Section 1: Design Specification

Performance Requirements

- Overall Dimensions: 26’-0” x 5’-9” x 10’-4”
- Up to five actors will be pacing or standing on the top of the platform – each are average weight
- Masking wall and façade will be attached to the platform
    - Not included in budget
- Working drawbridge door on front side
    - 150 pounds
    - Door may open while actors are on platform
- Escape stairs on SR side of platform
- In use for 8 weeks
- Columns cannot be visible through doorway
- Stationary, stand-alone unit
- Cannot sound hollow

Constraints and Available Resources

- $400 budget
- Basic fasteners are in stock, specialized fasteners must be purchased
- Project Schedule:
    - 10/18: First Production Meeting
    - 10/20: Second Production Meeting
    - 10/25: Submission of bridge design to production manager and design team
    - 10/22-10/29: Construction of bridge
    - 10/19: Installation of bridge
- Two carpenters available to build for a week
    - Shop does not have metalworking capabilities
- Installation in an hour
    - Extra hands available for installation
    - Chain hoist(s) available for installation
- Strike in 20 minutes

Standards

- Minimum specifications for mass-produced portable platforms, ramps, stairs, and choral risers for live performance events (ANSI E1.62 – 2021)

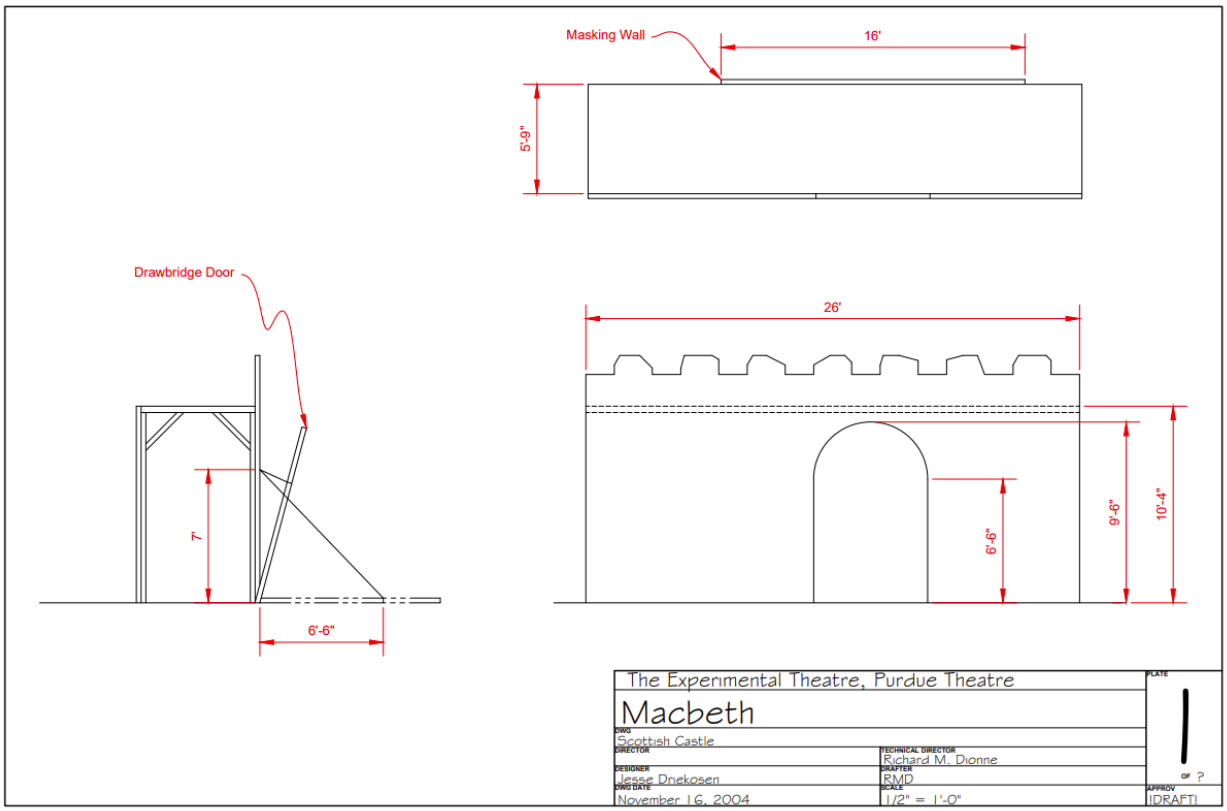


Figure 1: Given Drafting of Platform

Additional Dimensions

- Doorway is 5’-0” wide
- Distance from SL side of platform to door opening is 6’-0”

