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## Modeling a Wood Structure with Revit Structure

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**SE214-2** The objective of this class is to explore how a large, wooden structure is modeled in Revit Structure. We'll examine the model creation process for two projects: a 4-story university student-housing building and a church chapel. In each case, the project architect is using Revit. We will investigate how the structural model is linked and coordinated with the architectural model and how it is used during the design process. We'll focus on wood framing and wood shear-wall modeling, as well as other specific techniques required for this form of building design. The other main focus will be the derivation of 2D documentation from the model. After completing this class, you'll have a better understanding of the techniques for wood modeling using Revit Structure.

### About the Speaker:

Tom is Director of BIM & CAD Operations at Brandow & Johnston Incorporated, a structural engineering consulting firm in Los Angeles, California. An early adopter and enthusiast of Revit modeling software, he is the founder and president of the Los Angeles Revit Users Group. Tom wrote the first AOTC "Revit Structure Essentials" manual for Autodesk, is moderator on the AUGI Revit Structure forum, and has taught at Autodesk University for the past two years.

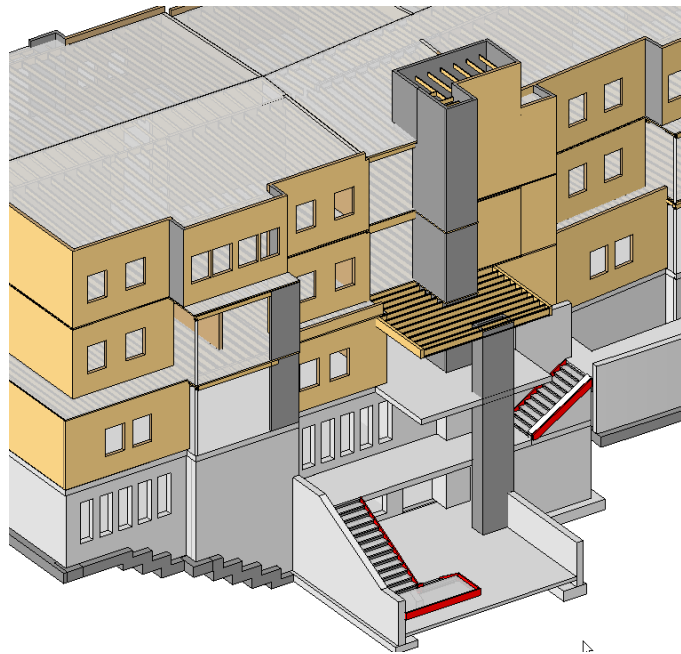
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## Introduction

First let me thank you for signing up this course. Over the last three and a half years I have had the opportunity to work on over 100 projects using Revit Structure software. Quite a number of those have involved wood design in some way or another. None of these projects were residential in nature. Most involved some concrete and light steel framing as well as wood materials. I work in California with its complex earthquake code requirements, adding another level of complexity to the projects. So this class is intended to display some of those projects and to explore how they were developed.



## Objectives for this class:

Today's objective will be to examine several of these larger wood structure projects in order to examine the modeling techniques I have been using to create the construction documents. We will examine the elements necessary to create a BIM solution from this type of structure. I will not examine any residential projects, nor will I talk about the structural analysis of these structures. I will present the problem areas that I have experienced and suggest solutions that I think need to be incorporated into the basic Revit Structure program.

## Overview:

The challenge for us today is to define and generate a BIM solution for the design of wood structures, and to prove the need of more support from the Revit Structure developers.

That is why I was so impressed to see over 130 people signing up for this class. I was expecting half this many at best. Perhaps that is our first indication that a lot of people are doing this sort of design work with Revit Structure.

When I heard my proposal for this course had been accepted I decided to contact the Revit Structure developer's to question them on their intent for the program in regards to improvements and additions for wood design that might be included in future releases. By chance I was going on vacation in my home state of Massachusetts (GO Patriots!) and decided I would pay a visit to my friends at Autodesk at the Revit Structure "factory" in Waltham. So I prepared a list of questions concerning problem areas that I am seeking some help on, and we met one afternoon for a long conversation.



**Fishing as the sun rises on Cape Cod**



**the "Factory"**

### **Problems posed to the Revit Structure developers:**

1. Modeling a complete stud wall parametrically: showing the top and bottom plates as well as the stud layout, and wood sheathing in the case of a shear wall.
2. Modeling shear wall hold downs that appear in plan and elevation and are hosted by the wall family. Hold down anchor annotations with coordination between plan and elevation
3. Door headers: we normally see a symbolic hidden line on the floor above, but the header itself is on the floor below if accurately modeled.



4. Making window and door families that have the framing already attached, i.e. studs, headers and sills, and are hosted by parametrically driven complete walls.
5. Shear wall tags that automatically calculate and display the shear wall length.
6. A steel beam family with shaped nailers on top that works parametrically.
7. Adding bridging in a more automated fashion.
8. A way to model floor and roof framing so that not every piece shows in course mode, even though all the members are modeled and show in 3D.

The result of our conversation, in short, was that there has not been as much development in wood design as I had hoped. Part of our conversation touched on the fact that over 70% of buildings constructed in the world use concrete as their primary material. So as might be expected this has tended to receive more of the research dollars at the company. Indeed much of our conversation centered on improvements pending in the concrete portions of the program.

At my company we do hundreds of projects, large and small, each year. We do a mix of concrete, steel, and wood design on both new and existing structures. The Revit developers said that most of the engineering companies in the world only work in one material, and most of those are in concrete. That is not true for my company and this surprised me. But as they pointed out wood construction it is quite prevalent in the Southern California market due to the abundance of wood that is available.

I said that for me the BIM software solution that I want to purchase will be an all around program that gives me design capabilities in wood, steel, and concrete.



**The RST lineup: Wai Chu, Matt Jezyk, and Nicolas Mangon**

I was challenged to prove to the developers that there was sufficient interest and need in the AEC community for them to put more effort into this area. My experience has been, having known this group for several years, that these developers are the most attentive to its customers as any I have ever come upon. So I take their challenge seriously, and decided that this class would be my first effort at defining and providing examples that they can work with in the future.

I hope that you will join me in this effort and together that we can convince them to make some user-friendly additions to Revit Structure in the area of wood structure design. We can do much of what we need to do right now, but I want the methods to be more specific and to be able to make it more efficient to implement in a real project.

