BEAM DREAMERS
EST. 2024

PCI Big Beam

Final Presentation

CENE 486C - May 02, 2025

Payton Correia
Isabella Velasco
Zach Fukumoto
Caitlin Yazzie

Figure 1: Big Beam

Project Introduction

Purpose[1][2]

- Design an 18’ prestressed concrete beam
- Fabricate
- Predict
- Test

Client: Precast/Prestressed Concrete Institute (PCI)

PCI Producing Member: Tpac

Technical Advisor: Dr. Ben Dymond

Figure 2: PCI and Tpac Logos

Intro to Prestressed Beams

What is Prestressed Concrete?

- internal stresses are introduced
- counteracts stresses caused by applied loads

Key Advantages

- Beam has to reach a state of equilibrium before experiencing negative deflection
- Can withstand higher cracking capacity
  - Longer spans allowed
  - Less materials used

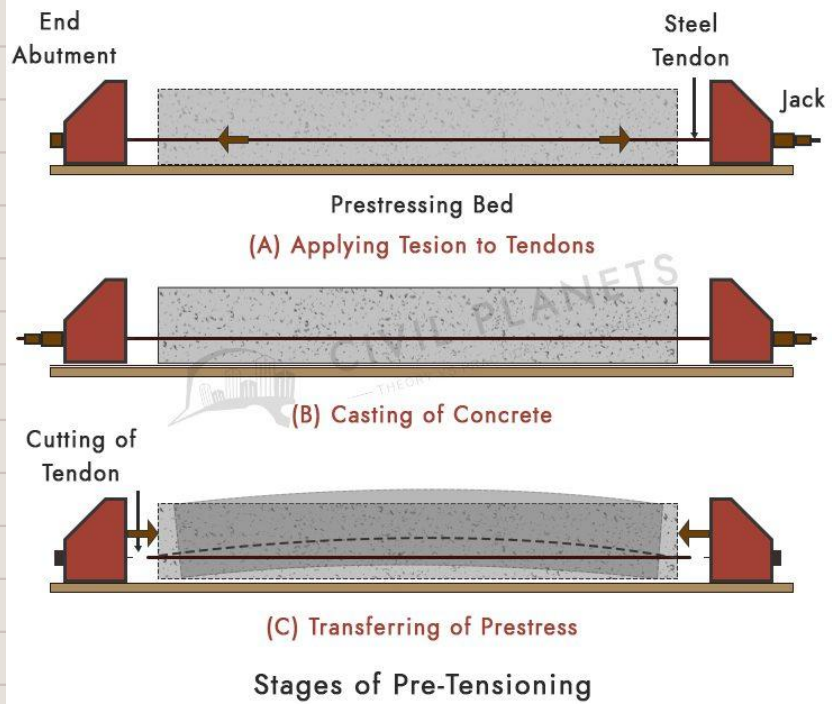


Figure 3: Prestressing Concrete [3]

PCI Big Beam Competition Criteria

1. Design constraints
    - Must crack between 20<2P< 32 kips
    - Must fail between 32<2P<40 kips
2. Lowest cost
3. Lowest weight
4. Highest deflection
5. Most accurate predictions
6. Report Quality

