Structural Engineering (Risa Project)

ENGR 310

Prepared For:

Robabeh Jazaei

Department of Physics and Engineering

Slippery Rock University

Prepared By: M.A

Abstract

The idea of this project was to design structures/structure that met the condition of using the 3-materials concrete, steel, and wood. The structure I decided to build will be a house consisting of all three. It is a residential house made for a family that has 2 parents and 1 child.

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Floor Plan

Here is a picture of the floor plan that was designed. The dimensions of the house itself is a 40ft x 40ft. It is made of 3 floors, including the basement, with a total room count of 7. Also shown is the placement of columns. The spacing of these pillars are provided in Fig 1.

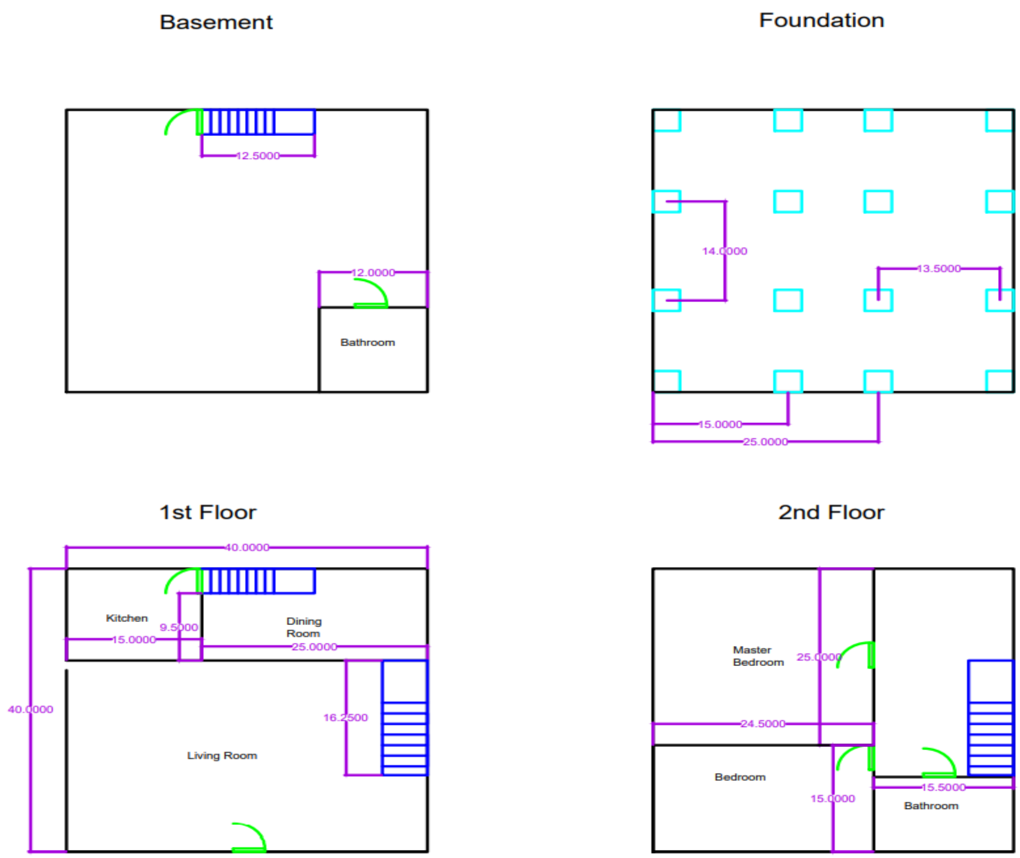


Figure 1 Dimensions of the house and rooms, as well as foundations.

Modeling

When the modeling process in Risa began, it was started at the foundation itself, consisting of the concrete columns. These columns will be conc3000NW with the shape CRND8, meaning a diameter of 8in. All of the columns used will have a height of 7ft.

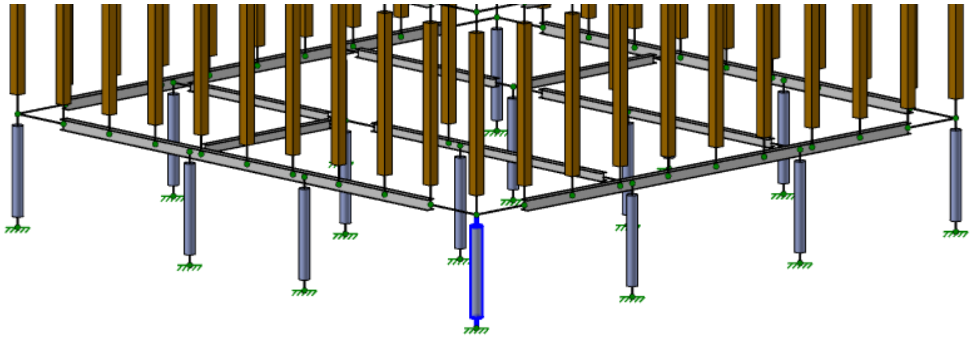


Figure 2 Concrete Column

Next, I moved on designing the steel that would support most of the wood. All steel will be made of the material A992. For the Girders, I use wide flanged pieces with the dimensions W8X24 (Fig 3) and for the beams I used W6X20 (Fig 4). I want the Girders to be a little beefier than the beams since most of the weight will be translating to them from the rest of the structure.