STORY: In my Revit Users meeting several months ago I was approached by a fellow who was just doing his first Revit Structure project, which happened to be in wood. After he had done much of the wall, floor, and roof of the model he showed a great 3D view to his Boss who got quite upset when every stud was not showing in the walls. What could my colleague say to him?

STORY: On the AUGI Revit Structure forum a recent thread on wood had this comment: "Before I got into architecture, I worked as a Carpenter for some 25 years. I would say that a framing plan like this (showing every stud and joist) would be helpful for take-offs, but more than likely the guys in the field wouldn't find a framing plan that detailed all that useful."

Those two stories illustrate some of the differences we see in peoples thinking about this subject. So what is the BIM solution for wood structures. We are not building a static model, but rather using your BIM application to traverse the long and arduous design process; starting with a hazy version of the building until we work through to document every detail of the structure. Our application must be able to flex the model robustly in response to the building design.

Modeling a wood structure is difficult because there are so many pieces in the model to coordinate. I think that is the first and overriding fact to deal with in preparing your model. Are you going to show every stud in the wall, and every joist in the floors and roof? The way we have worked at my office in the dim 2D past (if I can remember that far back into the pre BIM days) is that we would not show each floor joist but rather just a few to indicate the direction of the framing with arrows then pointing to the extent.

But for a BIM solution don't you need to show every piece in order to do clash detection and to ensure the integrity of the structure? If you have seen any of my previous classes you will know that I emphasize the notion that the integrity of the model is of prime importance when creating a BIM model. Since you derive all of your 2D plans, sections, elevations, schedules, etc. from the model the emphasis should be on maintaining the integrity of the model throughout the design process in order to ensure the 2D accuracy.

How can you rely on your model if you have faked part of it by using 2D line work, or if you have left out many elements of the model? If the model is to have downstream value in an integrated design setting you will have to be vigilant in updating your model through the period of the design process.

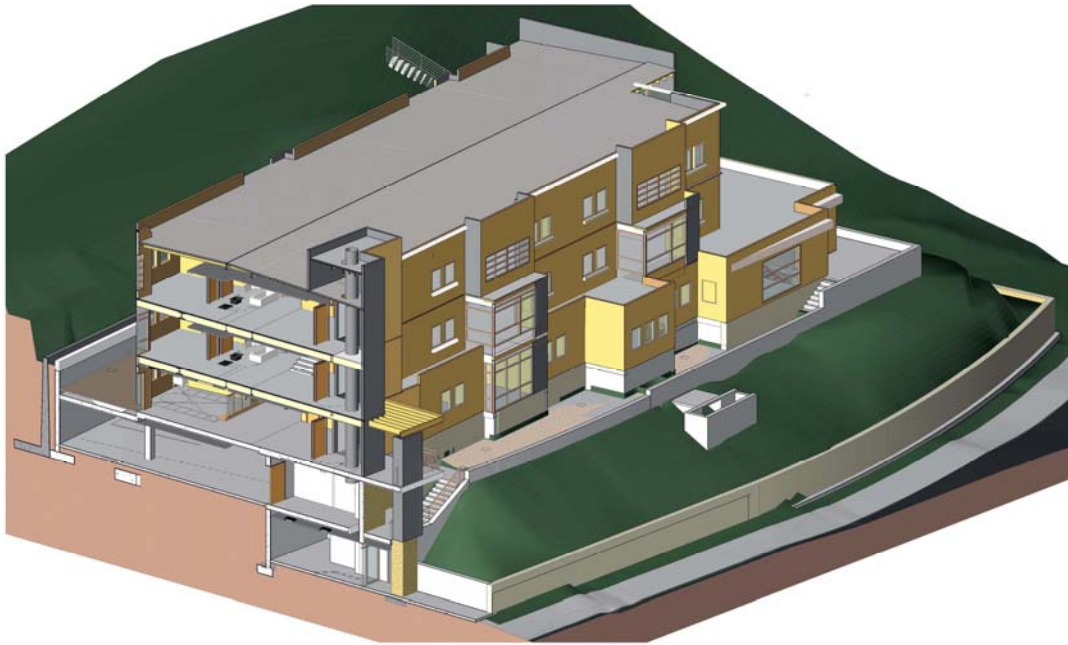
Let's examine some real projects and see how Brandow & Johnston has faced these issues.



## Project Examples:

This example is a three story student housing project on a concrete podium parking garage. This is combined architectural/structural model. The project is now under construction and we are seeing a smaller than expected amount of RFI's, or unexpected conditions on the project. This will be a main focus during the class.

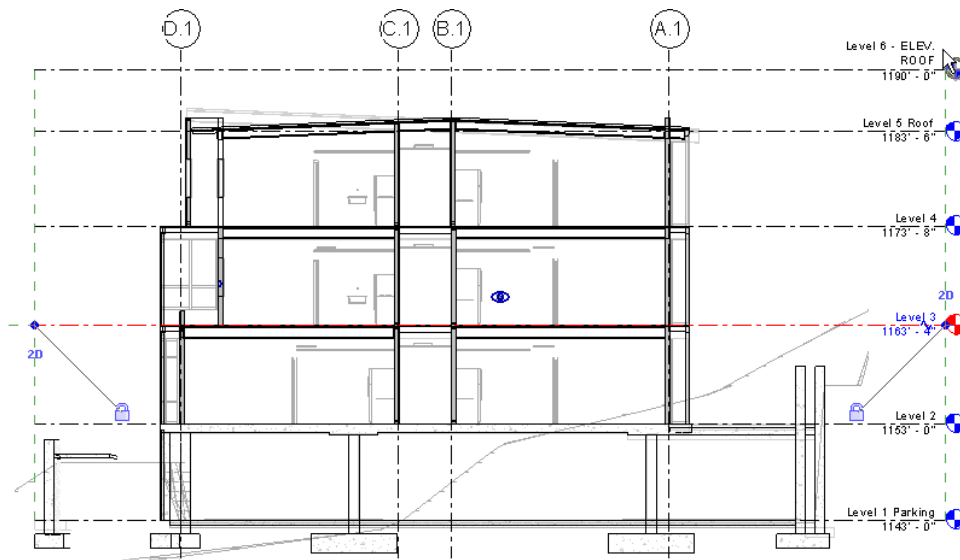
### Example #1: Student Housing



**Student Housing**

Here are the issues we will be discussing:

