Final Project Report

Structural Engineering: CIVIL 310

December 3, 2021

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Table of Contact

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Executive Summary

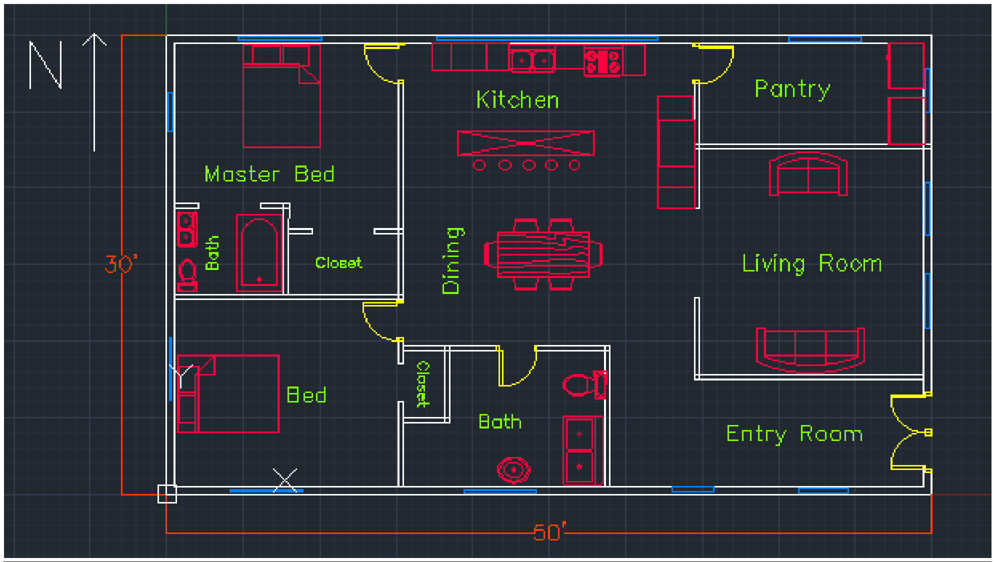
The purpose for this project was to create one or more structures using concrete, steel, and wood. Using RISA software, we were to create a realistic structure and assign realistic loads to the structure to ensure each member (as well as the entire structure) would surpass the allowable stresses provided by the codes. I chose to create two structures. The first structure I designed was a single-story ranch-style house designed with only wood. For my other structure, I chose to create a model of a bridge. The materials I used for my bridge were steel and concrete.

Using AutoCAD, I designed a floor plan of the house and added dimensions. After this, I created a plan for the columns. Since it is a single-story house with minimal superstructure load, I decided to keep the columns on the outside so that I could maintain an open space floor plan. Next, I used RISA software to create my model. By researching common materials and sizesI used section sets in RISA to detail a list of structural components. In the following pages, you will see the dimensions of wood I used, the material properties, its shear/moment/deflection diagrams, and if it passed the code. I then designed my structure according to my column plan and added outside girders, inside beams, floor joists, interior/exterior walls, and trusses to support the roof load. I designed it in a way to distribute the load evenly to the columns.

The next structure I modeled was a triple-span bridge. First, I researched different types of bridge designs using steel and concrete. I decided to create a bridge with concrete columns and steel girders. I wanted to make it a relatively long bridge, because it was three spans. The overall length of the bridge is 90’, and 30’ wide to accommodate for two 12’ lanes, and two 3’ shoulders. The middle columns were designed at a greater height so their base could be placed in the water. I also created the pier connectors and the beam supports so the load from the superstructure and live traffic could be evenly distributed to the piers and down to the ground.

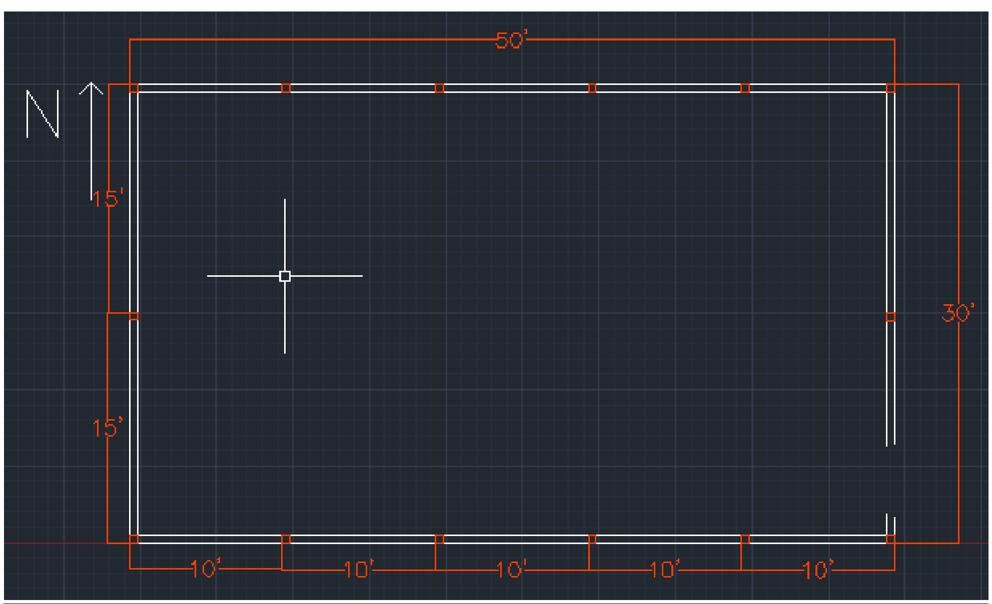
House Floor Plan

This picture details the floor plan of the single-story ranch style home I want to model in RISA. This structure would be a rectangle with dimensions of 50’x30’.



