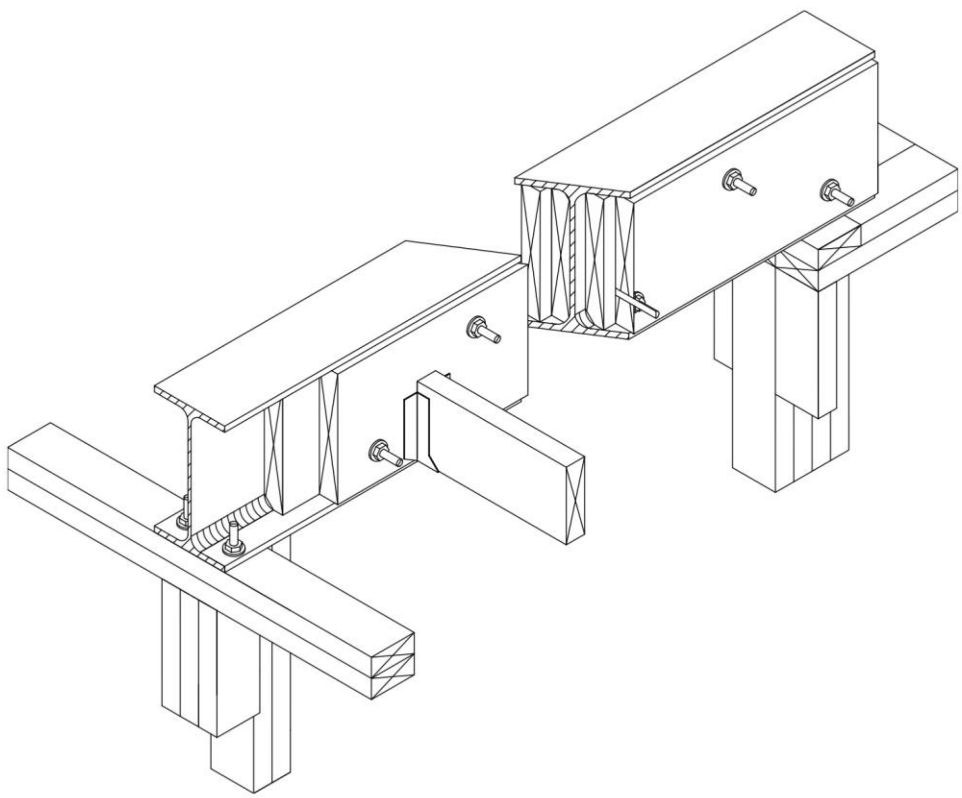
RYAN LI

STRUCTURAL ENGINEERING PORTFOLIO

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN
CIVIL & ENVIRONMENTAL ENGINEERING

JULY 2026



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RESIDENTIAL LOAD-BEARING WALL OPENING ANALYSIS AND BEAM DESIGN

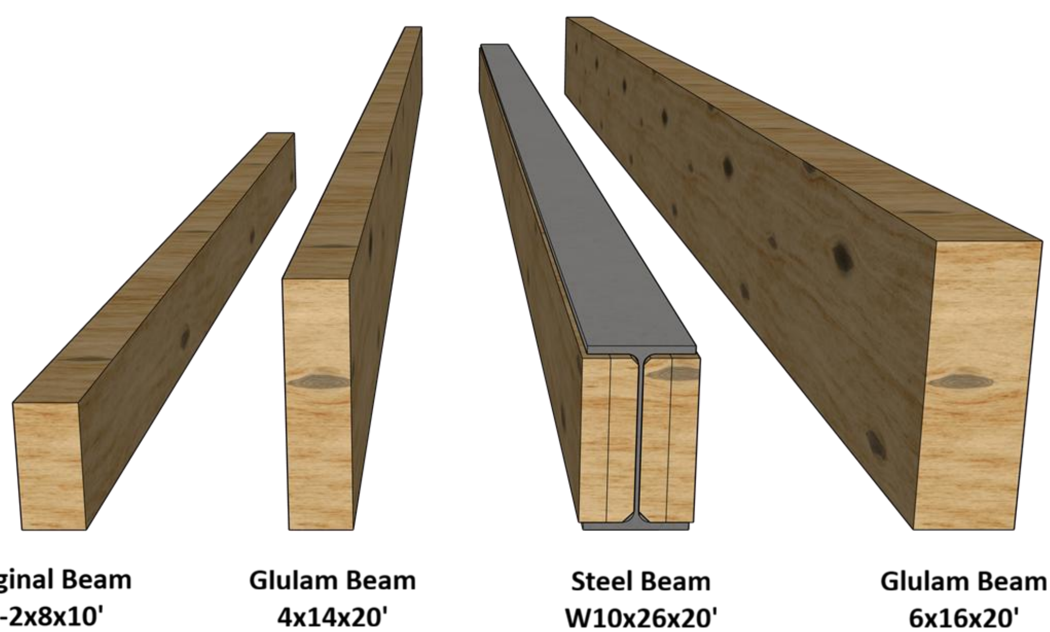
Bridgewater, NJ | July 2026

This project involved replacing a load-bearing wall with a structural beam system to open up the floor plan of a residential home in Bridgewater, NJ. The design needed to safely transfer the ceiling joist and roof loads while meeting building code requirements.

I developed a full 23-sheet drawing set in AutoCAD, performed manual beam sizing calculations in Excel, and built a 3D model in SketchUp to visualize the framing. The project covers two material options—Glulam and steel—along with a cost comparison to help inform the decision.

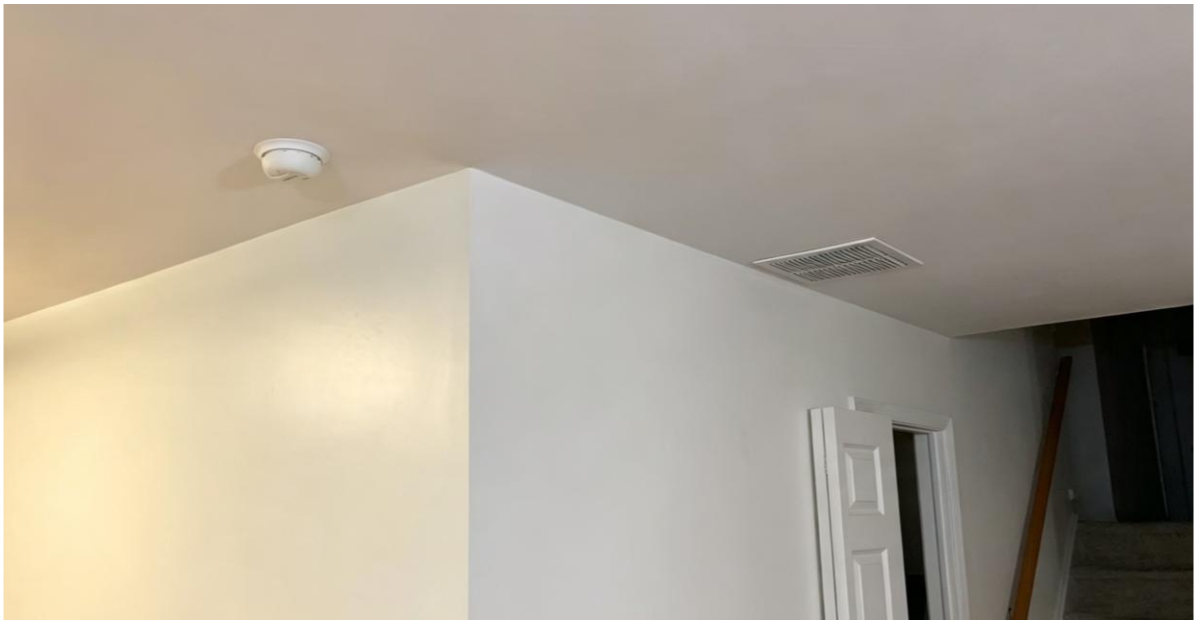
Overall, this was a valuable opportunity to practice structural drafting, load path analysis, and engineering documentation from start to finish.