- Wall type creation
- Wall sections
- Hold down anchors in plan and elevation
- The header issue
- Curb conditions
- Shear wall notations
- 3D stud wall creation

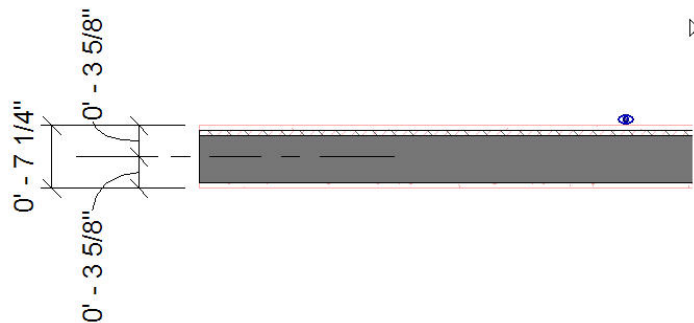


## Building Section

### Linking the architectural model:

The architectural file was linked to the structural file. I then used the copy/monitor feature to add elements to my own model. You will see how that process works.

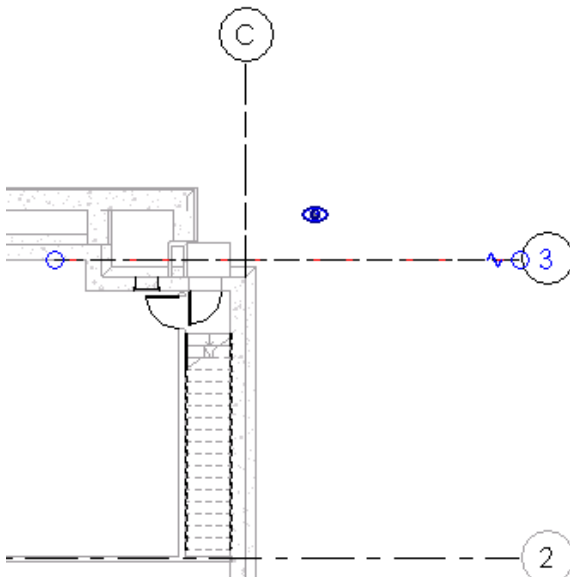
You will also see how the architectural categories were manipulated using the Visibility Graphics controls. With this example you will see how shear wall families were created and used.



### Architectural wall with copied structural wall

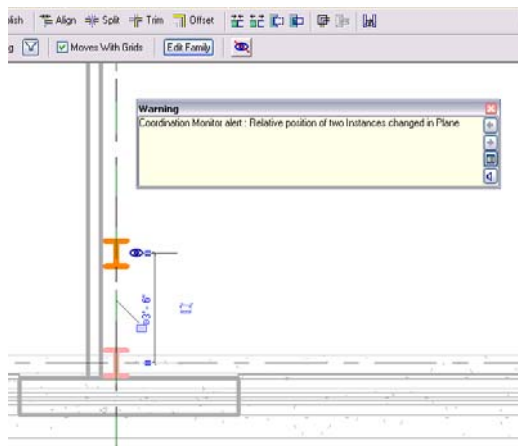
- You need to set your view display discipline to “coordination”
- Link the architectural model using the origin-to-origin option





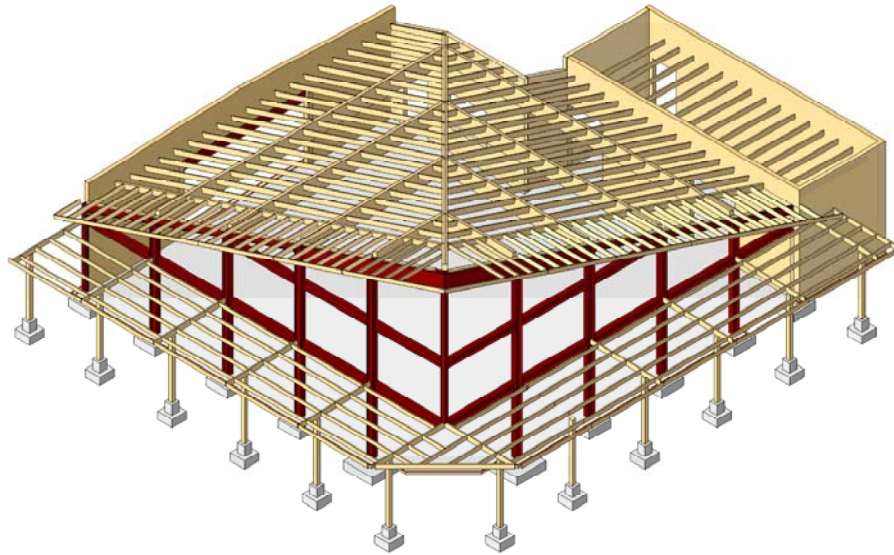
Using the copy/monitor feature:

- In the options prepare the wall mapping from the architectural file
- Add Grids and levels
- Add Columns
- Add Walls and Floors