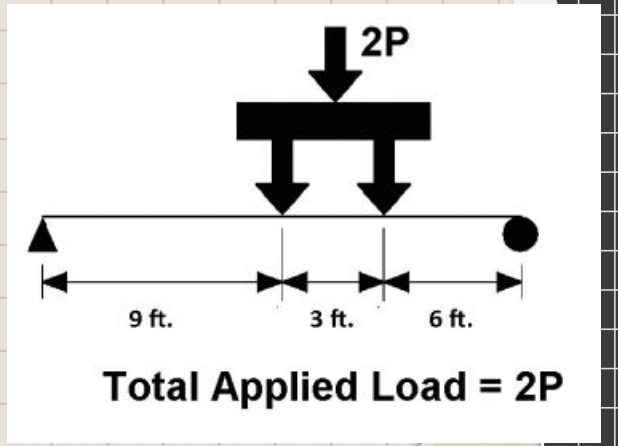


Figure 4: Load Configuration Diagram

Preliminary Beam Designs

Best of Initial Designs

Refined Designs

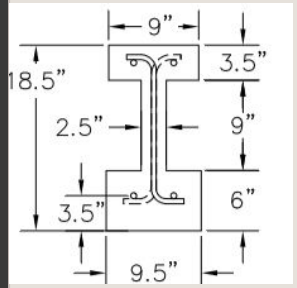
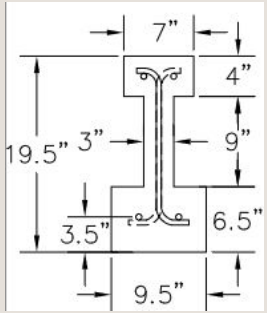
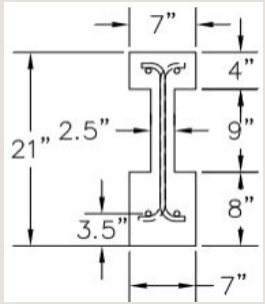
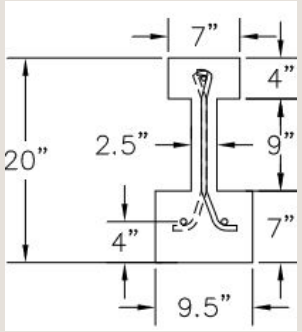
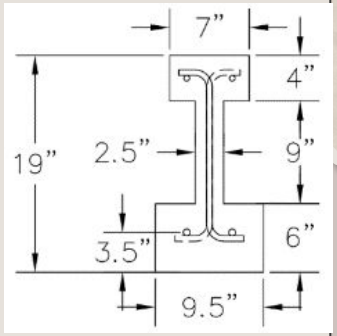
	Design 1	Design 2	Design 3	Design 4	Design 5
Design					
Change	Thinner top & bottom flange Small overall height	Narrow top flange & wider bottom flange and web	Top & bottom flanges same width Tall beam	One strand at top to hold stirrup Higher deflection & failure load	Bottom flange reduced
Result	Weight low Deflection high	High weight Increased deflection	Low deflection Decreased weight	Clear cover excessive High weight Stirrup design not constructible	Clear cover reduced Decreased weight

Figure 5: Alternative Designs

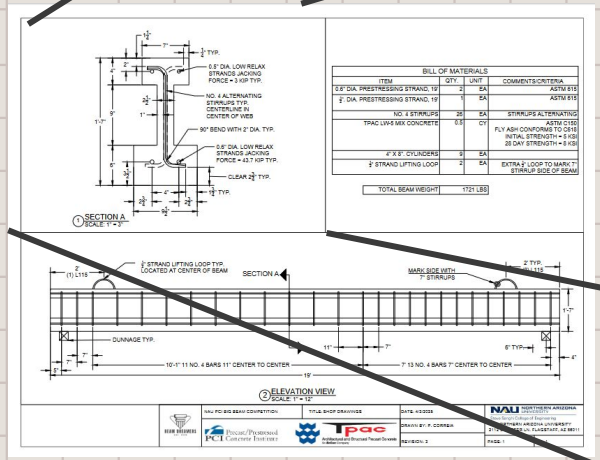
Decision Matrix - Initial Scores

Score based on Rules[2]

Score = 1 * (value in entry-worst value)/(best value-worst value)

Design	Criteria						Initial Score (max: 3)
	Weight (lbs)		Deflection (in)		Cost ($)		
	Value	Score	Value	Score	Value	Score	
1	1759	0.74	0.113	0.56	236.3	0	1.30
2	1849	0.13	0.117	0.72	234.4	0.5	1.35
3	1721	1	0.099	0	234.4	0.5	1.50
4	1868	0	0.124	1	232.5	1	2
5	1721	1	0.117	0.72	234.4	0.5	2.22

