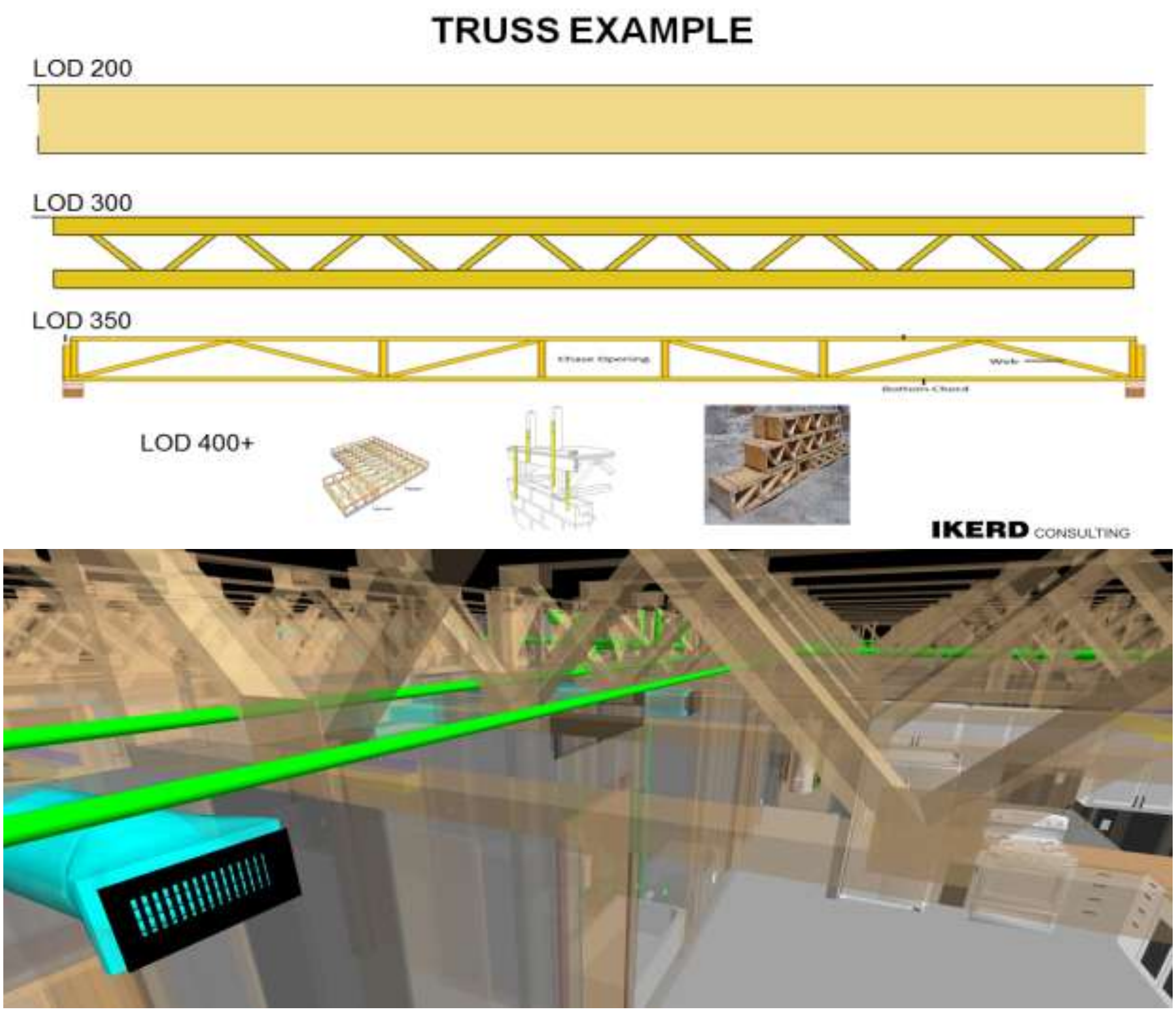


Figure 14-Level of Development Applies to Light Frame Wood Systems