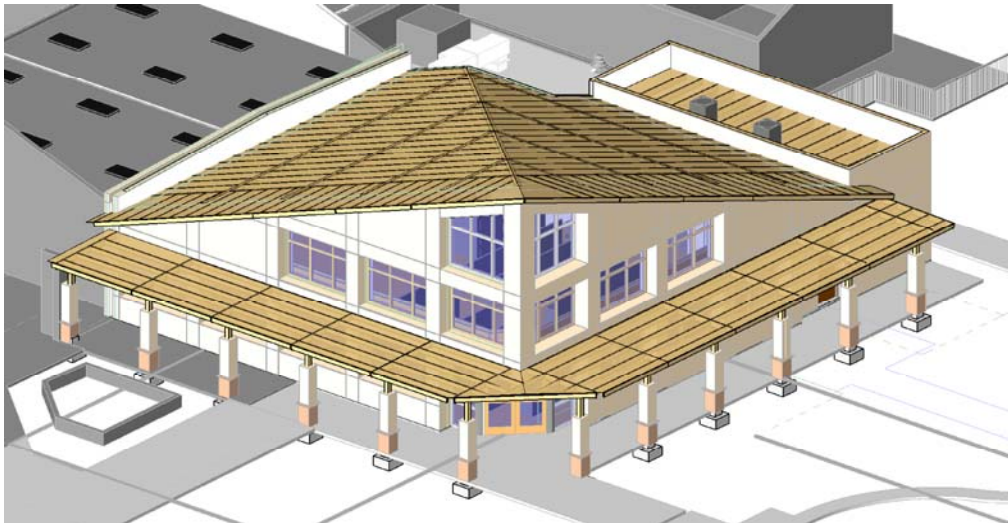


- Pay attention to Coordination Alerts

## Example #2: Church Addition

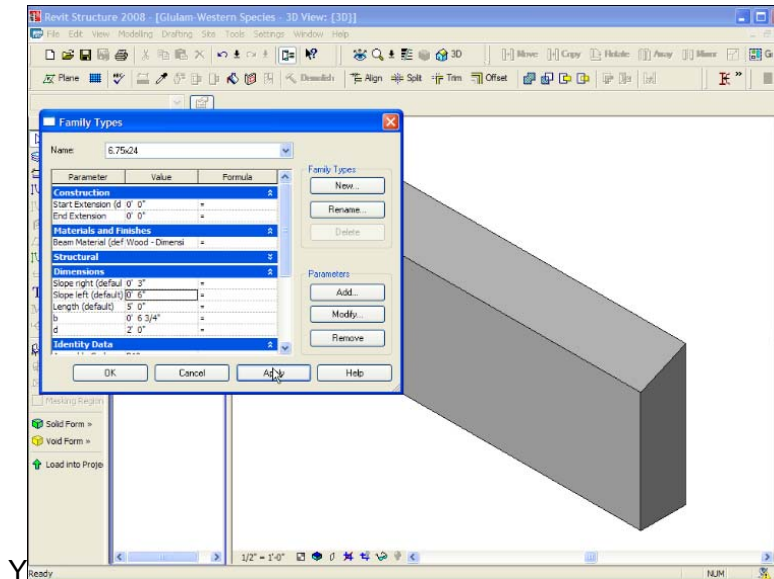


**Structural Church Addition**



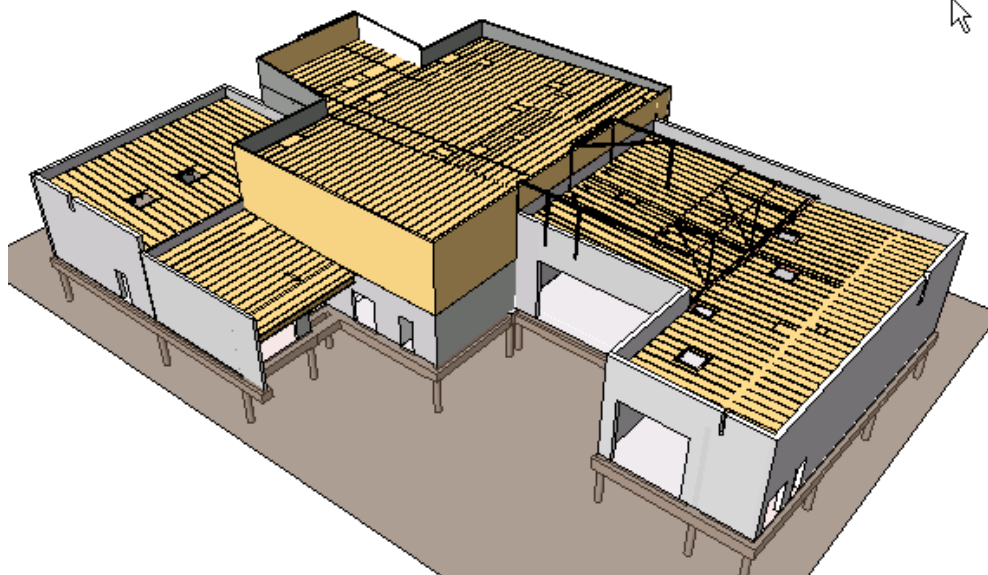
**Partial Architectural view**

This small church addition has large windows areas that necessitated two large steel rigid frames to be added. The roof is made with glulam girders with shaped tops. You could make them with solid extrusions, or a more advanced way is to adapt the wood family for the sloped top.