Shop Drawings



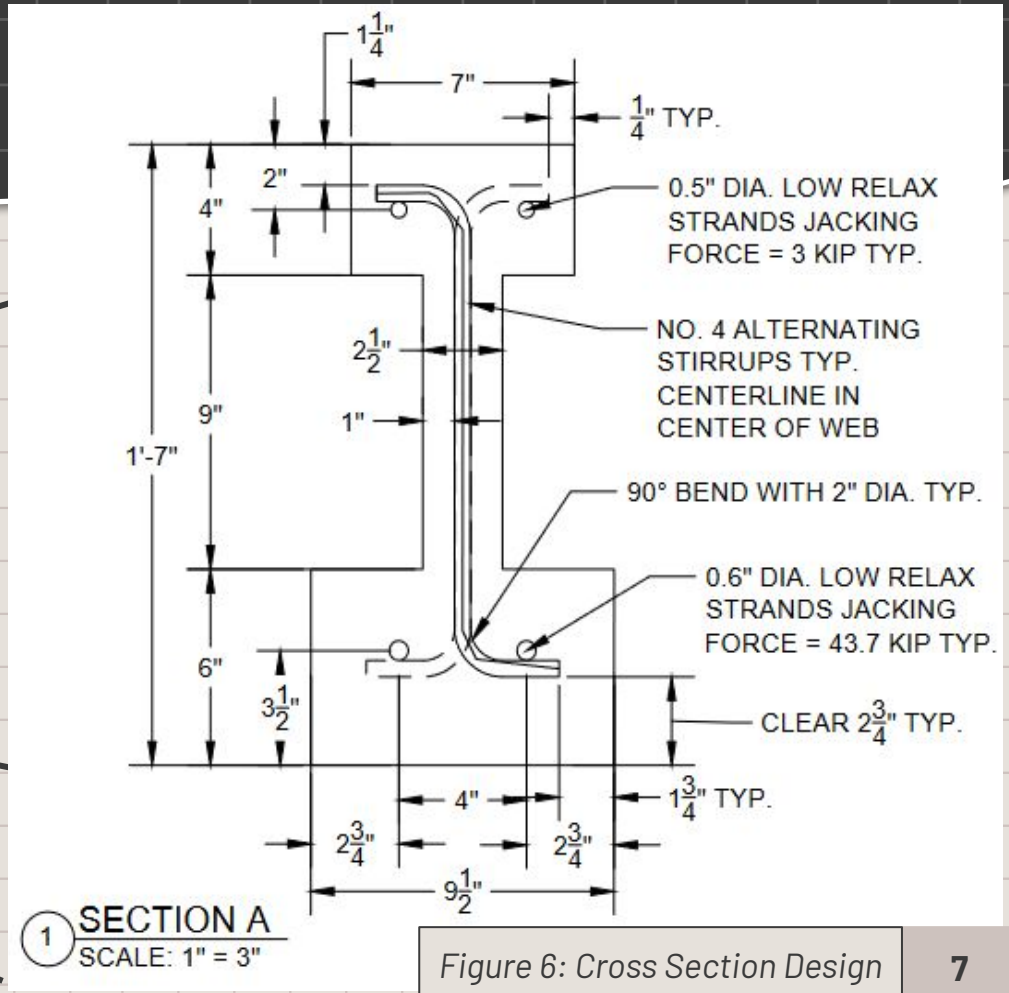
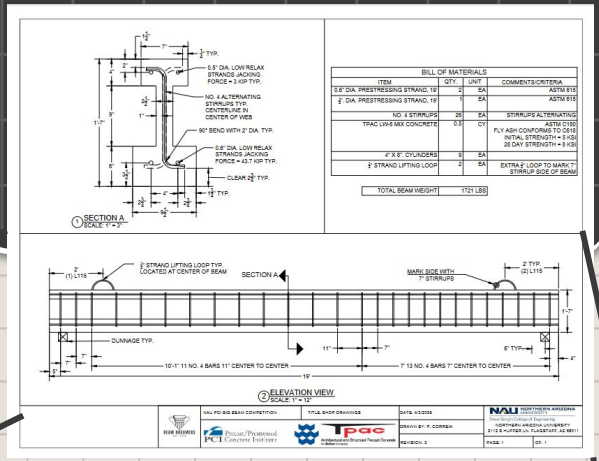