Software: AutoCAD, Excel, SketchUp
Materials: Glulam, Steel
Role: Structural Design & Drafting



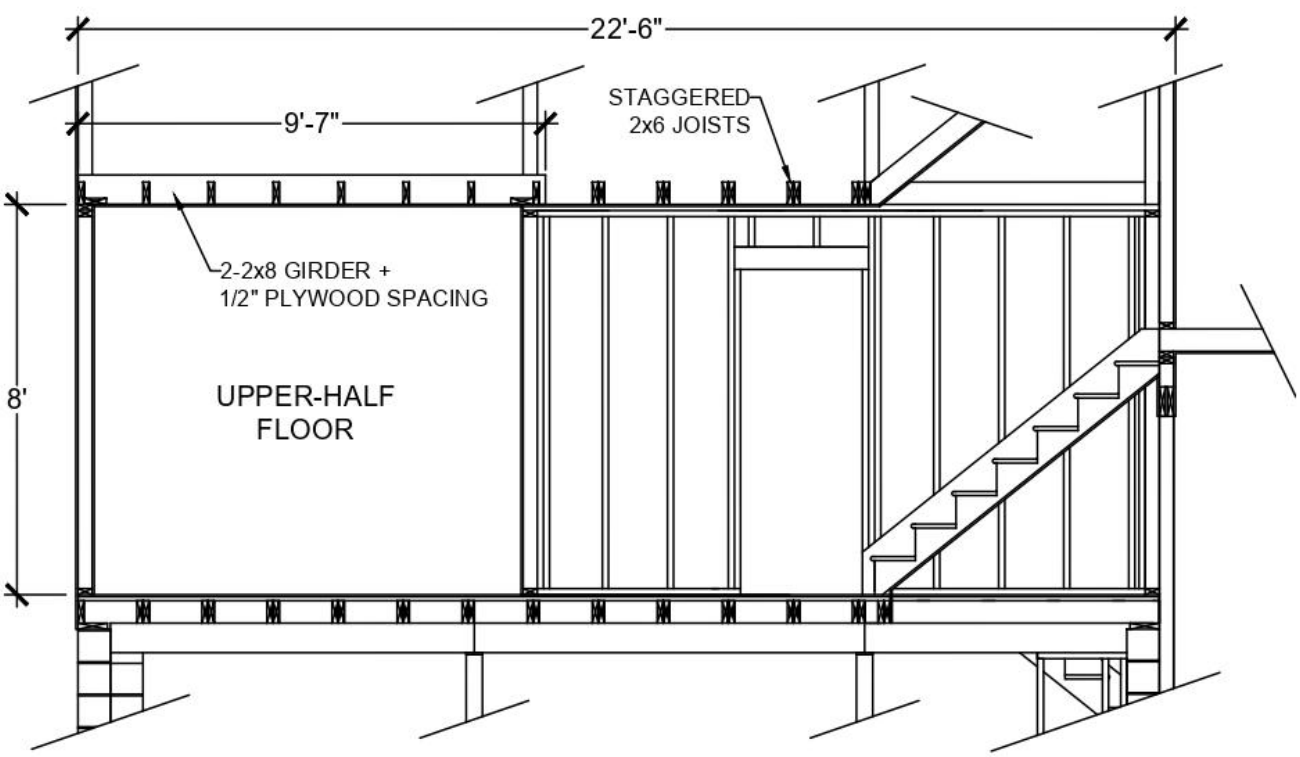
EXISTING CONDITIONS

Existing Structure (covered in drywall)



AutoCAD Drawing of Existing Conditions

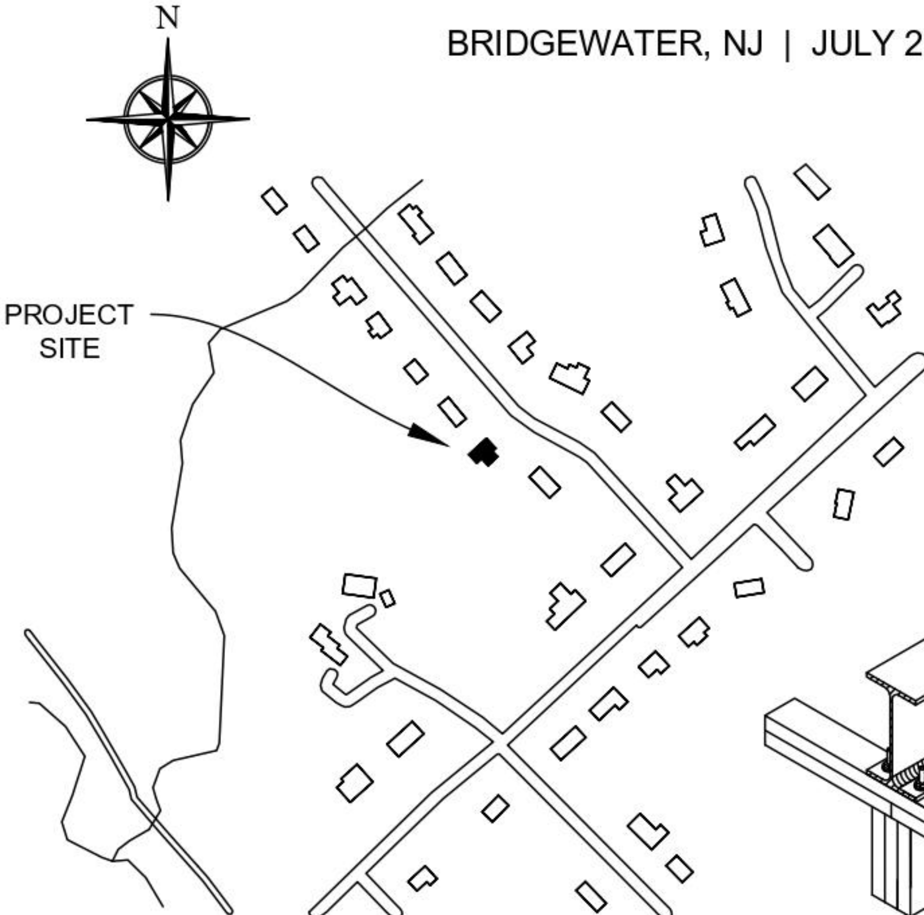
EXISTING SECTION – FRONT	
S-30	Original scale: 3/16" = 1'



Existing walls are framed with 2x4 studs at 16" O.C.
Ceiling framing consists of 2x6 joists.

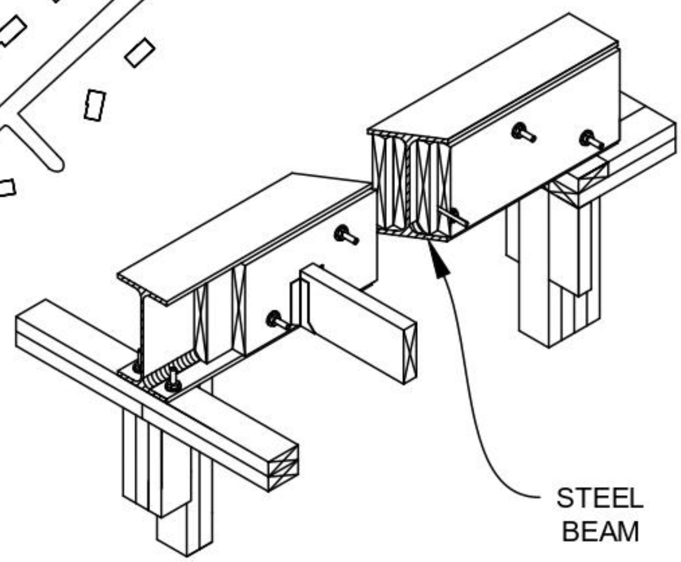
RESIDENTIAL LOAD-BEARING WALL OPENING ANALYSIS AND BEAM DESIGN

BRIDGEWATER, NJ | JULY 2026



UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN
CIVIL & ENVIRONMENTAL ENGINEERING
INDEPENDENT STRUCTURAL DESIGN PROJECT

OBJECTIVE: DESIGN A STRUCTURAL BEAM SYSTEM TO REPLACE A LOAD-BEARING WALL SEGMENT OF A RESIDENTIAL HOME WHILE MAINTAINING ADEQUATE LOAD TRANSFER AND CODE-COMPLIANT SUPPORT CONDITIONS.



STRUCTURAL NOTES:

1. COMPLY WITH ALL APPLICABLE LOCAL BUILDING CODES.
2. ALL WORK TO BE PERMITTED / INSPECTED PER LOCAL JURISDICTION.
3. ALL CONNECTIONS TO BE DESIGNED BY OTHERS PER CALCS.
4. ALL BEARING SURFACES TO BE SHIMMED & GROUTED AS REQUIRED.
5. ALL FASTENERS TO BE ASTM A307 GALVANIZED STEEL.
6. ALL WOOD IN CONTACT WITH CONCRETE TO BE PT LUMBER.
7. ALL FRAMING LUMBER TO BE #2 GRADE OR BETTER.
8. ALL DIMENSIONS FOR LUMBER ARE NOMINAL
9. ALL STRUCTURAL STEEL TO BE ASTM A992.
10. CONCRETE: 4,000 PSI @ 28 DAYS.
11. MINIMUM BEARING LENGTH: 3-1/2" UNLESS NOTED OTHERWISE.
12. FIELD VERIFY ALL DIMENSIONS BEFORE FABRICATION.
13. SEE ARCHITECTURAL DWGS FOR FINISH FLOOR & CEILING HEIGHTS.
14. DISCLAIMER: THIS IS A STUDENT PROJECT, NOT FOR CONSTRUCTION. MUST BE REVIEWED BY A LICENSED STRUCTURAL ENGINEER.

REVISION TABLE			
#	DESCRIPTION	DATE	BY
0	INITIAL ISSUE	7/18/26	R.L.