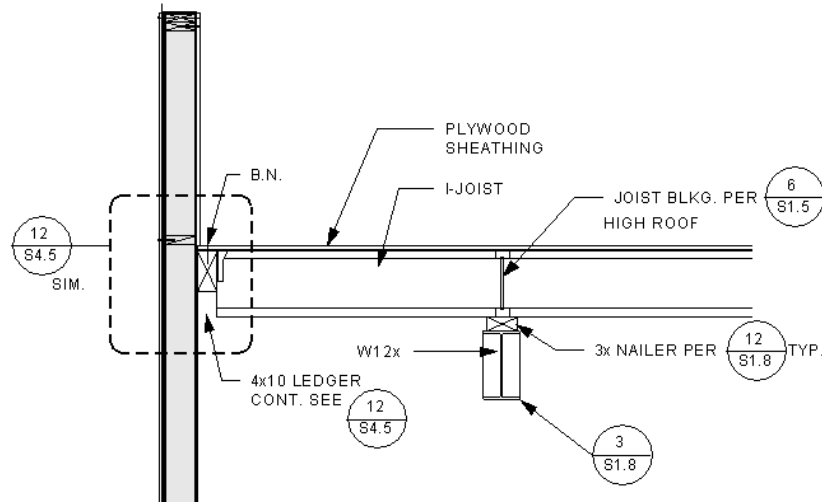


**Adapting the wood family for a sloped top**

### Example #3: Fire Station



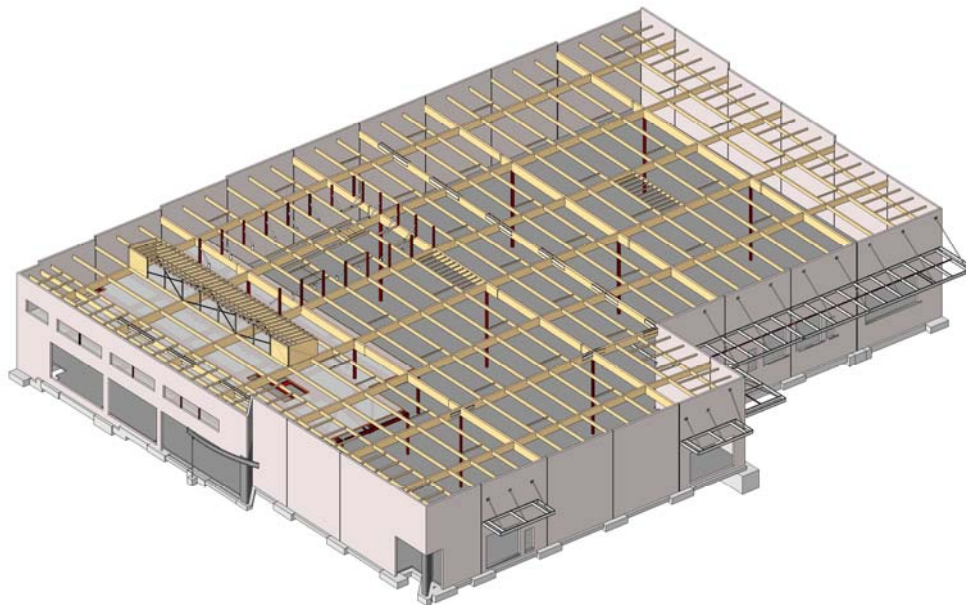
**Fire Station**



**Fire Station Detail**

This example is to show the variety of wood structures that we have been working on. The walls are wood and CMU and the framing members are TJI. We will consider what of the many members we will model and which we will not

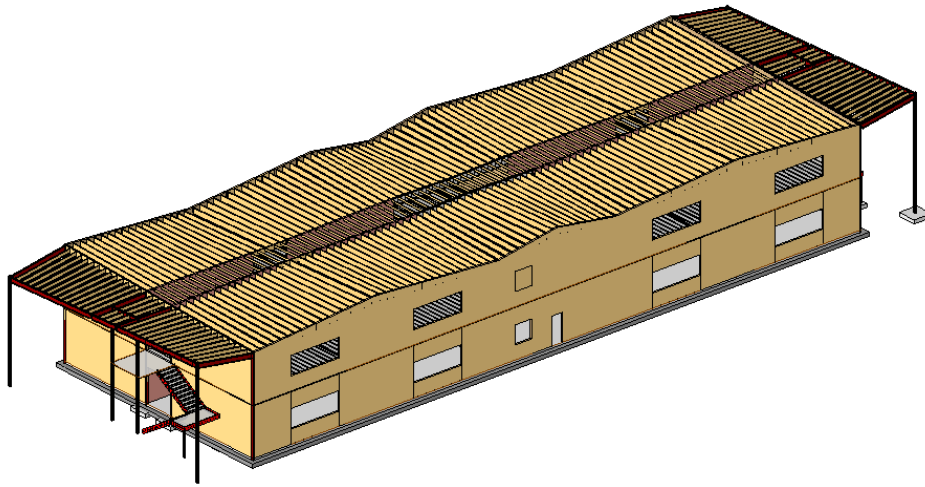
#### **.Example #4: Warehouse**



**Warehouse**

The warehouse is a concrete tilt-up building with glulam girders on steel posts. The whole roof is warped for drainage. This and the next example will demonstrate how to solve warped roof conditions.

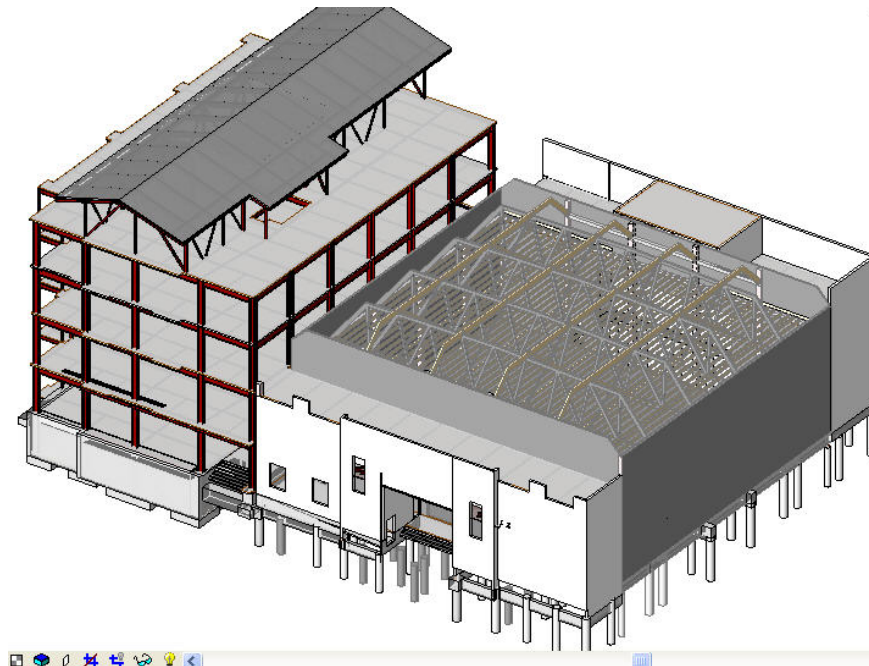
## Example #5: Elementary School



### Elementary School

The elementary school has an extremely difficult roof condition. You will see how this condition can be created. This school was also started with the help of an inserted Form\_Z model.