Figure 6: Cross Section Design

- March 23: Revised Shop Drawing sent to TPAC

Shop Drawings



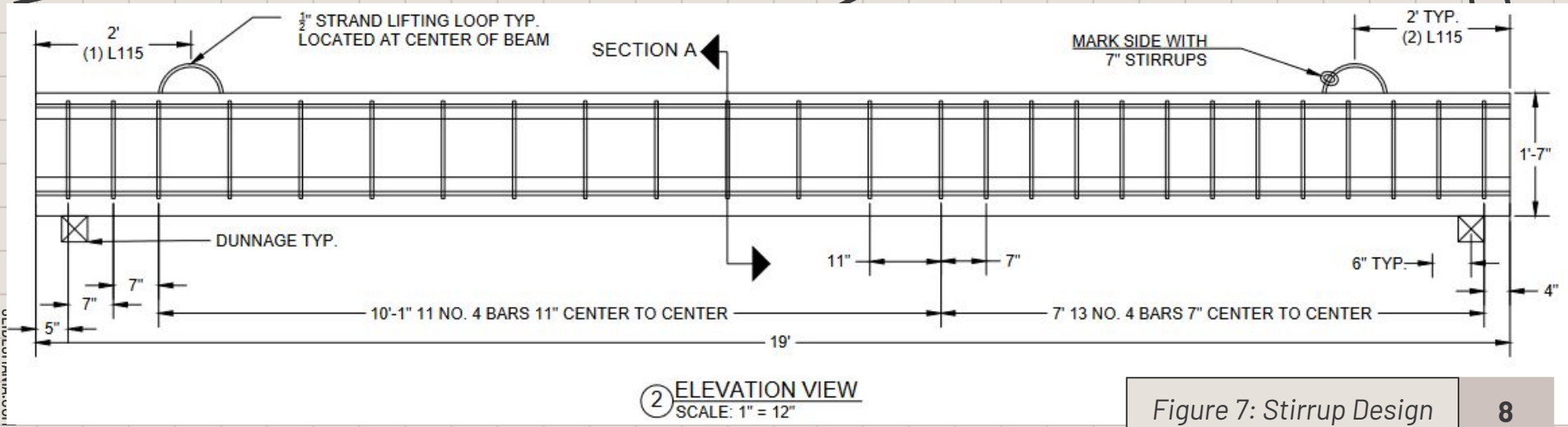


Figure 7: Stirrup Design

Beam Fabrication

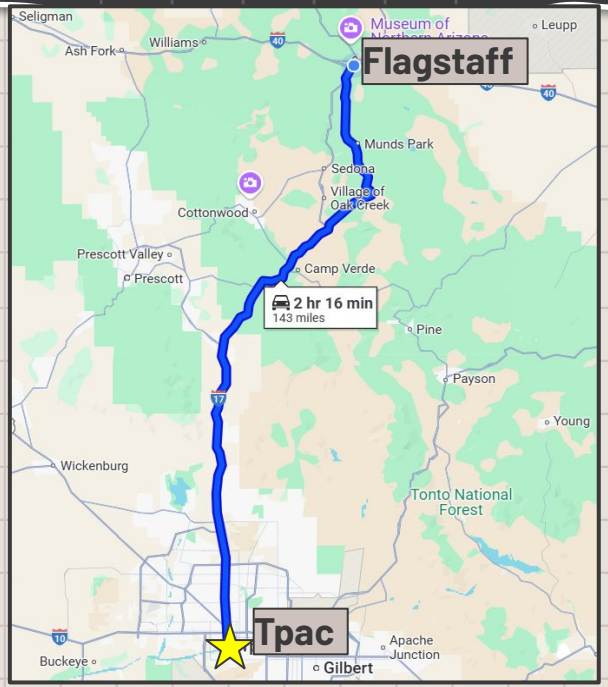


Figure 8: Project Location

Figure 9: Tpac Entrance

Figure 10: Team Touring Tpac

Fabrication - Initial Concrete Tests

Category	Test Results
Spread	27.5 in
Estimated Air	7.25%
Unit Weight	118.1 pcf (lb/ft^3)