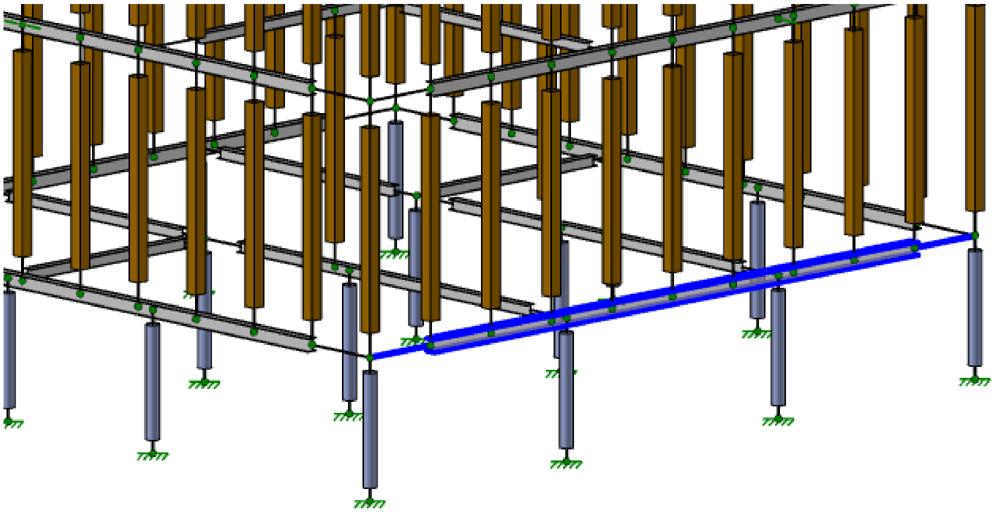


Figure 3 Steel Girder

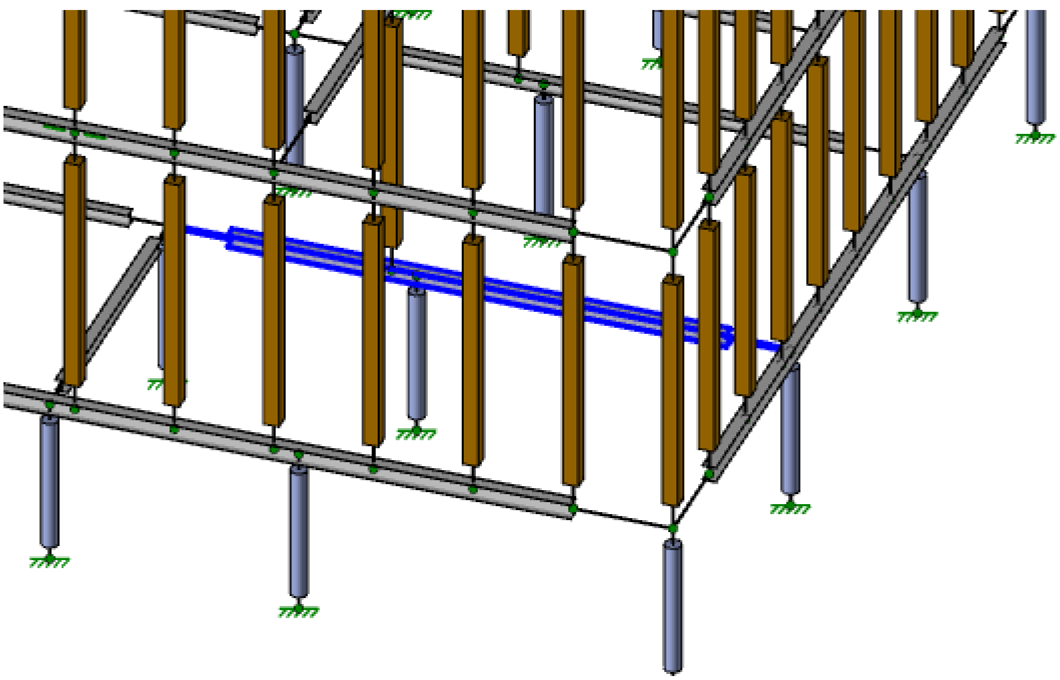


Figure 4 Steel Beam

The wooden studs used for the walls were designed to be evenly distributed around the house. To achieve that, I would split beams into 10 points that were equally distant and place stud at each one. These studs would be made of Douglas Fir. These studs will be 8ft long, 8ft wide, and 12.5ft tall.