NAME: RYAN LI

DRAWING #: S-01

SHEET #: 1 of 23

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S-02	DEMOLITION PLAN	S-35	STEEL SECTION - SIDE
S-03	UPPER-HALF FLOOR LAYOUT	S-40	GLULAM CONNECTIONS - FRONT
S-04	FOUNDATION FLOOR LAYOUT	S-41	GLULAM CONNECTIONS - SIDE
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S-12	STEEL UPPER-HALF FRAMING	S-44	GLULAM/STEEL COLUMN BEARING DETAIL
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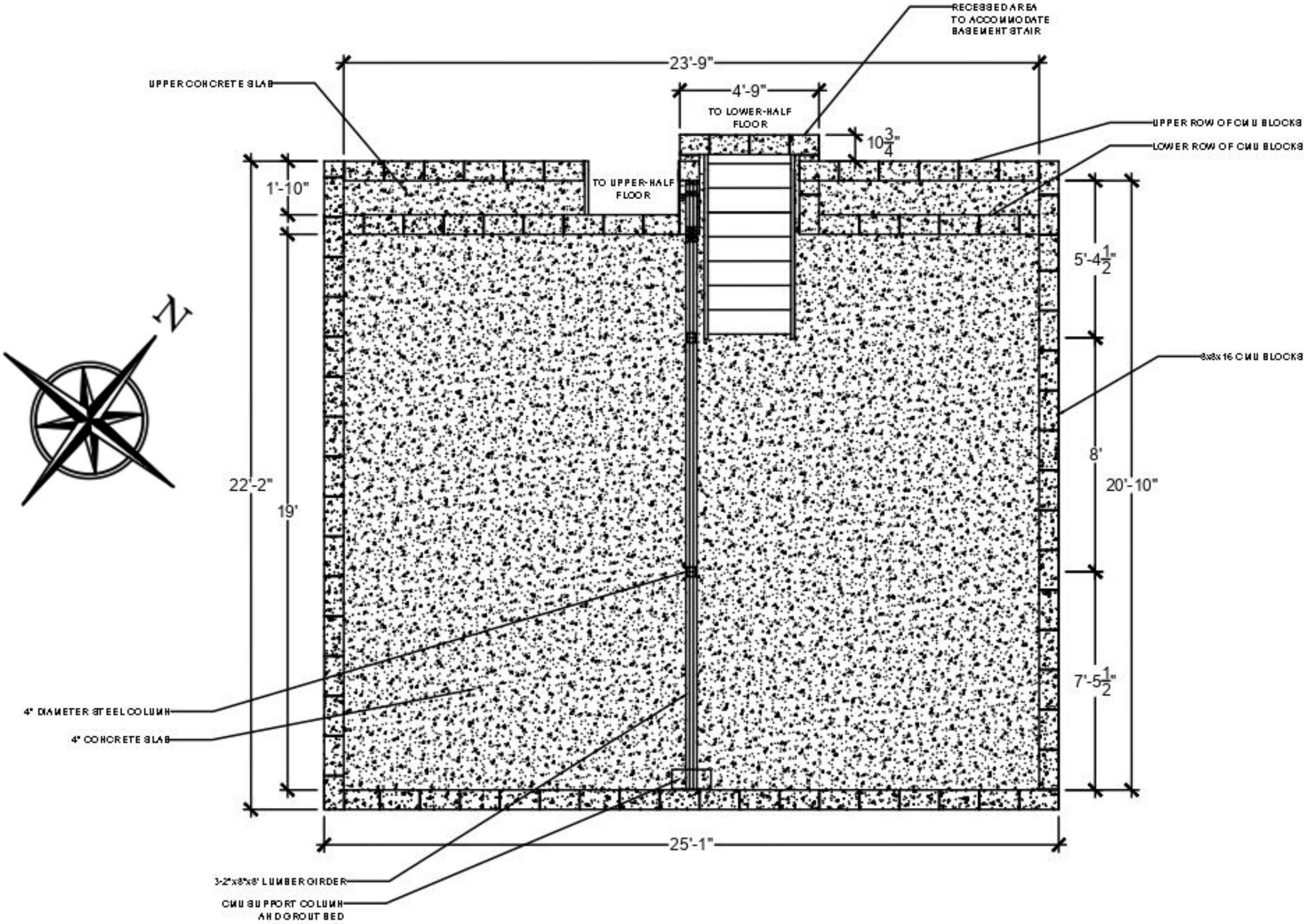
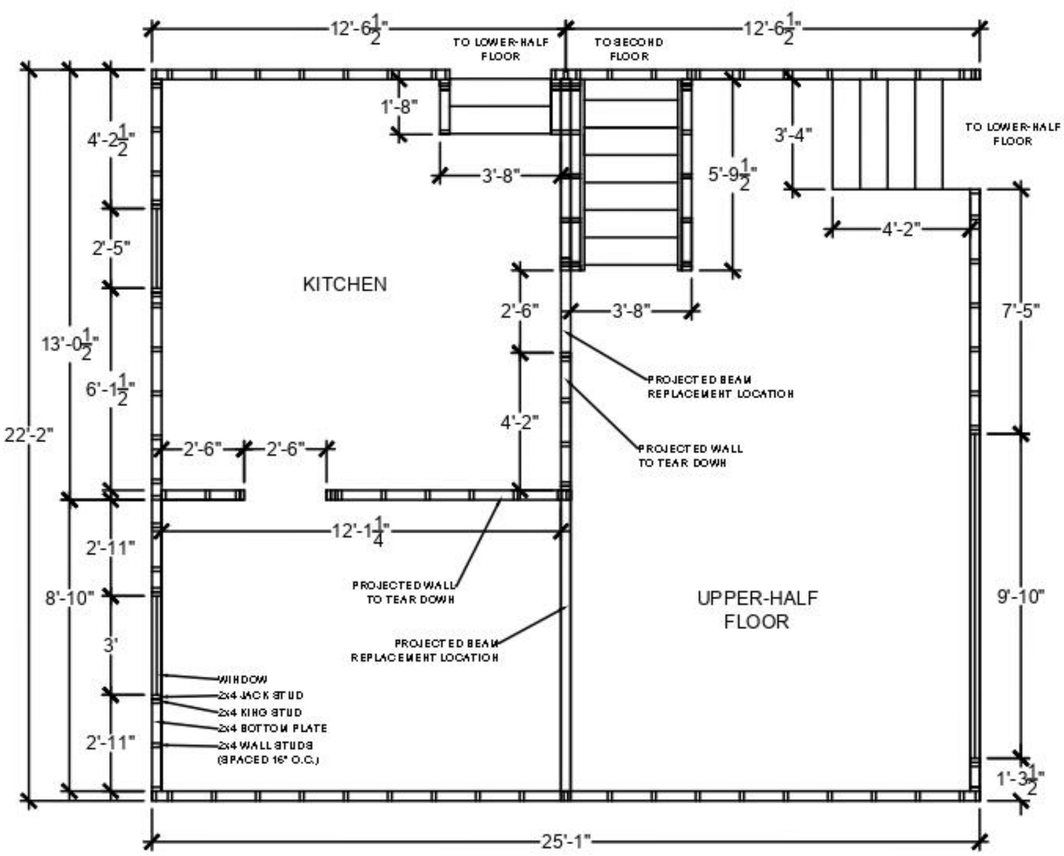
		S-49	STEEL BEAM ISOMETRIC DRAWING

DRAWING S-01 COVER SHEET

This is the cover sheet for the 23-sheet structural drawing set. The sheet is reformatted for portfolio layout.





FOUNDATION FLOOR LAYOUT

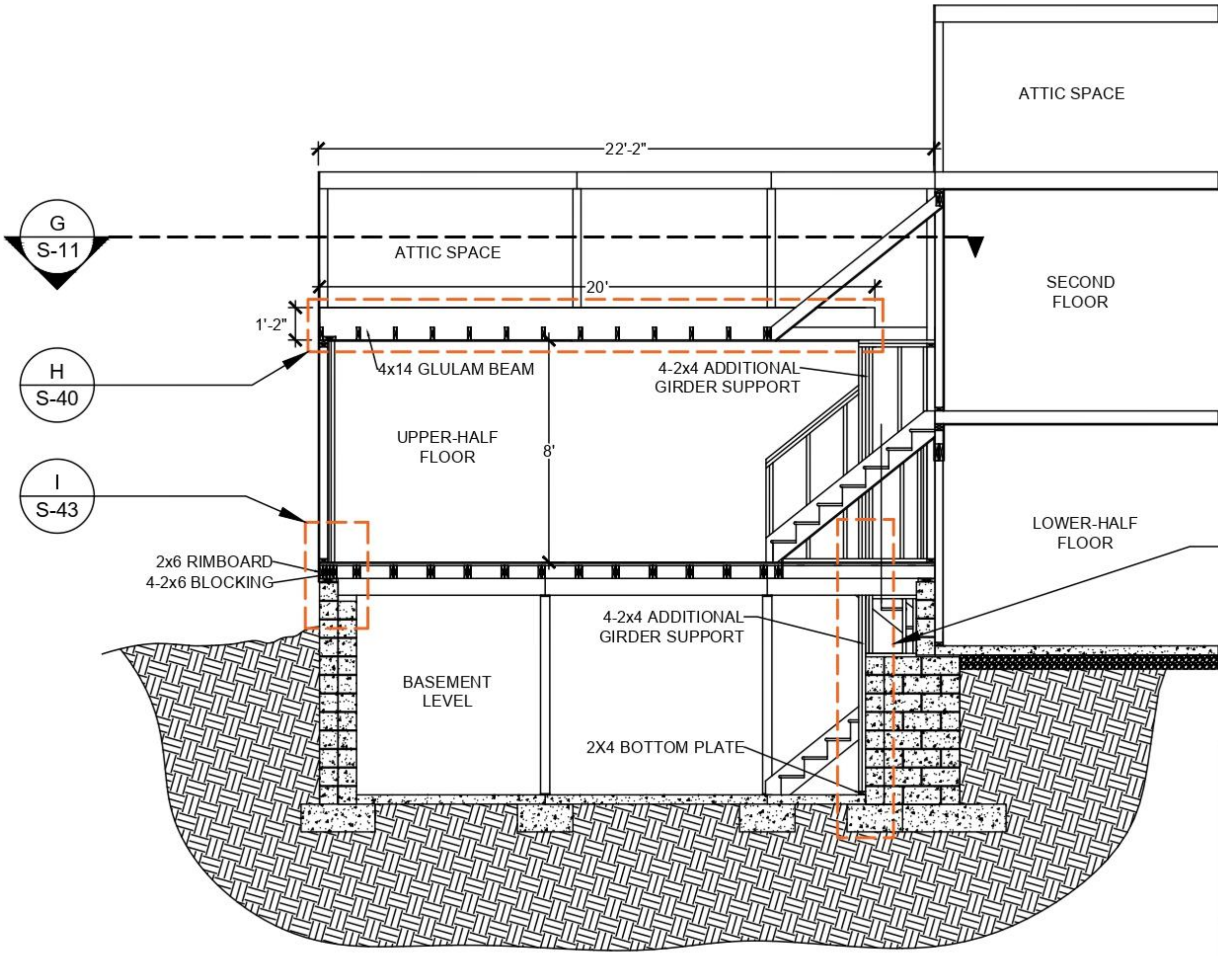
Original scale: 3/16" = 1'