Figure 11: Concrete test cylinders

Figure 12: Spread Test

Fabrication - Form

Figure 13: Beam Form

Figure 14: Close up of strands

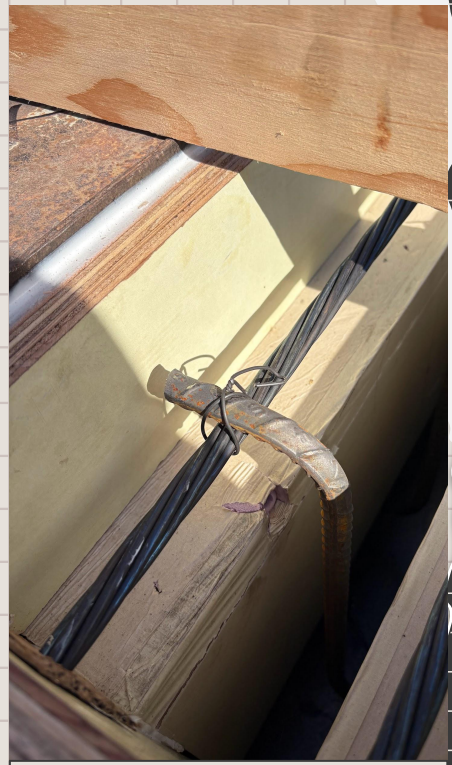


Figure 15: View of Stirrup attachment

Fabrication - Quality Assurance

Figure 16: Verification of 11 in. stirrups

Figure 17: Verification of 7 in.stirrups

Figure 18: Verification of strand measurements

SLIDESMP

Fabrication - Pour

