

Term Project 14.551 Advanced Steel Design

Fall 2014 | Section 201 | Team: GLZ Design

Ana Gouveia, E.I.T.
Matthew Laskey, E.I.T.
Zachary Zavallianos, E.I.T.



Learning with Purpose

DESIGN TEAM

Design Team



Matthew Laskey, E.I.T.
STRUCTURAL ENGINEER

Matthew Laskey is a Structural Engineer at GLZ Design, where he has been working since 2010. He has a Bachelor's degree in Civil Engineering from the University of Massachusetts Lowell.



Ana Gouveia, E.I.T.
STRUCTURAL ENGINEER

Ana has been in Brazil where she started her college education in Civil Engineering. As a challenge-seeking, she transferred to Massachusetts in 2009. Since then, she has been a member of the American Institute of Steel Construction (AISC) and the American Concrete Institute (ACI). She is currently working on her Master's degree in Civil Engineering from the University of Massachusetts Lowell.



Zachary Zavallianos, E.I.T.
STRUCTURAL ENGINEER

Hardworking and enthusiastic structural engineer with experience in design and inspection of bridge structures. Certified in bridge inspection and proficient in inspection software such as PVSIST and 4-D, as well as MC2 and CEBridge analysis programs. Seeking to progress career by obtaining a masters degree and working towards a PE license through the upcoming years.

Company Information

GLZ Design
Always Doing Better

GLZ Design, LLC
1 University Ave. Lowell, MA
01854-2900

DESIGN SUMMARY

Project Summary

Project Riverside is a two-story, steel-framed, office building located in Lowell, MA. GLZ Design has assigned the design team composed by Structural Engineers: Matthew Laskey, Ana Gouveia and Zachary Zavallianos to perform the structural analysis, evaluation and design of this project.

Guided by local regulations, the design team used of the most up to date references, associated to outstanding optimization analysis, along efficient construction practices as the project's design criteria. A more accurate overview of these values can be found in page 7 of this report. Building classifications and initial information can be found in page 8 of this report.

Riverside's design process started through a complete identification vertical and lateral loads, which were further analyzed by the Load & Resistance Factor Design (LRFD). These initial values were used in the preliminary-sizing of project horizontal and vertical members.

In the second phase of the project, these preliminary members were further evaluated and analyzed. Final framing plans for both first and roof floor were obtained. Two different lateral load resisting systems (LLRS) were designed: a moment-frame resists longitudinal loads, and braced frames are responsible for transverse loads. Given building risk categories, per code used, ordinary moment-frame and braced-frame were allowed in the design, reducing the project's final budget.

In the project's final phase, composite floor deck, roof joints, girders and diaphragms, and connections were designed. For quality assurance and control, all of the project's information, calculations, analysis and drawings were further back checked. The final results of this project can be found in this report. Calculations, Analysis and Drawings are referred in its respective section on the report and can also be found at this report's appendices.

Design Criteria	_____
Design Criteria and Constraints	_____
References and Regulations	_____
Methods of Design and Analysis	_____
Building Information and Requirements	_____
Classifications	_____
Building Layout	_____
Loads	_____
Lateral Load Resisting Systems	_____
Floor Systems	_____
Roof Systems	_____
Exterior Wall Systems	_____
Scope of Work	_____
Overview	_____
Members	_____
Lateral Load Resisting Systems	_____
Composite Deck	_____
Roof Design	_____
Connections	_____
Schedule	_____
Cost Estimate	_____

DESIGN CRITERIA

Design Criteria

Design Criteria and Constraints

The following figure represents the design criteria which guided the team.

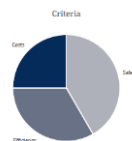


Figure 6 - Riverside's guiding criteria.

Building Information and Requirements

Classifications

- Occupancy: Group B, Office
- Construction Type: IIB
- Risk Category: II
- Seismic Risk Class: C
- Environmental Exposure: C

Building Layout

- Total Area: Approx. 17,000 sq ft (gross)
- Floor Plate: 110 ft x 75 ft
- Column Grid: 10 ft x 24 ft

References and Regulations

- Massachusetts Building Code (CMR 780)
- 2012 International Building Code (IBC 2012 IBC)
- Historic Design Loads for Buildings and Other Structures (ASCE 1-10)
- 14th Edition of the Steel Construction Manual (AISC 14th)
- American Concrete Institute Manual (ACI)
- 2007 Steel Deck Institute Design Manual (2007 SDI)
- Vertical Joints and Girders (VJG)
- 14th Edition Structural Steel Design, McGraw-Hill Construction (2014)

30% SUBMITTAL

- Load Analysis
- Preliminary Sizing

Presented by: Ana Gouveia, E.I.T.