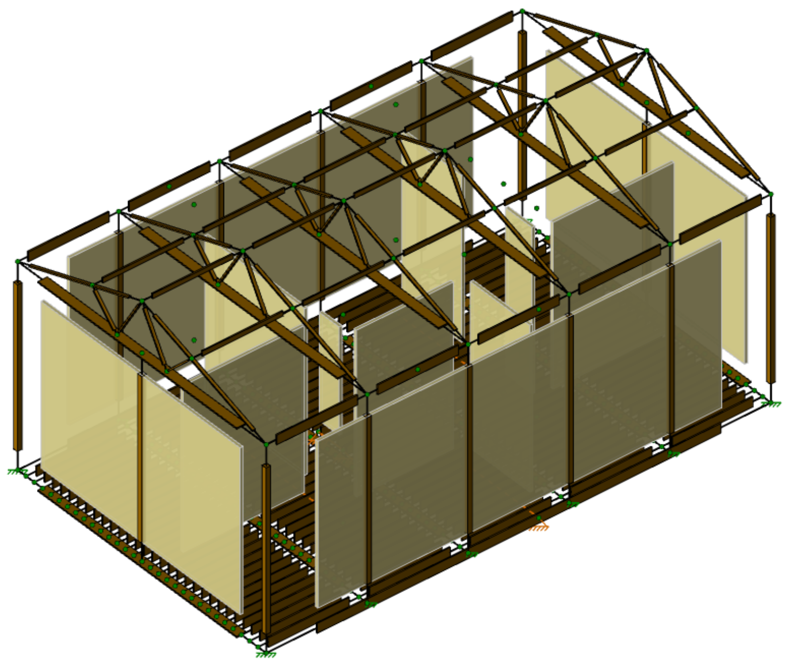
Column Floor Plan

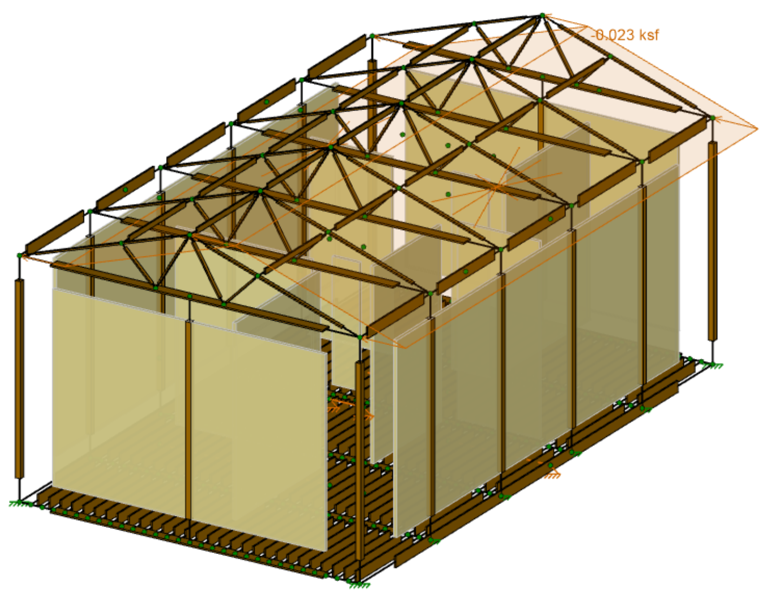
This picture shows my column plan. On the short side, I designed the columns to be on the ends, and one in the middle. These would be spaced 15’ apart. On the longer side, I have a total of 6 columns, with a spacing of 10’.



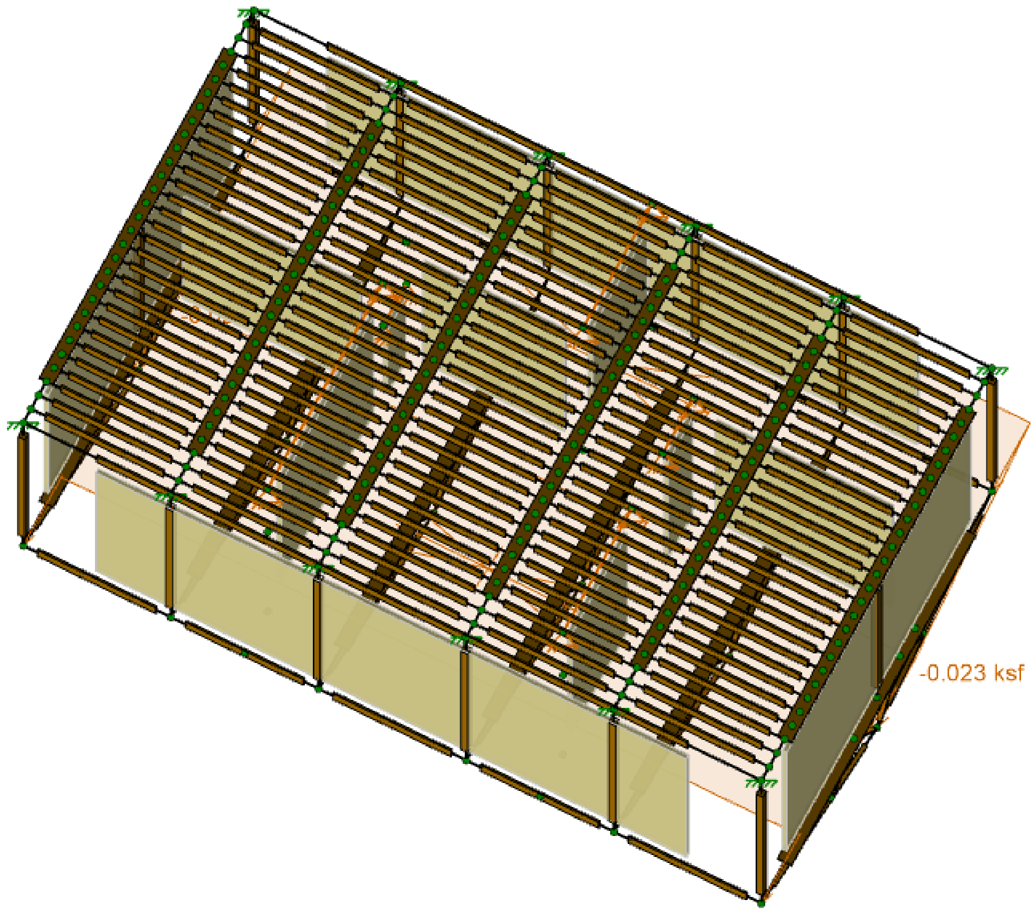
General House Structure:

The following pictures show the general house structure. The interior walls match the floor plan, and the columns match the column plan. Also, the loads are shown distributed to the trusses, which evenly distributes down to the columns. Additionally, my trusses are located above my columns which provides the roof load to be equally distributed toward the bottom of the structure.