Figure 19: Concrete Truck

Figure 20: Concrete Pour

Figure 21: Finished Pour

Beam Setup

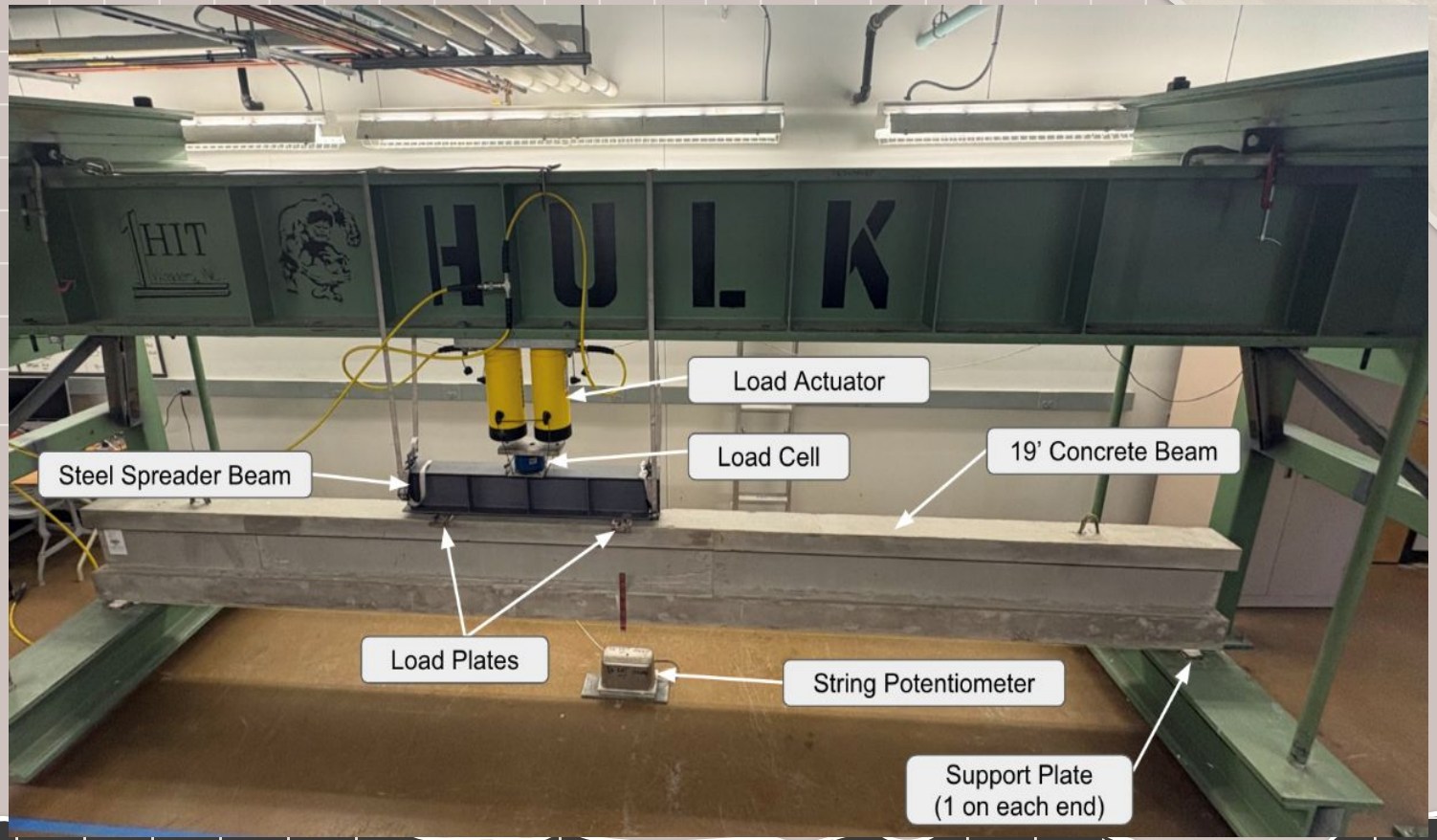


Figure 22: Beam Test Setup

Compressive Strength Test (ASTM C39)

	Pounds	PSI	PSI Sec
Test 1	86,600	7,120	28.5
Test 2	92,890	7,390	38.7
Average	**89,700**	**7,260**	**34.0**

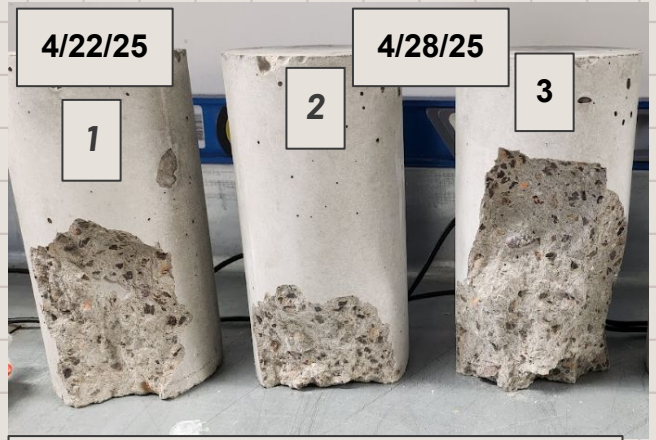


Figure 23: Broken Test Cylinders (n = 2)