MEMBERS

Members

The members in the project were labeled as shown in the figures below:

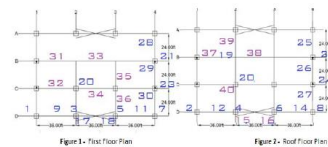


Figure 1- First floor Plan

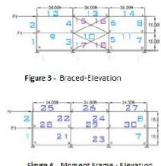


Figure 3 - Braced-Elevation



Figure 4 - Moment Frame - Elevation

BUILDING LOADS

- **BUILDING LOADS:**
 - DEAD
 - LIVE
 - SNOW
 - WIND
 - SEISMIC
- **REGULATIONS:**
 - 2012 IBC
 - CMR 780
 - ASCE 7-10
- **METHOD OF LOAD ANALYSIS:**
 - LRFD

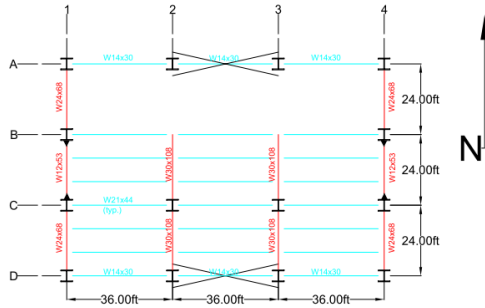
Project Name: Project Name		Project Manager: Project Manager	Project Start Date: Project Start Date
2. Resource Utilization by Resource ID			
Resource ID	Resource Name	Resource Type	Resource Status
101	John Doe	Software Engineer	Available
102	Jane Smith	Software Engineer	Available
103	Mike Johnson	Software Engineer	Available
104	Sarah Lee	Software Engineer	Available
105	David Kim	Software Engineer	Available
106	Emily White	Software Engineer	Available
107	Chris Brown	Software Engineer	Available
108	Alex Green	Software Engineer	Available
3. Resource Allocation by Task			
Task ID	Task Name	Resource ID	Resource Name
1.1	Task 1.1	101	John Doe
1.2	Task 1.2	102	Jane Smith
1.3	Task 1.3	103	Mike Johnson
1.4	Task 1.4	104	Sarah Lee
1.5	Task 1.5	105	David Kim
1.6	Task 1.6	106	Emily White
1.7	Task 1.7	107	Chris Brown
1.8	Task 1.8	108	Alex Green
4. Resource Allocation by Task ID			
Task ID	Task Name	Resource ID	Resource Name
2.1	Task 2.1	101	John Doe
2.2	Task 2.2	102	Jane Smith
2.3	Task 2.3	103	Mike Johnson
2.4	Task 2.4	104	Sarah Lee
2.5	Task 2.5	105	David Kim
2.6	Task 2.6	106	Emily White
2.7	Task 2.7	107	Chris Brown
2.8	Task 2.8	108	Alex Green
5. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
3.1	Task 3.1	101	John Doe
3.2	Task 3.2	102	Jane Smith
3.3	Task 3.3	103	Mike Johnson
3.4	Task 3.4	104	Sarah Lee
3.5	Task 3.5	105	David Kim
3.6	Task 3.6	106	Emily White
3.7	Task 3.7	107	Chris Brown
3.8	Task 3.8	108	Alex Green
6. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
4.1	Task 4.1	101	John Doe
4.2	Task 4.2	102	Jane Smith
4.3	Task 4.3	103	Mike Johnson
4.4	Task 4.4	104	Sarah Lee
4.5	Task 4.5	105	David Kim
4.6	Task 4.6	106	Emily White
4.7	Task 4.7	107	Chris Brown
4.8	Task 4.8	108	Alex Green
7. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
5.1	Task 5.1	101	John Doe
5.2	Task 5.2	102	Jane Smith
5.3	Task 5.3	103	Mike Johnson
5.4	Task 5.4	104	Sarah Lee
5.5	Task 5.5	105	David Kim
5.6	Task 5.6	106	Emily White
5.7	Task 5.7	107	Chris Brown
5.8	Task 5.8	108	Alex Green
8. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
6.1	Task 6.1	101	John Doe
6.2	Task 6.2	102	Jane Smith
6.3	Task 6.3	103	Mike Johnson
6.4	Task 6.4	104	Sarah Lee
6.5	Task 6.5	105	David Kim
6.6	Task 6.6	106	Emily White
6.7	Task 6.7	107	Chris Brown
6.8	Task 6.8	108	Alex Green
9. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
7.1	Task 7.1	101	John Doe
7.2	Task 7.2	102	Jane Smith
7.3	Task 7.3	103	Mike Johnson
7.4	Task 7.4	104	Sarah Lee
7.5	Task 7.5	105	David Kim
7.6	Task 7.6	106	Emily White
7.7	Task 7.7	107	Chris Brown
7.8	Task 7.8	108	Alex Green
10. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
8.1	Task 8.1	101	John Doe
8.2	Task 8.2	102	Jane Smith
8.3	Task 8.3	103	Mike Johnson
8.4	Task 8.4	104	Sarah Lee
8.5	Task 8.5	105	David Kim
8.6	Task 8.6	106	Emily White
8.7	Task 8.7	107	Chris Brown
8.8	Task 8.8	108	Alex Green
11. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
9.1	Task 9.1	101	John Doe
9.2	Task 9.2	102	Jane Smith
9.3	Task 9.3	103	Mike Johnson
9.4	Task 9.4	104	Sarah Lee
9.5	Task 9.5	105	David Kim
9.6	Task 9.6	106	Emily White
9.7	Task 9.7	107	Chris Brown
9.8	Task 9.8	108	Alex Green
12. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
10.1	Task 10.1	101	John Doe
10.2	Task 10.2	102	Jane Smith
10.3	Task 10.3	103	Mike Johnson
10.4	Task 10.4	104	Sarah Lee
10.5	Task 10.5	105	David Kim
10.6	Task 10.6	106	Emily White
10.7	Task 10.7	107	Chris Brown
10.8	Task 10.8	108	Alex Green
13. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
11.1	Task 11.1	101	John Doe
11.2	Task 11.2	102	Jane Smith
11.3	Task 11.3	103	Mike Johnson
11.4	Task 11.4	104	Sarah Lee
11.5	Task 11.5	105	David Kim
11.6	Task 11.6	106	Emily White
11.7	Task 11.7	107	Chris Brown
11.8	Task 11.8	108	Alex Green
14. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
12.1	Task 12.1	101	John Doe
12.2	Task 12.2	102	Jane Smith
12.3	Task 12.3	103	Mike Johnson
12.4	Task 12.4	104	Sarah Lee
12.5	Task 12.5	105	David Kim
12.6	Task 12.6	106	Emily White
12.7	Task 12.7	107	Chris Brown
12.8	Task 12.8	108	Alex Green
15. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
13.1	Task 13.1	101	John Doe
13.2	Task 13.2	102	Jane Smith
13.3	Task 13.3	103	Mike Johnson
13.4	Task 13.4	104	Sarah Lee
13.5	Task 13.5	105	David Kim
13.6	Task 13.6	106	Emily White
13.7	Task 13.7	107	Chris Brown
13.8	Task 13.8	108	Alex Green
16. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
14.1	Task 14.1	101	John Doe
14.2	Task 14.2	102	Jane Smith
14.3	Task 14.3	103	Mike Johnson
14.4	Task 14.4	104	Sarah Lee
14.5	Task 14.5	105	David Kim
14.6	Task 14.6	106	Emily White
14.7	Task 14.7	107	Chris Brown
14.8	Task 14.8	108	Alex Green
17. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
15.1	Task 15.1	101	John Doe
15.2	Task 15.2	102	Jane Smith
15.3	Task 15.3	103	Mike Johnson
15.4	Task 15.4	104	Sarah Lee
15.5	Task 15.5	105	David Kim
15.6	Task 15.6	106	Emily White
15.7	Task 15.7	107	Chris Brown
15.8	Task 15.8	108	Alex Green
18. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
16.1	Task 16.1	101	John Doe
16.2	Task 16.2	102	Jane Smith
16.3	Task 16.3	103	Mike Johnson
16.4	Task 16.4	104	Sarah Lee
16.5	Task 16.5	105	David Kim
16.6	Task 16.6	106	Emily White
16.7	Task 16.7	107	Chris Brown
16.8	Task 16.8	108	Alex Green
19. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
17.1	Task 17.1	101	John Doe
17.2	Task 17.2	102	Jane Smith
17.3	Task 17.3	103	Mike Johnson
17.4	Task 17.4	104	Sarah Lee
17.5	Task 17.5	105	David Kim
17.6	Task 17.6	106	Emily White
17.7	Task 17.7	107	Chris Brown
17.8	Task 17.8	108	Alex Green
20. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
18.1	Task 18.1	101	John Doe
18.2	Task 18.2	102	Jane Smith
18.3	Task 18.3	103	Mike Johnson
18.4	Task 18.4	104	Sarah Lee
18.5	Task 18.5	105	David Kim
18.6	Task 18.6	106	Emily White
18.7	Task 18.7	107	Chris Brown
18.8	Task 18.8	108	Alex Green
21. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
19.1	Task 19.1	101	John Doe
19.2	Task 19.2	102	Jane Smith
19.3	Task 19.3	103	Mike Johnson
19.4	Task 19.4	104	Sarah Lee
19.5	Task 19.5	105	David Kim
19.6	Task 19.6	106	Emily White
19.7	Task 19.7	107	Chris Brown
19.8	Task 19.8	108	Alex Green
22. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
20.1	Task 20.1	101	John Doe
20.2	Task 20.2	102	Jane Smith
20.3	Task 20.3	103	Mike Johnson
20.4	Task 20.4	104	Sarah Lee
20.5	Task 20.5	105	David Kim
20.6	Task 20.6	106	Emily White
20.7	Task 20.7	107	Chris Brown
20.8	Task 20.8	108	Alex Green
23. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
21.1	Task 21.1	101	John Doe
21.2	Task 21.2	102	Jane Smith
21.3	Task 21.3	103	Mike Johnson
21.4	Task 21.4	104	Sarah Lee
21.5	Task 21.5	105	David Kim
21.6	Task 21.6	106	Emily White
21.7	Task 21.7	107	Chris Brown
21.8	Task 21.8	108	Alex Green
24. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