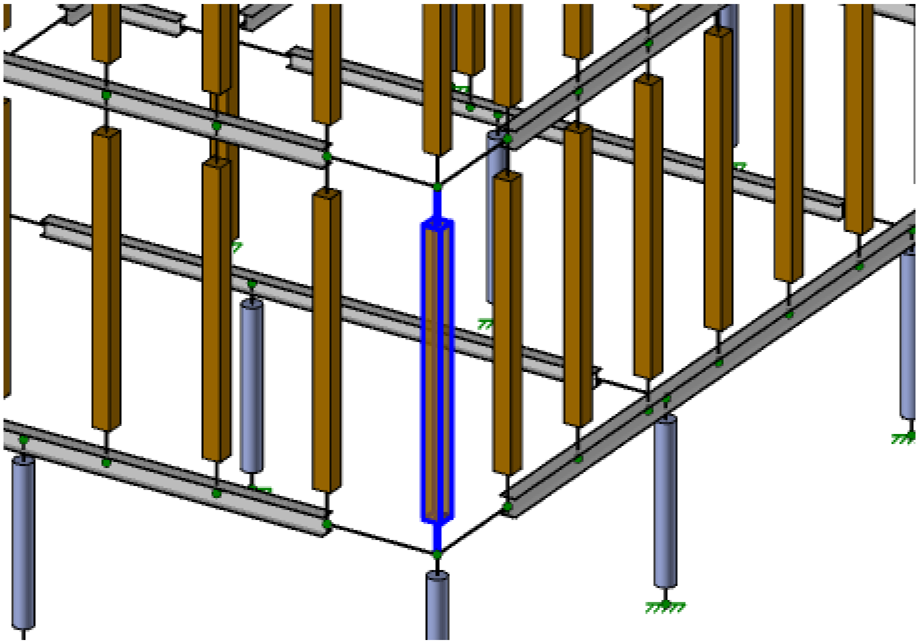


Figure 5 Wooden Studs

For the trusses, I had gone with much bigger dimensions to hold up to the various loads the roof will be under. These will also be made of Douglas Fir. The chords will be 10X12 pieces with a total length of 21.19ft to connect with each other at the top of the roof. The webs will have dimensions of 12X16 to handle the weight of the chords along with the rood loads.

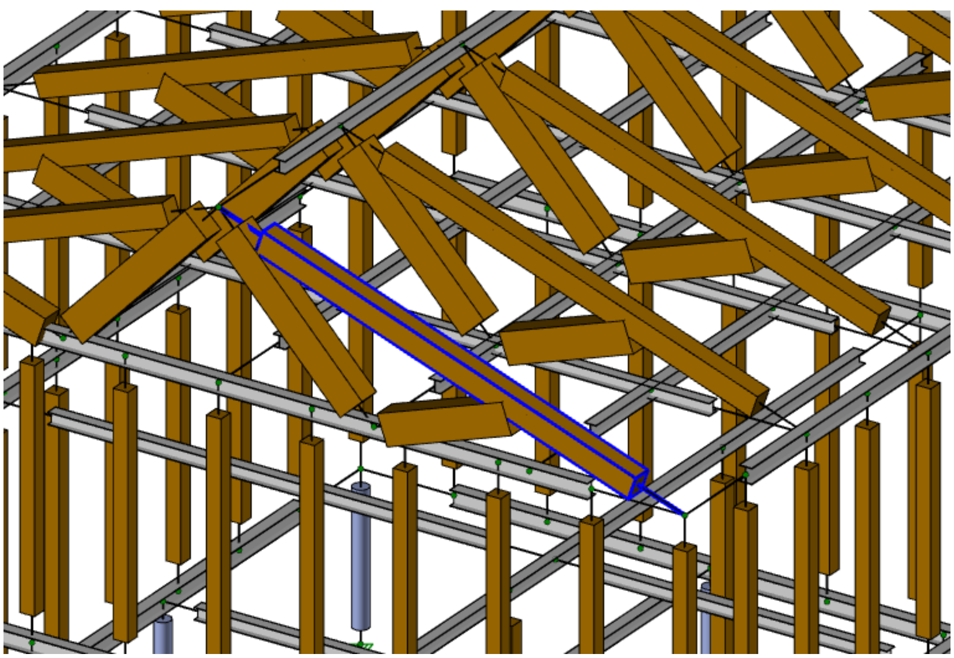


Figure 6 Wooden Chords

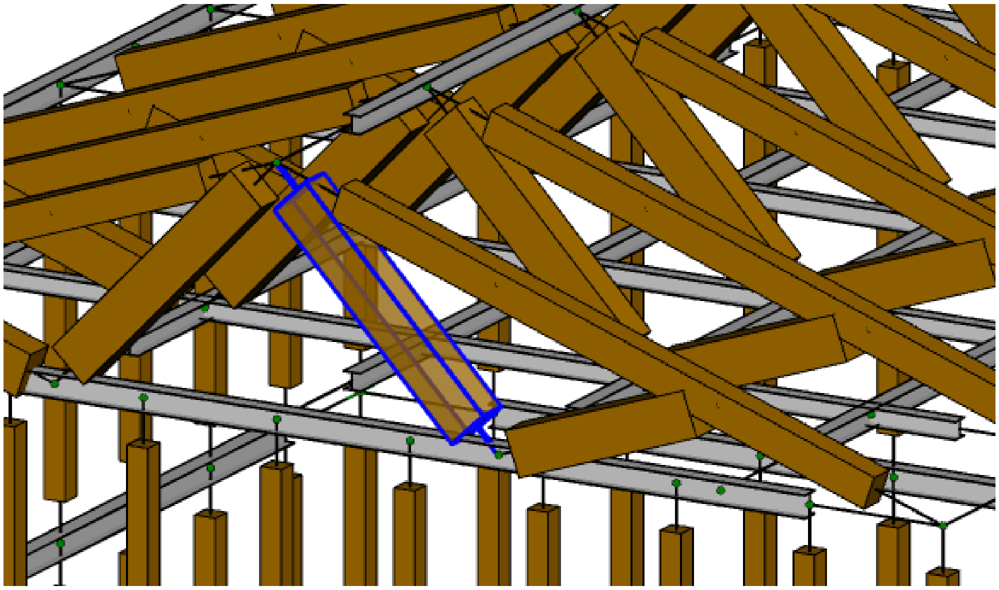


Figure 7 Wooden Web

Finally, the entire 3d model will be completed. This house had factored in loads such as rain, wind, snow, and a combination of dead load and live load. During the creation, there were many uses of pinned reactions for connections such as the steel girders to the wooden studs. The concrete is a part of the foundation, therefore being fixed reactions at the bottom of the house.