## Example #6: Existing wood studio

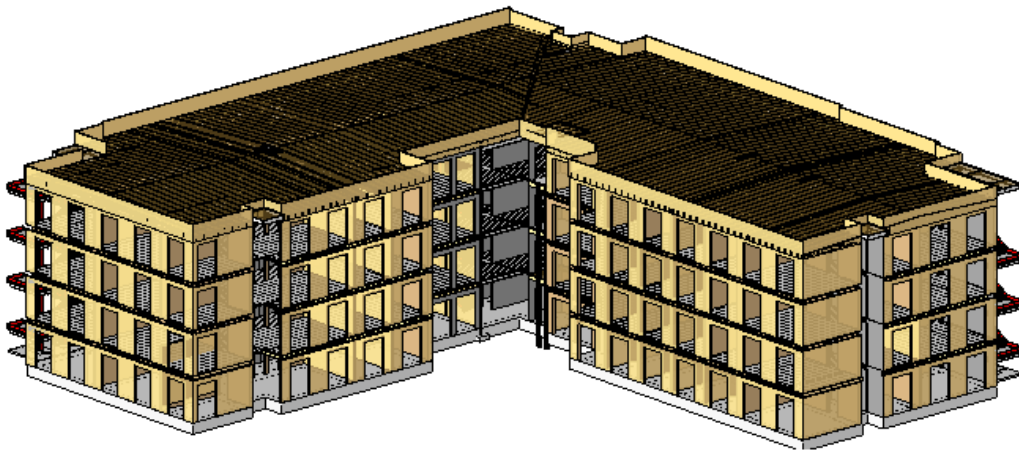


### Existing Film Studio Expansion



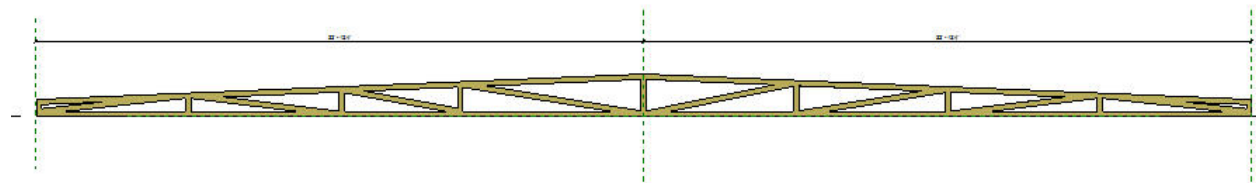
In this case we have large cross wood trusses with bracing in this existing entertainment studio which needs to be retrofitted, as well as the addition of a steel and concrete service building.

## Example #7

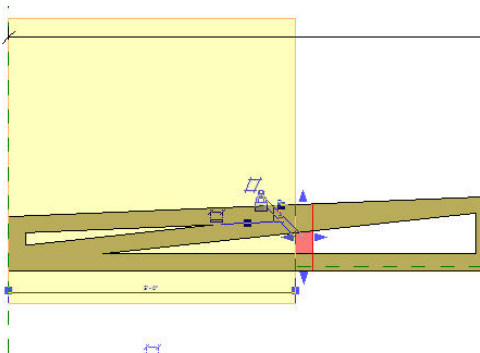


### More Student Housing

In this next example we have some tricky wood truss conditions. Though the centerline of the trusses must be the same for each member, each one is cut back from the standard layout, making many different types. In this case the truss wizard was not quite enough help. I created my own truss family. I then added a void to the truss family in order to cut back the truss where needed. I also arrayed and grouped similar types for easier updating.



### Shallow Wood Truss

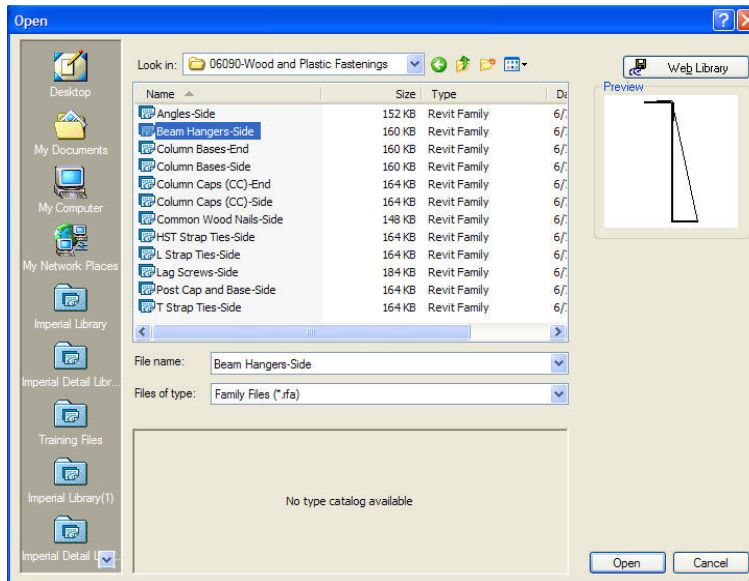


By adding a void with a vertical member attached to it, I was able to adjust the in-place family to automatically shorten the truss at either end.

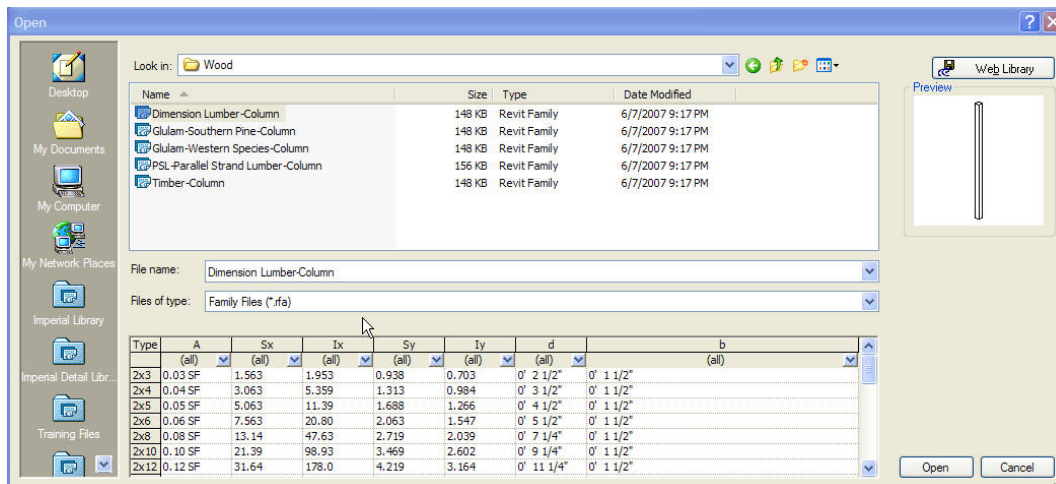
## Survey of existing Wood families and components:

Let's take a quick check of what wood functionality does exist within Revit Structure:

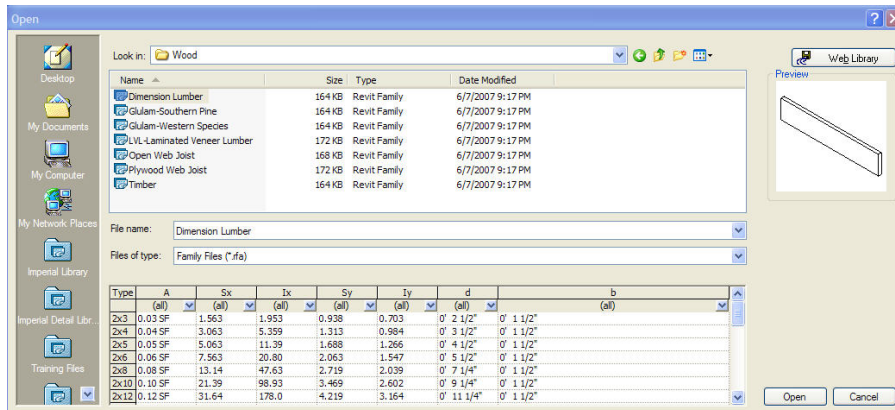
- Model elements: we have basic libraries for columns, sheathing, and framing elements
- Detail components: Bolt and nail, and basic wood connection detail components.