22.1	Task 22.1	101	John Doe
22.2	Task 22.2	102	Jane Smith
22.3	Task 22.3	103	Mike Johnson
22.4	Task 22.4	104	Sarah Lee
22.5	Task 22.5	105	David Kim
22.6	Task 22.6	106	Emily White
22.7	Task 22.7	107	Chris Brown
22.8	Task 22.8	108	Alex Green
25. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
23.1	Task 23.1	101	John Doe
23.2	Task 23.2	102	Jane Smith
23.3	Task 23.3	103	Mike Johnson
23.4	Task 23.4	104	Sarah Lee
23.5	Task 23.5	105	David Kim
23.6	Task 23.6	106	Emily White
23.7	Task 23.7	107	Chris Brown
23.8	Task 23.8	108	Alex Green
26. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
24.1	Task 24.1	101	John Doe
24.2	Task 24.2	102	Jane Smith
24.3	Task 24.3	103	Mike Johnson
24.4	Task 24.4	104	Sarah Lee
24.5	Task 24.5	105	David Kim
24.6	Task 24.6	106	Emily White
24.7	Task 24.7	107	Chris Brown
24.8	Task 24.8	108	Alex Green
27. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
25.1	Task 25.1	101	John Doe
25.2	Task 25.2	102	Jane Smith
25.3	Task 25.3	103	Mike Johnson
25.4	Task 25.4	104	Sarah Lee
25.5	Task 25.5	105	David Kim
25.6	Task 25.6	106	Emily White
25.7	Task 25.7	107	Chris Brown
25.8	Task 25.8	108	Alex Green
28. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
26.1	Task 26.1	101	John Doe
26.2	Task 26.2	102	Jane Smith
26.3	Task 26.3	103	Mike Johnson
26.4	Task 26.4	104	Sarah Lee
26.5	Task 26.5	105	David Kim
26.6	Task 26.6	106	Emily White
26.7	Task 26.7	107	Chris Brown
26.8	Task 26.8	108	Alex Green
29. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
27.1	Task 27.1	101	John Doe
27.2	Task 27.2	102	Jane Smith
27.3	Task 27.3	103	Mike Johnson
27.4	Task 27.4	104	Sarah Lee
27.5	Task 27.5	105	David Kim
27.6	Task 27.6	106	Emily White
27.7	Task 27.7	107	Chris Brown
27.8	Task 27.8	108	Alex Green
30. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
28.1	Task 28.1	101	John Doe
28.2	Task 28.2	102	Jane Smith
28.3	Task 28.3	103	Mike Johnson
28.4	Task 28.4	104	Sarah Lee
28.5	Task 28.5	105	David Kim
28.6	Task 28.6	106	Emily White
28.7	Task 28.7	107	Chris Brown
28.8	Task 28.8	108	Alex Green
31. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
29.1	Task 29.1	101	John Doe
29.2	Task 29.2	102	Jane Smith
29.3	Task 29.3	103	Mike Johnson
29.4	Task 29.4	104	Sarah Lee
29.5	Task 29.5	105	David Kim
29.6	Task 29.6	106	Emily White
29.7	Task 29.7	107	Chris Brown
29.8	Task 29.8	108	Alex Green
32. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
30.1	Task 30.1	101	John Doe
30.2	Task 30.2	102	Jane Smith
30.3	Task 30.3	103	Mike Johnson
30.4	Task 30.4	104	Sarah Lee
30.5	Task 30.5	105	David Kim
30.6	Task 30.6	106	Emily White
30.7	Task 30.7	107	Chris Brown
30.8	Task 30.8	108	Alex Green
33. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
31.1	Task 31.1	101	John Doe
31.2	Task 31.2	102	Jane Smith
31.3	Task 31.3	103	Mike Johnson
31.4	Task 31.4	104	Sarah Lee
31.5	Task 31.5	105	David Kim
31.6	Task 31.6	106	Emily White
31.7	Task 31.7	107	Chris Brown
31.8	Task 31.8	108	Alex Green
34. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
32.1	Task 32.1	101	John Doe
32.2	Task 32.2	102	Jane Smith
32.3	Task 32.3	103	Mike Johnson
32.4	Task 32.4	104	Sarah Lee
32.5	Task 32.5	105	David Kim
32.6	Task 32.6	106	Emily White
32.7	Task 32.7	107	Chris Brown
32.8	Task 32.8	108	Alex Green
35. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
33.1	Task 33.1	101	John Doe
33.2	Task 33.2	102	Jane Smith
33.3	Task 33.3	103	Mike Johnson
33.4	Task 33.4	104	Sarah Lee
33.5	Task 33.5	105	David Kim
33.6	Task 33.6	106	Emily White
33.7	Task 33.7	107	Chris Brown
33.8	Task 33.8	108	Alex Green
36. Resource Allocation by Task ID and Resource ID			
Task ID	Task Name	Resource ID	Resource Name
34.1	Task 34.1	101	