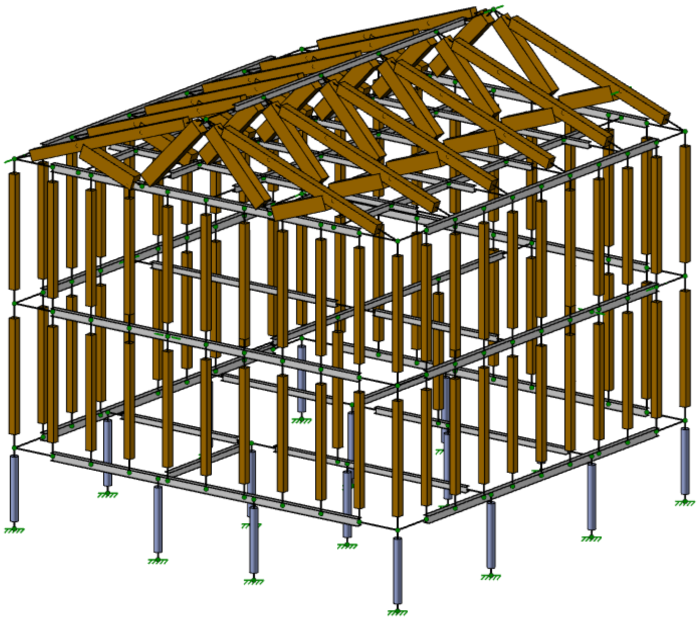


Figure 8 Finished 3D Model

Structural Analysis

One of the other important parts of this project is to get the resultants in deflections, shears, and moments within the structure and its members. In Figure 9, you will see the combinations of loads that are factored in the model when we solve our members for their displacements and such.

Description	Solve	P-Delta	SRSS	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
DL+LL	☑	Y		DL	1	LL	1								
Deflection...	☑	Y		DL	1										
Deflection...	☑	Y		LL	1										
Deflection...	☑	Y		DL	1	LL	1								
IBC 16-1	☑	Y		DL	1.4										
IBC 16-2 (a)	☑	Y		DL	1.2	LL	1.6	LLS	1.6	RLL	0.5				
IBC 16-2 (b)	☑	Y		DL	1.2	LL	1.6	LLS	1.6	SL	0.5	SLN	0.5		
IBC 16-2 (c)	☑	Y		DL	1.2	LL	1.6	LLS	1.6	RL	0.5				
IBC 16-3 (a)	☑	Y		DL	1.2	RLL	1.6	LL	0.5	LLS	1				
IBC 16-3 (c)	☑	Y		DL	1.2	SL	1.6	SLN	1.6	LL	0.5	LLS	1		
IBC 16-3 (e)	☑	Y		DL	1.2	RL	1.6	LL	0.5	LLS	1				
IBC 16-3 (b)	☑	Y		DL	1.2	RLL	1.6	WL	0.5						
IBC 16-3 (d)	☑	Y		DL	1.2	SL	1.6	SLN	1.6	WL	0.5				
IBC 16-3 (f)	☑	Y		DL	1.2	RL	1.6	WL	0.5						
IBC 16-4 (a)	☑	Y		DL	1.2	WL	1	LL	0.5	LLS	1	RLL	0.5		
IBC 16-4 (b)	☑	Y		DL	1.2	WL	1	LL	0.5	LLS	1	SL	0.5	SLN	0.5
IBC 16-4 (c)	☑	Y		DL	1.2	WL	1	LL	0.5	LLS	1	RL	0.5		
IBC 16-6	☑	Y		DL	0.9	WL	1								

Figure 9 Load Combinations

The first analysis we will look at will be that of the concrete columns. The one being examined is toward the center of the base, taking up more force than the ones on the outside. As we can see, the concrete has almost no issues in both the shear and deflection.