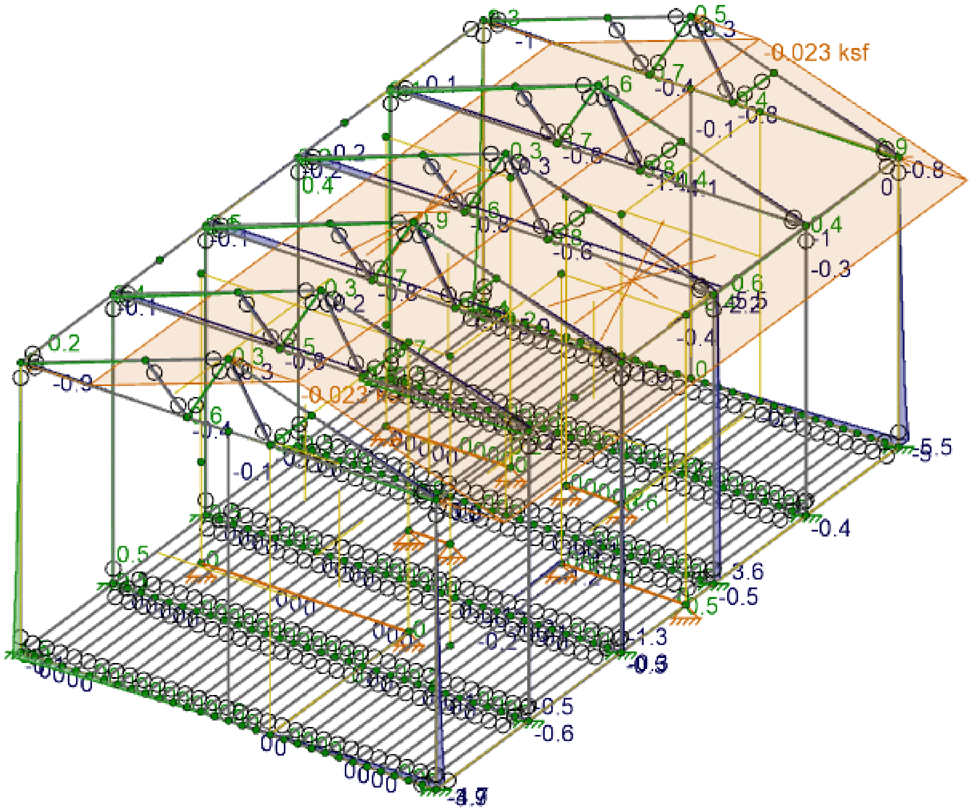


This picture shows the structure from the underside. I have my joists pinned connected to my beams, and my beams pin connected to my columns. Through research, I decided to space my joists 1’ apart due to common practice. This design provides equal load distribution to the ground.



Structure Loads

This picture is unique because it displays the load that each member carries, and it also displays the shear diagram each member has.



Load Calculations and Descriptions

Asphalt shingles: 1.93 psf

½" Plywood: 1.42 psf

14" Snow load: 20 psf

Total Load: 23.35 psf = 0.02335 ksf

Therefore, -.023ksf was applied as an area load in the negative Z direction.

Note: RISA shows a rounded number, but used the full number in the calculations

Detailed Report of House:

The following pages include the reports for each structural member that RISA software calculated. The type of member is listed before the detailed report.

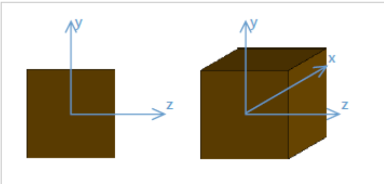
Node Reactions

Using this chart, I am able to see the load carried to each node, and the direction of the load. I am also able to determine the directional moment at each node.

Node Reactions (By Combination)

	LC	Node Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	1	N4	0.131	5.203	-5.538	-0.654	0.036	-0.07
2	1	N1	0.037	5.196	5.297	-0.653	0.039	-0.067
3	1	N2	0.103	6.948	7.57	-0.716	0.023	0.033
4	1	N3	-0.089	6.673	-6.503	-0.714	-0.017	0.041
5	1	N9	0.028	0.727	1.051	-2.839	0.135	-0.092
6	1	N11	0.09	1.163	0.603	-4.522	0.005	0.058
7	1	N13	0.101	1.137	0.72	-3.919	-0.003	0.005
8	1	N15	0.134	0.876	0.771	-2.266	-0.09	0.09
9	1	N16	0.123	0.842	-0.759	-1.858	0.096	0.095
10	1	N14	0.602	0.757	-2.616	-1.613	-1.243	-0.129
11	1	N12	-0.501	0.754	-5.752	-1.282	0.537	0.333
12	1	N10	-0.09	0.394	-0.435	-1.528	-0.092	-0.129
13	1	WP3	-1.095	10.608	-8.729	3.057	0	1.127
14	1	WP4	-0.122	2.466	9.928	-63.457	0	0.98
15	1	WP7	0.866	2.919	-1.756	-51.977	0	-1.886
16	1	WP8	0.011	0.878	0.003	-6.223	0	0.098
17	1	WP11	-0.33	13.913	6.144	-217.007	0	-0.923
18	1	N254	NC	NC	NC	LOCKED	NC	NC
19	1	N247	NC	NC	NC	LOCKED	NC	NC
20	1	N240	NC	NC	NC	LOCKED	NC	NC
21	1	N233	NC	NC	NC	LOCKED	NC	NC
22	1	N226	NC	NC	NC	LOCKED	NC	NC
23	1	N221	NC	NC	NC	LOCKED	NC	NC
24	1	Totals:	0	61.455	0			
25	1	COG (ft):	NC	NC	NC			

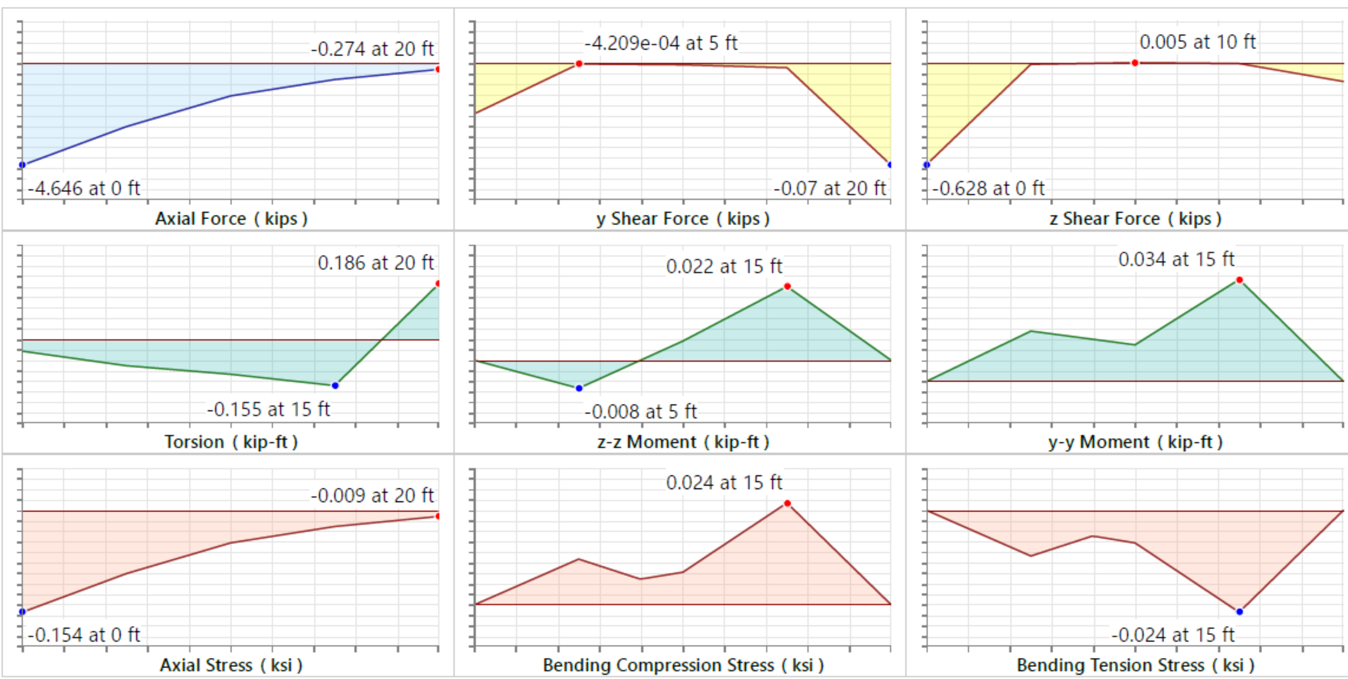
Column



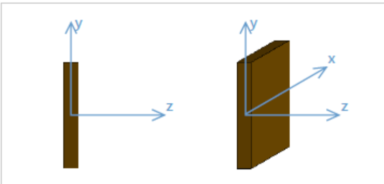
Input Data:

Shape:	6X6 (nominal)	I Node:	N4
Member Type:	Beam	J Node:	N5
Length (ft):	20	I Release:	BenPIN
Material Type:	Wood	J Release:	BenPIN
Design Rule:	Typical	I Offset (in):	N/A
Number of Internal Sections:	5	J Offset (in):	N/A

Limit State	Required	Available	Unity Check	Result
Applied Loading - Bending/Axial	-	-	-	-
Applied Loading - Shear + Torsion	-	-	-	-
Axial Compression Analysis	0.000 ksi	0.191 ksi	-	-
Axial Tension Analysis	-0.154 ksi	0.55 ksi	-	-
Flexural Analysis, Fb1'	0.006 ksi	0.85 ksi	-	-
Flexural Analysis, Fb2'	0.114 ksi	0.629 ksi	-	-
Bending & Axial Compression Analysis	-	-	0.467	Pass
Bending & Axial Tension Analysis	-	-	0.467	Pass
Shear Analysis	0.07 ksi	0.125 ksi	0.56	Pass



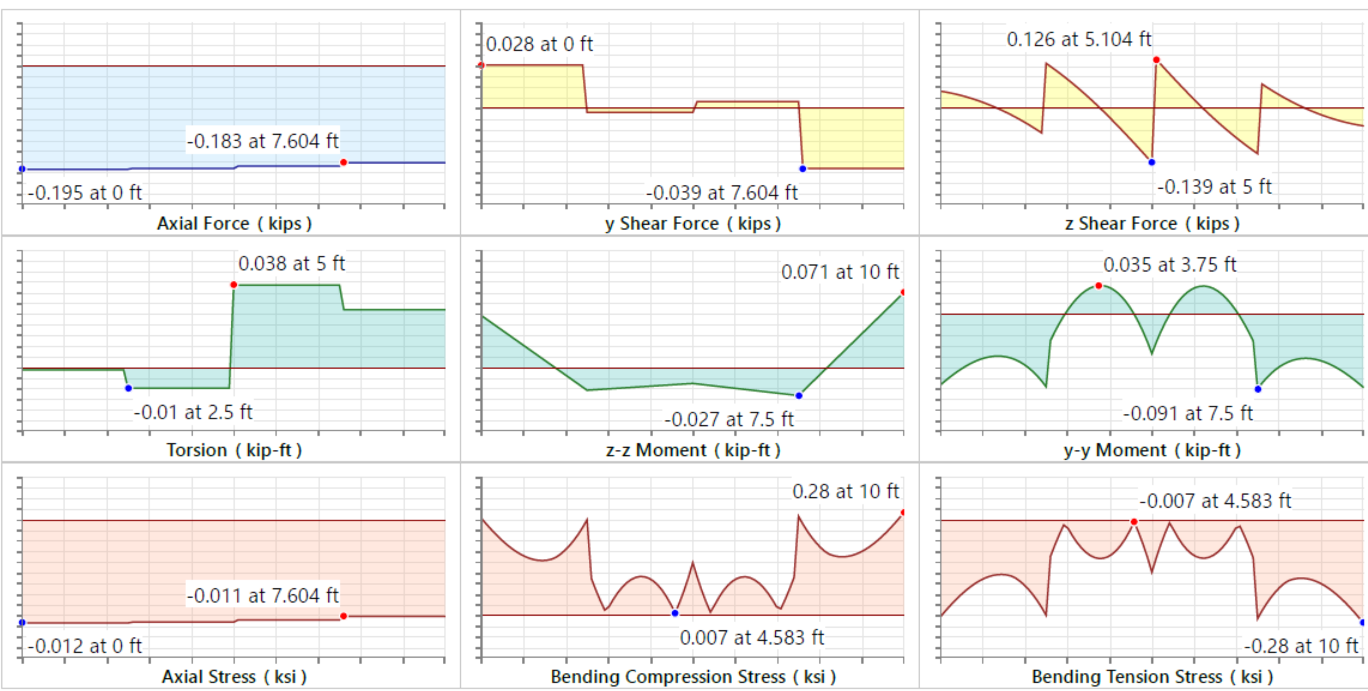
Girder



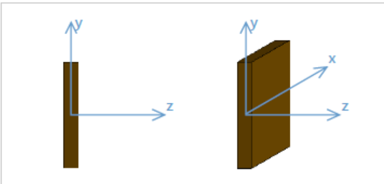
Input Data:

Shape:	2X12 (nominal)	I Node:	N243
Member Type:	Beam	J Node:	N236
Length (ft):	10	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

Limit State	Required	Available	Unity Check	ɫesult
Applied Loading - Bending/Axial	-	-	-	-
Applied Loading - Shear + Torsion	-	-	-	-
Axial Compression Analysis	0.000 ksi	0.065 ksi	-	-
Axial Tension Analysis	-0.011 ksi	0.45 ksi	-	-
Flexural Analysis, Fb1'	0.027 ksi	0.763 ksi	-	-
Flexural Analysis, Fb2'	0.253 ksi	1.05 ksi	-	-
Bending & Axial Compression Analysis	-	-	0.296	Pass
Bending & Axial Tension Analysis	-	-	0.296	Pass
Shear Analysis	0.071 ksi	0.135 ksi	0.525	Pass