VERTICAL LOADS

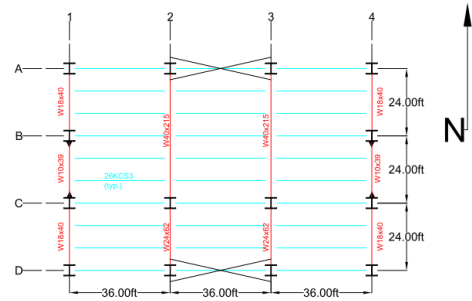
- DEAD
- LIVE
- SNOW
- WIND

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BRACED/MOMENT FRAMES-LEVEL 2

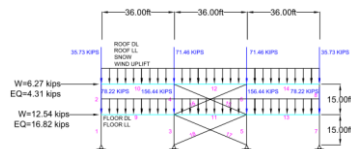


BRACED/MOMENT FRAMES-ROOF LEVEL



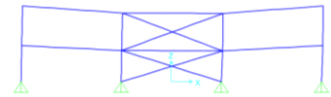
BRACED FRAME

- Braced frame analyzed using the direct analysis method
- Developed braced frame model in SAP2000 using loading as shown
- Model reflected beam/column sizes determined from 30% design



BRACED FRAME

- Deformed shape:



- First order analysis forces found from SAP output:

First Order Analysis Forces	Top	Bottom
Ultimate Axial Load, P_u	295.99 kips	295.99 kips
Ultimate Moment, M_u	13.37 kip-ft	0 kip-ft

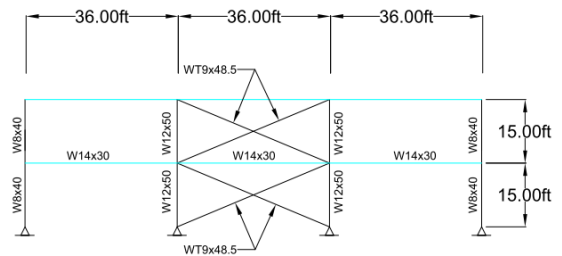
BRACED FRAME

- Columns determined in 30%: **W12x40**
 - This section did not satisfy requirements for combined moment/bending
- Re-run calculation with **W12x50**
 - Section satisfied requirements as seen below:

Summary			
Moment Required, M_r	13.37 kip-ft	Eq A-8-1	
Moment Capacity, M_n	270.00 kip-ft	Referenced Above	
Axial Required, P_r	295.9 kips	Eq A-8-2	
Axial Capacity, P_n	355 kips	Referenced Above	
Combined Forces Interaction Equation			
P_r/P_n	0.83		
M_r/M_n	0.88	Eq H1-1a	
$P_r/P_n + 8M_r/M_n$	0.47	Eq H1-1b	
Design Check	0.88 SECTION OK		

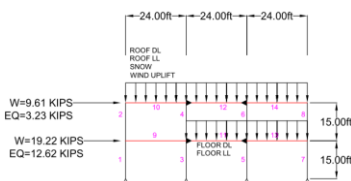
BRACED FRAME

- Final braced frame shown below:



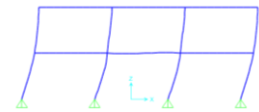
MOMENT FRAME

- Moment frame analyzed using the direct analysis method
- Developed moment frame model in SAP2000 using loading as shown
- Model reflected beam/column sizes determined from 30% design

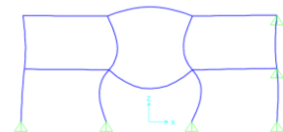


MOMENT FRAME

- Deformed shape (Lateral translation):



- Deformed shape (No lateral translation):



MOMENT FRAME

- Columns determined in 30%: **W8x40**
 - This section did not satisfy requirements for combined moment/bending
- Re-run calculation with **W10x68**
 - Section satisfied requirements as seen below:

Moment Required, M_u	261.96 kip*ft	Eq A-8-1
Moment Capacity, M_n	320.00 kip*ft	Referenced Above
Axial Required, P_u	99.8 kips	Eq A-8-2
Axial Capacity, P_n	629.06 kips	Referenced Above
Combined Forces Interaction Equation		
P_u/P_n	0.16	
$P_u/P_n > 0.2$	0.89	Eq H1-1a
$P_u/P_n < 0.2$	0.90	Eq H1-1b
Design Check	0.90	SECTION OK

MOMENT FRAME

- Level 2 Beams determined in 30%: **W18x35**
 - This section did not satisfy requirements for combined moment/bending
- Re-run calculation with **W12x53**
 - Section satisfied requirements as seen below:

Moment Required, M_u	239.01 kip*ft	Eq A-8-1
Moment Capacity, M_n	249.06 kip*ft	Referenced Above
Axial Required, P_u	19.9 kips	Eq A-8-2
Axial Capacity, P_n	261.33 kips	Referenced Above
Combined Forces Interaction Equation		
P_u/P_n	0.08	
$P_u/P_n > 0.2$	0.93	Eq H1-1a
$P_u/P_n < 0.2$	1.00	Eq H1-1b
Design Check	0.998	SECTION OK

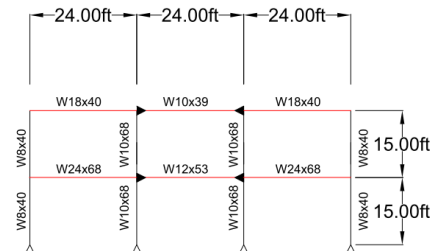
MOMENT FRAME

- Roof Level Beams determined in 30%: **W12x19**
 - This section did not satisfy requirements for combined moment/bending
- Re-run calculation with **W10x39**
 - Section satisfied requirements as seen below:

Moment Required, M_u	77.18 kip*ft	Eq A-8-1
Moment Capacity, M_n	136.34 kip*ft	Referenced Above
Axial Required, P_u	10.7 kips	Eq A-8-2
Axial Capacity, P_n	122.80 kips	Referenced Above
Combined Forces Interaction Equation		
P_u/P_n	0.09	
$P_u/P_n > 0.2$	0.59	Eq H1-1a
$P_u/P_n < 0.2$	0.61	Eq H1-1b
Design Check	0.61	SECTION OK

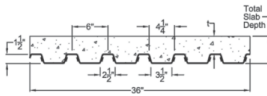
MOMENT FRAME

- Final moment frame shown below:



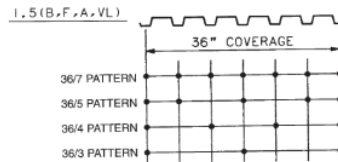
FLOOR SYSTEM

- Utilized composite design
- Floor System Specifications:
 - Total Slab Depth=5"
 - Normal weight concrete (145pcf)
 - Camber=1"
 - # of Studs/beam=60
 - Stud diameter=3/4"
 - Stud Length=4"
 - Equally Spaced
 - Temporary bracing required
 - 1.5VLR19 (Vulcraft) Metal Deck
 - Ribs perpendicular to beam



ROOF SYSTEM

- Open web steel joists with steel (W) girders
 - Vulcraft 26KCS3 joists
- Metal Deck: Vulcraft B18 (3span)
- 36/3 fastener layout
- Support Fasteners: 5/8" puddle welds
- Side lap fasteners: (2) #10 tek screws
- Vertical and Lateral deflections under allowable limit



100% Material

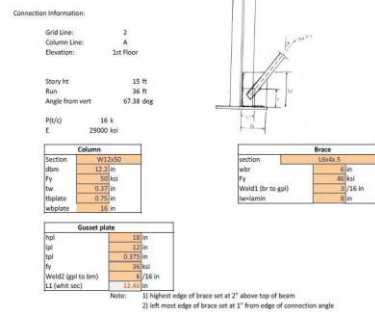
- Bracing Connections
- Hanger Connection
- Shear and Moment Connections
 - Cost Estimation
 - Drawings

Presented by: Matt Laskey, E.I.T.

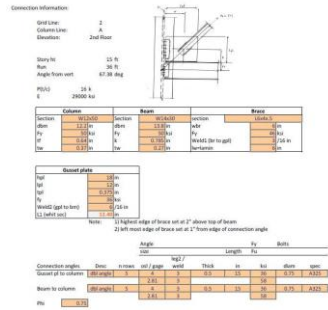
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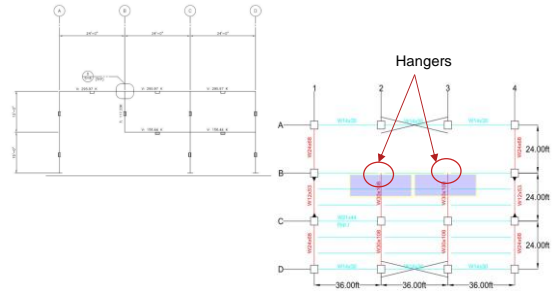
Gusset Plate Connection- 1st Floor



Gusset Plate Connection- 2nd Floor

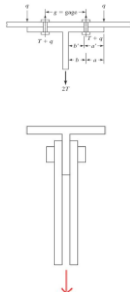


Hanger Detail



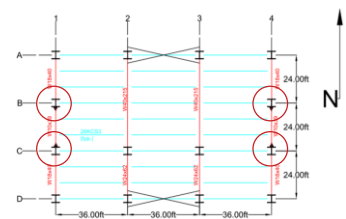
Hanger Detail

- Hanger connection: WT12x96
 - Connected to roof using $\frac{3}{4}$ " diameter A325 bolts
- Hanger member is constructed of two 1"x14" steel plates
 - Treated as tension-only members
 - Connected to WT member by one horizontal row of (3) $\frac{3}{4}$ " diameter A325 bolts.
 - Double shear
- Trib Area = 432 ft²
- Wu = 271.6 psf
- Pu = 117.33 k per hanger



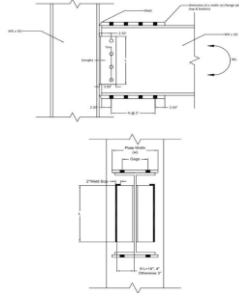
Moment Connection – Roof Level

- Girder: W10x39
- Column: W10x68
- Mu = 77.18 k-ft
- Vu = 35.73 k



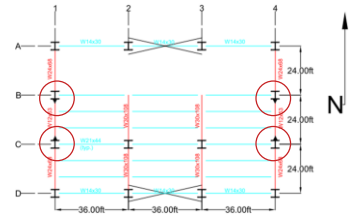
Moment Connection – Roof Level

- Flange Plate:
 - $t_f = 0.5$ in
 - $w = 8$ in
- Connection
 - 7/8" Dia A325 Bolts
 - $n = 2$ rows
 - # bolts per row = 4 (per flange)
 - Gage = 6 in
- Flange – Column Weld:
 - Electrode: 70 ksi
 - Complete Joint Penetration weld (CJP)
 - Length = 8 in
 - Size = 0.5 in
- Double Angle Connection: L3.5x3x1/4
 - Length = 8.5 in
 - Weld to column
 - Electrode: 70 ksi
 - Leg = 3 in
 - Weld size = 0.25 in
 - Bolt to girder
 - 3/4" dia STD hole A325 bolts
 - # bolts = 3 bolts (spaced 3 in on center)