Figure 24: Ideal cylinder break

Final Design Calculations Sample

CROSS SECTION PROPERTIES

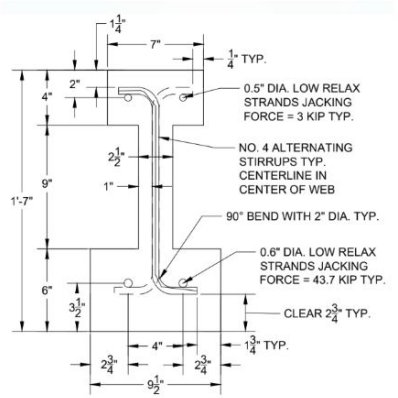


Figure 1: cross section design from shop drawings

$L_{tot} := 19\ ft$ beam length

$L := 18\ ft$ $x := 0\ ft, 0.1\ ft .. L$ span length

$t_{tf} := 3.5\ in$ thickness of top flange

$t_{bf} := 6\ in$ thickness of bottom flange

$h_w := 9\ in$ height of web

$b_{tf} := 9\ in$ width of top flange

$b_{bf} := 9.5\ in$ width of bottom flange

$b_w := 2.5\ in$ width of web

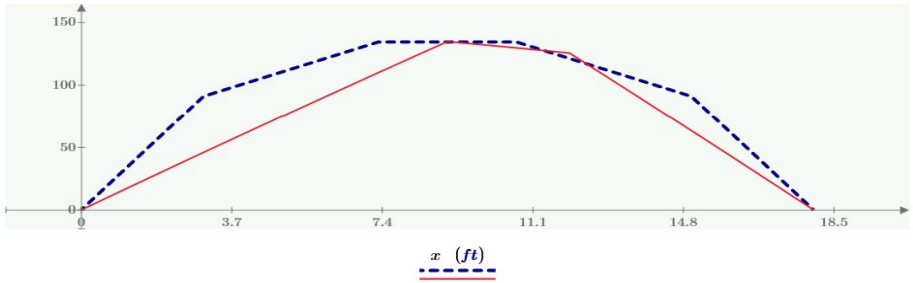
$h := t_{tf} + t_{bf} + h_w = 18.5\ in$ beam height

$L_{p.xs} := 2 \cdot (t_{tf} + t_{bf} + h_w) + b_{tf} + b_{bf} + (b_{tf} - b_w) + (b_{bf} - b_w) = 69\ in$ perimeter of cross section

Figure 25: Cross Section Measurements

$\phi M_n(x)$ $(kip \cdot ft)$

$M_u(x)$ $(kip \cdot ft)$



$check := \text{if}(M_u(AB) > \phi M_n(AB), \text{"Fail"}, \text{"Not Fail"}) = \text{"Fail"}$

$M_u(AB) = 134.9\ kip \cdot ft$ $\phi M_n(AB) = 134.5\ kip \cdot ft$ $M_u(AB) \div \phi M_n(AB) = 1.00$

Figure 26: Failure Calculations

Results

	Prediction	Test Results	% Difference
Cracking Load	22.8 kip	22.7 kip	- 0.4%
Breaking Load	34.9 kip	38.6 kip	+11%
Midspan Deflection (32 kips)	1.09	1.04 in.	- 4.7%
Midspan Deflection (Max)	1.8 in.	2.7 in.	+50%

