2025 PCI Big Beam

Payton Correia, Zachary Fukumoto, Isabella Velasco, Caitlin Yazzie
Department of Civil Engineering, Construction Management and Environmental Engineering

BEAM DREAMERS EST. 2024

NAU NORTHERN ARIZONA UNIVERSITY
Steve Sanghi College of Engineering

PROJECT DESCRIPTION AND LOCATION

The PCI Big Beam Competition, hosted by the Precast/Prestressed Concrete Institute, tasks student teams with designing, fabricating, and testing an 18-foot-long precast, prestressed concrete beam. Our team, Beam Dreamers, at NAU is competing nationally, with judging based on structural performance, prediction accuracy, deflection, weight, and rule compliance.

The beam will be fabricated at Tpac in Phoenix, Arizona, and tested at NAU's Concrete Lab in the Engineering Building.

The beam must:
- Experience its first crack between 20 kips and 32 kips of live load.
- Fail in flexure between 32 kips and 40 kips of live load.

The primary judging categories are:
- Most accurate predictions
- Largest midspan deflection at maximum total applied load.
- Lowest weight
- Lowest Cost

Regulatory Requirements:
- Follow PCI Big Beam 2024-2025 Rules
- Comply with ACI 318-19
- Fabrication must adhere to Tpac's safety and process standards
- Testing must adhere to NAU's concrete lab protocols and OSHA safety standards.

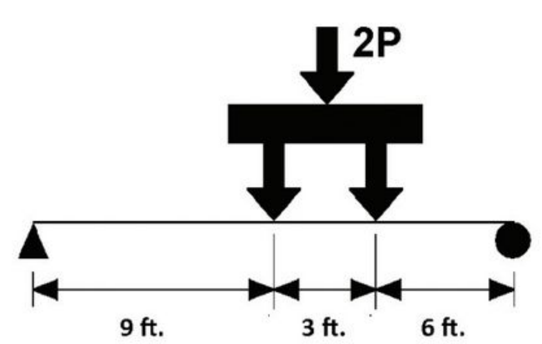


Figure 1: Loading Diagram

BEAM FABRICATION

On March 4th, 2025, the team went to the Tpac plant in Phoenix, AZ, to oversee fabrication after communicating about the design via AutoCAD drawings. The team verified that all measurements were as directed in the plans.


Figure 2: Test Cylinders

Tpac made the lightweight concrete on-site and conducted preliminary tests, shown below:
- Slump/Spread: 27.50%
- Percent Air: 7.25%
- Weight: 1721 lbs

The lightweight mix used had a design spread of 27" ± 3". As an indicator of workability, the slump being within the specified range indicates that the concrete was workable and there is not likely to be gaps in the concrete when it sets.


Figure 3: Big Beam Fabrication

The prestressing strands were cut 3 days after the concrete pours and exceeded the required strength at release. The risk of the beam failing at release was mitigated.

9 test cylinders were created for NAU team use in order to test the compressive concrete strength (ASTM C39) and tensile concrete strength (ASTM C78).

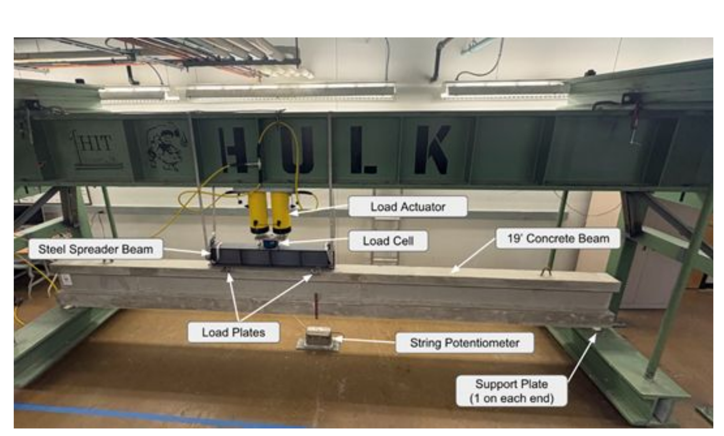


Figure 4: Big Beam in lab awaiting testing in NAU Concrete Lab

DESIGN

The final design cross section is shown in Figure X.