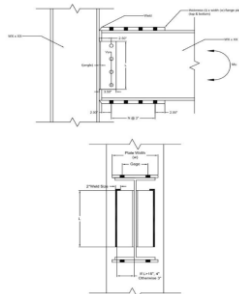
Moment Connection – 2nd Level

- Girder: W12x53
- Column: W10x68
- $M_u = 239.01$ k-ft
- $V_u = 78.22$ k



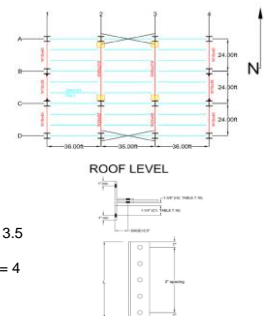
Moment Connection – 2nd Level

- Flange Plate:
 - $t_f = 0.75$ in
 - $w = 10$ in
- Connection
 - 7/8" Dia A325 Bolts
 - $n = 2$ rows
 - # bolts per row = 10 (per flange)
 - Gage = 7 in
- Flange – Column Weld:
 - Electrode: 70 ksi
 - Complete Joint Penetration weld (CJP)
 - Length = 10 in
 - Size = 0.5 in
- Double Angle Connection: L3.5x3x1/4
 - Length = 11.5 in
 - Weld to column
 - Electrode: 70 ksi
 - Leg = 3 in
 - Weld size = 0.25 in
 - Bolt to girder
 - 3/4" dia STD hole A325 bolts
 - # bolts = 4 bolts (spaced 3 in on center)



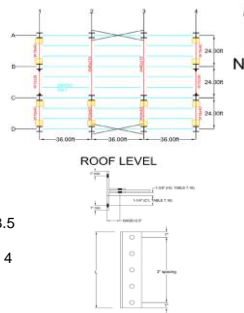
Shear Connection – Roof Level

- Use all **bolting** double angle connections
 - $P_u = 295.97$ k
 - $n = 9$ rows
 - 3/4 in diameter bolts
 - STD Hole
 - Group A
 - Threads included
 - t_f , Angle = 3/8 in
 - # Spaces, $N = 8$
 - t_w , Girder = 0.65 in
 - Gage = 2.5 in
 - Min edge dist = 1 in
 - Length of leg bolted to Girder = 3.5 in
 - Length of leg bolted to Column = 4 in
 - Angle Length = 26 in
- (2) 4 x 3.5 x 3/8 x 2'-2" Angles Used



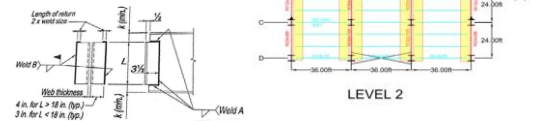
Shear Connection – Roof Level

- Use all **bolted** double angle connections
 - $P_u = 71.46 \text{ k}$
 - $n = 4$ rows
 - $\frac{3}{4}$ in diameter bolts
 - STD Hole
 - Group A
 - Threads included
 - t , Angle = $\frac{1}{4}$ in
 - # Spaces, $N = 3$
 - t_w , Girder = 0.43 in
 - Gage = 2.5 in
 - Min edge dist = 1 in
 - Length of leg bolted to Girder = 3.5 in
 - Length of leg bolted to Column = 4 in
 - Angle Length = 11 in
- (2) $4 \times 3.5 \times \frac{1}{4} \times 11$ " Angles Used



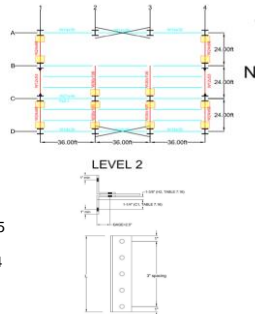
Shear Connection – 2nd Level

- Use all **welded** double angle connections
- $P_u = 39.11 \text{ k}$
 - $L = 6$ in
 - Weld A = $\frac{3}{16}$ in
 - Weld B = $\frac{5}{16}$ in
 - Angle used: (2) $L3.5 \times 3 \times \frac{1}{4}$ angl



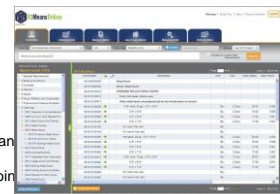
Shear Connection – 2nd Level

- Use all **bolted** double angle connections
 - $P_u = 156.44 \text{ k}$
 - $n = 5$ rows
 - $\frac{3}{4}$ in diameter bolts
 - STD Hole
 - Group A
 - Threads included
 - t , Angle = $\frac{3}{8}$ in
 - # Spaces, $N = 4$
 - t_w , Girder = 0.545 in
 - Gage = 2.5 in
 - Min edge dist = 1 in
 - Length of leg bolted to Girder = 3.5 in
 - Length of leg bolted to Column = 4 in
 - Angle Length = 14 in
- (2) $4 \times 3.5 \times \frac{3}{8} \times 14$ " Angles Used