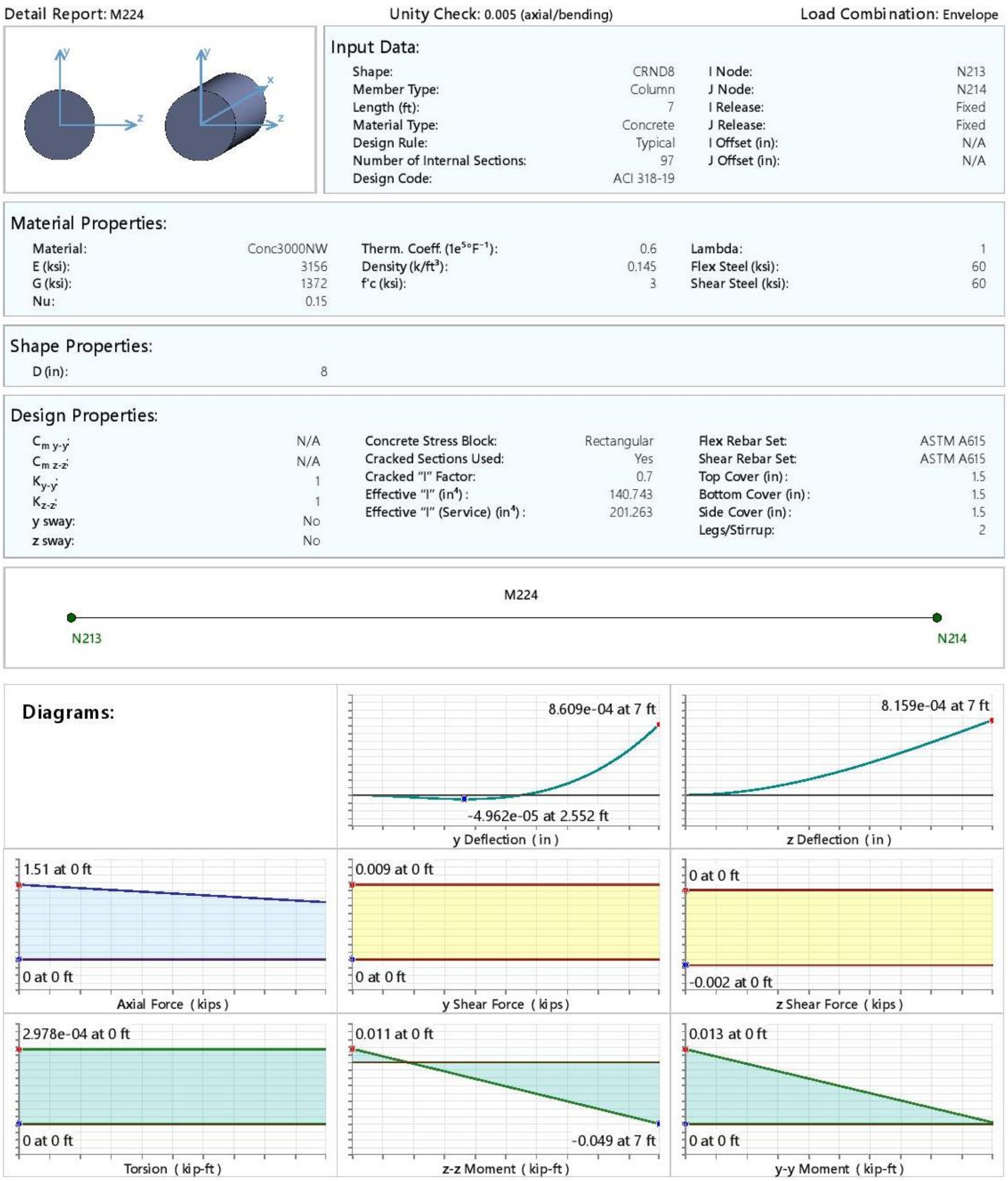


Figure 10 Concrete Column Report

For the steel beam, we are examining the beam that is under the center of the trusses on the roof. This beam is under the most load in the structure, but despite this, will not have a deflection of over an inch at any given point. Within the shear diagram, we can the location of these trusses on the beam by the jumps on the graph, but again these jumps are nothing major.

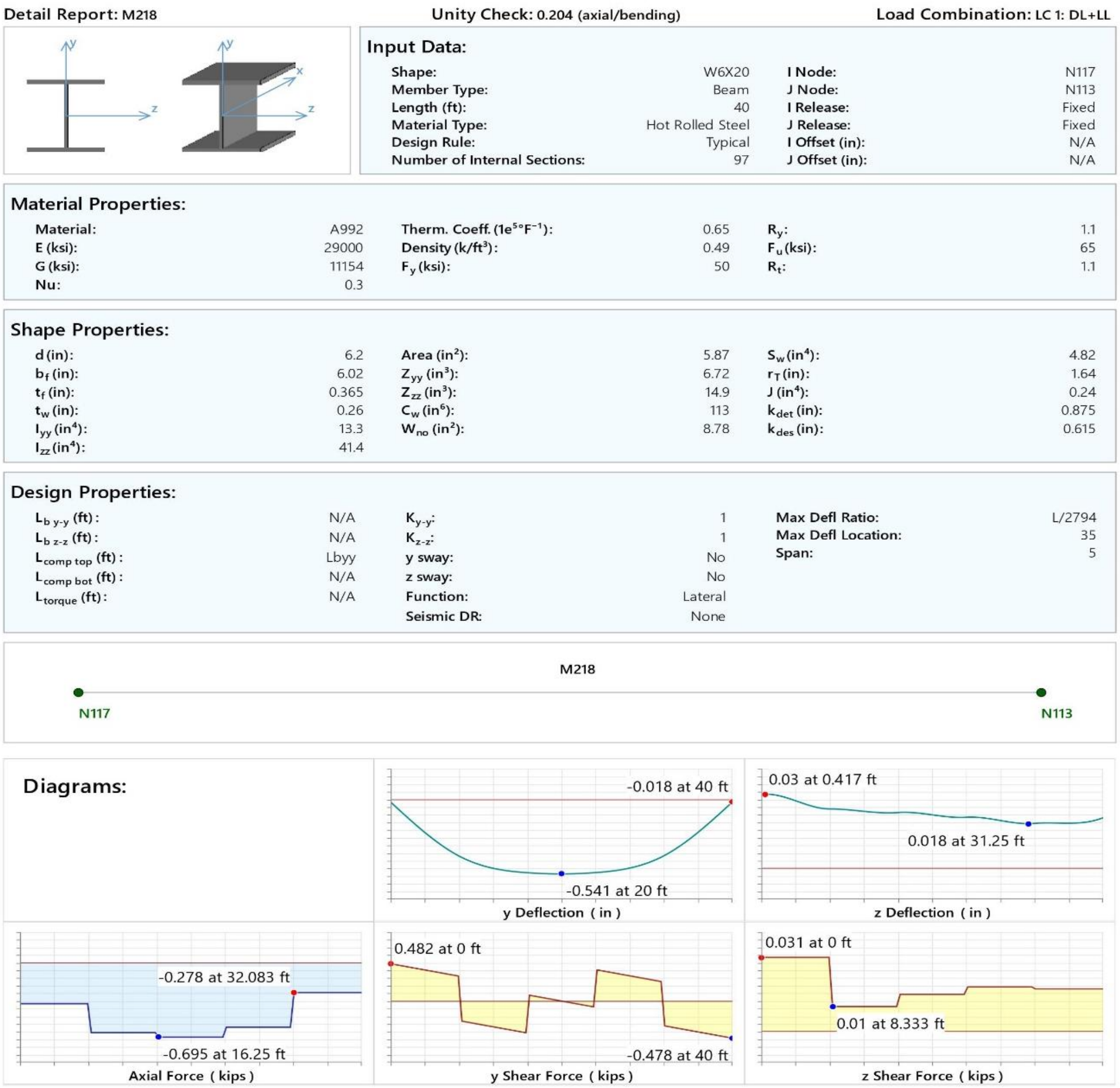


Figure 11 Steel Beam Report

For the steel girder, we will be examining one that is to the right or left on the first floor. Unlike the front or back girders, these ones have evenly spaced opening, leading to the high shear force compared to the rest. However, the deflection will still be kept to a minimum.