Section 2: Concept Design

Column Design Ideas:

- Square Posts
- Built-Up I-Beam for critical columns, square posts everywhere else
- Circular Posts
- Stud Walls

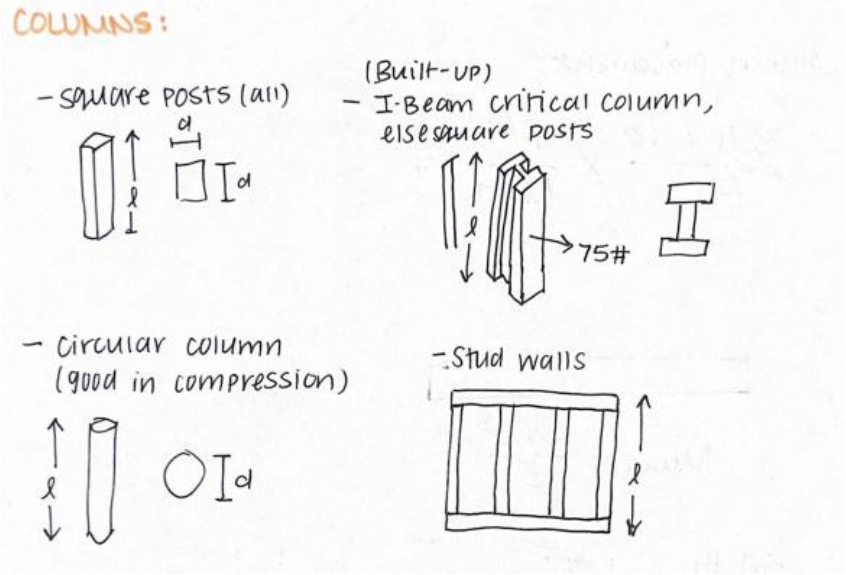


Figure 2: Column Concept Ideation

Platform Design Ideas:

- 3-4 Parallel Framed Platforms
- 3 Girders stretching the 26' span
- 2 Girders stretching the span with perpendicular beams

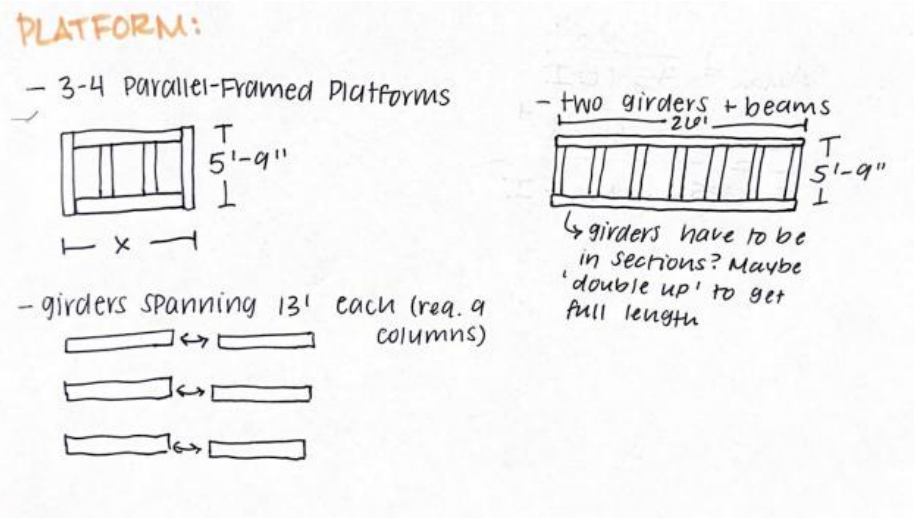


Figure 3: Platform Concept Ideation

Concept Evaluation:

Each column and platform design idea are ranked alongside the rest in the decision matrices below. The highest-ranked column and platform designs will be paired together for the final concept that will be analyzed.