Cost Estimation

- The cost of the project will be determined using R.S. Means Online Cost Estimating Tool.
 - Factors to consider
 - Material types
 - Sizes
 - Quantities (lengths, area, volume, weight etc.)
 - Location of project
 - Labor
 - The type of cost estimation will be an engineer's estimation
 - Determine reasonable price point for this job



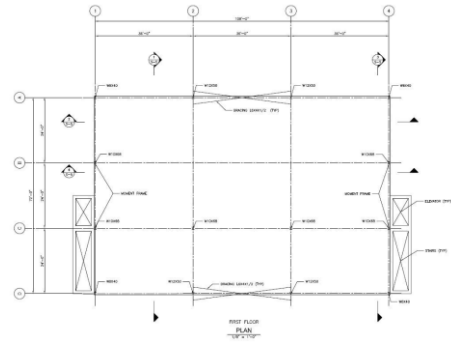
FINAL DRAWINGS

Presented by: Matt Laskey, E.I.T.

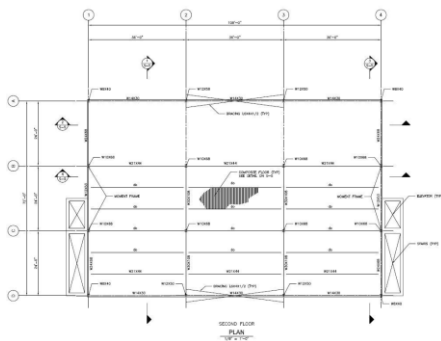


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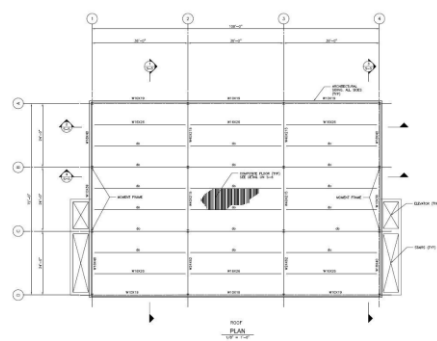
Drafting – 1st Floor Steel



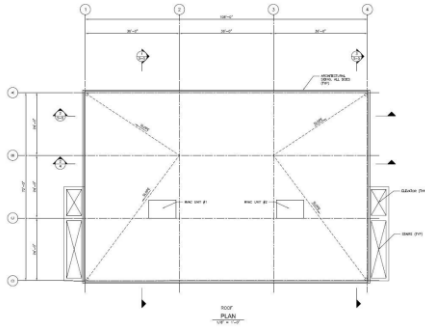
Drafting – 2nd Floor Steel



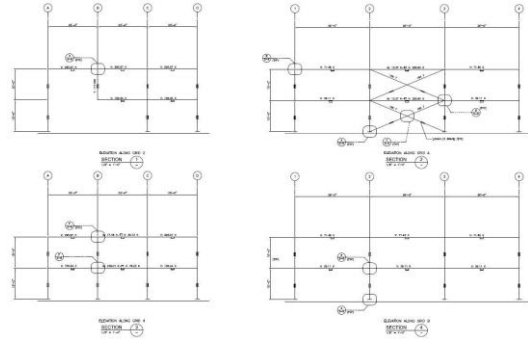
Drafting – 3rd Floor Steel



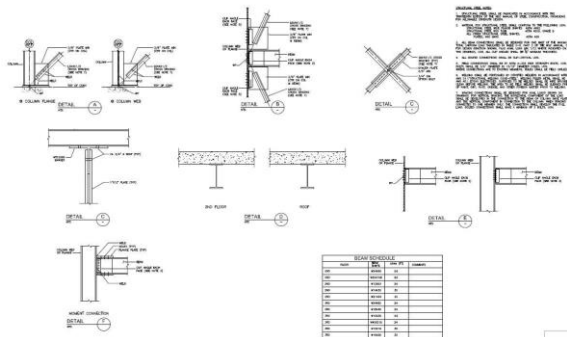
Drafting – Roof



Drafting – Steel Sections



Drafting – Standard Details



DRAWINGS:

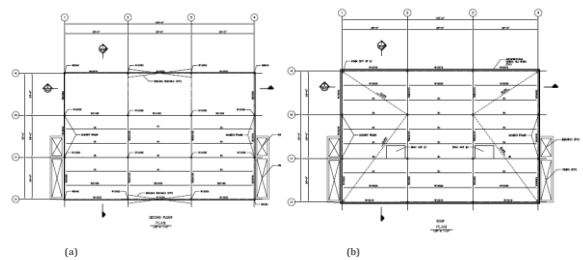
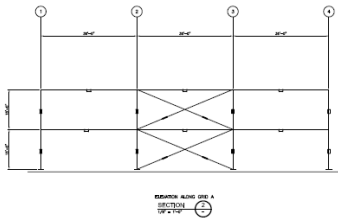


Figure 7. (a) First Floor Plan (b) Roof Plan

DRAWINGS:



QUESTIONS?

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