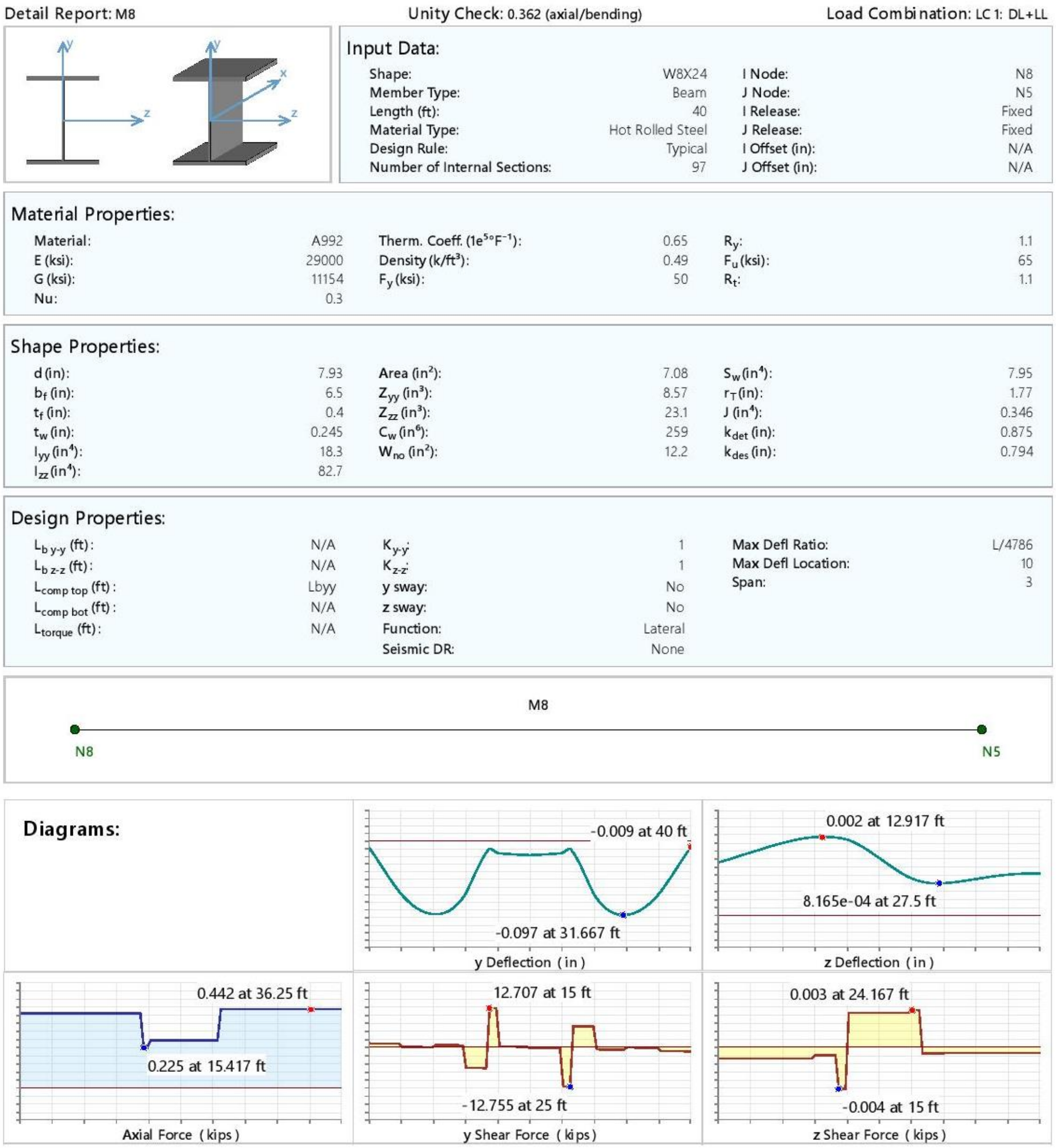


Figure 12 Steel Girder Report

For the wooden studs, we can examine any of them in the building, as the are all roughly the same. They will not contain any shear force but will vary in a small amount of deflection. This is due to some studs on the second floor being under one of the trusses on the roof.