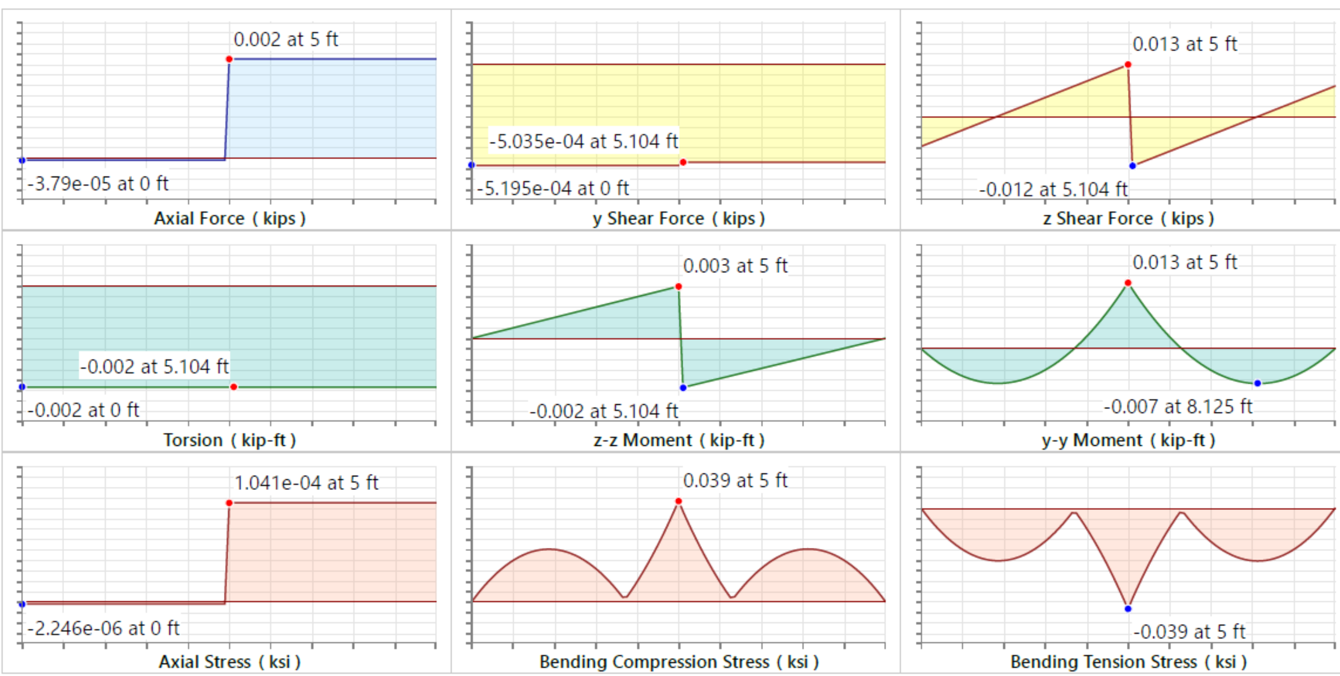
Joist



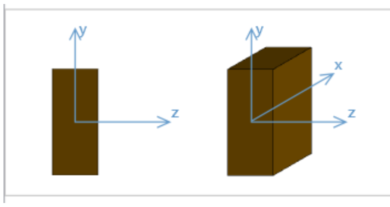
Input Data:

Shape:	2X12 (nominal)	I Node:	N107
Member Type:	Beam	J Node:	N135
Length (ft):	10	I Release:	BenPIN
Material Type:	Wood	J Release:	BenPIN
Design Rule:	Typical	I Offset (in):	N/A
Number of Internal Sections:	97	J Offset (in):	N/A

Limit State	Required	Available	Unity Check	Result
Applied Loading - Bending/Axial	-	-	-	-
Applied Loading - Shear + Torsion	-	-	-	-
Axial Compression Analysis	0.000 ksi	0.065 ksi	-	-
Axial Tension Analysis	0.000 ksi	0.45 ksi	-	-
Flexural Analysis, Fb1'	0.001 ksi	0.763 ksi	-	-
Flexural Analysis, Fb2'	0.038 ksi	1.05 ksi	-	-
Bending & Axial Compression Analysis	-	-	0.038	Pass
Bending & Axial Tension Analysis	-	-	0.037	Pass
Shear Analysis	0.005 ksi	0.135 ksi	0.034	Pass



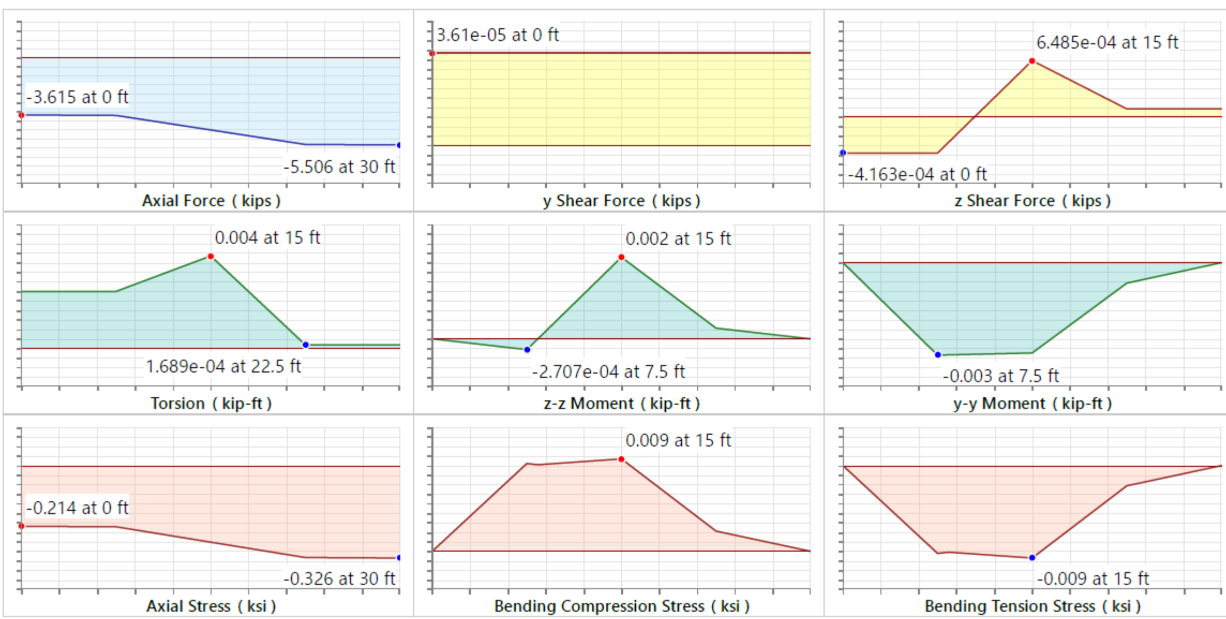
Truss



Input Data:

Shape:	2X4 (nominal)	I Node:	N226
Member Type:	Beam	J Node:	N230
Length (ft):	15.811	I Release:	BenPIN
Material Type:	Wood	J Release:	BenPIN
Design Rule:	Typical	I Offset (in):	N/A
Number of Internal Sections:	5	J Offset (in):	N/A

Limit State	Required	Available	Unity Check	₹esult
Applied Loading - Bending/Axial	-	-	-	-
Applied Loading - Shear + Torsion	-	-	-	-
Axial Compression Analysis	0.000 ksi	0.007 ksi	-	-
Axial Tension Analysis	-0.326 ksi	0.45 ksi	-	-
Flexural Analysis, Fb1'	0.000 ksi	0.331 ksi	-	-
Flexural Analysis, Fb2'	0.000 ksi	1.05 ksi	-	-
Bending & Axial Compression Analysis	-	-	0.725	Pass
Bending & Axial Tension Analysis	-	-	0.725	Pass
Shear Analysis	0.007 ksi	0.135 ksi	0.05	Pass