S-04

UPPER-HALF FLOOR LAYOUT

Original scale: 3/16" = 1'

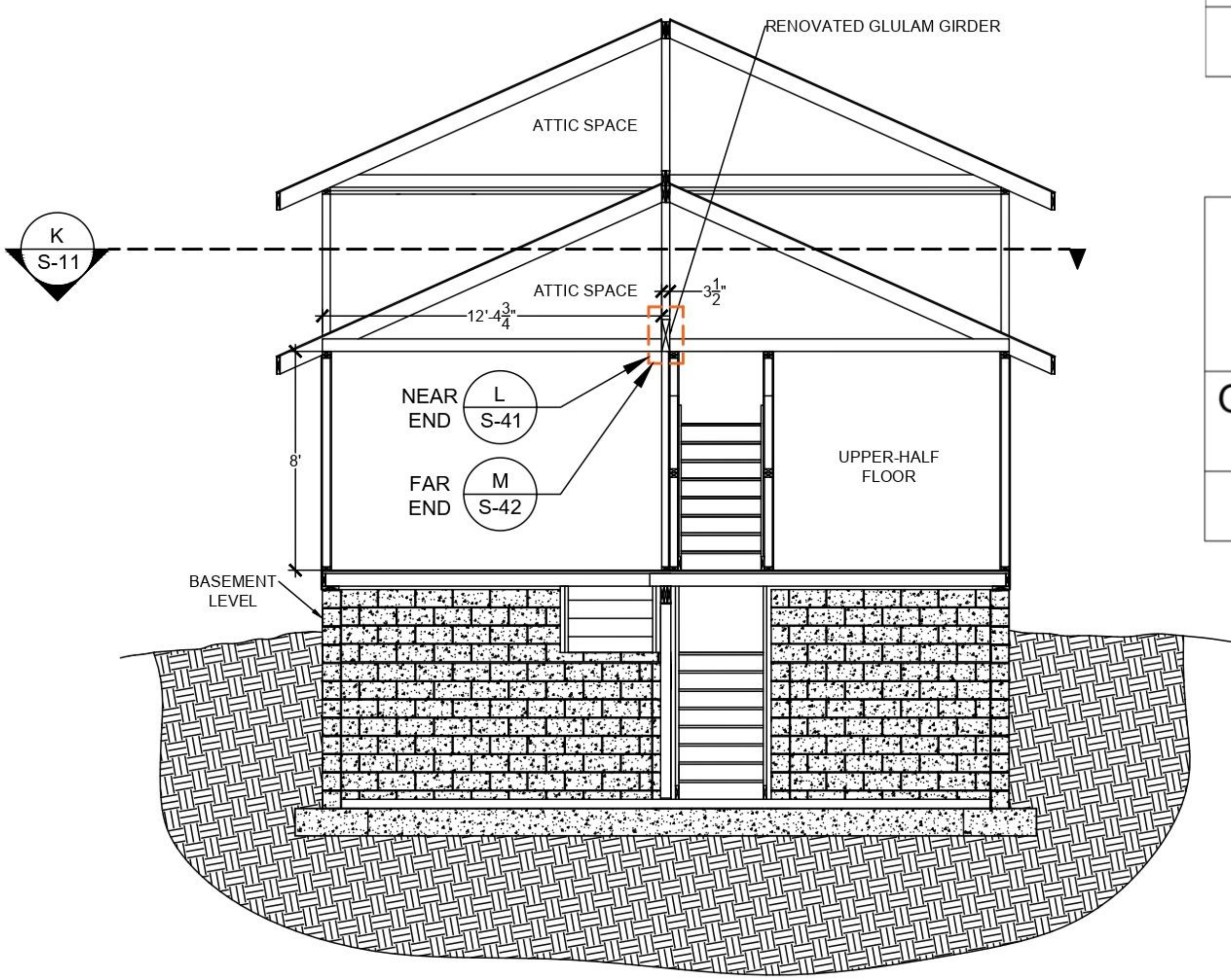
S-03



GLULAM SECTION - FRONT

Original scale: 3/16" = 1'