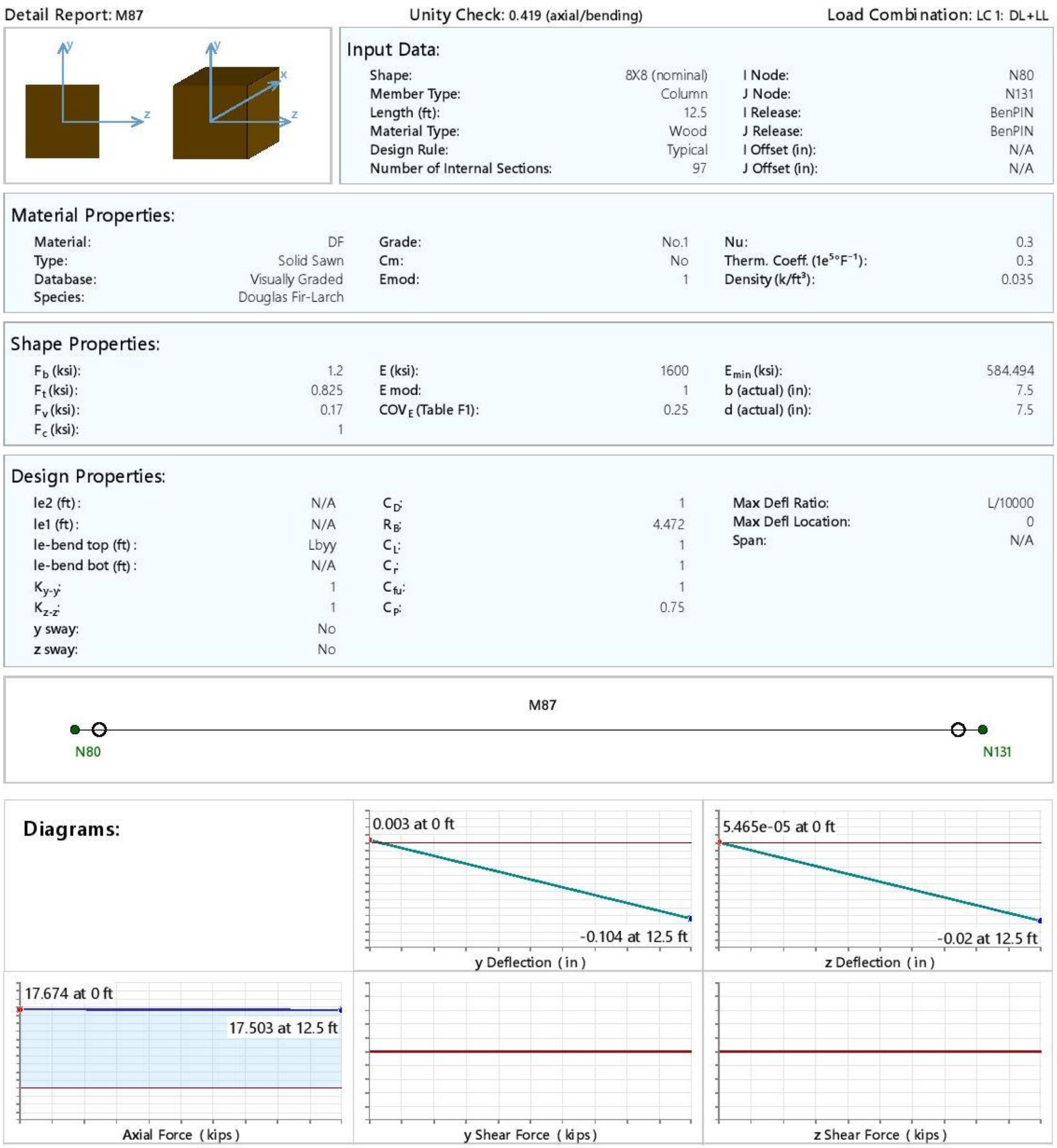
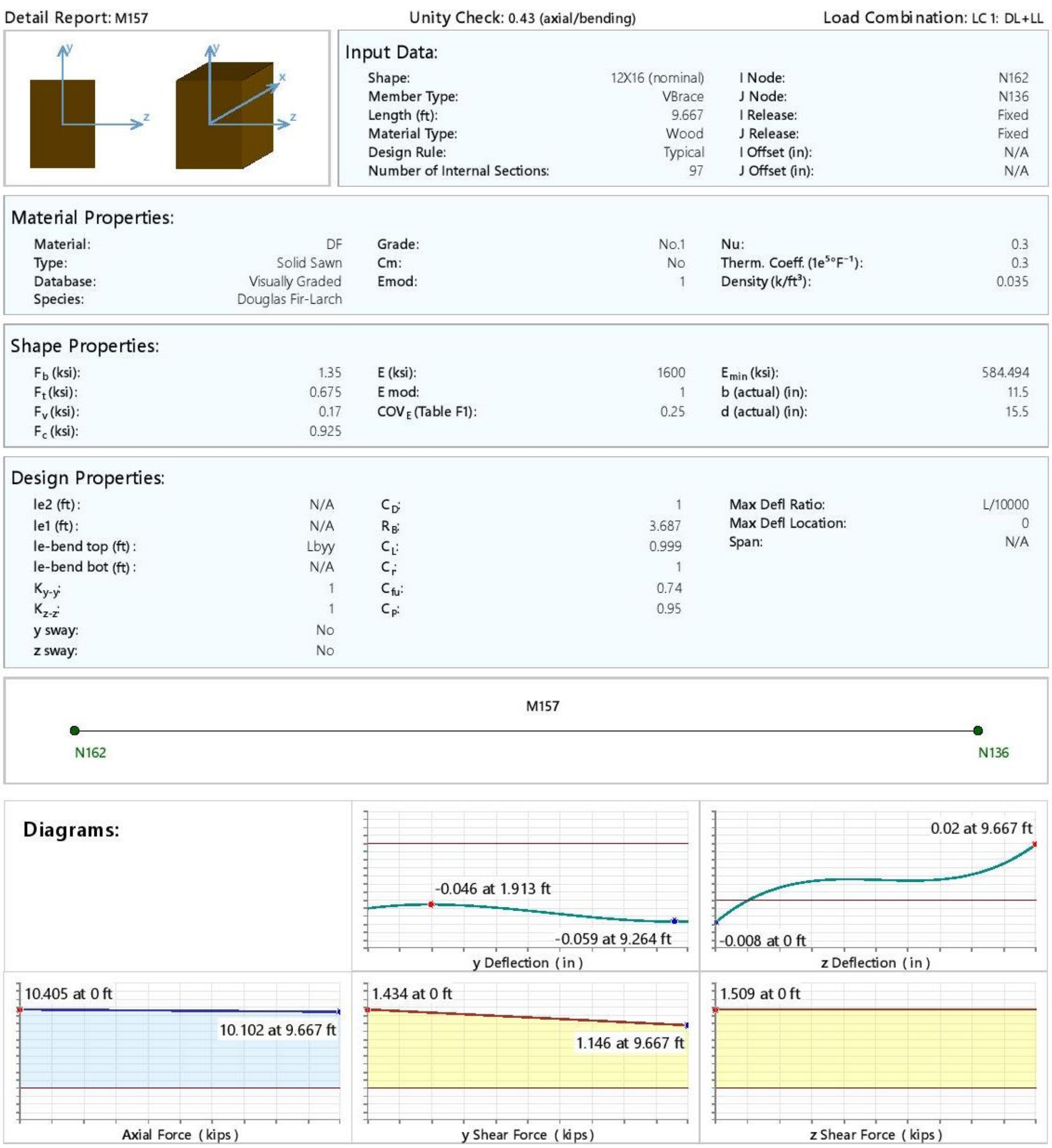