Cost Analysis of Structural Materials

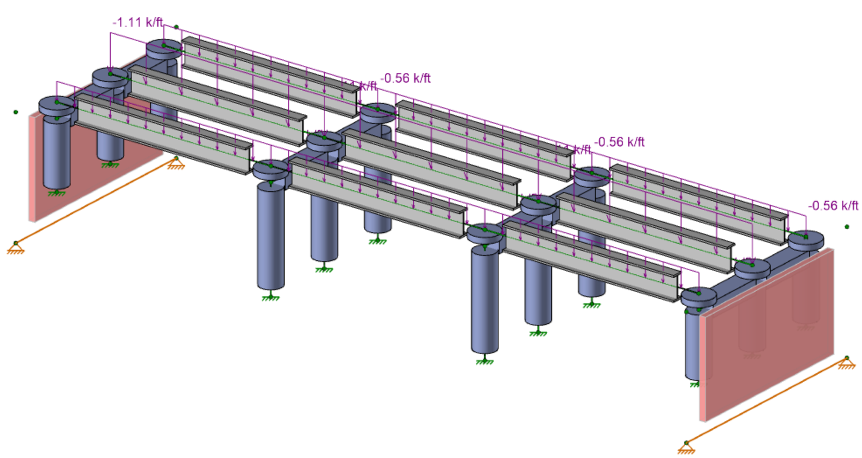
The most accurate way of calculating lumber cost is to find a cost of the number of pieces at a specified length, and then multiple the number of pieces by a unit price. Through research, I found the price per unite of wood for SPF lumber. It is important to note that this is the price of the lumber and does not include shipping or labor costs.

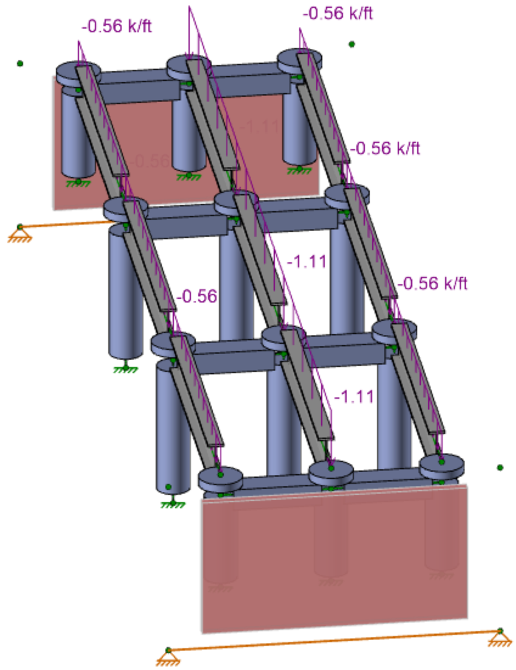
House Cost Analysis

Type	Size	# of Pieces	Total Length	Cost per unit	Total Cost
SPF	2X4	48	543.6	$8.15	$391.20
SPF	2X6	12	252	$21.15	$253.80
SPF	2X8	48	950	$25.60	$1,228.80
SPF	2X12	168	2010	$22.15	$3,721.20
SPF	6X6	20	240	$45.18	$903.60
				Total Cost:	$6,498.60

General Bridge Structure

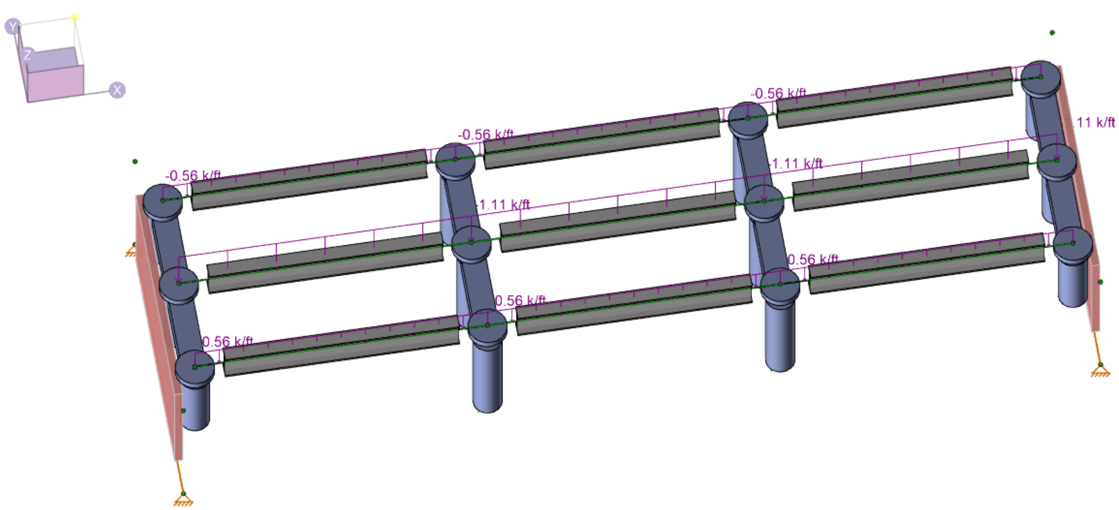
The following pictures so the general bridge structure. The walls are made out of masonry concrete. The three span bridge totals 90' in length and is 30' wide which allows for two 12' lanes and two 3' shoulders. The pier connectors are made of concrete and provide an equal load distribution to the columns, which distribute the load to the ground.





<u>Structure Loads</u>

For the scope of this project, I just wanted to estimate a typical load on a bridge in a simplified way. Typically, loads are broken up by axles and calculated into an equivalent single axle load. These loads would be classified as moving loads, and would transfer from the concrete to deck to the beams, to the columns, and down into the earth.



Load Calculations

For simplification and experimental purposes I researched that the maximum load a truck could carry is an 80-kip load. Most trucks with this weight are around 72 feet in length. Dividing these two numbers, we would get a distributed load of 1.11 kips/ft. I also estimated two 80 kip trucks on each side so a total of 2.22 kips/ft distributed load for the entire structure. Since this is a 3 span bridge, I can treat each span individually and each span as a one way slab. This allowed me to put double the load on the center beam, and the rest on the outside beams.

Detailed Report of Bridge:

The following pages include the reports for each structural member of the bridge that RISA software calculated. The type of member is listed before the detailed report.

Node Reactions

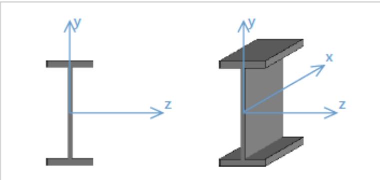
Using this chart, I can see the load carried to each node, and the direction of the load. I am also able to determine the directional moment at each node.