S-32

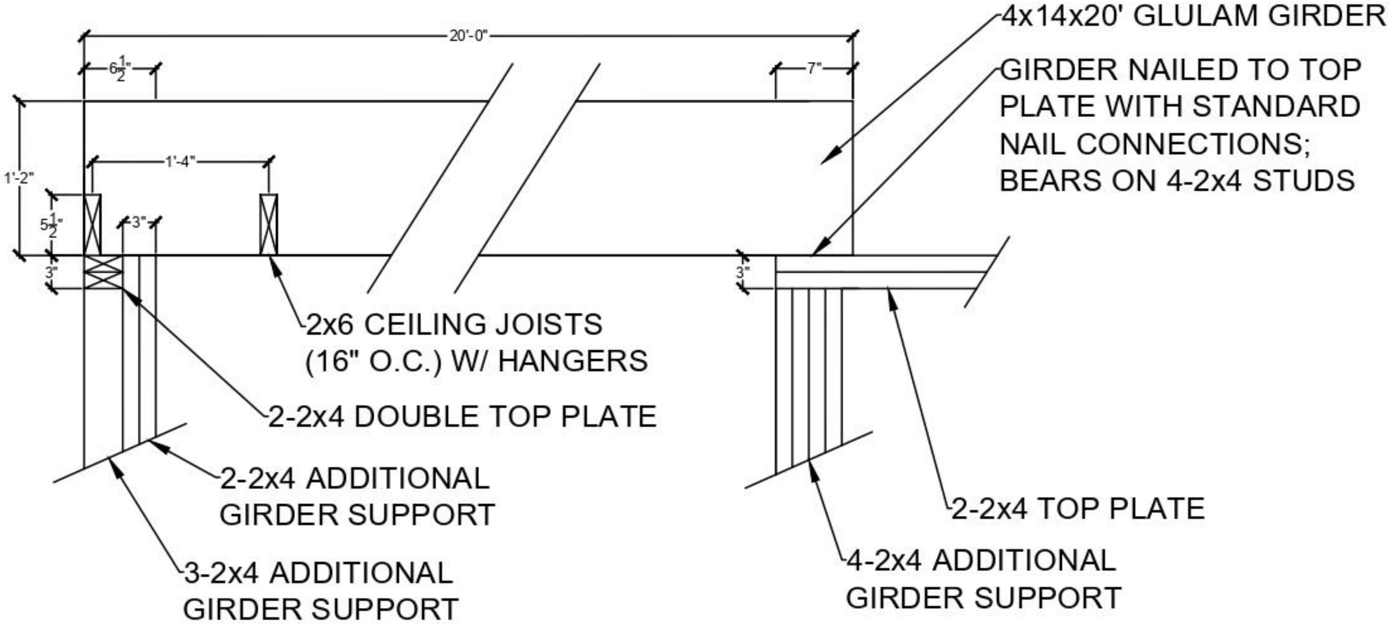


GLULAM SECTION - SIDE

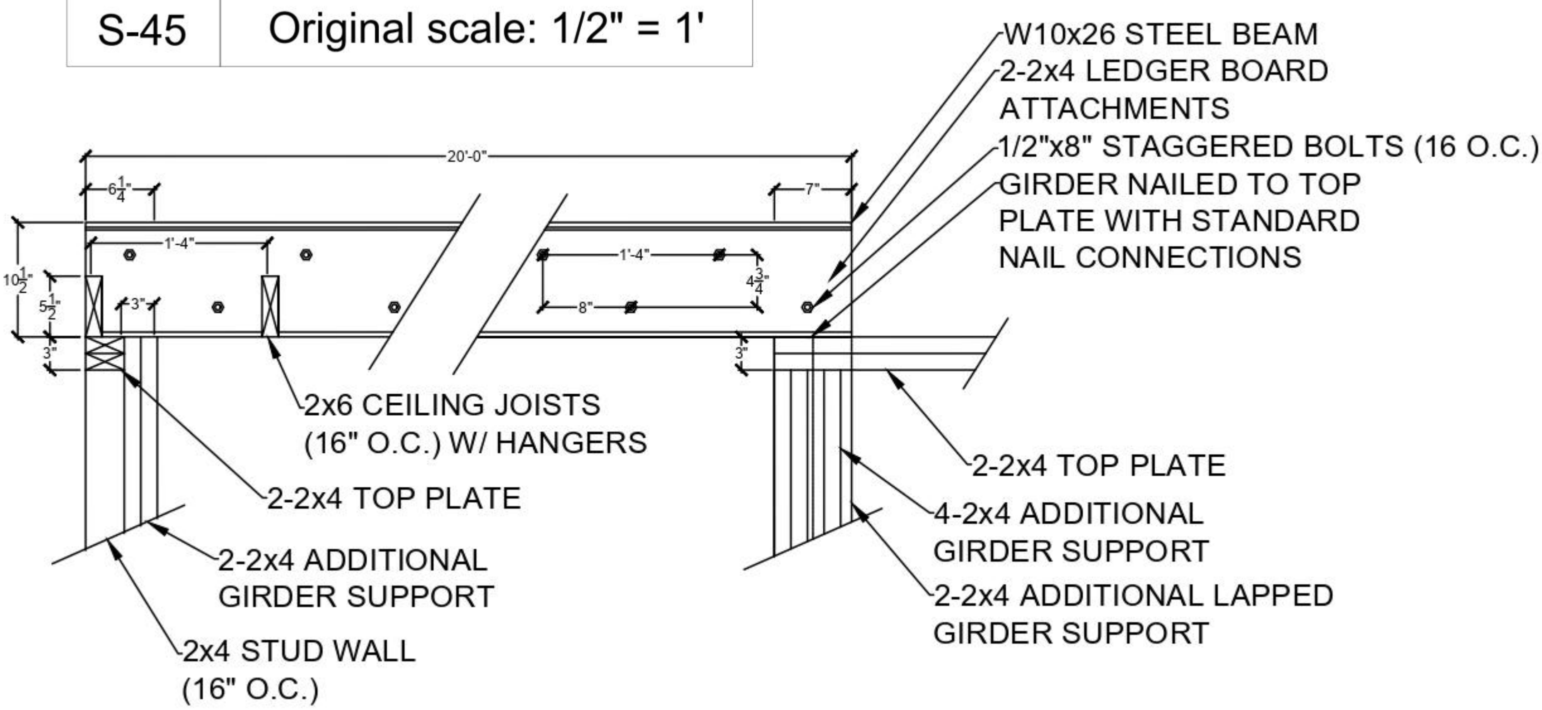
Original scale: 3/16" = 1'

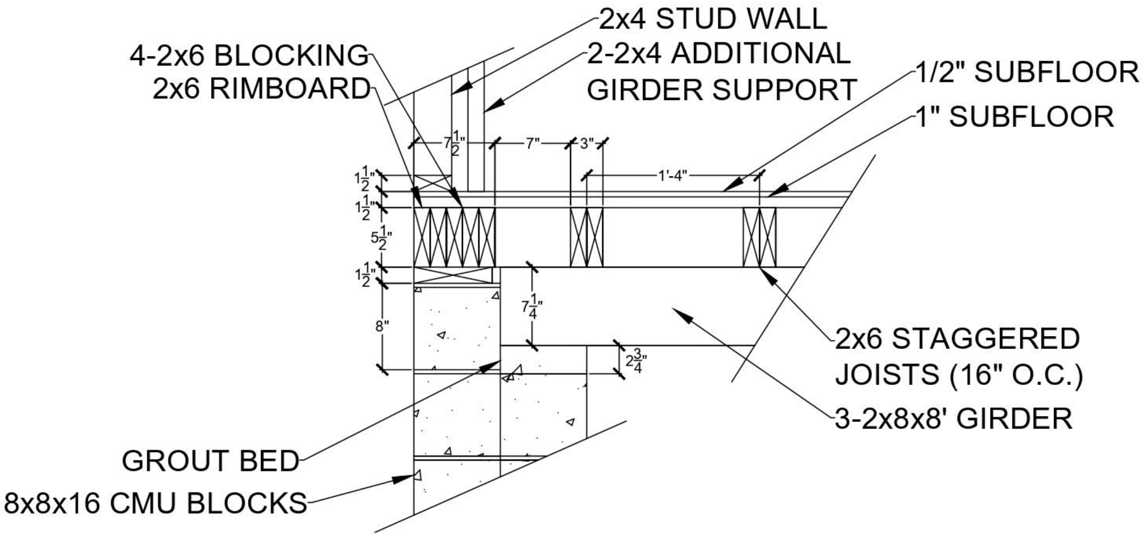
S-33

GLULAM CONNECTIONS - FRONT	
S-40	Original scale: 1/2" = 1'



STEEL CONNECTIONS - FRONT	
S-45	Original scale: 1/2" = 1'

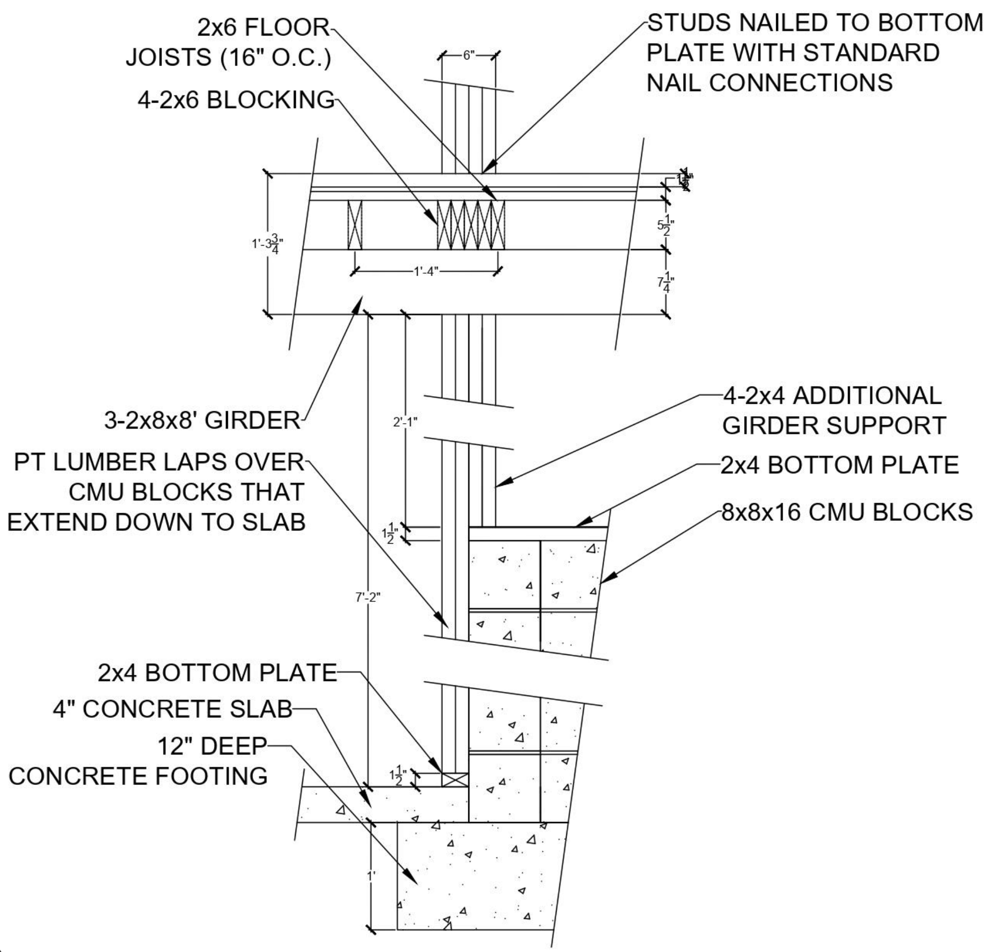




ADDITIONAL SUPPORT DETAIL

Original scale: 1" = 1'