		Square Posts		Built-Up I-Beam Critical Columns		Circular Posts		Stud Walls	
	Weight	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value
Construction Time	2	3	6	2	4	3	6	1	2
Installation Time	2	3	6	3	6	3	1	2	4
Within Budget	2	3	6	1	2	1	1	1	2
Weight	1	3	3	2	4	3	6	1	2
Good Under Bending	2	2	4	3	6	1	1	2	4
Good Under Compressior	2	2	4	2	4	3	6	3	6
Repeated Parts	1	3	3	1	2	3	6	1	2
Few Pieces	1	3	3	1	2	3	6	1	2
			35		30		33		24

Figure 4: Column Design Decision Matrix

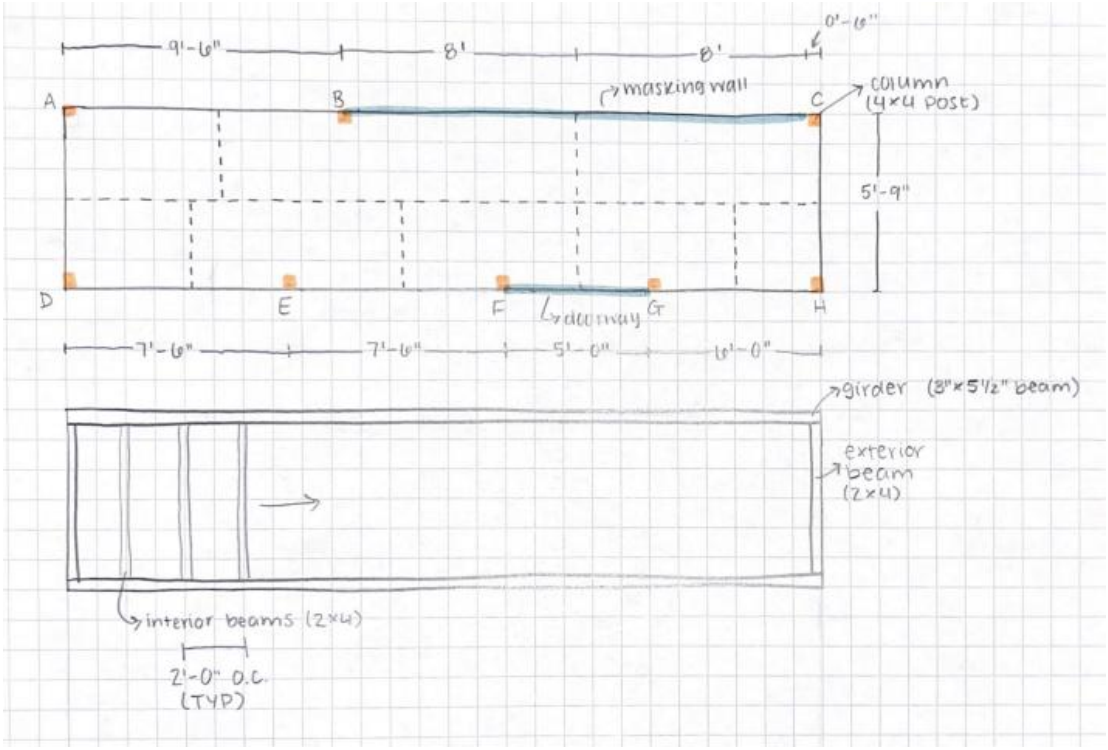
Based on the column design decision matrix, square columns will be used. Exact dimensions for these columns will be determined during the detail analysis stage. Although using built-up I-beams for the critical columns seems like an idea that should be focused on, it may not be necessary to be overly concerned about the combined loading on these columns. If the square columns end up being too weak to support these loads, the design will be edited to reflect that. Although circular posts scored relatively high, they aren't a feasible solution because attaching the platform to these columns would be difficult. It's also hard to find these posts in stores at the correct diameter, so they would likely have to be specially ordered.

		Multiple Parallel Framed Platforms		Three Girders		Two Girders and Beams	
	Weight	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value
Construction Time	2	1	2	3	6	3	6
Installation Time	2	3	6	2	4	1	2
Within Budget	2	2	4	1	2	2	4
Weight	1	2	2	3	6	3	6
Strength	2	2	4	2	4	3	6
Repeated Parts	1	1	1	3	6	2	4
Few Pieces	1	1	1	3	6	2	4
			20		34		32

Figure 5: Platform Design Decision Matrix

Based on the platform design decision matrix, the three-girder design should be used. However, since the last design I analyzed for the class was a similar design, I want to try to use the girder and beam design. If the girder and beam design does not work or is too expensive, I will revisit the three-girder design. It is also important to note that the "repeated parts" and "few pieces" specifications were not included in the design specifications. These were added to ensure simplicity for the carpenters building this bridge, as having a simpler overall will make the bridge easier to build, install, and organize within the shop. Having too many different variations of column styles and platforms could lead to confusion. Because these specifications are based on personal preferences and not actual requirements depicted in the project description, they are weighted lower than the other categories.