Node Reactions (By Combination)

	LC	Node Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	1	N1	0	0	52.219	0	0	0
2	1	N3	0	0	72.344	0	0	0
3	1	N5	0	0	52.219	0	0	0
4	1	N13	0	0	52.219	0	0	0
5	1	N15	0	0	72.344	0	0	0
6	1	N17	0	0	52.219	0	0	0
7	1	N25	0	0	31.396	0	0	0
8	1	N27	0	0	43.271	0	0	0
9	1	N29	0	0	31.396	0	0	0
10	1	N37	0	0	43.271	0	0	0
11	1	N38	0	0	31.396	0	0	0
12	1	N41	0	0	31.396	0	0	0
13	1	WP1	0	0	26.774	0	0	0
14	1	WP2	0	0	26.774	0	0	0

Steel Beam (Outside)

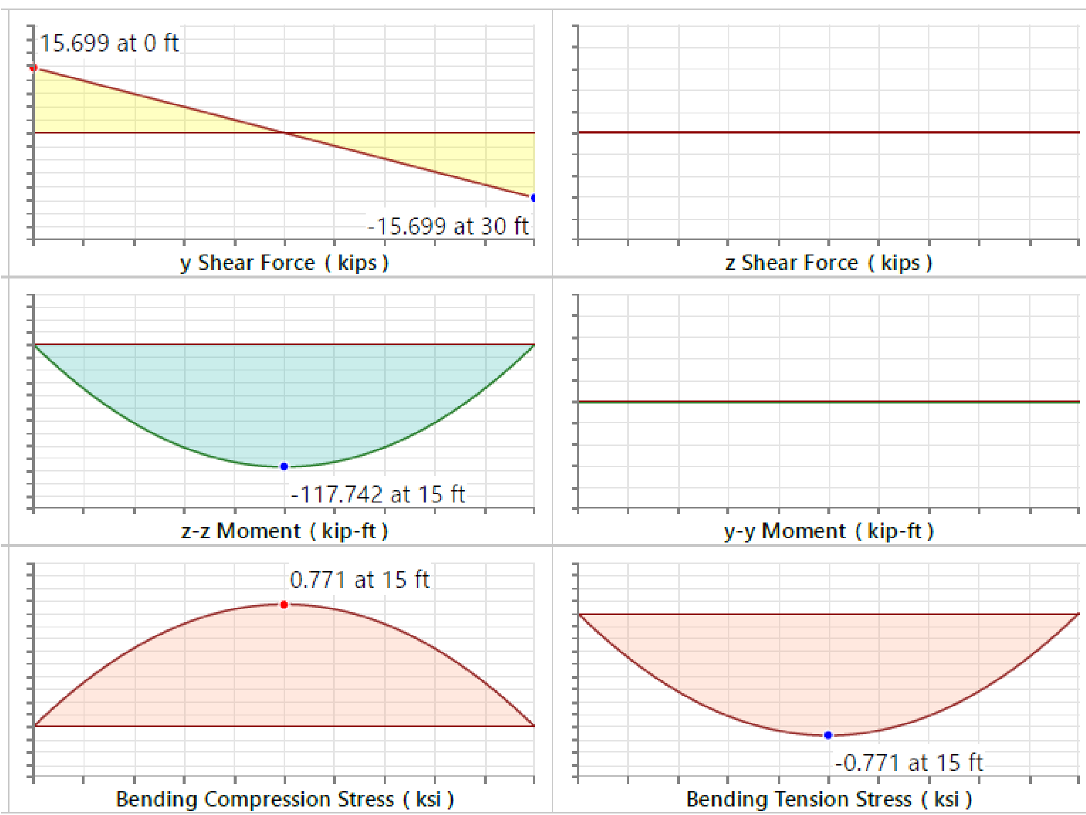
Detail Report: M40 **Unity Check:** 0.023 (axial/bending) **Load Combination:** LC 1: DL+LL



Input Data:

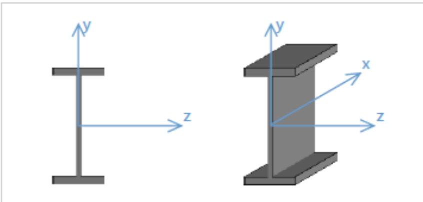
Shape:	W36X487	I Node:	N12
Member Type:	Beam	J Node:	N24
Length (ft):	30	I Release:	BenPIN
Material Type:	Hot Rolled Steel	J Release:	BenPIN
Design Rule:	Typical	I Offset (in):	N/A
Number of Internal Sections:	97	J Offset (in):	N/A

Limit State	Required	Available	Unity Check	₹esult
Applied Loading - Bending/Axial				
Applied Loading - Shear + Torsion	-	-	-	-
Axial Tension Analysis	0.000 k	4281.437 k	-	-
Axial Compression Analysis	0.000 k	2344.416 k	-	-
Flexural Analysis (Strong Axis)	117.742 k-ft	5202.121 k-ft	-	-
Flexural Analysis (Weak Axis)	0.000 k-ft	1027.944 k-ft	-	-
Shear Analysis (Major Axis y)	15.699 k	1179 k	0.013	Pass
Shear Analysis (Minor Axis z)	0.000 k	1646.515 k	0.000	Pass
Bending & Axial Interaction Check (UC Bending Max)	-	-	0.023	Pass



Steel Beam (Inside)

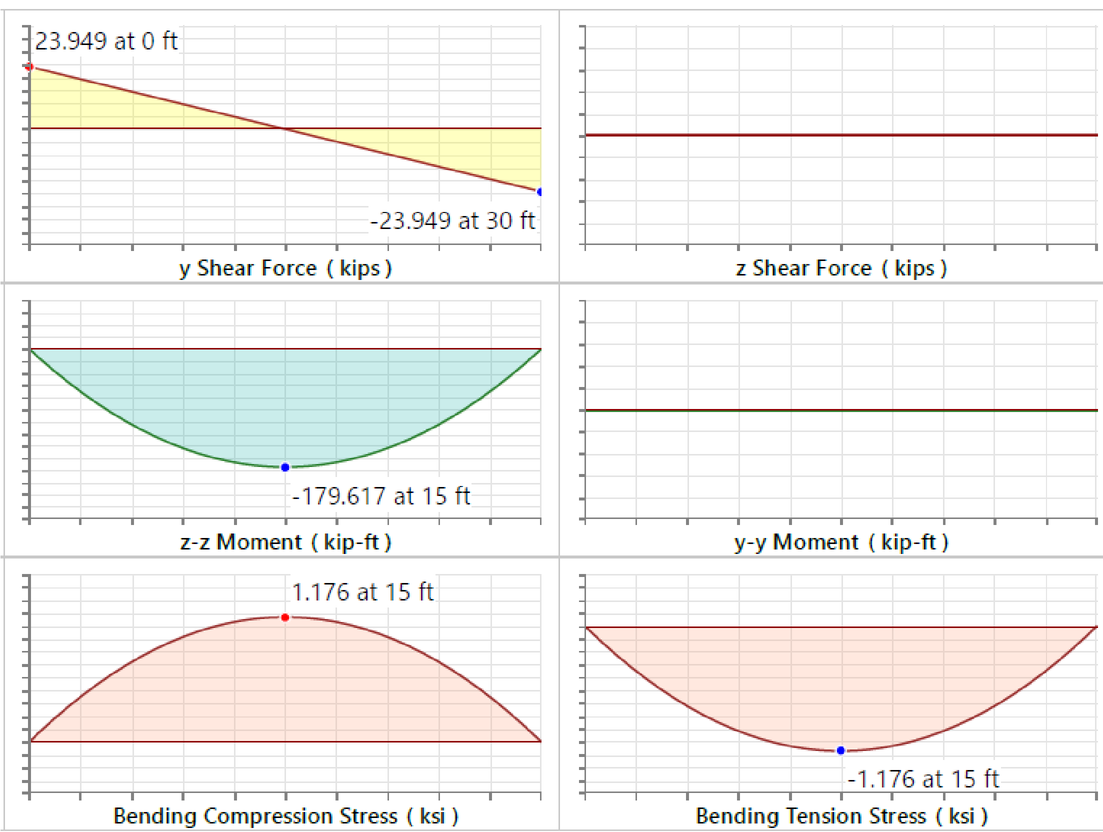
It is important to notice that the inside beam has a greater maximum shear and moment because it is carrying more load.