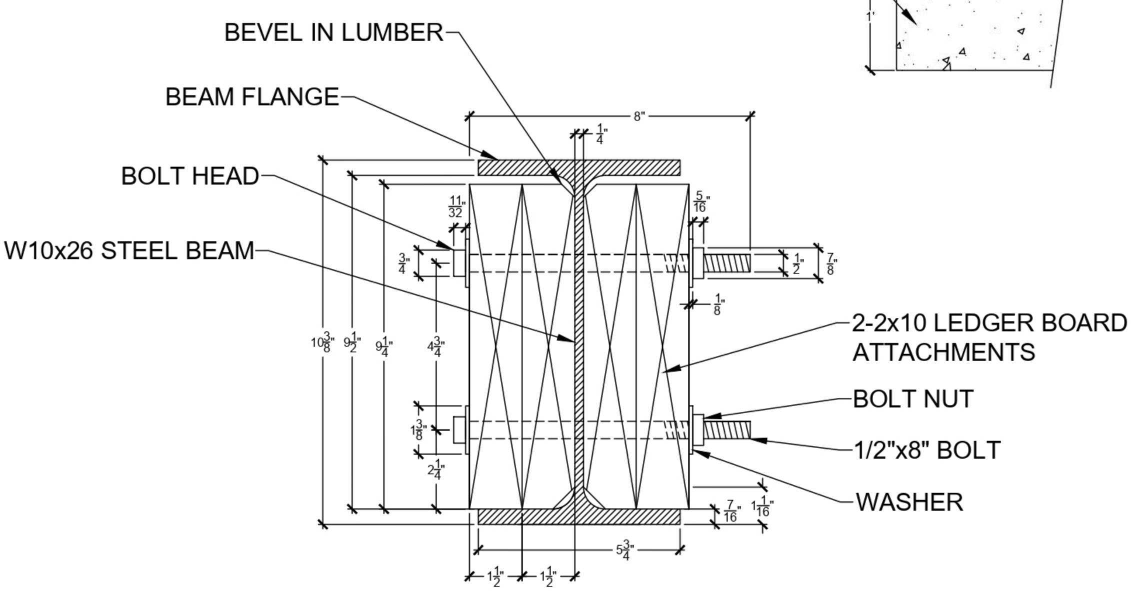
S-43



ADDITIONAL SUPPORT DETAIL

Original scale: 1/2" = 1'

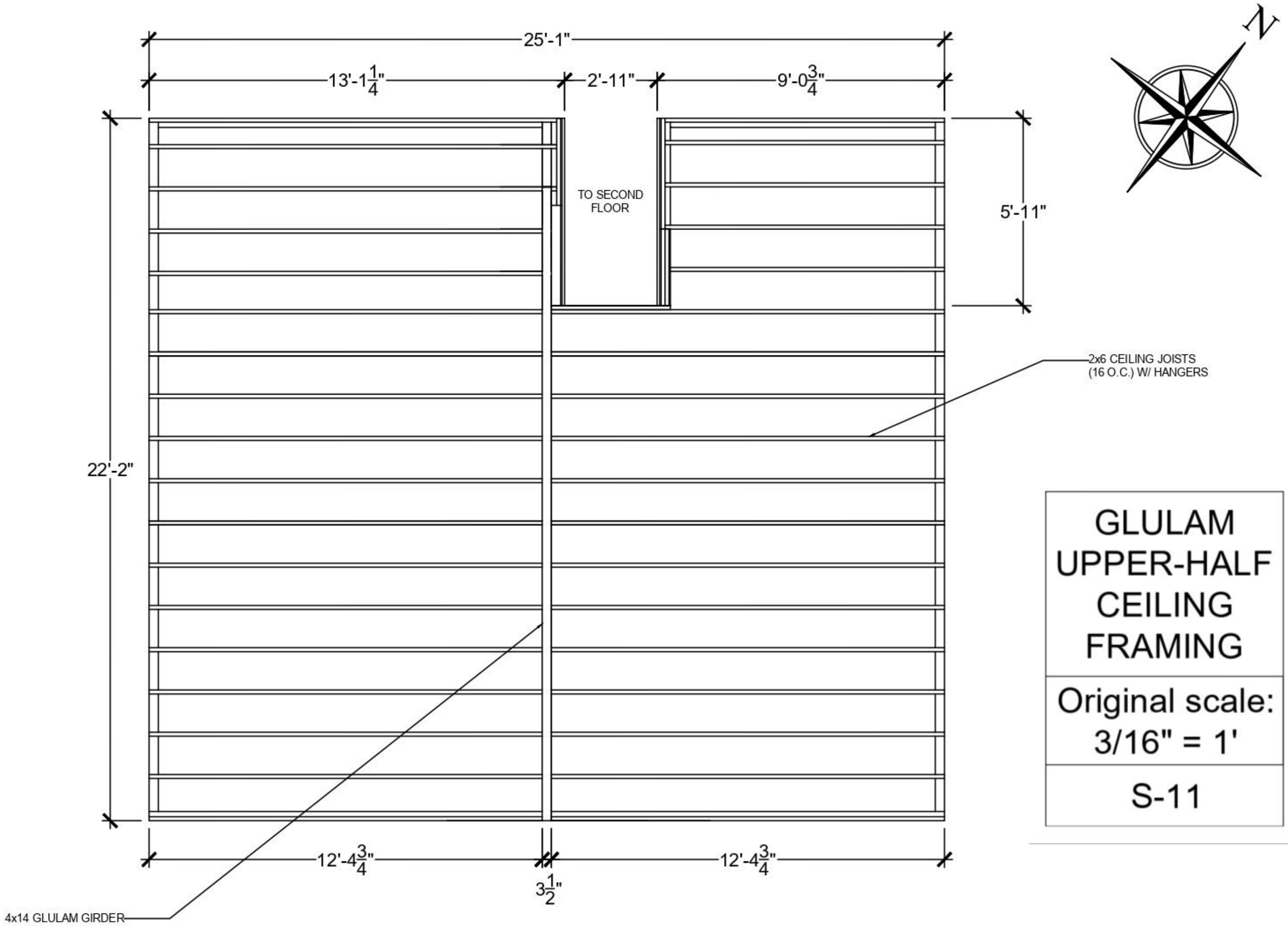
S-44



STEEL BEAM FABRICATION DETAILS

Original scale: 3" = 1'

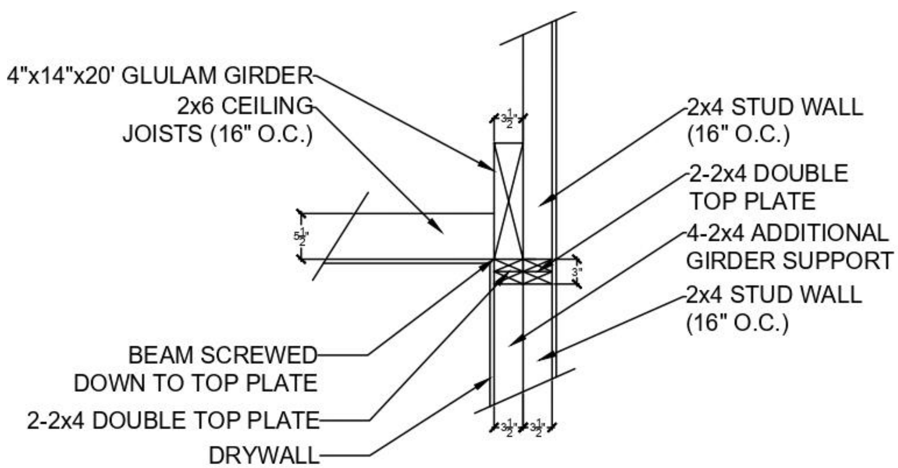
S-48



GLULAM UPPER-HALF CEILING FRAMING

Original scale: 3/16" = 1'

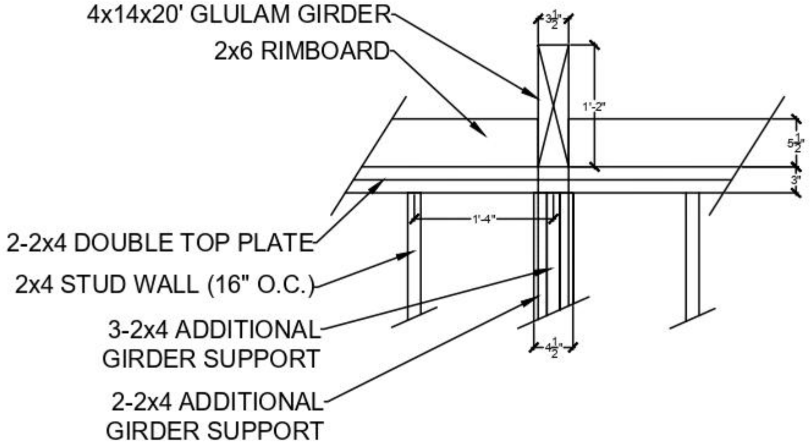
S-11



GLULAM B. TO STUD CONNECTION

Original scale: 1" = 1'

S-42



GLULAM CONNECTION - SIDE

Original scale: 1" = 1'

S-41

BEAM SIZING CALCULATIONS - GLULAM AND STEEL BEAM

Glulam Beam (4x14x20')

BEAM PROPERTIES	SYMBOL	UNITS	VALUES	NOTES
Beam Width	b	in	3.5	Beam size (known)
Beam Depth	d	in	14	Beam size (known)
Span	L	in	226	Project requirement (18'-10")
Area	A	in^2	49	Calculated: b × d
Weight	w_beam	lb/ft	11.91	Based on glulam density (~35 pcf)
Bending Stress (Reference)	F_b	psi	2400	24F-V4 grade (manufacturer spec)
Modulus of Elasticity	E	psi	1800000	24F-V4 grade (manufacturer spec)
Moment of Inertia	I_x	in^4	800.33	$(b \times d^3) / 12$
Section Modulus	S_x	in^3	114.33	$(b \times d^2) / 6$