Final Concept Sketch:

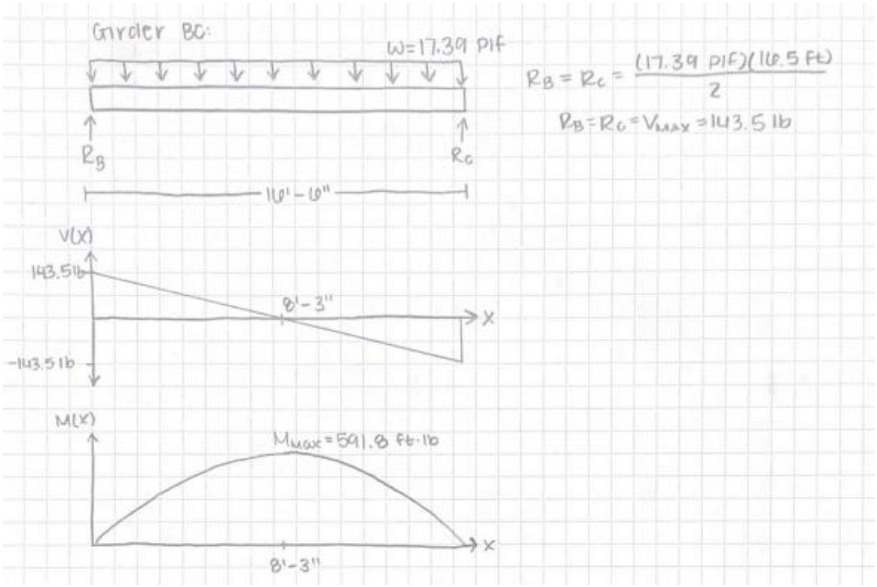


Section 4: Detail Analysis

Assumptions

- Sheathing for top of platform is 75 lbs per 4x8 sheet
- Force from drawbridge door on "critical" columns is a steady 75 lb force acting perpendicular to the column
- Actors are 200 lb each on average

Girders:



Load on Girders:	
Live& Dead Load (psf)	50
Live & Dead Load (psi)	0.347
Distributed Load (plf)	17.39
Distributed Load (pli)	1.449

Beam Properties:	
A (in^2)	16.5
S (in^3)	15.125
I (in^4)	41.594

No. 2 SPF	
Fv (psi)	135
Fb (psi)	875
E (psi)	1400000

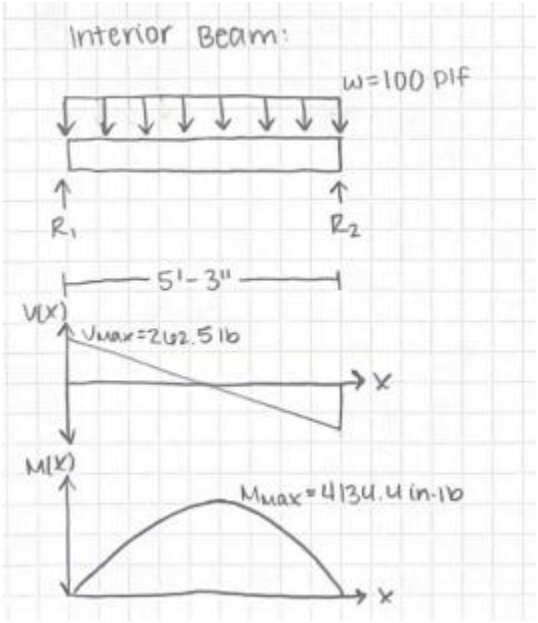
Girder Adjustment Factors:			
CM	1	CF	1.5
Ct	1	Cfu	1
CD	1.15	Cr	1
CL	1	CH	1

Fv'	232.875
Fb'	1509.375

Girder	Length (ft)	Length (in)	Vmax	Mmax (ft-lb)	Mmax (in-lb)	Δmax (in)	fv (psi)	fb (psi)	E (psi)
AB	9.5	114	82.6087	196.19565	2354.34783	0.475	7.50988	155.659	174989.8101
BC	16.5	198	143.4783	591.84783	7102.17391	0.825	13.0435	469.565	916840.4731
DE	7.5	90	65.21739	122.28261	1467.39130	0.375	5.92885	97.0176	86104.47719
EF	7.5	90	65.21739	122.28261	1467.39130	0.375	5.92885	97.0176	86104.47719
FG	5	60	43.47826	54.34783	652.17391	0.25	3.95257	43.1189	25512.43769
GH	6	72	52.17391	78.26087	939.13043	0.3	4.74308	62.0913	44085.49232

Note that $f_v < F_v'$, $f_b < F_b'$, and $E_{actual} < E_{required}$ for each of the girders. Because of this, no further analysis has to be performed.