## Wood connection 2D components



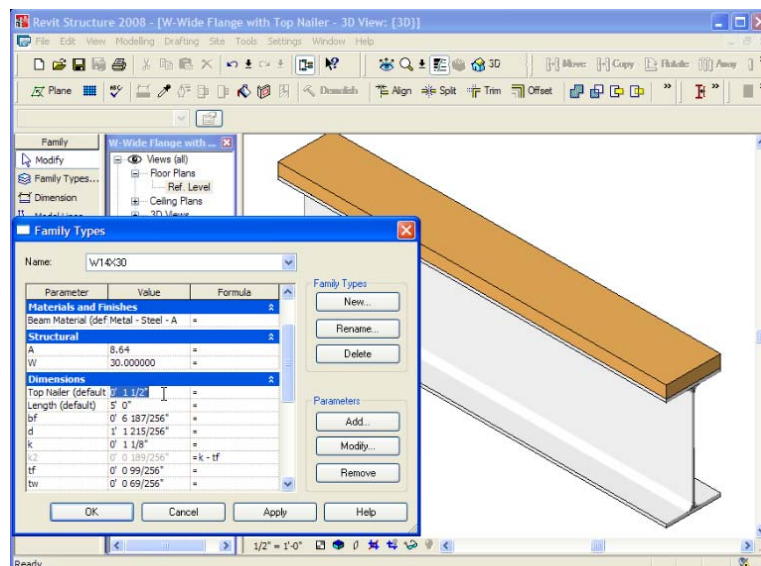
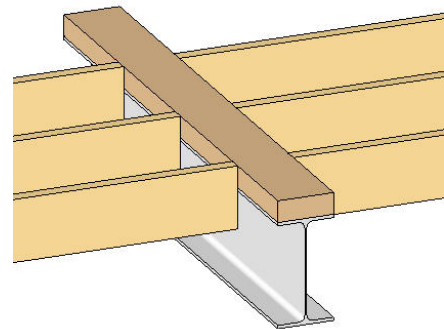
## Wood column libraries



Wood framing libraries

## Building a “nailer” on the Steel Beam Family

- Many commercial buildings, such as strip malls, and educational facilities use light steel, and wood as their materials.
- When wood joists intersect with steel girders a wood “nailer” is bolted to the girder top, in order to attach the wood joist element.
- Revit should have that family available. It doesn't... Instead we will make our own family.
- Since it does not exist we will adapt the default beam family to add in the “nailer” on top





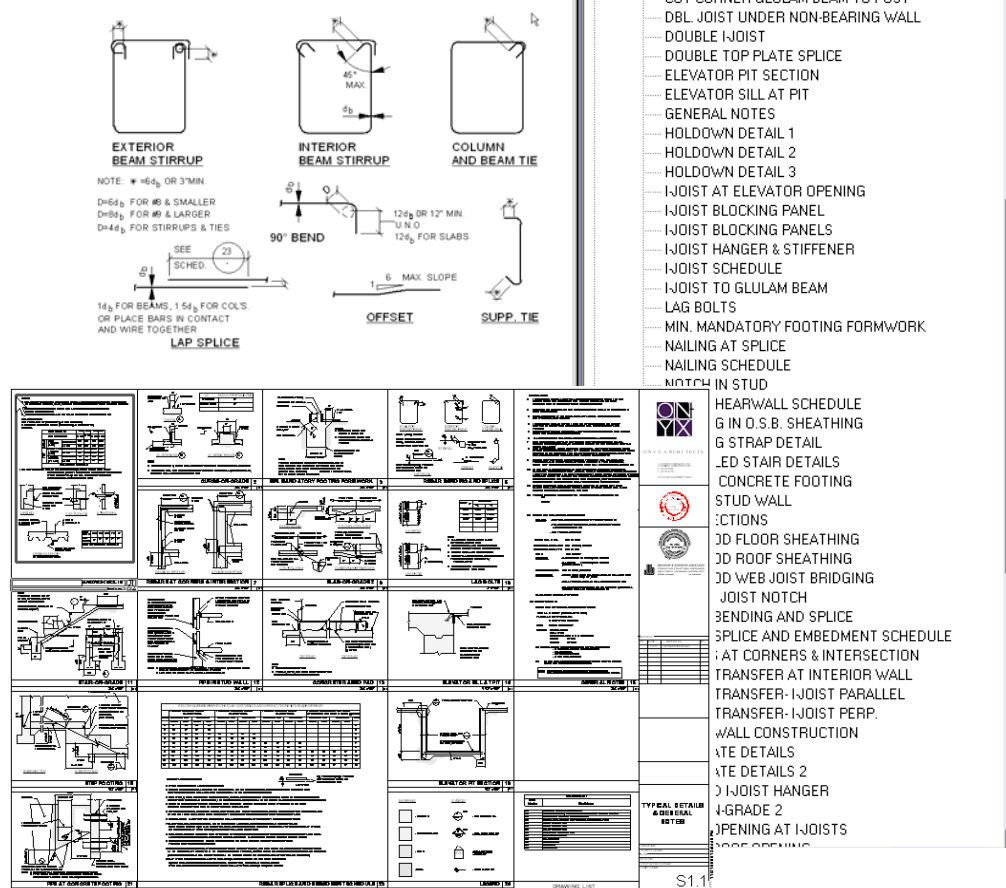
## Typical Details

With the advent of Revit Structure 2008 typical detail preparation became considerably easier. You have the option:

- Of importing and linking Autocad details
- Of importing and partially, or fully exploding Autocad details

Once your Revit typical details have been prepared you can:

- Save individual drafting views to a file from your project
- Then insert the details individually
- Or insert a whole sheet of details at once into your project



- With the new Revit extension you can also freeze a detail
- You can map your .shx fonts in AutoCAD to Revit TrueType fonts by editing the file "shxfontmap.txt". This method of mapping text fonts will give you more control on how your text appears in Revit.