LOADS	SYMBOL	UNITS	VALUES	NOTES
Roof Dead Load	D_roof	psf	15	Standard residential assembly
Roof Snow Load	S_roof	psf	30	NJ snow load (3/12 pitch)
Attic Dead Load	D_attic	psf	10	Ceiling joists + drywall (IRC)
Attic Live Load	L_attic	psf	10	Uninhabitable attic (IRC)
Tributary Width	TW	ft	12.5	Half of 25 ft span
Weight	w_beam	lb/ft	11.91	Based on glulam density (~35 pcf)
Total Uniform Load	w	plf	824.4	(D_roof + S_roof + D_attic + L_attic) × TW + w_beam
Live Load for Deflection	w_live	plf	500.0	(S_roof + L_attic) × TW

CALCULATIONS	SYMBOL	UNITS	VALUES	NOTES
Span	L	ft	18.83	Clear span (L(in) / 12)
Moment	M	lb-ft	36551.7	$(w \times L^2) / 8$
Moment	M	lb-in	438620.3	M (lb-ft) × 12
Actual Bending Stress	f_b	psi	3836.3	M / S_x
Volume Factor	C_v	-	0.85	Per NDS for 5.5" x 16" beam
Fb' (Adjusted)	F_b'	psi	2040.0	F_b × C_v
Bending Check	-	-	**FAIL**	f_b ≤ F_b'
Live Load for Deflection	w_live	pli	41.7	(S_roof + L_attic) × TW / 12
Deflection	Δ	in	1.13	$5 \times w\_live \times L^4) / (384 \times E \times I) \times 1.15$
Allowable Deflection	Δ_allow	in	0.63	L / 360 (per IBC)
Deflection Check	-	-	**FAIL**	Δ ≤ Δ_allow

Steel Beam (W10x26x20')

BEAM PROPERTIES	SYMBOL	UNITS	VALUES	NOTES
Beam Depth	d	in	10.3	AISC W10x26 Dimensions
Beam Area	A	in^2	7.61	Section Property
Span	L	in	226	Project Requirement (18'-10")
Weight	w_beam	lb/ft	26	AISC designation (W10x26)
Moment of Inertia	I_x	in^4	144	AISC section property
Section Modulus	S_x	in^3	31.3	Elastic section modulus (Sx)
Yield Strength	F_y	ksi	50000	ASTM A992
Modulus of Elasticity	E	psi	29000000	Steel material property
Flange Width	b_f	in	5.77	AISC dimenison

LOADS	SYMBOL	UNITS	VALUES	NOTES
Roof Dead Load	D_roof	psf	15	Standard residential assembly
Roof Snow Load	S_roof	psf	30	NJ snow load (3/12 pitch)
Attic Dead Load	D_attic	psf	10	Ceiling joists + drywall (IRC)
Attic Live Load	L_attic	psf	10	Uninhabitable attic (IRC)
Tributary Width	TW	ft	12.5	Half of 25 ft span
Weight	w_beam	lb/ft	26.00	AISC designation (W10x26)
Total Uniform Load	w	plf	838.5	(D_roof + S_roof + D_attic + L_attic) × TW + w_beam
Live Load for Deflection	w_live	plf	500.0	(S_roof + L_attic) × TW

CALCULATIONS	SYMBOL	UNITS	VALUES	NOTES
Span	L	ft	18.83	Clear span (L(in) / 12)
Moment	M	lb-ft	37176.4	$(w \times L^2) / 8$
Moment	M	lb-in	446116.9	M (lb-ft) × 12
Actual Bending Stress	f_b	psi	14252.9	M / S_x
Allowable Stress Coefficient	-	-	0.60	AISC ASD
Allowable Bending Stress	F_b'	psi	30000	0.6 × F_y
Bending Check	-	-	**PASS**	f_b ≤ F_b'
Live Load for Deflection	w_live	pli	41.7	(S_roof + L_attic) × TW / 12
Deflection	Δ	in	0.34	$5 \times w\_live \times L^4) / (384 \times E \times I)$
Allowable Deflection	Δ_allow	in	0.63	L / 360 (per IBC)
Deflection Check	-	-	**PASS**	Δ ≤ Δ_allow

GLULAM AND STEEL BEAM SIZING CALCULATIONS

Glulam Beam (6x16x20')				
BEAM PROPERTIES	SYMBOL	UNITS	VALUES	NOTES
Beam Width	b	in	5.5	Beam size (known)
Beam Depth	d	in	16	Beam size (known)
Span	L	in	226	Project requirement (18'-10")
Area	A	in^2	88	Calculated: b × d
Weight	w_beam	lb/ft	21.39	Based on glulam density (~35 pcf)
Bending Stress (Reference)	F_b	psi	2400	24F-V4 grade (manufacturer spec)
Modulus of Elasticity	E	psi	1800000	24F-V4 grade (manufacturer spec)
Moment of Inertia	I_x	in^4	1877.33	$(b \times d^3) / 12$
Section Modulus	S_x	in^3	234.67	$(b \times d^2) / 6$
LOADS	SYMBOL	UNITS	VALUES	NOTES
Roof Dead Load	D_roof	psf	15	Standard residential assembly
Roof Snow Load	S_roof	psf	30	NJ snow load (3/12 pitch)
Attic Dead Load	D_attic	psf	10	Ceiling joists + drywall (IRC)
Attic Live Load	L_attic	psf	10	Uninhabitable attic (IRC)
Tributary Width	TW	ft	12.5	Half of 25 ft span
Weight	w_beam	lb/ft	21.39	Based on glulam density (~35 pcf)
Total Uniform Load	w	plf	833.9	(D_roof + S_roof + D_attic + L_attic) × TW + w_beam
Live Load for Deflection	w_live	plf	500.0	(S_roof + L_attic) × TW
CALCULATIONS	SYMBOL	UNITS	VALUES	NOTES
Span	L	ft	18.83	Clear span (L(in) / 12)
Moment	M	lb-ft	36972.0	$(w \times L^2) / 8$
Moment	M	lb-in	443663.6	M (lb-ft) × 12
Actual Bending Stress	f_b	psi	1890.6	M / S_x
Volume Factor	C_v	-	0.85	Per NDS for 5.5" x 16" beam
Fb' (Adjusted)	F_b'	psi	2040.0	F_b × C_v
Bending Check	-	-	PASS	f_b ≤ F_b'
Live Load for Deflection	w_live	pli	41.7	(S_roof + L_attic) × TW / 12
Deflection	Δ	in	0.48	$5 \times w\_live \times L^4) / (384 \times E \times I) \times 1.15$
Allowable Deflection	Δ_allow	in	0.63	L / 360 (per IBC)
Deflection Check	-	-	PASS	Δ ≤ Δ_allow

I ran all the beam sizing calculations manually in Excel, following the Allowable Stress Design (ASD) method. I checked for bending strength and deflection using the National Design Specification (NDS) for wood and AISC standards for steel.

I started with a 4x14x20' Glulam beam, but it didn't quite cut it—it was overstressed in bending (fb = 3,836 psi > Fb' = 2,040 psi) and deflected too much (Δ = 1.13 in > 0.63 in). So I sized up to a 6x16x20' section, which passed all the checks (fb = 1,891 psi ≤ 2,040 psi; Δ = 0.48 in ≤ 0.63 in).

I also sized a steel alternative (W10x26x20') for comparison (fb = 14,253 psi ≤ 30,000 psi; Δ = 0.34 in ≤ 0.63 in). Setting up the Excel sheet made it easy to test different sizes and compare materials quickly. The results then fed directly into the structural design and the cost comparison later in this portfolio.

COST COMPARISON: GLULAM VS. STEEL BEAM

This cost comparison was developed to evaluate two material options for the beam replacement. Costs include materials, labor, permits, utility rerouting, finishing work, and a 20% contingency buffer.

The Glulam 4x14x20' option is the least expensive, but it was eliminated because it failed the bending and deflection checks. The Glulam 6x16x20' passes all structural checks and is approximately $420 less than the Steel W10x26x20' option.

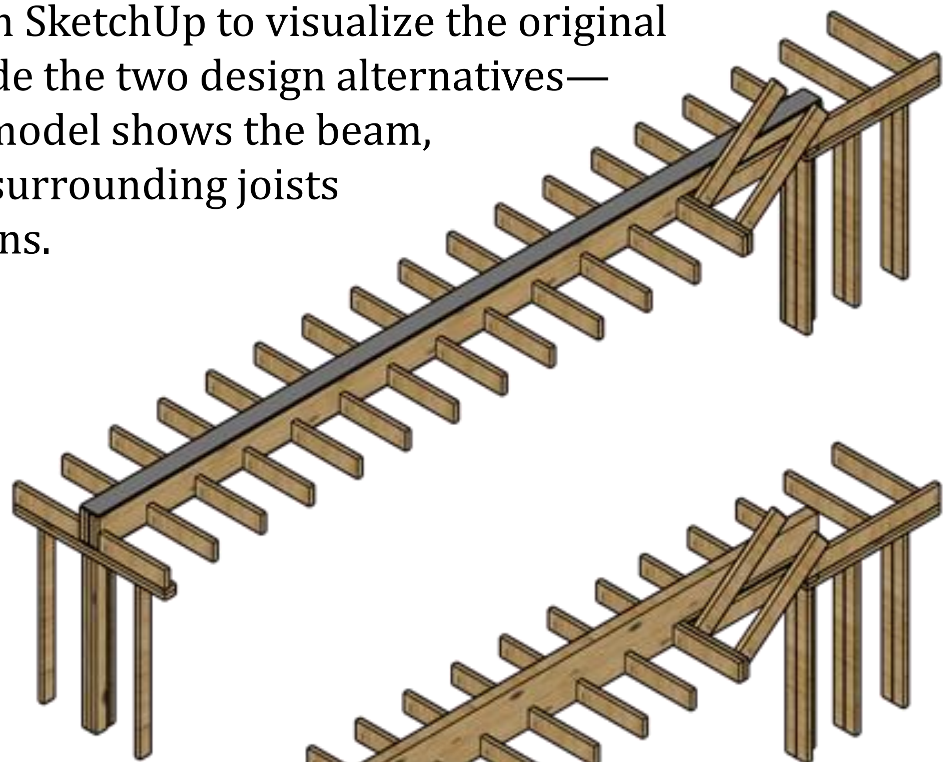
Glulam also simplifies the installation since standard joist hangers and nails are used directly, while steel requires bolting a ledger to the beam flange first, adding time and labor.