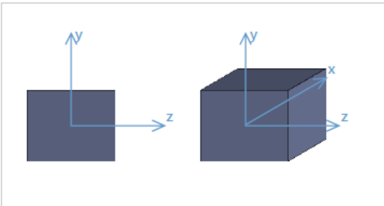
Input Data:

Shape:	W36X487	I Node:	N23
Member Type:	Beam	J Node:	N11
Length (ft):	30	I Release:	BenPIN
Material Type:	Hot Rolled Steel	J Release:	BenPIN
Design Rule:	Typical	I Offset (in):	N/A
Number of Internal Sections:	97	J Offset (in):	N/A

Limit State	Required	Available	Unity Check	₹esult
Applied Loading - Bending/Axial				
Applied Loading - Shear + Torsion	-	-	-	-
Axial Tension Analysis	0.000 k	4281.437 k	-	-
Axial Compression Analysis	0.000 k	2344.416 k	-	-
Flexural Analysis (Strong Axis)	179.617 k-ft	5202.121 k-ft	-	-
Flexural Analysis (Weak Axis)	0.000 k-ft	1027.944 k-ft	-	-
Shear Analysis (Major Axis y)	23.949 k	1179 k	0.02	Pass
Shear Analysis (Minor Axis z)	0.000 k	1646.515 k	0.000	Pass
Bending & Axial Interaction Check (UC Bending Max)	-	-	0.035	Pass

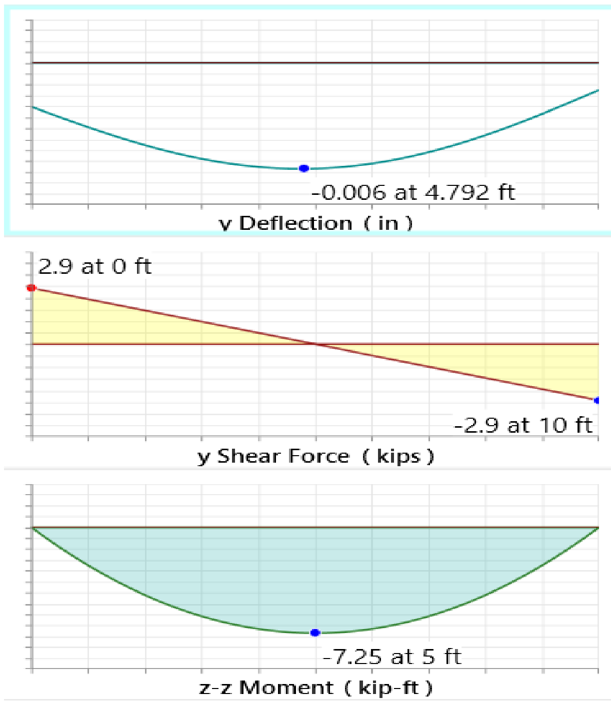


Pier Connectors

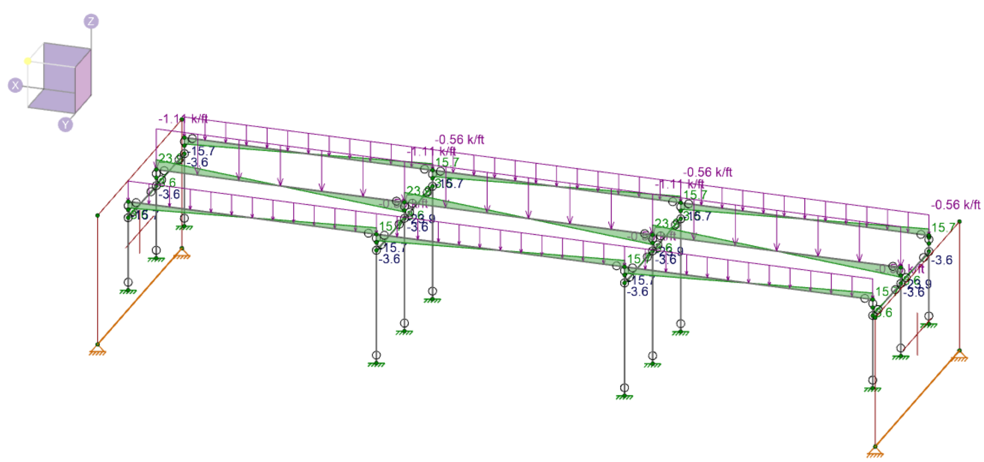


Input Data:

Shape:	CRECT24X30	I Node:	N20
Member Type:	Beam	J Node:	N21
Length (ft):	10	I Release:	BenPIN
Material Type:	Concrete	J Release:	BenPIN
Design Rule:	Typical	I Offset (in):	N/A
Number of Internal Sections:	97	J Offset (in):	N/A
Design Code:	ACI 318-19		



Entire Bridge Shear Diagram



Cost Analysis of Bridge

The hardest price to find for the bridge was the price of steel. I estimated on the higher end. Depending on the availability of the wide flanged beam, the price is subject to change.

Bridge Cost Analysis

Material	Size	Pieces	Length (ft)	Weight (kips)	Unit Cost	Total Cost
Hot Rolled Steel	W36X487	9	270	131.381	$375 per 1000 lbs	$49,267.88
A992						

Material	Size	Pieces	Volume (yds^3)	Weight (kips)	Unit Cost	Total Cost
Masonry Walls		2	28.5	61.599	$117 per yds^3	3334.5
Concrete Matl						

Material	Size	Pieces	Volume (yds^3)	Weight (kips)	Unit Cost	Total Cost
Conc4000NW	CRECT24X30	8	14.8	58	$117 per yds^3	6984.9
Conc4000NW	CRND36	12	39.3	153.742		
Conc4000NW	CRND48	12	5.6	21.865		
		Total Volume of Concrete:	59.7			
					Total Cost:	$59,587.28

Conclusion

Overall, this project was pivotal to my journey in becoming a civil engineer. I was able to provide some preliminary structural models, estimate loads, and learn how each load affected each member of my structure. The shear and moment diagrams the RISA software gave me were very similar to what I would expect to calculate if done by hand. All the detailed report outputs provided by RISA need to be interpreted and other tests need to be done before the design of the final project would be completed. Also, the material takeoff tool is a very unique tool to estimate quantities and prices. However, all materials would need to be researched for availability and quotes from a supplier. In conclusion, both the house structure and the bridge structure that I modeled are a good start to the design of two projects using wood, concrete, and steel.