Some prominent design features are highlighted below.
- I beam allowed for reduction in weight and cost
- Single leg stirrup
- 2 prestressed strands at a bigger size allowed for cost reduction and constructability.
- 2 prestressing strands at top to anchor stirrup

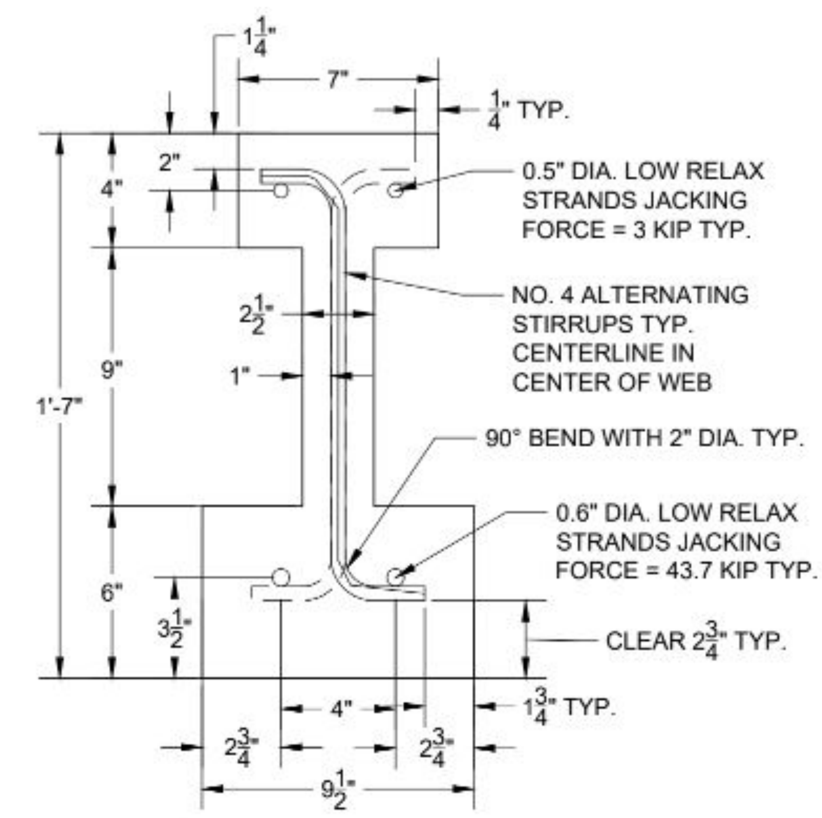


Figure 5: Cross Section Design

The final stirrup spacing is shown below

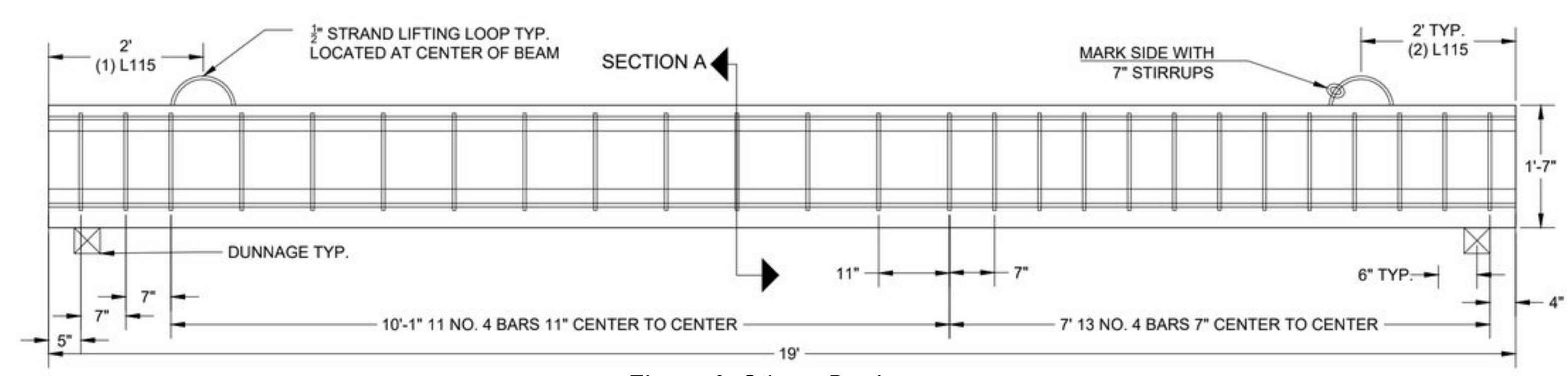


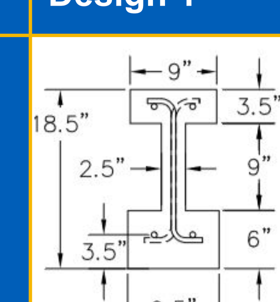
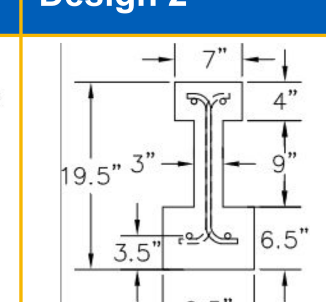
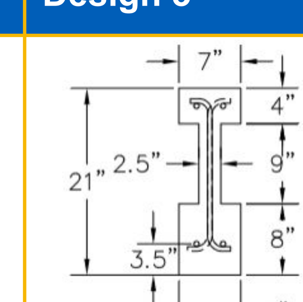
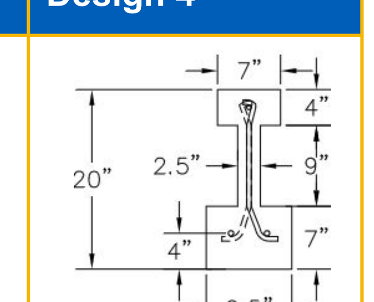
Figure 6: Stirrup Design

Stirrups are spaced 11" apart towards the left, where there is less shear demand, and 7" apart towards the right, where there is more shear demand.

DESIGN ALTERNATIVES

The NAU team used MathCad to complete their calculations. For full calculations, please visit https://www.ceias.nau.edu/capstone/projects/CENE/2025/PCI/. The design alternatives are as follows.

Table 1: Design Alternatives

	Design 1	Design 2	Design 3	Design 4
Design				
Difference	-Thinner top and bottom flange -Small overall height	-Narrow top flange and wider bottom flange and web	-Top and bottom flanges same widths -Tall beam	-One strand at top to hold stirrup
Result	-Weight low -Deflection high	-High weight; -Increased deflection	-Low deflection -Decreased weight	-Stirrup design not constructible -Clear cover excessive -High weight

COST OF BEAM

The PCI Big Beam Competition designates how cost is calculated in order to keep the criteria fair across different vendors. The following shows how cost is calculated for the NAU team's beam.

Table 2: Cost Calculations

Material	Cost Basis		Cost Equation	Cost
Concrete	Concrete Strength at Test	8 ksi	\$20 + (\$10 ● *Concrete Strength at Test in ksi*)	\$100.00
Formwork	Contact Surface Area	93.4 ft^2	\$1.25 ● (*Contact Surface Area*)	\$116.75
Stirrups	\$0.45/lb	26 stirrups 0.668 lb/ft	\$0.45 ● (1.71 ft) ● 0.668 lb/ft ● 26 stirrups	\$13.35
0.6" Prestressing Strands	\$0.33/ft	2 strands	\$0.33 ● (*2 strands*) ● (*19 ft*)	\$12.54