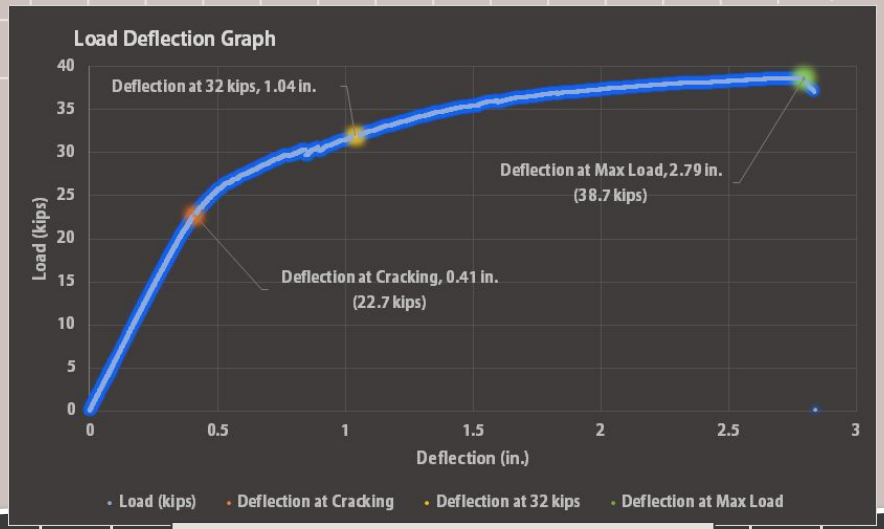


Figure 27: Load Deflection Graph

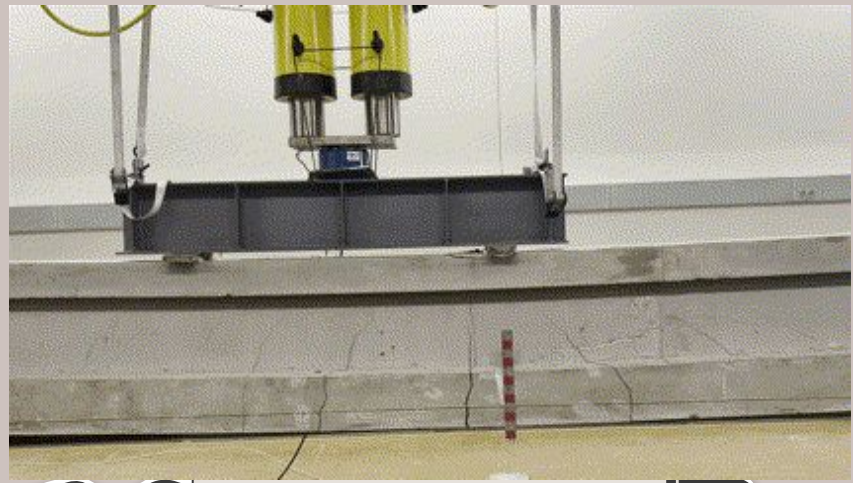


Figure 28: Beam Breaking GIF

Impacts of Prestressed/Precast Concrete

	Cons	Pros
Economic	- Upfront cost higher because of lead time	- Time on site reduced; labor much cheaper
Environmental	- Carbon emissions from transportation	- Longer span lengths and optimal size options - less materials required
Social		- More aesthetic options - Less disruption due to construction and road closures

2022 PCI Design Award
Transportation Award: Best Non-Highway Bridge

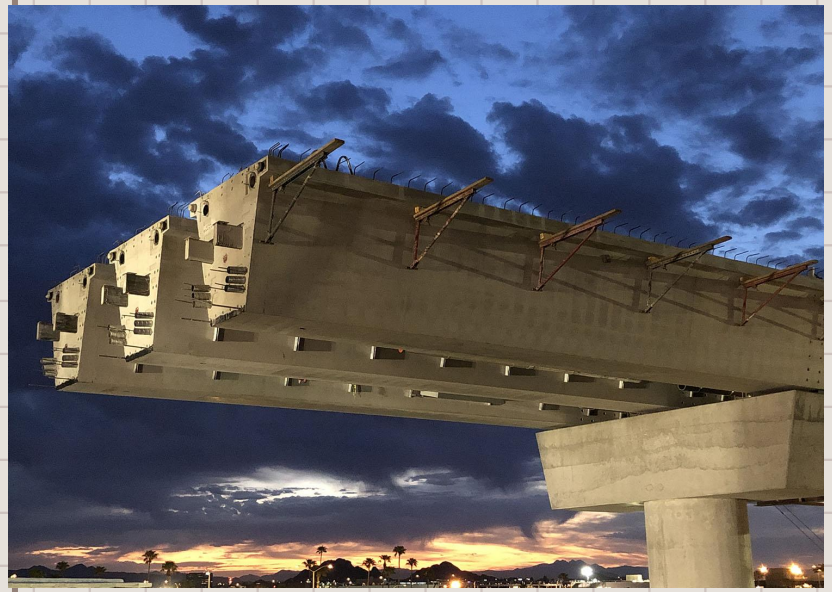


Figure 29: Phoenix Sky Train Stage 2
Produced by Tpac

2022 PCI Design Award
Best Mixed Used Building & BIM Award

Figure 29:Little Island at Pier 55
2.4 acre park space, New York City

Thank You

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PCI Big Beam Capstone Website

Works Cited

[1] PCI, "PCI Big Beam Competition," [Online]. Available: https://www.pci.org/PCI/PCI/Education/Student_Competitions.aspx.

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[4] Google Maps

[3] Prestressing Concrete Image https://williams-works.com/wp-content/uploads/2020/07/Prestress-Concrete-101-03.png