Beams:



Beam Geometry	
l (in)	63
b (in)	1.5
d (in)	3.5
A (in^2)	5.25
S (in^3)	3.0625
I (in^4)	5.359375

Load on Beams:	
Live& Dead Load (psf)	50
Live & Dead Load (psi)	0.347222
Interior Beam Load (pli)	4.166667
Exterior Beam Load (pli)	8.333333

No. 2 SPF	
Fv (psi)	135
Fb (psi)	875
E (psi)	1400000

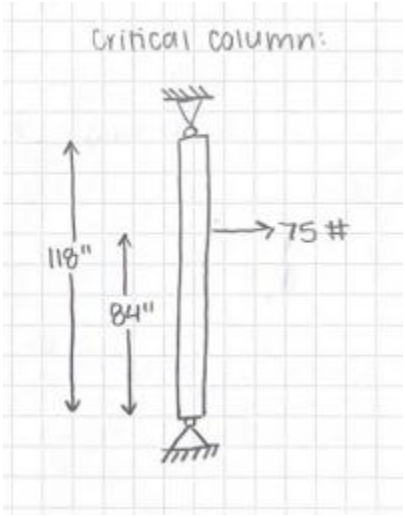
Girder Adjustment Factors:			
CM	1	CF	1.5
Ct	1	Cfu	1
CD	1.15	Cr	1.15
CL	1	CH	1

Fv'	267.8063
Fb'	1735.781

	w (lb/in)	Vmax (lb)	Mmax (in-lb)	Δmax (in)	fv (psi)	fb (psi)	E (psi)
Exterior Beam	4.167	131.25	2067.1875	0.2625	37.5	675	658983.0508
Interior Beam	8.333	262.5	4134.375	0.2625	75	1350	1317966.102

Note that $f_v < F_v'$, $f_b < F_b'$, and $E_{actual} < E_{required}$ for each of the beams. Because of this, no further analysis has to be done.

Columns:



No. 2 Southern Pine	
Fv (psi)	175
Fb (psi)	1050
Fc (psi)	1100
E (psi)	1400000
Emin (psi)	510000

Column Properties	
l (in)	118.5
b (in)	3.5
d (in)	3.5
A (in^2)	12.25
S (in^3)	7.145833
I (in^4)	12.50521

Column Adjustment Factors:			
CM	1	CF	1.5
Ct	1	Cfu	1
CD	1.15	Cr	1
CL	1	CH	1

Compression Calculations	
Fc* (psi)	1897.5
FCE (psi)	365.7138279
FCE/FC*	0.19273456
Cp	0.184396653
Fc' (psi)	349.8926488

Column Bending Calculations	
Mmax (in-lb)	1835.4
fb (psi)	256.849
CD	1.15
CF	1.5
Fb' (psi)	1811.250

Column	Tributary Area (in^2)	Applied Load	fc (psi)
A	1966.5	682.8125	55.7398
B	5278.5	1832.8125	149.617
C	3519	1221.875	99.7449
D	1552.5	539.0625	44.0051
E	3105	1078.125	88.0102
F	2587.5	898.4375	73.3418
G	2277	790.625	64.5408
H	1242	431.25	35.2041

Column	Combined Loading Ratio
F	0.221317525
G	0.20622177

Note that $f_c < F_c'$, $f_b < F_b'$, and the combined loading ratio is less than one for each of the columns. Because of this, no further analysis needs to be done for the critical columns.

Cost Estimate:

Item	Quantity	Cost per	Cost
4x4 Post	6	$ 14.58	$ 87.48
6x6 Post	2	$ 39.50	$ 79.00
2x6x18 Beam	6	$ 12.90	$ 77.40
Post-Beam Connector	6	$ 4.97	$ 29.82
Joist Hanger	28	$ 1.05	$ 29.40
2x4x12 Beam	7	$ 4.74	$ 33.18
			$ 336.28

With a 10% contingency, this becomes $370.