- In regards to %% shortcuts a find and replace can be used along with the windows character map shortcut in the autocad detail. Example %%C can be substituted for alt+0216 (Ø)  
The symbol may vary dependant upon text style so check your map.
- Prior to insertion from Autocad we run a lisp filtering function that prepares the detail for insertion into Revit.

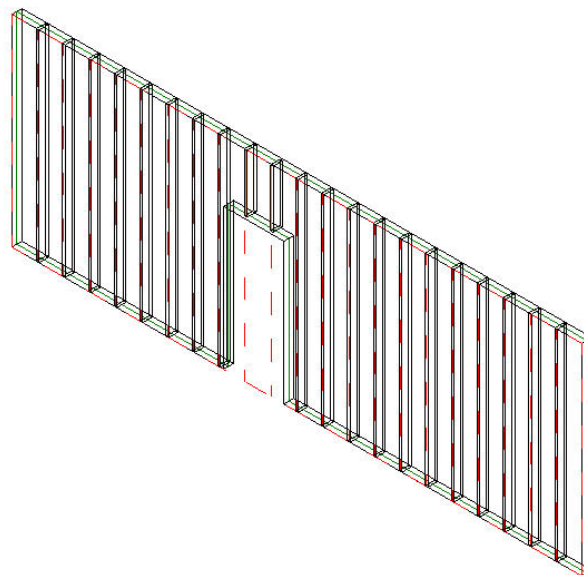
```
(defun dwgfilter ( / blkent aent fent);
  (setq aselnam (entnext))
  (while aselnam
    (convertentityfunc aselnam)
    (setq aselnam (entnext aselnam)))
  );while
  (if (setq blkent (tblnext "BLOCK" 1))
    (prompt "\nChanging all block entity definition colors... ")
  );if
  (while (/= blkent nil)
    (setq aent (cdr (assoc -2 blkent)))
    (while (/= aent nil)
      (convertentityfunc aent)
      (setq fent (entnext aent))
      (if (/= fent nil)
        (setq aent fent)
        (setq aent nil blkent nil))
      );if
    );while
    (setq blkent (tblnext "BLOCK"))
  );while
  (setvar "clayer" "0")
  (setq styleval (tblnext "style" 1))
  (while styleval
    (setq stylename (cdr (assoc 2 styleval)))
    (command "-style" stylename "arial.ttf" 0 "" "" "" "")
    (setq styleval (tblnext "style"))
  );while
  (command "-purge" "all" "" "" "n")
  (command "regenall")
);defun
(defun convertentityfunc (aselnam / aselnam sentlist selentype)
  (setq sentlist (entget aselnam))
  (setq selentype (cdr (assoc 0 sentlist)))
  (cond ((wcmatch selentype "MTEXT")
```

### Lisp routine

## A completely modeled wall

In general all the studs will not be shown in the wall. That argument will keep going on for a long while. But what if we have specific cases where we would like to make a complete wall with studs, and top and bottom plates? Three methods are possible:

- Draw extrusions for all the members and array the studs
- Use the curtain wall system to define the studs and plates
- Use the beam system in an elevation view for the studs, and extrude the plates



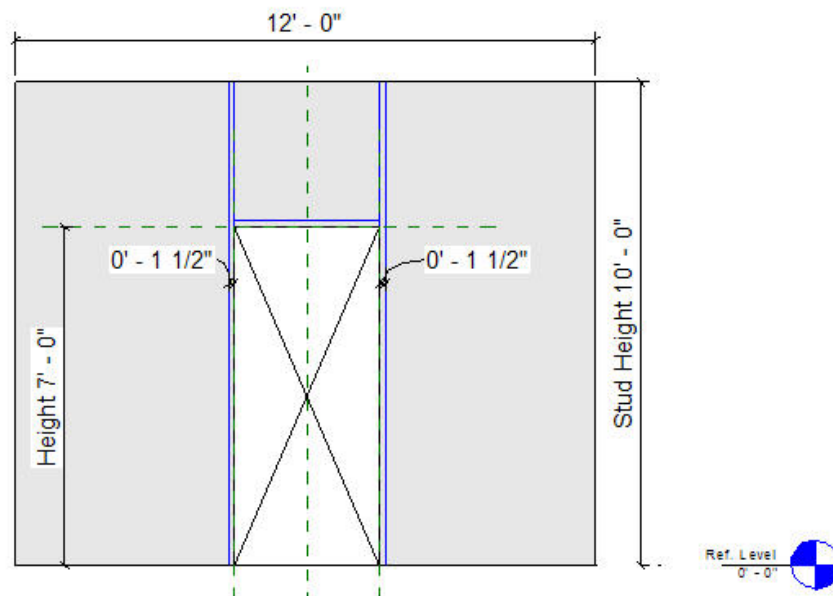
Stud wall using the beam system

The last method seems the most promising because stretching the wall will result in the automatic addition of members depending upon the layout rule that you use. But doors and windows cannot be hosted correctly in these scenarios so that they would automatically fit into the framing.

I would like to see the “factory” give us a wall that is capable of being fully parametric, showing studs and plates, and hosting fully framed window and door openings. And while they are at it walls should host hold downs and their plan annotation symbol.

## Window & Door Families

When we show door and window openings for a wood wall in elevation we normally show the framing around it along with hold down anchors. We will examine how to adapt the opening family to add members around openings.



### Adding door opening framing

Another major issue with door and window openings is the header issue, as described earlier. We will attempt to adapt the door opening family to also the header stick symbol in plan on the floor above.



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## Summary

In this class you have seen several wood structure projects in order to examine the modeling techniques I have been using to create the construction documents. You have had a chance to see wall, roof and floor framing adaptations to existing families, as well as a wish list of items I feel we need help from the developers to accomplish. This is a work in progress.

We have also examined and tried to define the elements and methods necessary to create a BIM solution for this type of structure.

I want to thank you once again for taking your valuable time attend this class and I hope being at Autodesk University this year has been a great learning experience for you.