Figure 13 Wooden Stud Report

For the wooden webs, we can pick any of them to examine as well. The one chosen with be one closet to the middle on the outside truss. The deflection will happen in both directions but are so minimum they can be neglected. There will also be a small amount of shear, but just like deflection we can ignore it since it still within the required amount.



Detail Report: M157 | Unity Check: 0.43 (axial/bending) | Load Combination: LC 1: DL+LL

Input Data:

Shape:	12X16 (nominal)	I Node:	N162
Member Type:	VBrace	J Node:	N136
Length (ft):	9.667	I Release:	Fixed
Material Type:	Wood	J Release:	Fixed
Design Rule:	Typical	I Offset (in):	N/A
Number of Internal Sections:	97	J Offset (in):	N/A

Material Properties:

Material:	DF	Grade:	No.1	Nu:	0.3
Type:	Solid Sawn	Cm:	No	Therm. Coeff. ($1e^{5}$°F^{-1}):	0.3
Database:	Visually Graded	Emod:	1	Density (k/ft^3):	0.035
Species:	Douglas Fir-Larch				

Shape Properties:

F_b (ksi):	1.35	E (ksi):	1600	E_{min} (ksi):	584.494
F_t (ksi):	0.675	E mod:	1	b (actual) (in):	11.5
F_v (ksi):	0.17	COV_E (Table F1):	0.25	d (actual) (in):	15.5
F_c (ksi):	0.925				

Design Properties:

le2 (ft):	N/A	C_D:	1	Max Defl Ratio:	L/10000
le1 (ft):	N/A	R_B:	3.687	Max Defl Location:	0
le-bend top (ft):	Lbyy	C_L:	0.999	Span:	N/A
le-bend bot (ft):	N/A	C_r:	1		
K_{y-y}:	1	C_{fu}:	0.74		
K_{z-z}:	1	C_P:	0.95		
y sway:	No				
z sway:	No				

Figure 14 Wooden Web Report

Cost Analysis

The house requires a numerous number of materials due to its large nature. After doing some searching online, I was able to find some estimates for the materials used. Thanks to Risa, we have the number of pieces used throughout the structure and the amount of ft or yards used by these pieces. Due to DF 10X12 and DF12X16 are very rare dimensions, I had to make some estimates with the help of the internet that could be wrong. The total cost of the project will be a grand total in $57116.38.

Material	Size	Pieces	Length[ft]	Weight[K]
Hot Rolled Steel				
A992	W6X20	19	586	11.705
A992	W8X24	16	640	15.419
Total HR Steel		35	1226	27.124
Wood				
DF	8X8	82	1025	14.014
DF	10X12	24	508.6	13.504
DF	12X16	24	200.8	8.698
Total Wood		130	1734.3	36.216
Concrete Members			Volume (yds^3)	
Conc3000NW	CRND8	16	1.4	5.669
Total Concrete		16	1.4	5.669

Figure 15 Number of materials used and their dimensions

Material	Size	Pieces	Length (ft or yards)	Weight(k)	Cost per unit length	Total Cost
A992 Hot Rolled	W6x20	19	586ft	11.705	$65.27/31ft piece	$1240.13
A992 Hot Rolled	W8X24	16	640ft	15.419	$99.04/40ft piece	$1584.64
DF	8X8	82	1025ft	14.014	$307.99/16ft	$19730.61
DF	10X12	24	508.6ft	13.504	$40/ft	$20344
DF	12X16	24	200.6ft	8.698	$70/ft	$14042
Concrete 3000NW	CRND8	16	1.4yrd^3	5.669	$125/yrd^3	$175
						$57116.38

Figure 16 Calculating the total cost of project

Conclusion

The project overall was a really exiting but also aggravating activity due many issues happening in Risa. This has taught me various ideas that will help me in my future. One of those would be to sticking to smaller scales for my first models. The size led to issues such as more materials used, leading to much more reactions that could cause the entire building to not calculate, or the materials having to be outrageous dimensions to be able to hold up. Despite this, this project gave me goof insight on how modeling inside a program would go and how to use it.