Based on structural performance and cost, the Glulam 6x16x20' beam is the recommended choice for this project.

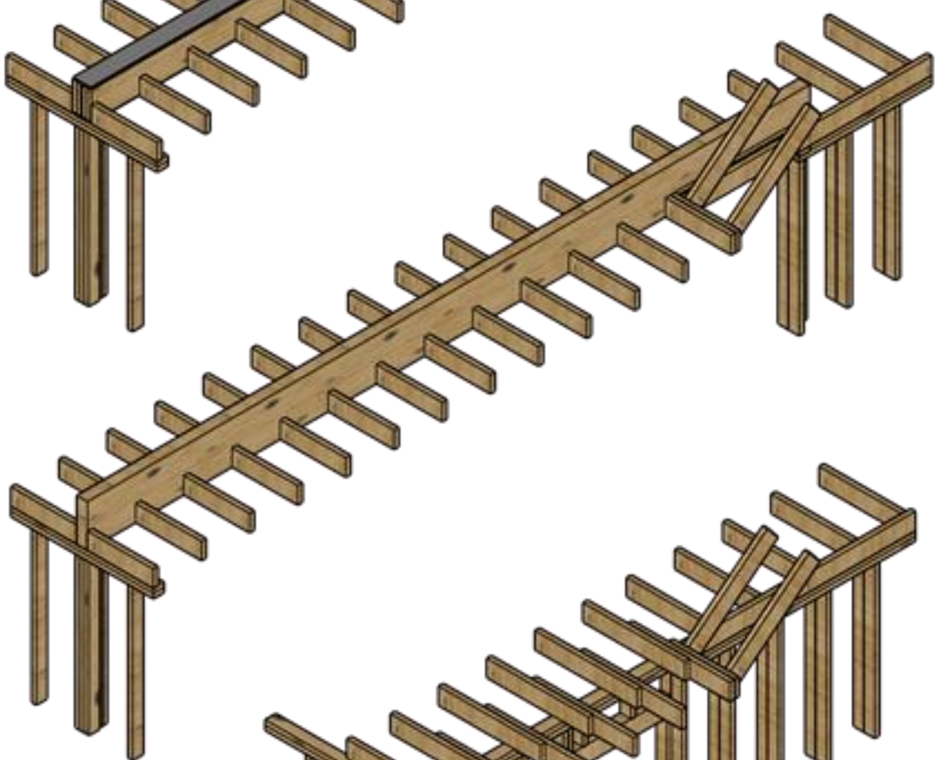
COST COMPARISON TABLE - GLULAM VS. STEEL BEAM				
	Cost Category	**Glulam Beam (4x14x20')**	**Glulam Beam (6x16x20')**	**Steel Beam (W10x26x20')**
Material Costs	Beam	$686.60	$1,174.00	$572.00
	Temporary Support	$320.00	$320.00	$320.00
	Additional Lumber	$103.00	$114.00	$203.00
	Connection Hardware	$96.00	$96.00	$159.00
	Total Material Costs	$1,205.60	$1,704.00	$1,254.00
Other Costs	Installation Labor	$2,400.00	$2,400.00	$3,200.00
	Engineering/ Permits	$1,050.00	$1,050.00	$1,050.00
	Rerouting Utilities	$1,800.00	$1,800.00	$1,800.00
	Finishing Work	$3,250.00	$3,250.00	$3,250.00
	Total Labor/Other Costs	$8,500.00	$8,500.00	$9,300.00
Totals	Subtotal	$9,705.60	$10,204.00	$10,554.00
	Miscellaneous	$1,941.12	$2,040.80	$2,110.80
	Grand Total	**$11,646.72**	**$12,244.80**	**$12,664.80**

3D STRUCTURAL MODEL: SKETCHUP

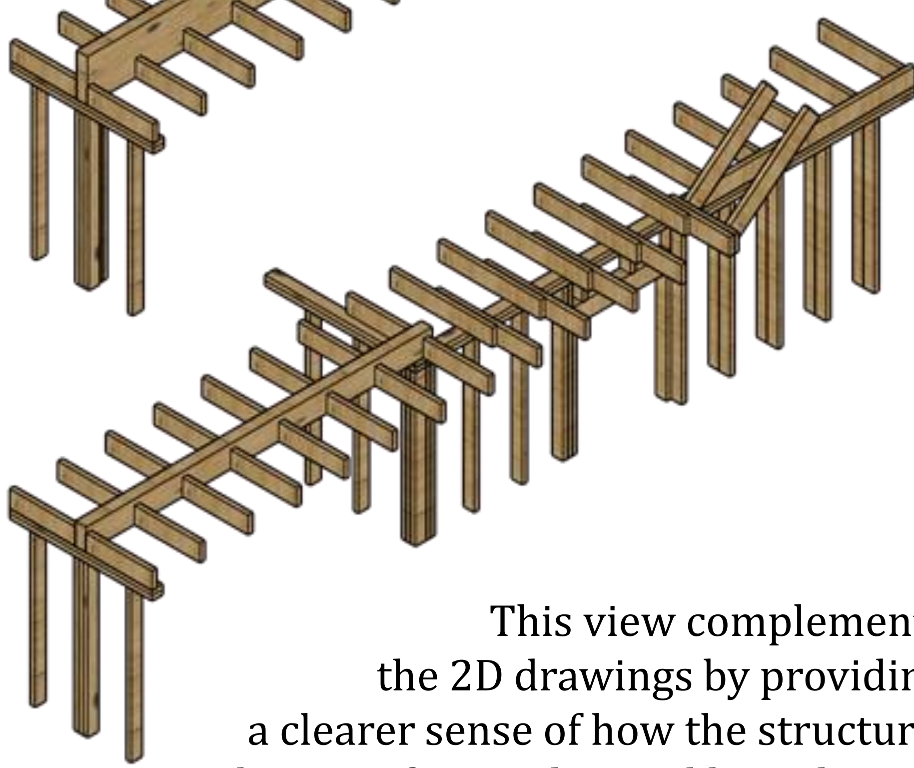
A 3D model was built in SketchUp to visualize the original framing layout alongside the two design alternatives—Glulam and steel. The model shows the beam, supporting studs, and surrounding joists in their relative positions.



Steel Beam Isometric (W10x26x20')



Glulam Beam Isometric (4x14x20')



Existing Structure Isometric

This view complements the 2D drawings by providing a clearer sense of how the structural elements fit together and how the two material options compare spatially.

DESIGN REFLECTIONS

One of the main challenges was keeping track of sections, numbers, and data across multiple drawings. AutoCAD projects are highly interconnected; a change in one view can often affect several others, and it's easy to miss something if you're not methodical. I was working from previous sketches and photos while away from the site, which made it harder to piece everything together accurately. I also relied heavily on 3D visualization to assemble something that didn't yet exist.

Another challenge was learning as I went. I had to figure out how to use Layout and build a title block from scratch—none of which I had formally learned yet. I also had to be mindful of industry drafting standards, which added another layer to the process. Overall, everything felt new and required a lot of trial and error.

One key takeaway was the importance of iteration. The initial Glulam beam (4x14x20') failed bending and deflection checks, which led to a revised design (6x16x20') that passed all requirements. This reinforced that engineering is not about getting it right on the first try, but about checking, refining, and verifying.

If I were to extend this project, I would explore LVL as a third material option and try modeling the structure in Revit after my first semester at UIUC to better understand BIM workflows.

If I were to do it all over again, I would start with a rough beam sizing calculation before diving into detailed drawings. I would also keep the drawings simpler early on and learn more efficient drafting method, like using dynamic blocks and Sheet Set Manager, to work more efficiently.

Overall, this project strengthened my AutoCAD drafting, structural analysis, Excel, and SketchUp skills, along with my engineering communication. It also reinforced the importance of consistency, checking, and planning ahead, and gave me confidence in taking a structural concept from start to completion.

CONCLUSION

Thank you for taking the time to review my portfolio!

If you would like to see the full 23-page AutoCAD structural drawing set, click here to download it or scan the QR code on the right.

If you would like to get in touch, I can be reached at:

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