0.5" Prestressing Strands	\$0.30/ft	2 strands	\$0.30 ● (*2 strands*) ● (*19 ft*)	\$11.40
Total Cost				**\$254.04**

IMPACTS OF PRECAST CONCRETE

Precast concrete refers to when concrete is cast off-site and transported to the site for assembly. The pros and cons of precast concrete construction is outlined below.

Table 3: Precast Concrete Positives and Negatives [1][2][3]

	Positives of Precast Concrete	Negatives of Precast Concrete
Economic	• Reduced labor time and amount on-site • Faster construction schedule • Removes reliance on weather conditions • Concrete poured in controlled environment, leading to more durability and consistency	• Transportation is more expensive with more wear-and-tear on roads • Lack of post-production design changes
Social	• Less disruption to civilians during construction because panels are ready to install • Growth of precast industry creates jobs • Safer working conditions for employees	• Less personnel required due to automation
Environmental	• Higher durability due to ideal lab conditions • No adhesives required, so less chemicals • Lower air infiltration in precast buildings	• Higher transportation cost and requirement

Overall, Precast concrete is more durable, cost-effective, and sustainable than traditional methods.

REFERENCES & ACKNOWLEDGEMENTS

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For more information on this project, our full calculations, reports, and our complete references, please visit https://www.ceias.nau.edu/capstone/projects/CENE/2025/PCI/

Poster references

[1] B. Julaton, "Cast-in-Place vs Precast Concrete: Pros & Cons Explained | Forming America," *Concrete Forms and Shoring Equipment Company*, Nov. 06, 2023. https://www.formingamerica.com/cast-in-place-vs-precast-concrete-pros-cons-explained/

[2] PCI, *Designer's Notebooks: Sustainability (DN-33)*. PCI. Available: https://www.pci.org/PCI/PCI/Bookstore/Item_Detail.aspx?iProductCode=DN-33

[3] "The Social and Economic Benefits of Precast Concrete – TKL GROUP," *Tklgroup.com*, May 16, 2023. https://www.tklgroup.com/the-social-and-economic-benefits-of-precast-concrete/